# Comparative Life Cycle Assessment of various Cup Systems for the Selling of Drinks at Events

Focussing on major events such as the European Football Championships UEFA EURO 2008™ in Austria and Switzerland as well as the German "Bundesliga"

Expertise provided by:
Österreichisches Ökologie-Institut,
Carbotech AG and
Öko-Institut e.V. Deutschland

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Note: All terms that are used in this document (e.g. “operator”, “client”, “host”, etc.) have been kept in neutral gender for the purpose of easy readability, but apply nevertheless to both the male and female gender.

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# 1 Summary


## Situation

In June 2007, Austria, Switzerland and EURO 2008 SA agreed to support ecological, economic and social action during UEFA EURO 2008™ and signed a respective sustainability charter. One of the objectives with regard to environmental protection is the use of catering systems, whose operation produces the least environmental burden/impact. This should result in the implementation of sustainability standards for future major events, for example by using ecologically optimized methods of serving/selling drinks. Various manufacturers and operators of drinking cups are stressing the ecological benefits of their product systems. As a result there has been significant uncertainty with regard to which system would offer the highest ecological benefits for major sports events such as the UEFA EURO 2008™. This study refers to the issue of the serving of drinks at major events, and its results cannot necessarily be transferred to other applications.

The environment ministries of Austria, Switzerland and Germany, supported by the counties or cities of Basel, Bern, Hanover, Klagenfurt, Salzburg, Vienna and Zurich, have commissioned the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), the German Institute of Ecology (Deutsches Öko-Institut e.V.) and the Swiss company Carbotech AG to prepare a comparative life cycle assessment (LCA) of various drinking cup systems. For this analysis the actual experience gathered from the FIFA World Cup 2006™ in Germany as well as specific general conditions for European football championships were to be taken into consideration.

The purpose of the study was to prepare an up-to-date basis for decision-taking with regard to the most ecologically beneficial drinking cup system. The results were presented to EURO 2008 SA and the drinks sponsors on 8th November 2007 in Nyon (Switzerland).

## Method

This life cycle assessment examines the use of various commercially available disposable and reusable cups at major events such as the UEFA EURO 2008™. It encompassed and assessed the ecological burden/impact over the entire life cycle of the products. The overall assessment was carried out using two recognised aggregating methods as well as eco-indicators and a point system for environmental burden. An external critical review by Paul W. Gilgen of EMPA confirmed the correctness of the study's procedure and applied methods as well as the robustness of its conclusions and recommendations. Furthermore Mr Gilgen certified that the study provided a practically relevant answer to the client's questions.

Assistant Professor Martin Patel who had originally been commissioned as critical reviewer was unable to finish the project due to delays in the project handling. Therefore it became necessary to assign the critical review to another reviewer at short notice. Mr Paul W. Gilgen was willing to take on this task, and he has long-term experience in preparing and reviewing life cycle assessments, especially in the field of packaging.

The study examined cups made from fossil materials as well as renewable raw materials and biodegradable materials. The comparative basis was the vending of a drink in a half-litre cup (beer or soft drinks). According to the LCA approach, the following environmentally-relevant processes were recorded and assessed over the entire life cycle:

- Provisioning of basic materials such as plastics, cardboard, PLA, etc.
- Processing of these materials, coating of materials and manufacturing of the cups
- Provision of the required energy mediums
- Transport
- Cleaning of reusable cups
- Effort/expenses for utilisation or disposal

The following environmental burden or eco-indicators were taken into consideration:

- Influence on the climate due to greenhouse gas potential (Global Warming Potential, GWP)
- Consumption of non-renewable resources such as oil or gas due to the cumulative energy demand (CED);
- Contribution to ozone build-up (summer smog) due to ozone built-up potential
- Contribution to soil and water acidification due to acid-forming potential
- Effects on human health (human toxicity)
- Effects on animals and plants due to the emission of certain substances (ecotoxicity)
- Changes in the nutrients equilibrium in soil and water due to eutrophication or excessive use of fertilisers
- Effects on biodiversity due to usage of large areas and their changes

The analysis included disposable drinking cups made of PET (polyethyleneterephthalate) and PS (polystyrene), coated cardboard, the biodegradable PLA (polylactide) and BELLAND® material over their life cycle.

The analysis distinguished between incineration and disposal or material utilisation (or even composting if possible) after one-off use of the cups.

For reusable cups made of PP (polypropylene) various scenarios were calculated. The essential difference between the various systems is down to a possible “UEFA EURO 2008™ branding”, which may prohibit any commercial use of the cups after UEFA EURO 2008™. However, drinking cups that are taken home by fans either pose a substitute for a souvenir with equal

demand in material or are taken home in addition to fan items or will be used in the home as drinking cups, thereby replacing other cups – either disposable cups or reusable cups. This kind of usage of cups that are taken home was discussed by a panel of experts. The results became part of the calculations.

The details regarding the usage cycles and rates for cups that are taken home during UEFA EURO 2008™ are based on experience from the FIFA World Cup 2006™ and on proposals by possible system operators for UEFA EURO 2008™ and our own model calculations. These sources were employed to check plausibility. In ambiguous cases, rather conservative (i.e. detrimental) values were used for the reusable cup systems. For example, a safety margin was introduced, which prescribed the inevitable utilisation/disposal of a relatively high number of cups in case their reuse was not allowed (due to branding issues). In contrast to the reusable cups, no safety margin was calculated for disposable cups. This means that the disposable cups had an advantage. For their assessment, the usual methods, i.e. the UBA procedure (by the Federal German Environment Ministry in Dessau) as well as the total aggregated methods of the «eco-indicator 99» and the «method of ecological scarcity, ecofactors 2006» (EBP 2006) were employed.

The results were examined for robustness using sensitivity analyses. This way it was possible to recognise the influence of changes in the LCA specifications and of an uncertain data position in the individual modules and to integrate them into the final assessment.

## Results

Like with all LCAs, the results only apply to the examined systems or products. Any conclusion regarding other applications can only be permissible with restrictions even if these applications have similar situation parameters. In order to achieve reliable results, the necessary adaptations must be made. In accordance with the issue, only those cup systems and materials were examined, which were relevant for use during EURO 2008. Especially the new materials from renewable raw materials (PLA) or recyclable materials (BELLAND® material) are at an early stage of development and warrant the expectation of future improvements, which were not investigated. The classic disposable systems or reusable systems also give rise to expectations of optimization, for example PET recycling for disposable cups or weight reductions/savings for reusable cups. Such optimization was also not included in our LCAs because they are not relevant for the application during EURO 2008.

To be precise, the results only refer to the application of the examined materials at their current stage of development. Also, the LCAs refer to the waste management situation in the examined countries (Switzerland, Austria, Germany), which mainly use incineration as the procedure of choice for disposing of residual waste. For countries, which are still championing

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l methods for residual waste, the results might be very different.

The examined cup systems allow the following conclusions:

- All reusable cup scenarios show lower environmental burden compared to the examined disposable cup scenarios. The differences for all examined cups are significant, with the exception of the cardboard cup, for which the differences are only significant to a certain extent.
- The best disposable cup scenario is awarded twice as many environmental burden points (EBPs) as the worst reusable cup scenario, for which subsequent reuse is impossible due to branding (PP EURO with branding (souvenir)).
- Amongst the reusable cup scenarios, the scenario with subsequent reuse of the cups (PP EURO without branding) is generally best in class.
- The LCAs for the German Bundesliga and for “public viewing” confirm these results!
- An important influence on the results is down to the number of cups that are taken home, their influence on the circulation numbers and the type of home use, which has been specified for the LCA. The latter cannot be excluded because of the principle of the LCA, which is to examine the entire life cycle of the products. For this reason, these aspects were taken very seriously (see chapters 6.3.4 and 6.3.5).
- Biodegradable disposable cups made of PLA (polylactide) do not pose any ecologically comparable alternative to reusable cups. Composting of the cups does not result in a reduced environmental burden because composting of this type of plastic does not render any tangible ecological benefit. Also, the effects of disposal are marginal compared to the production of the cups.
- The environmental burden of disposable PLA cups is comparable to that of disposable PET cups and much higher than that of disposable cups made of cardboard.
- The total aggregated environmental burden of disposable cups made of BELLAND® material is at the same level of that of conventional disposable cups such as cups made of PET. The above applies on the theoretical basis of a functioning recycling system. The proof for a functioning loop system for BELLAND® material in practical applications has not yet been delivered.

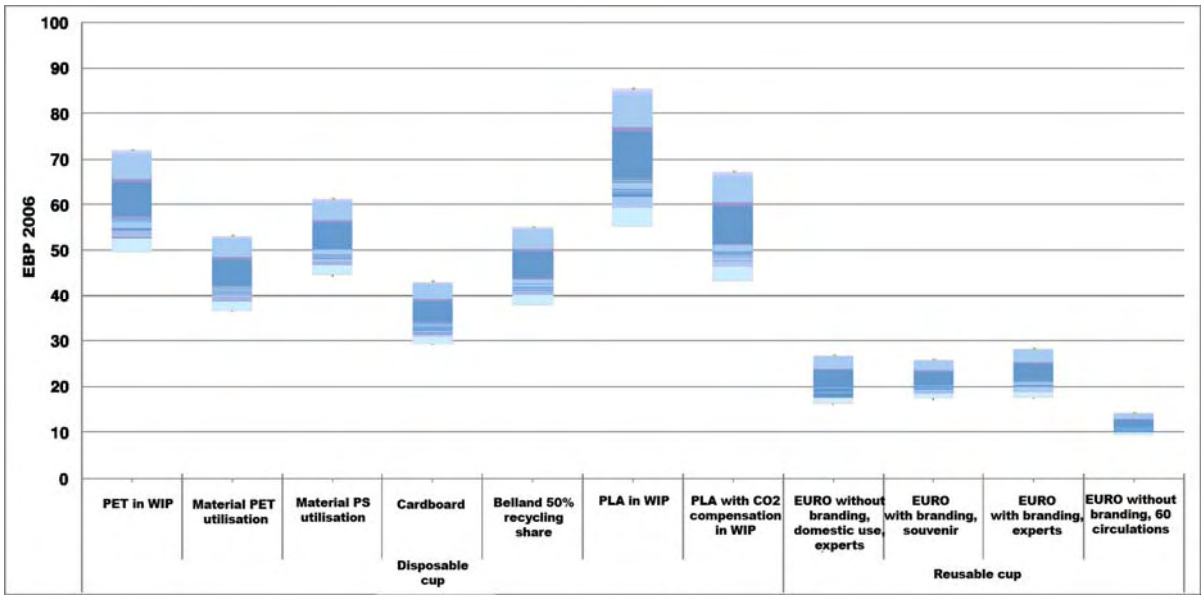



**Figure 1: Environmental burden of various drinking cups (assessed using the EBP 2006 method and including error ranges)**

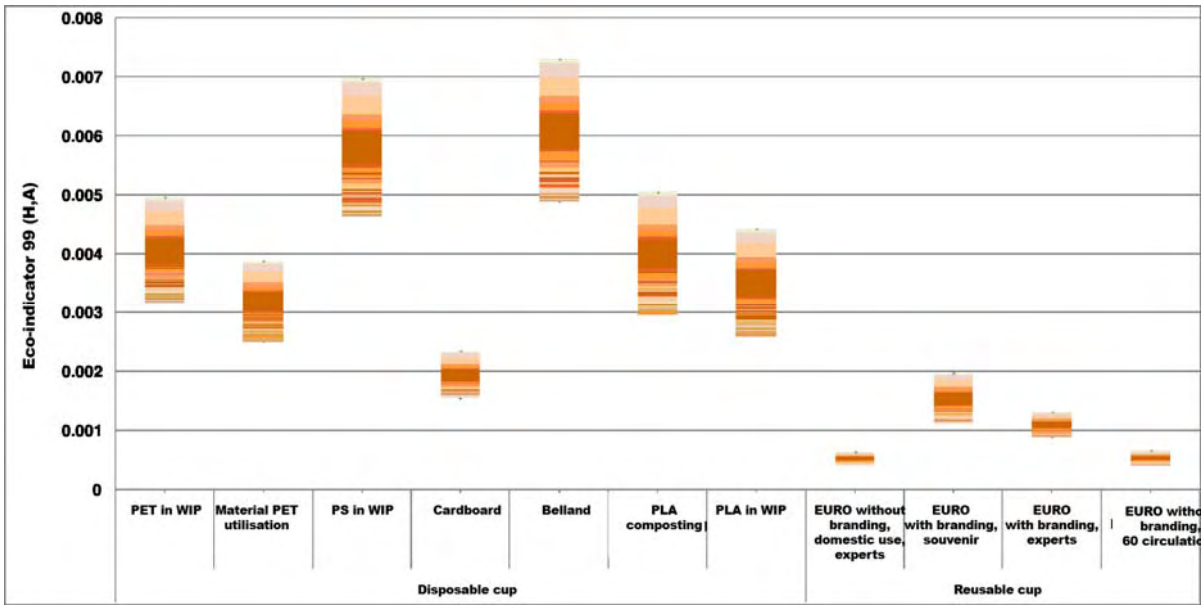



**Figure 2: Environmental burden of various drinking cups (assessed using the eco-indicator 99 HA method and including error ranges)**

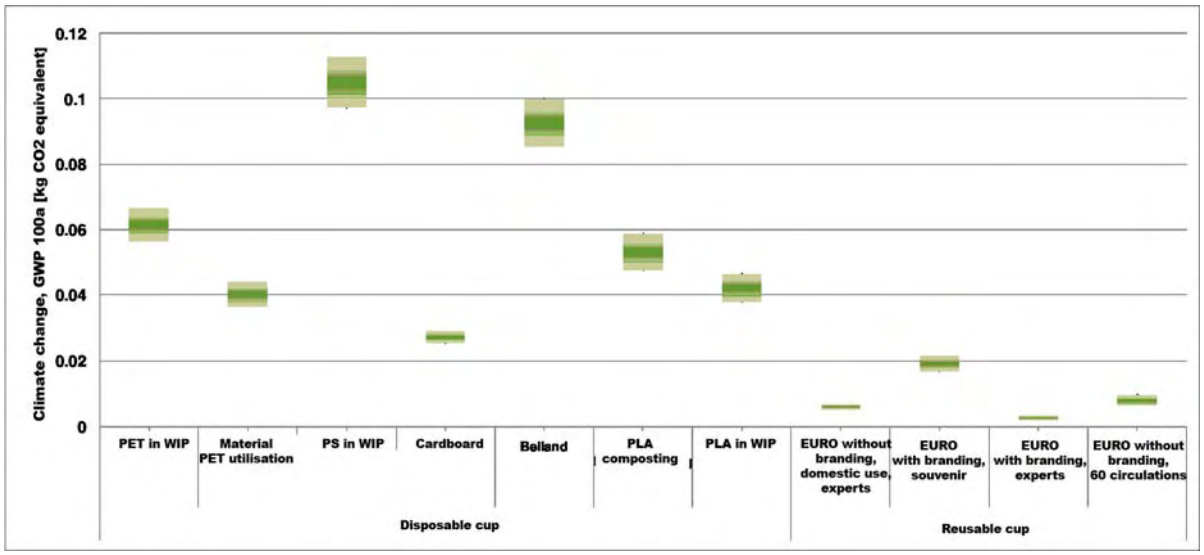



**Figure 3: Effects of various drinking cups on the climate (including error ranges)**

All reusable cup scenarios also showed to be more climate-friendly than disposable cup scenarios in the individual effects category of global warming potential (GWP). The comparison between the disposable cup scenarios shows the cardboard cup as being responsible for the least burden on the environment (for both assessment methods and for influence on the climate due to GWP).

All of the sensitivity examinations confirm the results trend from the standard scenarios:

- PET cup recycling for disposable PET cups leads to a clear environmental relief as compared to thermal utilisation in a WIP[2] but does not offer an ecological alternative to reusable systems. On the basis of experience with PET drinks bottles it can be expected that even a “PET to PET” drinking cup is technically feasible. Problems with its implementation can be due to the mixing of cups made of various other materials.
- As of today, a functioning loop system for Belland material has not been realised. Subject to the theoretical assumption that Belland was able to implement a closed loop recycling system with up to 50% of recyclable material (example for sensitivity assumption), the environmental burden would be much reduced but still remain significantly higher than that of the examined reusable versions.
- All reusable cup scenarios show the least environmental burden throughout. No disposable cup can be called an ecologically comparable container because all of them pose higher environmental burdens. The only exception is the cardboard cup, which for one assessment method (Eco Indicator 99) did not show a significant difference to the worst reusable scenario.

WIP = Waste Incineration Plant

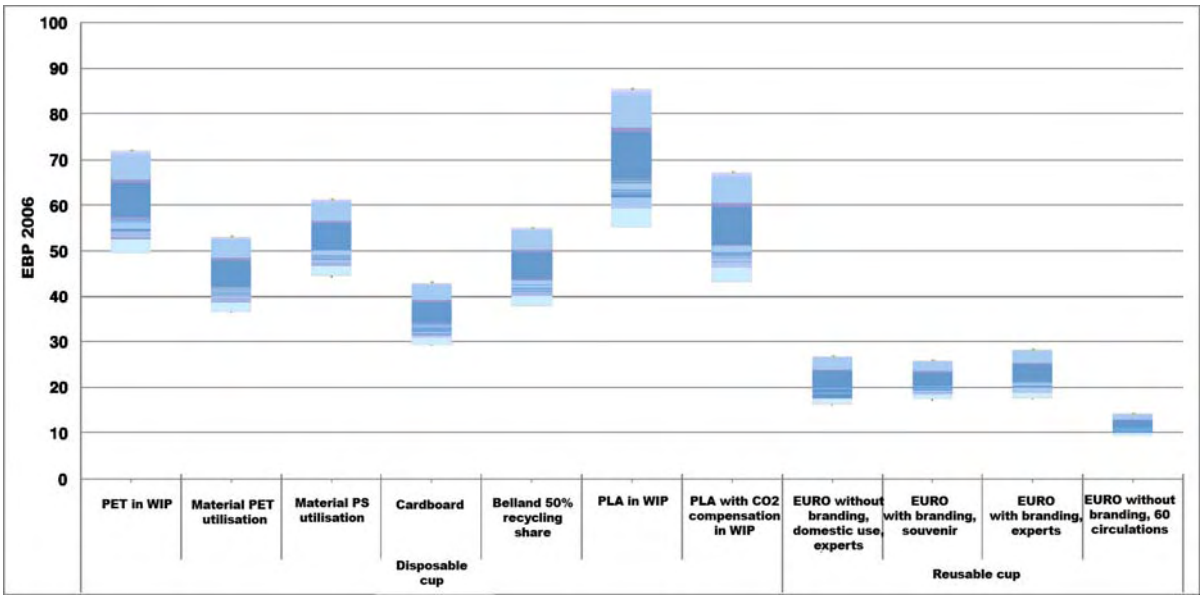



**Figure 4: Sensitivity analysis of the environmental burden of various drinking cups (assessed using the EBP 2006 method and including error ranges)**

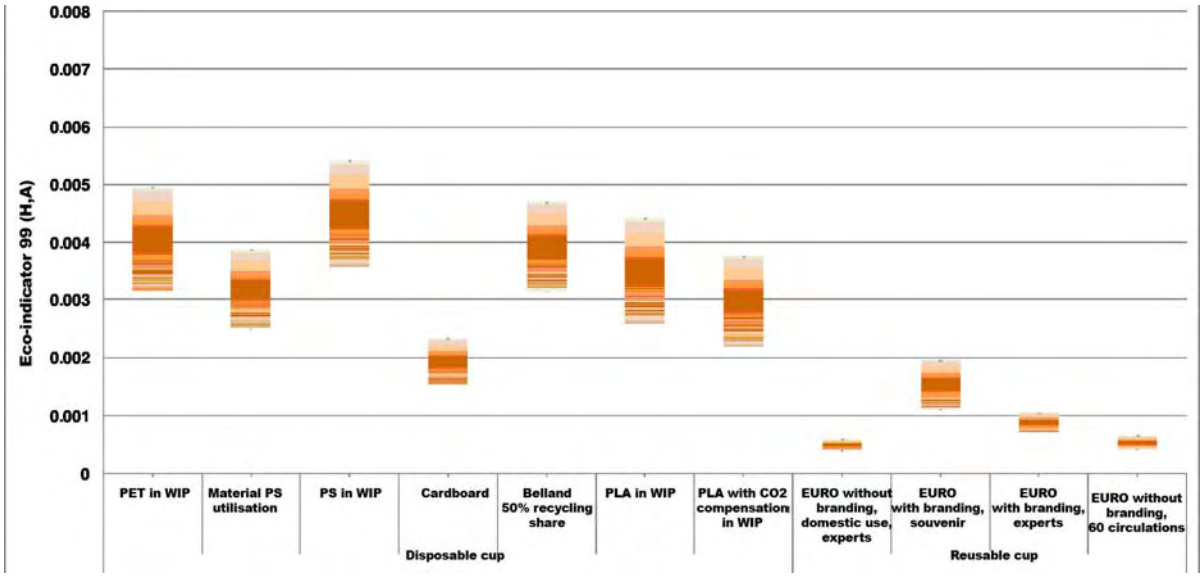



**Figure 5: Sensitivity analysis of the environmental burden of various drinking cups (assessed using the Eco-indicator 99 HA method and including error ranges)**

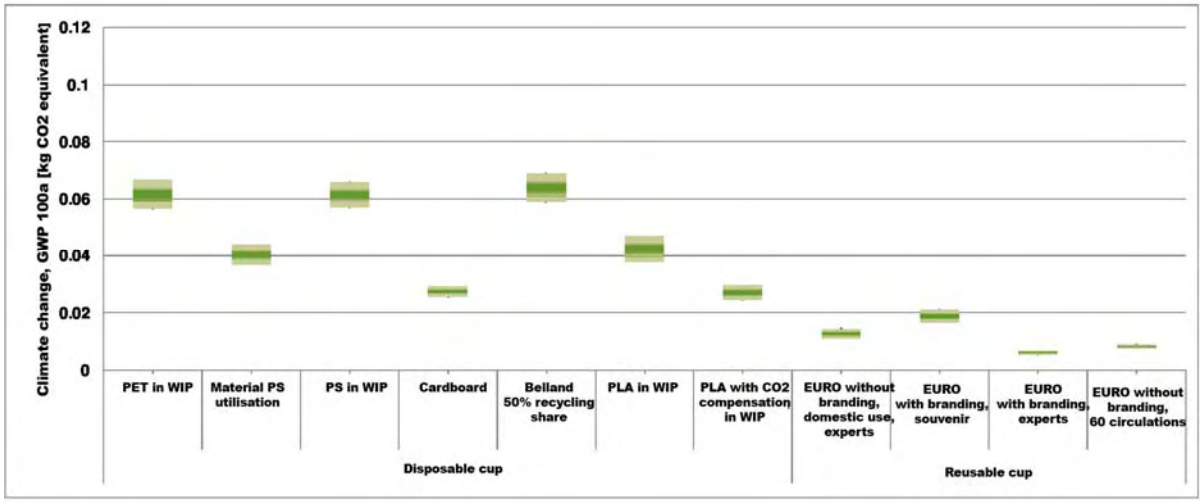



**Figure 6: Sensitivity analysis of the effects of various drinking cups on the climate (including error ranges)**

## Recommendations

- On the basis of the results from this study and taking ecological aspects into consideration, the authors recommend reusable drinking cups for
  - Major events (such as UEFA EURO 2008™)
  - Divisional operation (such as the German Bundesliga) and
  - Other major events (such as public viewing).
- All reusable cup scenarios display a lower environmental burden than scenarios for disposable cups, this despite the fact that LCAs for reusable cup versions were always based on the most disadvantageous scenario. This is confirmed by the results of the sensitivity analyses. Optimization potential for disposable cup systems should be realized on the one hand in the increase of the actual material recycling rates and on the other hand in the production of cups with the lowest possible weight. Despite the fact that material recycling (assumptions for PET and BELLAND® material) can lead to some relief compared to thermal utilisation, these disposable cup systems – in reality – do not offer an ecological alternative to reusable systems.
- Any subsequent reuse of the cups after UEFA EURO 2008™ by the Bundesliga or other organisers is recommended. This would result in a further reduction of the negative environmental burden as well as the avoidance of additional waste. This way, one of the requirements from the catalogue of the Austrian and Swiss sustainability concept for UEFA EURO 2008™ can be realised and implemented.
- The recommendations are based on clear and significant results, which were confirmed by the sensitivity analysis and, despite the rather conservative assumptions regarding the reusable

cup scenarios, display clear benefits in comparison to all disposable cup systems.

# 2 Initial situation

In football stadiums, at other major sports events such as the Olympic Games and also at other major events such as concerts or cultural events right down to town festivals, disposable cup systems as well as reusable cup systems are used for the selling of drinks. For the last few years, disposable systems have been available, which are manufactured from renewable raw materials or fossil raw materials with special recycling capabilities. Various manufacturers and system operators point to the ecological benefits of their systems and sometimes also provide proof on the basis of LCA studies. This has lead to some confusion about the sensibility of these systems from an ecological point of view. For example, in Germany and Switzerland some stadium operators and caterers have abandoned the reusable cup and, pointing to the ecological sensibility of their system, changed to using disposable cups.

Prior to this joint study by the Austrian Institute of Ecology, Carbotech AG and the German Institute of Ecology, no other comparable LCA for all relevant cup systems had ever been published. Furthermore it was possible to take current experience, for example from the Football World Cup 2006, and the specific conditions of the European Football Championships 2008 in Austria and Switzerland, into consideration. In June 2007, Austria, Switzerland and EURO 2008 SA (responsible for the organisation of UEFA EURO 2008™) agreed to support ecological, economic and social action during UEFA EURO 2008™ and signed a respective sustainability charter. One of the objectives in environmental aspects is the use of catering systems, which carry the least environmental burden/impact. This should result in the implementation of sustainability standards for future major events, for example by the use of ecologically optimized containers for the serving/selling of drinks. However, differing statements by cup manufacturers and distributors of drinking cups regarding the ecological benefits of their own systems caused significant confusion with UEFA decision-makers as well as the hosting nations and cities about the best ecological alternative for major sports events such as UEFA EURO 2008™.

The above reasons made clear that a comprehensive and broadly placed LCA was urgently required in order to achieve an up-to-date comparison of the various systems.

Apart from its importance for the normal Bundesliga operations, a basic reassessment of the various systems in preparation for an ecologically sound EURO 2008 in Austria and Switzerland is an urgent necessity.

All events under the EURO 2008 umbrella shall render long-term use, i.e. show a positive effect on the regional economy. At the same time, the negative effects on the environment shall be kept to a minimum. The EURO 2008 sustainability concept also demands social and cultural improvements. In this respect, the areas of catering at the event locations (football stadiums, public viewing areas) are of special importance.

During the preparation phase, and in the same way as during the Football World Cup 2006 in Germany, there are heated discussions in Austria about the credits and debits of reusable and disposable solutions regarding ecological impact, logistics and safety, etc. Often, economical interests and emotions play a large role.

This report describes the concept and results of a comparable LCA, which has been carried out by three independent and scientifically recognised institutes from Switzerland, Austria and Germany. The commissioning and support by the environment ministries of Austria, Germany and Switzerland as well as several cities and counties increase the acceptance and highlight the independence of this study and also ensures the widespread distribution of its results. The creation of an accompanying team from representatives of the client and project team guarantees a permanent exchange of ideas and comments. A critical review by a respected and neutral institution, which is commissioned by the environment ministries and which incorporates experts from these environment ministries and state environment agencies, proves that the LCA has been prepared according to up-to-date knowledge of methodology and mainly conforms to the standards for the preparation of LCAs (DIN EN ISO 14040 and 14044).[3]

The environment ministries of Austria, Switzerland and Germany, supported by the counties or Cities of Basel, Bern, Hanover, Klagenfurt, Salzburg, Vienna and Zurich, have commissioned the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), the German Institute of Ecology (Deutsches Öko-Institut e.V.) and the Swiss company Carbotech AG to prepare a comparative life cycle analysis of various drinking cup systems. For this analysis the actual experience gathered from the FIFA World Cup 2006™ in Germany as well as specific general conditions for European football championships were to be taken into consideration.

[3] Assistant Professor Martin Patel who had originally been commissioned as critical reviewer was unable to finish the project due to delays in the project handling. Therefore it became necessary to assign the critical review to another reviewer at short notice. Mr Paul W. Gilgen was willing to take on this task, and he has long-term experience in preparing and reviewing life cycle assessments, especially in the field of packaging.

# 3 Literature research for the comparison of drinking cups

## 3.1 Principles of the comparability and meaningfulness of LCAs

The comparability of study results depends on the framework of the examination, which is determined by the study authors and/or the clients. The parameters of the examination framework and therefore the comparability are:

- Product materials
- Circulation numbers
- Transport distances
- Type of disposal
- System boundaries/limits

Furthermore, the comparability and meaningfulness of studies depend on the availability of data and therefore the data quality. Here, the authors often have to rely exclusively on literature values and prognoses because real data from manufacturers are not available.

The scientific quality of LCAs depends in first instance on the selection of the method. A full LCA according to the standards series ISO 14040 to ISO 14043 contains the following elements:

- Definition of objective and examination framework (ISO 14040)
- Factual balance (ISO 14041)
- Estimate of effects (ISO 14042)
- Evaluation (ISO 14043)

ISO 14044 was published on 30$^{th}$ June 2006. This standard contains the previous individual standards ISO 14041 to 14043. ISO 14044 is, together with ISO 14040, the valid standard for an ISO-compliant LCA.

## 3.2 Publications for the comparison of cup systems

The following studies and papers were studied while focussing on practical insights into the preparation phase of this LCA (as of date 28th June 2007).

**Table 1: Publications for the comparison of cup systems**

| Authors | Study/paper title | Method |
|---|---|---|
| EBNER and GUP-<br>FINGER (2007) | Ökologisierung von Veranstaltungen in Wien (ecological aspects of Vienna events) | Survey |
| VINK (2007a)<br>(2007b) (2007c)<br>(2003) (2002) | Comparative LCA of Four Types of Drinking Cups used at event venues, OVAM, Mechelen, Belgium<br>Executive Summary of the Comparative LCA of 4 types of drinking cups used at events<br>Eco-efficiency analysis of 4 types of drinking cups used at events<br>Benchmarking NatureWorks® Polylactide Polymers with traditional polymers using Gross Energy Use and Climate Change as indicators<br>NatureWorks™ Polylactide Polymers and Ingeo™ Polylactide Fibersa<br>Applications of life cycle assessment to NatureWorks™ polylactide (PLA) production | LCA<br>Reusable: PC<br>Disposable: PP, PE cardboard, PLA_Basic, PLA_future<br>Eco-efficiency analysis<br>Material comparison between PLA and plastics, such as PP, PET, etc<br>International Conference on Bio-based Polymers, Japan<br>Disposable: PLA, PLA_future<br>Disposable: PLA and PLA future |
| OBERSTEINER and SCHNEIDER (2006)<br><br>SCHNEIDER (2005) | Einwegbechern aus nachwachsenden Rohstoffen im Wiener Tiergarten Schönbrunn (disposable cups made from renewable materials in the Vienna Schönbrunn zoo)<br>WieNaWARO - Beschreibung und praxisgerechte Planung von Umsetzungsprojekten zum Einsatz von Werkstoffen aus nachwachsenden Rohstoffen (description and practical planning of implementation projects for the use of renewable raw materials) | Analysis of disposable cups made from renewable materials: PLA, PET, PE cardboard, PP<br>Material: PP, PS, PE, PE cardboard, PLA |
| VERCALSTEREN and SPIRINCKX (2006a) (2006b)<br>Flemish Institute for Technological Research (VITO), Integral Environmental Studies and Public Waste Agency for the Flemish Region (OVAM), Belgium | Life Cycle Assessment of 4 types of drinking cups used on events,<br>Eco-Efficiency Analysis of 4 types of drinking cups used on events | LCA<br>Reusable: PC<br>Disposable: PP, PE cardboard, PLA<br>Eco-eficiency analysis<br>Reusable: PC<br>Disposable: PP, PE cardboard, PLA |

| | | |
|---|---|---|
| WOLF (2005) | Abfallvermeidungskonzeptes für die FIFA WM 2006 in Leipzig (waste avoidance concept for FIFA World Cup 2006 in Leizig, Germany) | Waste avoidance concept as a dissertation at Merseburg technical college<br>Reusable: PP<br>Disposable: PP, cardboard, BELLAND® material |
| DINKEL (2005)<br>(2004) (2001) | CARBOTECH, Basel<br>Ecologically-focused crockery selection<br>on behalf of Swiss Olympic<br>Ecological comparison: disposable cups – reusable cups<br>Ecological assessment of various crockery types incl. recommendations | LCA<br>Reusable: PC, PP<br>Disposable: PS, PP, PET, PLA, cellulose PE, cellulose starch, PE cardboard, cardboard starch, PET bottle, aluminium can<br>Reusable: PC, PP<br>Disposable: PS, PET, PLA, PE cardboard, PLA)<br>Starch, Chinese reed, palm leaves, recycling cardboard, PS |
| HACKEL (2004) | Innovatives Wiener Mehrwegsystem im Kino (Innovative reusable system Vienna in the cinema) | Ecological and economical comparison<br>Reusable: PP, PC, glass, china<br>Disposable: cardboard, PS, PET, PP |
| BASF (2003) | Serviceverpackungen im Kantinen-vergleich, Ludwigshafen 2003 (Service packaging in a catering comparison) | Eco-efficiency analysis<br>Reusable: glass, china<br>Diposable: PS, cardboard |
| BÄTTIG (2002), IN-FRAS, Zurich | Ökobilanz Einwegbecher – Mehrweg-Becher (LCA disposable cups – reusable cups) | LCA<br>Reusable: PC, PP<br>Disposable: cardboard, PS, PET |
| BUSCH (2001) Danish EPA, Copenhagen | Environmental assessment of plastic cups, Environmental assessment of plastic cups | LCA |
| HOCKING (1994): | Environmental Management 18(6), 1994, pp.889-899<br>Summary of ”Reusable and Disposable Cups: An Energy-Based Evaluation” | Energy balance<br>Reusable: ceramics, glass, plastic<br>Disposable: PS, paper |
| HAUER (1993): | Vienna Film Festival: Use of Reusable crcockery - effects and acceptance | Feasibility study and ecological comparisons<br>Reusable: china, glass<br>Disposable: paper, plastic |

## 3.3 Results and quotations

EBNER and GUPFINGER (2007): With regard to the question whether an event is ecologically sound or not, the use of reusable cups is the most-quoted reason or perception by guests of that event. Reusable systems can lower disposal costs by 50% to 70%. Disposal costs are also lowered by a reduced amount of littered waste. Both the extension of sales hours

and the heightened frequency of cup returns result in increased turnover.

VINK (2007b): For both types of events it can be concluded that none of the cup systems has the highest or the lowest environmental score for each environmental category. It is impossible to make an unambiguous statement about the preferred Basic cup system since no cup system scores best in all categories. The PC cups show the lowest environmental burden of the 4 Basic scenarios for the small event. This burden increases significantly moving to the large events, while the total burden stays the same for the three one-way cups.

OBERSTEINER and SCHNEIDER (2006): 80% of visitors to Vienna Schönbrunn zoo do not regard returning their deposit bottles as a nuisance during their visit.

WOLF (2005): Disposable plastic cups do not pose a real vending option, even when a deposit system and subsequent material utilisation are used. The short product cycle and the “down-cycling” during the recycling process are arguments against the use of these disposable cups. Also, the use of disposable plastic cups at public events is clearly prohibited by the preamble of the Leipzig waste management decree.

DINKEL (2005): In most cases, the use of reusable crockery is ecologically more sensible than the use of disposable crockery. However, the relevant factors are: type and distance of transport, availability and type of cleaning of the crockery as well as the existing infrastructure.

DINKEL (2004): Reusable cups have a significantly lower environmental burden than disposable cups. This burden is four to twenty times lower! Recommendation: From an ecological point of view, the use of reusable cups at major events is clearly the best choice. If the use of reusable cups is not possible, disposable cups made from recycled cardboard are recommended.

HACKEL (2004): The result of the study clearly shows a benefit of the reusable system. During production, the polypropylene cup shows a much higher environmental burden than the disposable cup. However, because of its long life span (which has been calculated at 100 circulations) this burden is spread over a long time, which means that the reusable cup is the ecologically better option.

BASF (2003): For the lowest normal breakage rates, reusable crockery is the most eco-efficient method. In this respect, the economic differences are more important than the ecological ones. For the low to normal breakage rates, reusable crockery is more economical than crockery made from polystyrene or coated cardboard. The breakage rate of reusable crockery is of importance because for higher breakage rates (3%), service packaging made from cardboard is equally eco-efficient to reusable crockery.

BÄTTIG (2002): “Reusable cups score much higher per individual use than disposable cups.” The LCA shows that reusable cups cause a significantly lower environmental burden than disposable cups. The calculated EC-99 point effects of the reusable cups range at least 5.5 times lower than the disposable cups. Between reusable PP cups

and disposable PS cups this factor increases to more than 42. For all cup varieties, the largest

part of the environmental burden is caused by their production. The two essential influencing factors in comparison are the circulation number and the transport distances. However, even for circulation numbers of 100 and 50 respectively the reusable cups cause less environmental burden than the disposable varieties. For 50 circulations, a reusable PC cup causes about half the environmental burden as compared to a disposable cardboard cup. The maximum transport radius for reusable systems is indicated provided that for this radius the reusable varieties cause a maximum of half of the environmental burden that is caused by the disposable varieties. Despite this high safety margin, the calculated radii for large cup quantities (20,000 pcs in a 3.5 ton van) range around the 300 km mark.

BUSCH (2001): The use of re-usable plastic glasses for serving drinks at large events such as football matches is more environmentally sound than the use of disposable glasses. Study based on experience from Lyngby Stadium, Tivoli, Roskilde Festival. The re-usable plastic glasses just need to be used five times to be environmentally more advantageous than disposable glasses. At the same time there is little economic difference so there are good reasons for introducing reusable glasses in many more places.

HOCKING (1994): Variation of the circulation numbers for reusable cups: This break-even point for reusable plastic is at 17 circulations for cardboard and 450 circulations for PS foam.

## 3.4 Summary of the literature research

All cup systems have ecological advantages and disadvantages. Therefore, a general statement concerning the ecological advantages and disadvantages of individual cup systems is not possible. The following influencing parameters have essential influence on the issue whether a certain system shows ecological benefits as compared to another system:

The cup material (decisive for reuse, recycling and the behaviour during waste disposal)

Type of the system: If disposable and reusable varieties are compared, the following factors play an important role:

Circulation numbers (How often can a certain cup be cleaned and reused?) A high circulation number (for reusable cups up to 150 circulations are possible) and low loss/breakage rates mean that throughout the entire life cycle assessment the reusable systems show ecological benefits as compared to disposable solutions. However, the following general conditions will be essential.

Transport distances within the system:

a. Reusable systems: raw material - production - event (use) - cleaning - event (reuse); for wastage cups: event (use) - disposal or recycling plant

b. Disposable systems: raw material - production - event (use) - recycling plant, utilisation plant, disposal plant

In the general assessment, the ecological criteria play a minor role because an ecologically sustainable decision also has to be economical, i.e. it has to come with comparable costs. Therefore, when comparing two or more systems, the relevant costs must be calculated and taken into consideration.

# 4 Quality considerations for the use of drinking cups

## 4.1 Safety considerations for the use of drinking cups

### 4.1.1 Functions fulfilled by drinking cups

In principle, cup systems can be categorized into disposable and reusable systems. For events such as football matches and fan zones at major sports events, the serving of drinks in glasses, china crockery or bottles of any kind of material is not permissible for safety reasons. Therefore, cup systems are being used for major events, with the drinking cup basically fulfilling the following functions.

Their primary function is to provide drinks in highest quality for the guests of events and subject to certain general conditions. A cup must protect the drink against external influences (protective function). Therefore, the drinking cup must be stable with regard to its shape. It must be impact-resistant, pressure-resistant, tear-resistant, temperature-resistant, leak-tight, dust-free, chemically neutral as well as food-safe, quantity-maintaining and flame-retardant.

Furthermore, drinking cups must fulfil the requirements of the supply chain, due to storage and transport. These are stability, stackability and the ability to be combinable into larger units. These factors are to ensure the optimum use of transport space (for delivery, transport to the cleaning plant or disposal/utilisation plant) and the efficient utilisation of storage facilities. For this reason, drinking cups must be stackable, standardized, manageable, suitable for automated systems, unit-forming, space-saving and footprint-saving.

The parameters of the sales and information functions are haptic, handling, comfort, simplicity, functionality, visual effect and design. They play an important role during the purchase decision. Accepted cup systems will create a strong customer relationship and lead to increased caterer turnover. Drinking cups are advertising media, information media and communications media all in one.

With regard to the function of usage, ecological compatibility is a central issue (i.e. the resulting burden due to production, use, distribution and disposal). Therefore, drinking cups should be reusable, recyclable, ecologically sound, easy to dispose of as well as hygienic.

In order to fulfil the requirements of the individual functions, various materials are used by manufacturers. The following cup materials are being regarded as relevant by the German Institute of Ecology, Swiss Carbotech AG and the Austrian Institute of Ecology. These materials are currently being assessed with regard to their possible use during UEFA EURO 2008™:

**Table 2: Cup systems and materials in use**

| Disposable cups: | Reusable cups: |
|---|---|
| PP (polypropylene),<br>PET (polyethyleneterephthalate),<br>PS (polystyrene),<br>PLA (polylactide, polylactic acid),<br>coated and uncoated cardboard as well as<br>BELLAND® material system. | PP (polypropylene).<br>For safety reasons, PC (polycarbonate) is not permissible and has therefore not been examined. However, it is equal to PP in many of its effects. Its higher weight is a negative factor. |

## 4.1.2 Safety rules for football championships

### *4.1.2.1.1 Preliminary comments regarding the FIFA Football World Cup 2006™ in Germany*

Intense discussions about the safety of individual drinking containers for vending at major events already took place prior to the Football World Cup 2006 in Germany. Dr. Rosenthal, safety officer and head of the safety department of the 2006 world cup, expressed his experience in Germany as follows: “In order to increase safety during public viewing, drinks vending using glasses and glass bottles was not permitted.” (ROSENTHAL, 2006)

Jürgen Mathies, Director of the North-Rhine Westphalia County Authority for Central Police Services (Landesamt für Zentrale Polizeiliche Dienste) provided the following standard for public viewing on the occasion of his talk “Public Viewing during the Football World Cup 2006 in Germany” during the meeting “EURO 2008 Public Viewing – The whole Country becomes a Stadium” on 28th August 2007 in Vienna (MATHIES, 2007): “No selling of bottles or glass containers!”

In June and July 2006, for the first time in football world cup history, the Green Goal™ programme of FIFA Football World Cup 2006™ in Germany successfully implemented an innovative and ambitious environmental programme, which sets new benchmarks for major football events.

Green Goal’s vision was to reduce and compensate the inevitable environmental burden caused by hosting the world cup in Germany to the highest possible degree. The focus of the Green Goal waste concept was on waste avoidance. In the stadiums as well as in their environment, action for best possible waste avoidance and reduction was taken.

For the first time at a football world cup, drinks for fans in the stadiums were exclusively served in reusable cups – a massive success for waste avoidance. No previous world cup or Olympic Games had seen the use of reusable systems. The initiatives for waste avoidance resulted in the almost total achievement of the central Green Goal objective, i.e. the reduction of waste volumes by 20% in all areas due to the use of mainly packaging-free systems or reusable systems in the stadiums and their environment. Reductions by more than 17% are quantifiable

with absolute certainty (STAHL, 2007).

#### *4.1.2.1.2 Safety regulations for UEFA EURO 2008™*

Dr. Monika Dalmatiner from the General Directorate for Public Safety of the German Federal Ministry of the Interior (Generaldirektion für öffentliche Sicherheit im Bundesministerium für Inneres (BMI)), Centre for Sports Affairs (Zentrum für Sportangelegenheiten, Project Office EURO 2008 and Prevention Sub-Team) comments on the use of drinking cups for EURO 2008 as follows:

"All drinks that are sold or distributed in the stadiums must be served in open cardboard or plastic containers, which cannot be misused (par. 4 item 8 of the Bundesliga regulations). This means that the use of all bottles, including those made of PET, is prohibited. Only Tetrapak drinks up to a filling volume of 0.5 litre are permissible as well as plastic containers up to 0.25 litre such as "twist and drink". (This is an exception from the prohibition of PET bottles.) Bottles, even if they are served without their cap, might be filled with liquid and used as missiles. We recommend the use of the lightest possible cup varieties with a short flight range. Within the area of the official fan miles and public viewings we only recommend the serving of light beers and only in cups."

With regard to safety considerations, public viewing events are a special focus of attention. From the point of view of the relevant safety authorities for the broadcasting of EURO 2008 matches in public places, the following precautions are necessary as well as recommended by the German BMI: The sales of drinks in bottles as well as glass containers and ceramics containers is prohibited.

The following cup systems were tested for use as drinking cups for EURO 2008 by the Austrian Ministry of the Interior (BMI):

- Cup Concept WM 2006 (reusable/polypropylene)
- Cup Concept with handle (reusable/polypropylene)
- Cup Concept PC (reusable/polycarbonate)
- Cup Schorm/AVE (reusable/polycarbonate)
- Motion Cup (reusable/unknown material)
- Cup made from BELLAND® material (disposable/styrene-acrylate polymer)

The BMIs technical safety assessment of the cups, which might come into use in the stadiums and fan zones during EURO 2008, states the following:

The disposable cup made from BELLAND® material is recommended purely for safety reasons because of its light weight.

The reusable PP cup from the Cup Concept (used for the 2006 world cup), the reusable PP cup from the Cup Concept with handle and the Motion Cup are regarded as suitable.

The reusable polycarbonate cups are classified as unsuitable and are not recommended for use in the stadiums and fan zones during EURO 2008 because they are made from a hard material

and might cause injuries.

The Austrian Federal Ministry of Agriculture and Forestry, the Environment and Water Management recommends the use of reusable cups or ecologically comparable containers for the serving of drinks during EURO 2008. The recommendations are aimed at the organisers of the official fan zones and the fan park in the four host cities and at the private organisers of additional public viewing events during UEFA EURO 2008™ (as of date: 9th July 2007).
The recommendations by the Swiss "Projektorganisation Öffentliche Hand UEFA EURO 2008", a public services organisation, are basically aimed at the relevant approval authorities but also at the organisers themselves and have the objective to ensure a uniform standard for the whole of Switzerland. Further concepts and information are subject to the Swiss cantons' and communities' approval.
The "Projektorganisation Öffentliche Hand UEFA EURO 2008", in association with the Federal State, the cantons and host cities, recommends the following action for public viewing during EURO 2008:
The cleanliness of the grounds is an essential part of subjective safety as well as objective safety and security. Therefore the following action for waste avoidance must have priority:
The serving of drinks in reusable cups or PET bottles / deposit systems / well

marked return stations for reusable containers

| |
|---|
| To summarize it can be stated that there are no reservations against a reusable polypropylene cup for EURO 2008 from a safety point of view. On the contrary, reusable systems are actually recommended by the relevant authorities and organisations. |

### 4.1.3 Austrian events laws

Safety and risk of injury: In order to minimize the risk of injury, drinking cups must be break-resistant to the highest possible degree. When a cup breaks, no splinters or sharp pieces must be formed/released.

**Table 3: Examples of the Austrian law regarding events**

| | Examples for the Austrian law regarding events |
|---|---|
| Lower Austria: Lower Austrian events law | The authority can specify that drinks at events may only be served in non-dangerous containers.<br>The approval authority specifies what exactly constitutes a dangerous container. |
| Steiermark: Law from 8th July 1969 regarding public displays, events and amusements (Steiermark events law) | In particular for major events, such as sports events in stadiums, the authority can rule that the organiser shall serve drinks only in non-dangerous containers within the event's grounds in order to ensure the proper running of the event. |
| Upper Austria: Upper Austrian events law 1992 | In the approval notice it must be clearly specified whether the Implementation of the event is subject to conditions for the avoidance of waste or, if this is not economically justifiable, for the proper disposal of waste. |
| Tirolia: Tirolian events law 1982 | For events with a high risk of hazards, the authority can specify that drinks may only be served in non-dangerous containers. This is to ensure the proper running of events such as sports events, pop concerts, etc. |
| Vienne: Vienne events venue law | For the protection of spectators and neighbourhood during sports events, and if no tables are provided, no bottles or glasses must be taken into the spectator areas or placed in theses areas. However, drinks bootles made from paper, non-splintering plastic and similar materials without a health and safety risks for spectators may be taken into these areas.<br>The Vienna law for regulating events (Vienna events law) does not contain any relevant note. |
| Burgenland: Law from 7th October 1993 regarding public events in the Burgenland – Burgenland events law | The registration authority can specify that the organiser may serve drinks only in non-dangerous containers. This is to ensure the proper running of sports events. |

The Vorarlberg law regarding events, the Kärnten events law from 1997 (K-VAG 1997) and the Salzburg events law from 1997 do not contain any relevant notes. Apart from the relevant events laws, other federal/county laws also contain regulations, which are applicable to events. These are for example county police laws, decree authorizations, safety/security police laws, laws for protecting underage people, etc. However, no relevant notes with regard to the use of drinking

cups for events were found in the above laws.

### 4.1.4 Swiss events laws

The **canton of Basel City** has announced a special decree for the European Football Championships 2008 (11/12/2007). This decree has the following core statements:

§ 5. For the avoidance and utilisation of waste produced by industrial and commercial companies (incl. club caterers) as well as for minimizing risks in public areas:

In the stadium on match days and in the public areas of the official fan zones and other events in public places on these days (from 6th June - 29th June 2008:

Stadium: Drinks may only be served openly in reusable cups made of polypropylene (mandatory deposit of CHF 2.00)

Fan zones: Drinks for consumption in external areas may only be served in reusable cups made of polypropylene or in PET bottles without caps ("cap off"). (Mandatory deposit of CHF 2.00 applicable to all containers.)

Further actions contain:

Food may only be served using minimised packaging or with a reusable tray (deposit of CHF 2.00). (This applies to the stadium, fan zones and public areas.)

Printed matter and advertising material may only be distributed subject to the approval of the Swiss Environment and Energy Authority (Amt für Umwelt und Energie). (The principles of saving resources and avoiding waste must be observed.) (This applies to the stadium, fan zones and public areas.).

In the backstage area, waste regarding glass, PET, aluminium as well as paper and cardboard must be separated.

**Bern law:** For events in public places, which require authorisation, in principle deposit crockery and reusable crockery must be used.

The operator is responsible for complying with these regulations.
In individual cases, the obligation to use deposit crockery and reusable crockery may be inappropriate as well as out of proportion:

- Justified applications for exceptions and
- Suitable action for the avoidance and reduction of waste: finger food, French fries, crêpes, etc. (napkin, paper bags)

Decree for EURO 2008 in fan zones and fan axes:

- Drinks may only be served openly and in reusable cups made of plastic with a deposit of 2.00 CHF (1.2)
- Food only with napkins

## 4.2 Biodegradable plastic materials for use as drinking cups: compostability and gene technology considerations

Biodegradable plastic materials can be produced from renewable raw materials such as starch, cellulose, soja protein or lactic acid as well as petrochemical substances. Currently, polylactic acid (PLA) and polyhydroxyalkanoate (PHA) made of maize starch together with the petroleum-based esters (e.g. BASF Ecoflex) are the most important basic substances for biodegradable plastic.

Polylactic acid can be produced synthetically or via fermentation from renewable raw materials (PRINGER and FISCHER, 2003). For the mass production of lactic acid, carbon is the basic substance, and carbon is extracted from raw materials such as maize, cereals or sugar beet (GROOT et al., 2000). Currently, however, maize starch is predominantly used. During the production of polylactic acid from maize, the maize grain is separated into the germ and the enveloping husk. The maize germ is turned into edible oil whereas the rest is processed in a way that the maize starch in the grain retains the highest possible purity. Then the starch is converted into sugar, which serves as a nutrient for special microorganisms. Using fermentation (i.e. a biological reaction under the exclusion of air) the sugar is split into smaller units, and as a result lactic acid is formed. This lactid acid will split under the influence of heat and build ring-shaped molecules (so-called lactides). When catalysers are added (for example tin oxide), a ring-opening polymerisation takes place, and a long chain polymer – polylactid acid – develops from the individual lactide rings.

The material can widely be processed into products using conventional plants as well as all common plastic processing procedures (GROOT et al., 2000). Because of its physical and mechanical properties, PLA can be used as a substitute product for thermoplasts.

A disadvantage of PLA is its low softening point at approx. 60°C. This characteristic limits its area of use, for example for catering, to cold foods and cold drinks.

The leading PLA manufacturer is the American company NatureWorks™ LLC, which originated from a joint venture between the two major corporations Cargill and Dow Chemicals. Apart from the above company there are two Japanese manufacturers – Mitsui und Unitika – as well as Hycail, a European manufacturer, which exclusively use raw materials that are not genetically modified (sugar beet). For the future, Hycail is planning a production plant with an annual capacity of somewhere between 25,000 and 150,000 tons (www.hycail.com) (SCHNEIDER, 2005).

Considerations regarding the use of genetically modified raw materials for the production of disposable cups made of PLA

The question that arises in this respect is whether producers and distributors of disposable PLA cups are able to guarantee that no genetically modified maize has been used. Such a guarantee can only be given by the producer if an independent body has checked and verified that the plant raw materials for the basic material have not been genetically modified. This guarantee can only

be given for statistically proven checks (i.e. scope and size of the spot check) and regular checks. A statistically proven procedure, the transparency of the definition of “not genetically modified”, the publication of the results and the permission for a qualified public discussion are the necessary basic requirements for such a statement. It might well be possible to find a labelling system that is similar to the labelling of non-genetically modified foods, which is currently discussed at EU level. The majority of the PLA that is currently available on the market is based on the raw material of maize starch, which is manufactured in the US. This leads to the assumption that this maize is genetically modified. However, the scenarios that are calculated in this LCA do not take possible negative effects of gene technology for the farming of maize into consideration. The PLA cups themselves do not contain any genetically modified organisms.

The discussion in connection with possible effects of genetically modified vegetables and plants can be summarized as follows:
At the present time nobody is able to estimate the consequences of these manipulations of genes for human health and the environment. Science is not able to specifically direct the exact location where the gene is built into the plant and neither can it predict the interaction with other genes and proteins. This might result in surprising side effects for the farming of genetically modified plants. Once these genes have been released into the environment, genetically modified plants cannot be reversed. They could pose a danger to the ecological balance as well as human health. This is quite dramatically shown by the large-scale farming of genetically modified plants in North America and Argentina: increased pesticide consumption, development of super weeds, damage to beneficial organisms, displacement of traditional plant species and therefore the endangerment of our variety of species.

Furthermore, there is the basic question whether the use of renewable raw materials (and the soil for their farming) is ethically justifiable for the gain of energy or the processing of disposable cups as opposed to the production of food.

**PLA drinking cups: biodegradable vs. compostable!**

In principle, it must be distinguished between biodegradable and compostable.

Organic material such as kitchen waste, vegetation cuttings, wood and paper are biodegradable. These materials can be separated into their components and degradation products under the influence of natural processes and microorganisms (e.g. bacteria).

Biodegradable materials can be processed in the same way as conventional plastics (thermo-plasts) using common plastic technology procedures. Products made from biodegradable materials are able to replace plastic products. In contrast to plastics, all organic components

of biodegradable materials can be fully degraded into $CO_2$ and water by microbial degradation. DIN EN 13432 provides the general conditions for “biodegradability”. The biodegradability is a consequence of the chemical structure, and not of the origin of the raw material: There are also oil-based biodegradable materials, which show this characteristic. For reasons of

environmental protection and product image, many biodegradable materials are produced on the basis of renewable raw materials such as starch, sugar or cellulose.
Composting is the controlled exothermal biological conversion of organic matter into a humic-rich material with a minimum of 20 mass percent of organic substance.

The objective of composting is the quickest and least loss-causing degradation of the original organic substances (i.e. highly molecular, natural carbon/hydrogen compounds) while building-up stable and plant-tolerant humus substances.

Various labels and logos confirm the compostability of so-called biodegradable materials. If the degradation takes place in technical composting plants over the usual rotting periods (6-12 weeks), biodegradable materials are called “compostable”.
However, the fact that a material is biodegradable does not mean that this conversion in a rotting process of the technical composting procedure is really taking place to the desired extent. In contrast to “biodegradability”, “compostability” is subject to a specific timeframe. In order to proof the compostability of biodegradable material, the new standards DIN V 54900 and CEN 13432 were created.
According to the Austrian composting decree, biodegradable packaging materials with a minimum of 95% of natural origin from renewable raw materials, which might be chemically modified, are permissible basic materials for ordinary compost and high-quality sludge compost, but not for quality compost, unless its suitability for composting has been proved by means of a proper report. The report must at least confirm the complete degradation (not just the disintegration) in the course of the commonly applicable rotting periods for the manufacturing procedure and is required for each delivery.
That leaves the issue whether composting of PLA material as a disposal alternative makes ecological sense. Since PLA material does not contain any plant-available nutrients (structural formula) and does not contribute to the built-up of the soil structure, composting is purely a disposal alternative.

# 5 Methodology and approach

## 5.1 Quantitative ecological assessment

The LCA captures the effects of the material/substance flows and energy flows on the environment during the entire product life
cycle.

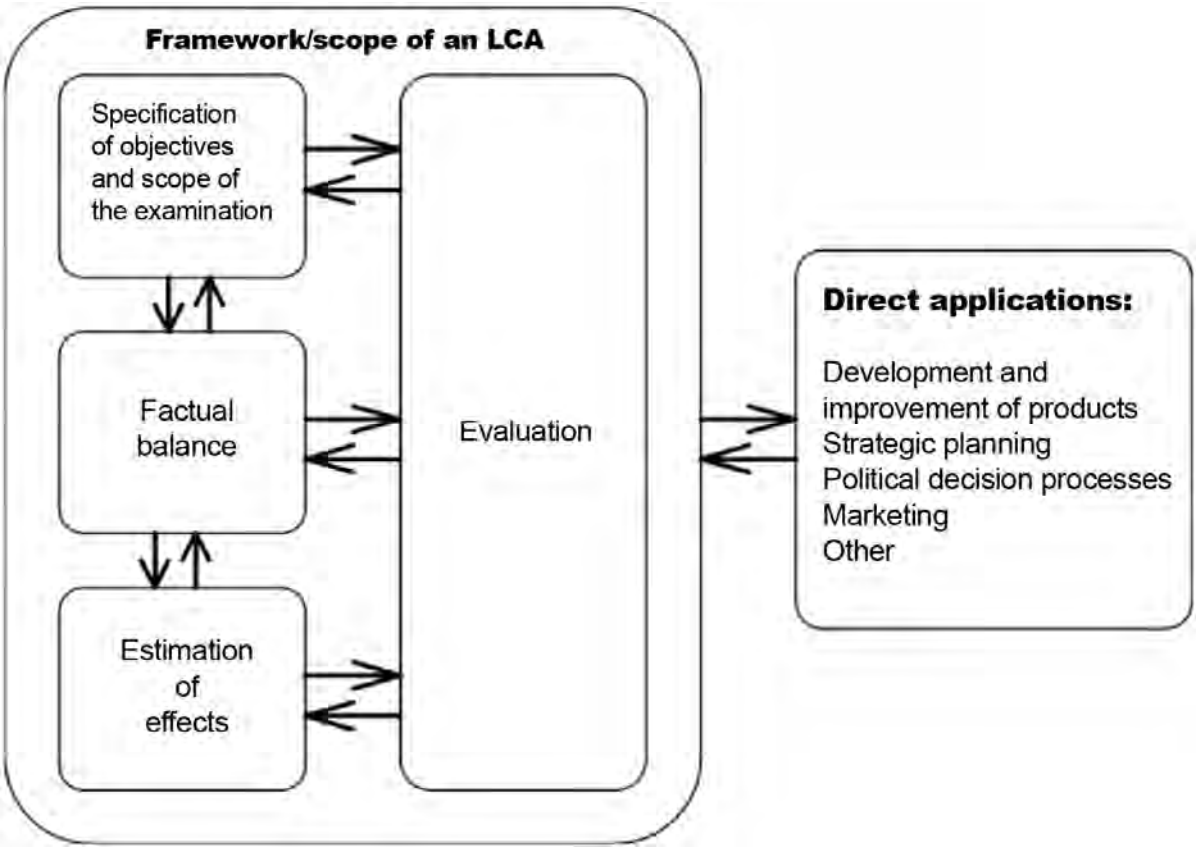



**Figure 6: Components of an LCA (from DIN EN ISO 14040)**

It has been ensured that the cup systems that were to be examined were comprehensively captured over their entire life span and that all environmental impact with relevance to the result was taken into consideration for the LCA. An LCA compares the environmental impact of products/processes over their entire life span in order to allow the selection of the better product/process. It also allows the analysis of products, processes or operations with regard to sources of relevant environmental burden and supports decision-makers when prioritising improvement action.

According to ISO 14040 an ecological assessment contains the following steps:

- Problem and general conditions: specifying the scenarios and system boundaries
- Factual balance

- Effects balance
- Interpretation and assessment of the results

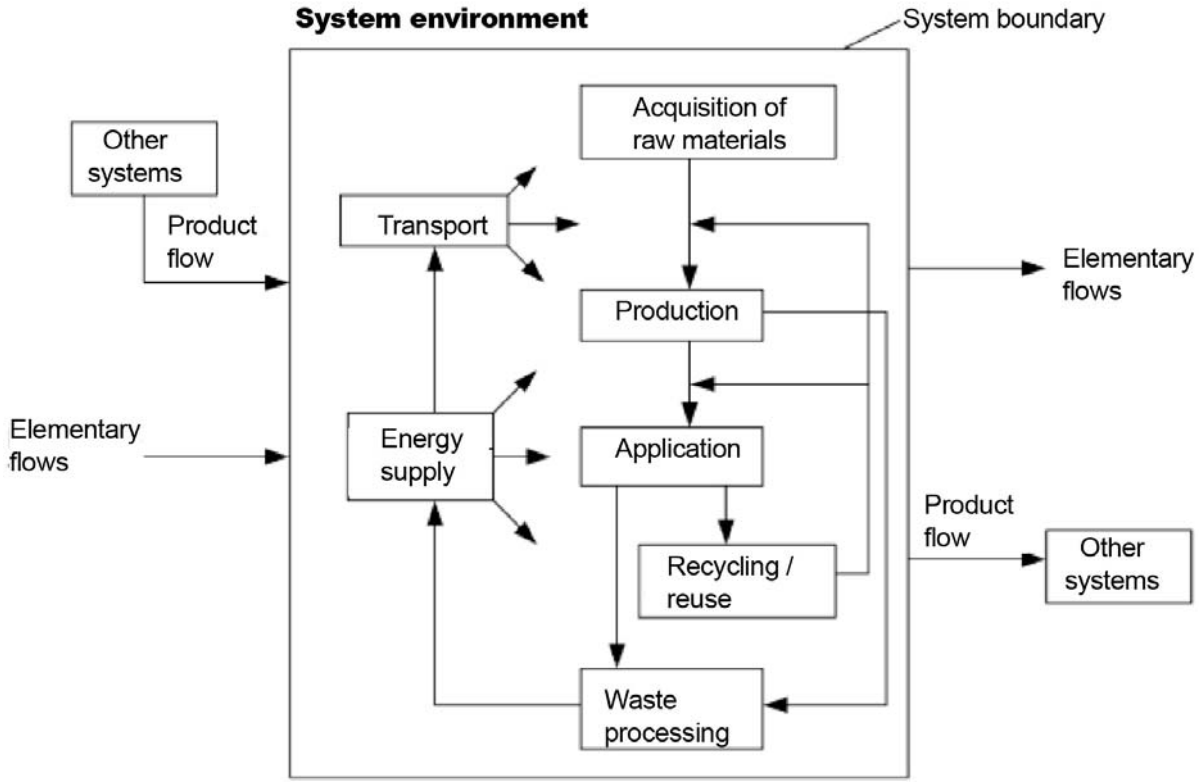



**Figure 7: Example of a product system for an LCA (from DIN EN ISO 14040)**

The LCA was carried out according to the relevant provisions of DIN EN ISO 14040 and 14044 and supplemented by the application of various assessment methods (see chapter 8). The following diagram shows the comprehensive LCA approach.

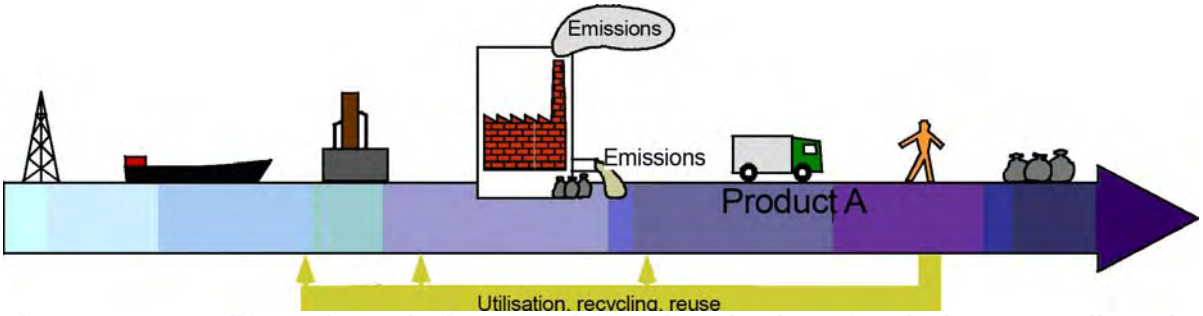



**Figure 8: LCA – life cycle analysis: capturing and evaluation of emissions as well as the consumption of energy and operating resources during the entire life span**

## 5.2 Problem and general conditions

This analysis covers the following issues:

- This study investigates which system shows the least environmental burden for the open serving of drinks. Which drinking cup variety causes the least environmental burden at major events such as football matches, major tournaments such as world cups or other major events?
- Will the use of renewable raw materials result in a reduced environmental burden?
- Is it possible to significantly reduce the environmental burden by composting products made of biodegradable plastic?
- How high is the environmental burden due to the use of BELLAND® material for drinking cups?

The environmental burden shall be captured as comprehensively as possible. This means that the entire life span is to be taken into consideration. The results of this study are destined for external communication. A review (external critical review) will be carried out by the independent expert Paul W. Gilgen of EMPA.

The LCA primarily focuses on the use of cup systems for normal football matches in Bundesliga stadiums in Germany, Austria and Switzerland. Apart from the normal divisional operations, the LCA also focuses on UEFA EURO 2008™. The Football World Cup 2006 in Germany and its Green Goal project have demonstrated that the cup selection for serving drinks plays a central role for the environmental and sustainability concepts at major sports events. The LCA always starts with the question which examination scope to use and which cup systems to examine.

## 5.3 System boundaries

The capturing of the material/substance flows and energy flows is carried out over the entire life span, i.e. from the provision of the raw materials and the production to the use and reuse/disposal respectively. For this examination this means in essence:

Provision of basic materials such as plastics, cardboard, maize starch, etc.

- Processing of these materials, coating of materials and manufacturing of the cups
- Provision of the required energy mediums
- Transport including manufacturing, maintenance, operation and disposal of the means of transport as well as the required infrastructure
- Cleaning of the reusable cups
- Processing of the recyclable plastics
- Expenses for recycling or disposal

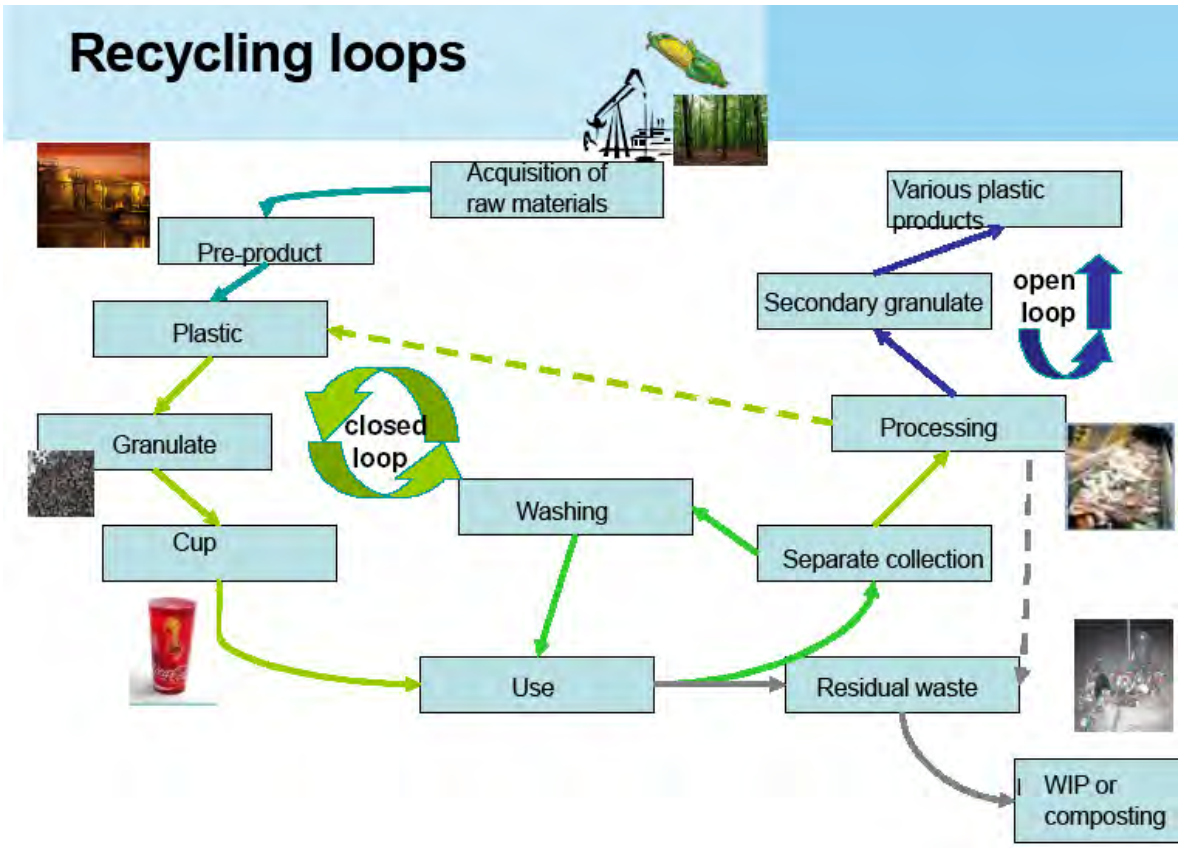



**Figure 9: Recycling loops with closed loop and open loop in comparison for the reuse of used cups**

This LCA is not just limited to football stadiums. The 2006 World Cup in Germany has shown that broadcasting matches on large screens for public viewing in the host cities also classifies as a major event with a huge drinks turnover, which is actually much higher than the drinks consumption in the stadiums. This comprehensive LCA also examined such events (see chapter 9.2) and other specific aspects of inner-city events as well as the differences between divisional matches (Bundesliga) and a tournament such as UEFA EURO 2008™.

## 5.4 Functional unit

The following functional unit serves as a comparative basis for this study:

serving a drink in a 0.5 litre cup (beer or soft drink) regardless if the cup is a disposable or reusable cup.

# 6 Factual balance

## 6.1 General conditions for EURO, divisional operations (Bundesliga) and public viewing

**European Football Championships 2008**

The final stage of the 13th European Football Championships (UEFA EURO 2008™) from 7th to 29th June 2008 will take place for the first time in Austria and Switzerland. Initially sixteen national teams will play in four groups during the group phase, followed by a knockout system. The European Champion 2008 will be determined in the final in Vienna on 29th June 2008.

In total, during the 3-weeks tournament with the motto “Experience Emotion” more than one million tickets for 31 matches in 8 stadiums were sold. Apart from the spectators in the stadiums a further up to 10 million fans are expected in the official fan miles in the venue cities. In total, probably an expected more than 8 million people will watch the matches on television.

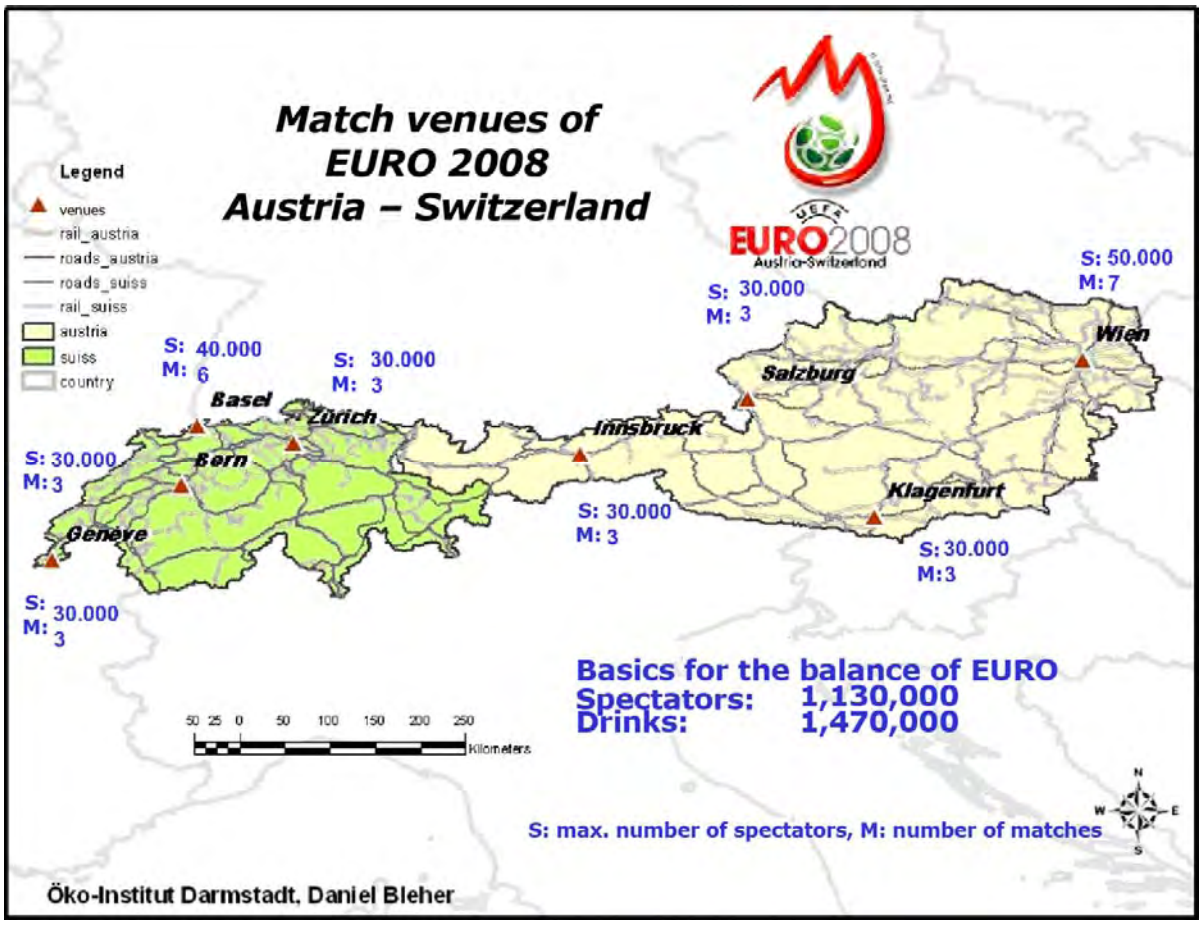



**Figure 10: Venue cities of EURO 2008 incl. details regarding the number of matches and the**

**maximum spectator number in the stadiums**

Austrian venues:

- Vienna, Ernst Happel Stadium: 50,000 spectators, 7 matches (3x in the preliminary round, 2x in the quarter finals and 1x in the semi-final and the final)
- Klagenfurt, Wörthersee Stadium: 30,000 spectators, 3 matches in the preliminary round
- Salzburg, Wals-Siezenheim: 30,000 spectators, 3 matches (3x in the preliminary round)

Innsbruck, new Tivoli: 30,000 spectators, 3 matches (3x in the preliminary round)

Swiss venues:

- Basel, St. Jakob-Park: 40,000 spectators, 6 matches (3x in the preliminary round incl. the opening match, 2x in the quarter final, 1x in the semi-final)
- Bern, Stade de Suisse Wankdorf: 30,000 spectators, 3 matches in the preliminary round
- Geneve, Stade de Genève: 30,000 spectators, 3 matches in the preliminary round
- Zurich, Letzigrund: 30,000 spectators, 3 matches in the preliminary round

**Public viewing / fan zones / fan miles:**

The term Public Viewing is a false Anglicism (i.e. it is not used in that sense in the English language) and means the joint watching of live media events (such as sports events) on large screens in public places by large numbers of people (town squares, whole streets, shopping malls, pubs, etc.). This phenomenon is not new to Germany, but the term “public viewing” has only really become established in German-speaking regions since the Football World Cup 2006 in Germany. The main reason for this initiative by the organising committee of the international football association FIFA was the insufficient number of available tickets for the matches.

At all match venues, parts of the cities will be converted into “fan miles” for the gathering of the expected millions of fans.

The official deadline for the registration of other public viewing areas is on 30th April 2008. Organisers who intend to provide public viewing offers with screens from a certain size must apply for a licence and, if their event has a commercial background, pay a fee.

Examples for public viewing and fan zones (focussing on Austria)

Vienna: 70,000 people on the Ring, the Kaiserwiese (Emperor’s Lawn) at the Prater, fan camp Vienna, Hanappi Stadium, etc.: In the capital Vienna the public viewing areas are mainly concentrated around the fan zone between Heldenplatz and Rathausplatz (town hall square). The 100,000 sqm area for 70,000 people will host a total of nine LED screens for live broadcasts of the matches. It is planned that the Kaiserwiese venue at the Prater with its capacity of up to 10,000 fans will offer video broadcasts on large screens.

In Kärnten there will be approx. 30 public viewing areas during EURO 2008. Apart from two official UEFA fan zones in the Klagenfurt inner city, the town will provide a third (unofficial) zone in the area of the Europapark at Lake Wörthersee. This area and a large public viewing area at lake Faaker will be organised by Kärnten Werbung (Kärnten Advertising).

The host city of Salzburg has completed its planning for the official public viewing zone in the Salzburg inner city. The concepts have been submitted to the relevant authorities and to UEFA. Public broadcasts of championship matches, which require a UEFA licence, are also planned in the “fan camp” in the Salzburg exhibition centre as well as in the communities of Saalfelden, Kaprun (Pinzgau) and Kuchl (Tennengau).

In Tyrol there will be 20 public viewing venues including the county’s capital. For each match date, capacities for approx. 50,000 football fans will be provided. There will even be a swimming fan zone on the vessel “City of Innsbruck” on lake Achensee.

The stage at lake Bregenz: Public viewing on the stage at lake Bregenz – the venue of the famous festival – will promise a very special atmosphere.

A permanent large public viewing zone in Lower Austria will be created in St. Pölten. Venues are the former tennis arena in the area of the Lower Austrian sports academy. There will be 2,300 seats and 3,000 to 5,000 standing places.

In Upper Austria the number of public viewing spaces has not yet been specified. It might easily be between 50 and 100. In Linz the area of the Urfahraner market and the Church Square might be possible venues.

In Austria, Coca-Cola and the Kronen newspaper will organise a fan tour with trucks and mobile screens.

In 16 Swiss cities (apart from the venues) so-called UBS arenas will be created.

In Liestal (Switzerland) the largest provisional Swiss stadium with the name “9th Stadium” with

8,000 seats and numerous standing places will be created where fans can watch matches on a large screen and also stay over night.

## 6.2 Characterising the examined systems

The examined cups are shown in the following table. Most cup types and their data stem in first instance from the manufacturers and possibly from published studies and LCAs (see references and sources).

**Table 4: Weight data for the examined disposable and reusable cups (* manufacturer's details, ** result of a weighing of PLA cups)**

| | Weight details | Used values |
|---|---|---|
| **Disposable cups made of:** | | |
| - Polystyrene, PS | 12 – 20 g | 16 g |
| - Polyester, PET | 8.5 – 17.5 g | 11.5 g |
| - Polylactide, PLA* | 9.9*-11.6** g | 10 g |
| - PE-coated cardboard | 11 g | 11 g |
| **Loop-capable cups:** | | |
| - Belland | 13.7 g | 13.7 g |
| **Reusable cups:** | | |
| - Polypropylene, PP | 30, 46, 55 g | 55 g |

The data from manufacturer details that are shown in the table were mostly transferred and only adapted if required. For example, for a range of values the weighed average was used for the LCA. General data (e.g. power supply, transport distances, etc.) were adapted to the conditions in Switzerland and Austria (LCAs for EURO) and Germany (Bundesliga divisional operation) and used as basic data for initial calculations of the eco-inventory data from 2006 (ecoinvent 1.3). The intermediate results were presented to the clients and to UEFA in November 2007 and also published on the Internet.

In December 2007 newly available eco-inventory data (ecoinvent 2.01) were used for a recalculation. The results that are published in this report are therefore based on the most up-to-date eco-inventory data and on basic data. This resulted in slight differences compared to the results, which had been presented to UEFA in November. However, these differences are so small that no differences for the entire examination had to be taken into consideration.

## 6.3 Important influencing factors

### 6.3.1 Development levels of cup systems

The various cup systems are at different stages/levels of development. For example, whereas the reusable cup or disposable cup made of PET, PP and PS is based on systems with a long and proven track record, the Belland system cannot yet point to long-term experience with the material. In order to avoid the study being criticised as outdated at the time of publication, not just the definite development level but also probable future development (scenarios) were taken into consideration.

Furthermore, sensitivity analyses were used to demonstrate the influence of various performance levels.

### 6.3.2 Cup utilisation

The type of utilisation or disposal of the drinking cups after their usage phase has an influence on the results, which must not be neglected. Whereas incineration is often used as the disposal option of choice, for cups that are sorted according to definite types (e.g. disposable cups with deposit), high-quality material recycling should be balanced as standard. For example, information in the course of the Green Goal project (STAHL, 2007) gives rise to the expectation that recycling of one-type cups leads to the substitution of primary plastic material. For a comprehensive approach, various disposal varieties were balanced and definite recycling options were researched and analysed. Also the effect of material recycling of disposable PS and PET cups was examined. These cups should then be collected according to a type-separated collection system. This could be achieved, for example, by using deposits and automated return systems.

The effort/expenses for producing the primary granulate will be credited to the cup systems and balanced with the effort/expenses that is/are required for producing the regranulate. The credit for the system only contains 50% of the expenses or the saved environmental burden from the new production because the product system, in which the recycled material is used, is also granted a respective credit. This allocation rule is necessary in order to avoid a double advantage due to recycling in the “open loop”. If the basis of the allocation had used the price relations between new material and regranulate instead of the 50/50 rule, for the PET for example about 40% of the credits would have to be assigned to the cup system and the remaining 60% to the new production.

The allocation for the “closed loop” recycling, which is intended for cups made of Belland material, is different. In this case, the recycled material remains within the system and thereby also 100% of the credits for the effort/expenses for producing the saved new material.

For the incineration in WIPs for the scenarios for Switzerland and Austria (EURO and public

viewing) the average Swiss WIP is assumed (SCHWAGER 2006), which also exactly represents the average of the Austrian plants for this LCA. For the scenarios that balance the German divisional operation the average German WIP is assumed (DEHOUST et al. 2005; DEHOUST et al. 2002).

The energy that is gained in the WIP in the form of electrical power, heat and process steam is credited to EURO 2008 according to the energy mixes in Switzerland and Austria and to the Bundesliga divisional operation and Hanover according to the mixes in Germany (FRITSCHE et al. 2004). The same energy mixes are also used for the required energy (power and heat).

The relevant data can be found in the flow charts in the enclosure (see chapter 16.1).

For the credits from the thermal usage of the cups in the WIP, the thermal value of different cup materials – apart from the performance data of the plants and the energy mixes – is of importance. For the balances the following thermal values are assumed:

- PS 40 MJ/kg
- PP 44 MJ/kg
- PET 24 MJ/kg
- PLA 30 MJ/kg
- Card-board 20 MJ/kg
- Fossil oil 42 MJ/kg

### 6.3.3 Transport

Apart from the production processes, the transport can be very important for the results of an LCA. This includes the transport of reusable cups to and from the cleaning stations, whereas for disposable cups the transport to the stadium and then to the utilisation plants or disposal plants are to be taken into consideration. The influence of the transport of the primary material for cup production was also examined.

**Table 5: Transport distances**

| | |
|---|---|
| PP, PE, PET | Plastic is a mixture from European plants |
| PLA | Maize farming and plastic production in the US |
| Reusable cups | The average distance between the washing stations and the stadiums is 100 km for EURO and Bundesliga operations as well as 5 km in Hanover and for Vienna public viewing |
| Reusable cups<br>Disposable cups | The average distance between production plant and stadiums is 400 km |
| WIP | The average distance from the stadiums is 30 km |

For the identification of the distances that are to be counted for delivery of reusable cups from the stadiums to the cleaning stations and back to the stadiums, the expected definite situation for EURO was balanced. In this respect, the distribution of the cups from the delivery stations (assumed station for Austria is Vienna and for Switzerland it is Basel) to the individual stadiums as well as the transport of the cups from preliminary round events to the stadiums in Vienna and Basel (the venues for the finals) was taken into consideration.
The following cleaning stations were accounted for in the LCA:

- Austria: Vienna and Munich
- Switzerland: Interlaken and Basel

This results in an average transport distance of approx. 100 km for each cup and each usage, which means that the cups cover an average distance of 200 km for delivery and subsequent return to the cleaning stations. This is an extremely conservative estimate and the possible maximum for the expected average transport distance.
For the German Bundesliga operation, the average transport distance of 100 km, which had been determined for Switzerland and Austria, was used as a conservative estimate for the LCA.

For the scenario of the Hanover stadium, a definite transport distance of 5 km was assumed due to the fact that a Hanover-based system provider will clean the cups in Hanover.

This distance was also used for the public viewing scenario (example: Vienna) because it reflects very well the situation for various major events.

### 6.3.4 Circulation cycles

With regard to reusable cups, their circulation numbers are of major importance for the environmental effects. In order to estimate the influence of such factors on the overall balance, various reusable cup varieties have already been examined in the core LCA. The following effects are important:

- Circulation cycles, which result from the breakage rates,
- Non-return rates
- Remaining cups at the shut-down of the system

Apart from the breakage rate, which determines the circulation frequency that would show in endless systems (usage cycles), the realistically achievable circulation numbers within the system are also determined by the non-return rate. In addition, the remaining cups after shutting-down of the event or after an assumed end to the system are identified. Basically these are the cups, which remain after the closure of the event or the usage series and that are materially utilised if no further reuse in a new system is possible. For branded cups such as those that were used for EURO, a reuse is often not intended or permissible. From the breakage rates, non-return rates and the maximum system usage, the circulation within the system (system cycles) results. Opposed to that are the cups that are taken home for domestic use or as a souvenir. The small percentage of faulty cups, which are deliberately taken out of the system, are also transferred to material recycling. The percentage of loss, which is very small for deposit cups, normally ends up in the WIP as normal waste together with the residual waste.

The circulation cycles refer to an examination period of three to four years in German football stadiums and are based on details from three reusable system operators from Germany and Austria.

For the calculations for EURO, the worst individual case was assumed (Stuttgart circulation frequency of 60) and for the divisional operation calculations in Germany the average value (107 circulations) was assumed.

**Table 6: Derivation of the circulation frequency from practical data from German Bundesliga stadiums**

| Stadium | Uses | Breakage rate | Circulation freq. |
|---|---|---|---|
| SC Freiburg | 906,155 | 0.83% | 121 |
| Herta BSC Berlin | 1,129,479 | 0.79% | 129 |
| VfB Stuttgard | 1,041,494 | 1.68% | 60 |
| Werder Bremen | 1,781,314 | 0.46% | 217 |
| Borussia Dortmund | 2,914,654 | 1.05% | 95 |
| **Total** | **7,773,096** | **0.93%** | **107*** |
| AWD-Arena Hanover | | 0.85% | 118 |

* weighed average

The details regarding the turnover cycles and non-return rates for EURO 2008 are based on the following:

- Experience and data from FIFA WM 2006™
- Proposal by a reusable system operator for EURO, containing a safety margin and
- his own model calculations

The results of the above three bases are used for testing plausibility. In questionable cases, rather conservative values were used. For example, a safety margin was taken into consideration. This means that a relatively high number of cups must be utilised or disposed of if their reuse is not permitted. For disposable cups, however, no safety margin was employed. This means that the calculation was made as if an equal number of cups were produced, delivered and disposed of as well as being used in the system. The non-return rate has a totally essential influence on the real circulation numbers within the system (system cycles). This means the number of cups (in relation to the overall served drinks), which have been taken home or not returned by the spectators. In the meaning of the life cycle assessment, which looks at the entire life span of a product and not just certain parts of the life span, the domestic use must be included in the balance.

This is supported by the fact that the customer is prepared to pay a price for the cup, which is above its purchase price. Therefore, the cup poses a real value for the customer. The experience from stadiums with reusable cup systems shows that virtually no cups are left behind in the stadium, because abandoned cups are returned by other people who then earn the deposit of CHF 2.00.

### 6.3.5 Domestic use of reusable drinking cups

The football world cup in Germany has shown that reusable cups with a special design were a

much-liked souvenir and were frequently taken home. The use of the

cups as souvenirs and their subsequent use at home might have an important influence on the environmental performance of a cup system, especially for major events. These considerations were thoroughly analysed in this study. Experience from an existing survey and the assessment of the accompanying group form the basis for the assessment.

Study of domestic use for the reusable cup sold by Basel zoo

In spring 2003, Basel zoo ("Zolli") introduced a reusable cup system in its restaurants and catering outlets. The reusable Zolli cups carry a deposit of 2 Swiss Franks and can be returned at all vending stations as well as three automated return systems. The (animal) motifs make the cups favourite advertising platforms and souvenirs, which means that visitors like to take them home. The tendency for reusable cups with attractive markings to be taken home is confirmed by other studies, for example from Denmark (BUSCH, 2001) and by the organisers of major events such as the Football World Cup 2006 in Germany. The domestic use of cups has not yet been confirmed by usage cycles or Circulation rates. Therefore, the Environment and Energy Authority of Basel city (Amt für Umwelt und Energie Basel-Stadt) conducted a survey with the objective to check the hypothesis stating "Reusable cups will have continued use at home" for its validity. Furthermore, the study is looking for answers to the question "Which turnover rates are achieved on average by Zolli cups in domestic use?"


The hypotheses regarding the subsequent use of Zolli cups in the domestic environment were confirmed by the survey's results. Visitors to the zoo's self-catering restaurants were questioned about the Zolli cup using a standardized questionnaire.

The survey questioned visitors who had purchased a Zolli cup previously and did not return it at one of the return stations.

All 175 questioned visitors stated that they continued to use the reusable cups at home. Not a single person disposed of the cup after purchase. Of the 175 questioned visitors, 168 (96%) are using their Zolli cups at home. At the time of the survey, the visitors on average had been using their Zolli cups for approx. 18 months and stated that they intended to use them for a certain amount of time to come. About 13% had only bought their reusable cups within the previous six months. More than 60% had the cup for more than one year and 23% for even more than two years. Approx. 65% used the reusable cups at least once a week. At the time of the survey, the cups had on average 224 circulation cycles and continued to be in use. However, this result does not reflect the final circulation number of the cups. The survey was carried out at a time when the reusable cups were still in use. The definitive circulation number of the cups until the time of their disposal is expected to be much higher. Several zoo visitors stated that they had been using the Zolli cups on a daily basis since the cups had been on offer in the zoo, which would lead to circulations of about 900 cleaning cycles. A few visitors use their cups more intensely over the summer because the cups are used in the garden, around swimming pools or

while camping. A small part of the visitors use the reusable cups as a tooth-cleaning cup, games cup or for washing their hair. 45% of the questioned zoo visitors have three or more cups at home. However, the majority owns one or two Zolli cups.

There are also other reusable cups in use: Questioned whether they were using other reusable cups at home, the visitors named mainly IKEA cups and FCB cups as well as those from a couple of local festivals (Klosterbergfest and Gurtenfestival).

Only 16 people stated that they once owned a Zolli cup, which is no longer in their possession. Five of those (31%) returned their cups to the zoo, thereby reintroducing them into the reusable cycle, and three cups were given as a present to other people. The remaining cups, which were no longer in use, either got lost or broke and were discarded (BAUER, 2006).

**Consideration of domestic use**

The experience with the world cup shows that the customer is prepared to pay a multiple of the costs for a cup. The non-return rate for printed cups is several times higher than for non-printed cups. This leads to the conclusion that the printed cups are certainly not just disposed of.

The study about domestic use also demonstrates that the cups continue to be used at home. Therefore it is essential that domestic cup use is included in an LCA. The domestic use of the EURO 2008 cups can only be estimated at the present time.

One possibility is the assumption that the cups are being used at home according to the breakage rate. This leads to the scenario “EURO 2008 without branding – 60 circulations”. The study of domestic use shows that this would result in an insufficient circulation number. Another possibility for considering domestic use is to estimate the use, which the non-returned cups will have. For this purpose, possible usage types were estimated by a panel of experts.

**Expert panel for considering domestic use**

How can the type of domestic use be taken into consideration for a LCA of different cup systems? Printed reusable drinking cups with attractive designs are taken home by football fans (and also by spectators to other events, for example rock concerts or music festivals) and are thereby removed from the reusable cup system. However, the reusable cups are in continued use of various kinds. Therefore, there will be no “artificial” lowering of the reusable rate by specific logo branding such as for the 2006 world cup, where subsequent use was prohibited.

The question is: How can the rate of this “cup loss for the reusable system” by “domestic use” be comprehensibly estimated and what is the result of this domestic use for the overall balance? The following kinds of usage might be contemplated:

**a) Use by fans as a substitute for souvenirs (fan items)**

Description: The cup is taken home as a souvenir, which means that a smaller number of the other souvenirs (fan items) are purchased. However, the cup is not reused as a drinking cup.

Accounting in the balance: substitution of souvenirs (fan items). For pragmatic reasons it must

be assumed that the production of the souvenirs is associated with the same environmental burden as the cup production.

**b) Use by fans in addition to other souvenirs (fan items)**

Description: The cup is taken home together with other souvenirs (fan items).

Accounting in the balance: no substitution.

**c) Continued use as a drinking cup and a substitute of disposable cups**

Description: A cup, which has been taken home, is used as a cup for various activities (e.g. parties, barbecues, picnics, hiking) and replaces disposable cups made from various materials.

Accounting in the balance: substitution of disposable cups; for the calculations, a disposable PS cup was used. The home cleaning is included in the balance.

**d) Continued use as a drinking cup and replacement of another reusable plastic cup**

Description: A cup that has been taken home replaces another reusable plastic cup (keyword: IKEA cup). A drinking glass was not replaced because it has another purpose of usage.

Accounting in the balance: substitution of the production of a reusable plastic cup. Cleaning at home does not require balancing because there is no difference to other reusable drinking cups.

In order to be able to carry out an estimate of cup loss due to domestic use, a discussion and a survey about the assumed purposes of use were carried out both within the core team (project team) and the accompanying group (client).

The following table summarizes the results of these surveys for the purpose of data acquisition.

**Table 7: Estimates by the accompanying group regarding the use of reusable cups that were taken home**

**EURO 2008™**
**Domestic use of reusable cups**

**General conditions for reusable cups**

| Estimate by the accompanying group (panel of experts) | Min | Average | Max | Used | Type of consideration |
|---|---|---|---|---|---|
| a) Used by fans as a substitute for a souvenir (fan item) | 0% | 22% | 80% | 20% | No effort/expenses for cup production |
| b) Used by fans in addition to another souvenir (fan item) | 0% | 31% | 55% | 30% | No credit for disposal in WIP |
| c) Reuse as a drinking cup and substitute for disposable cups | 0% | 18% | 60% | 20% | Replacement of 10 disposable cups<br>Disposal in WIP |
| d) Reuse as a drinking cup and substitute for another reusable cup | 0% | 28% | 50% | 30% | No effort/expenses for cup production |

## 6.4 Scenarios for disposable cups

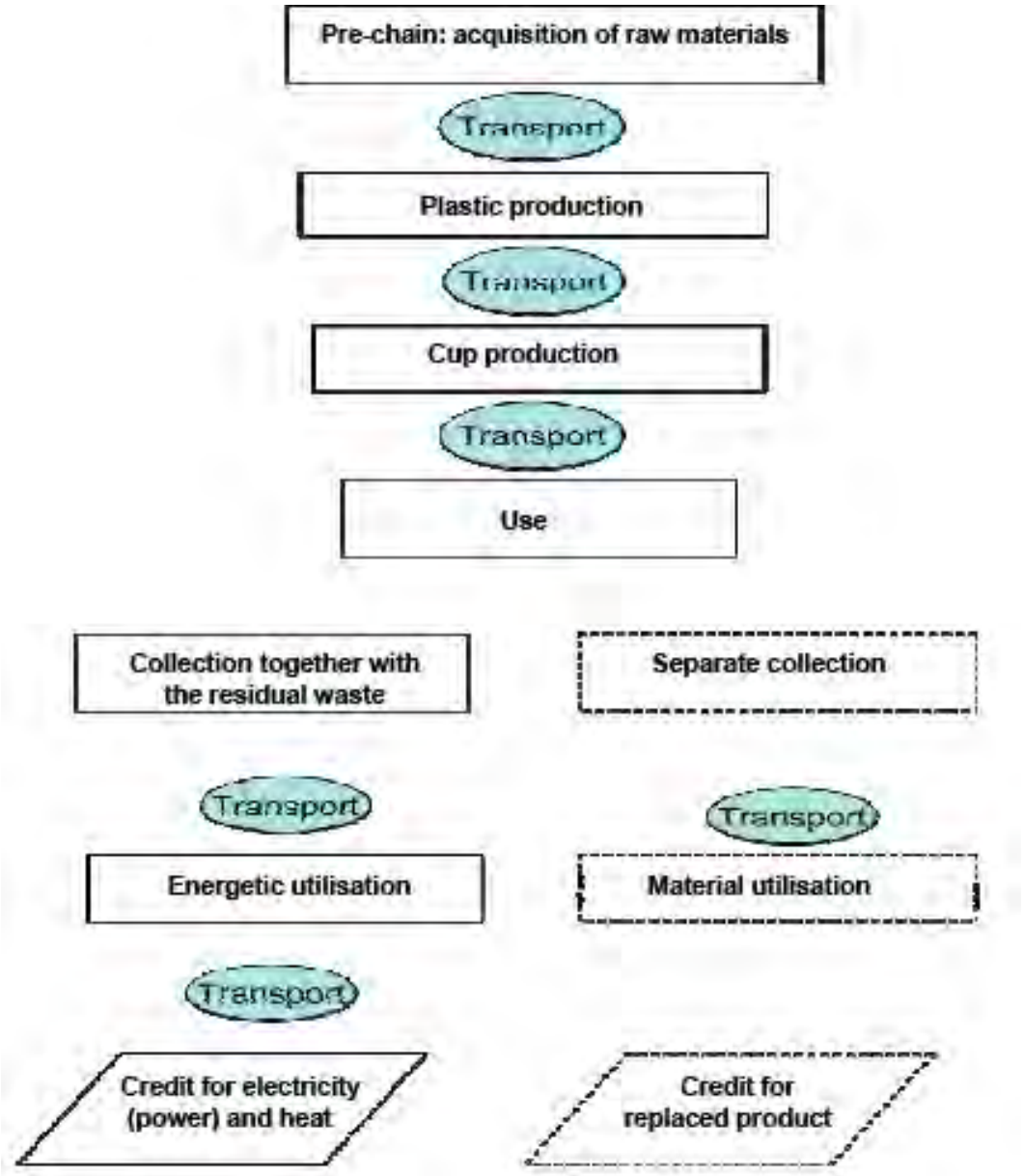



**Figure 11: Basic scheme for disposable scenarios; energetic utilisation means an energy usage or waste heat usage.**

The cup materials or systems, which are described in the following chapters, were regarded as relevant in the sense of the question and were analysed.

### 6.4.1 Scenarios for disposable PS and PET cups

For disposable PS and PET cups, the disposal of cups by incineration, together with the residual waste, is balanced in the standard scenario. The energy provided by the WIP in the form of power and heat according to the average level in Switzerland and Austria is credited for the balances.

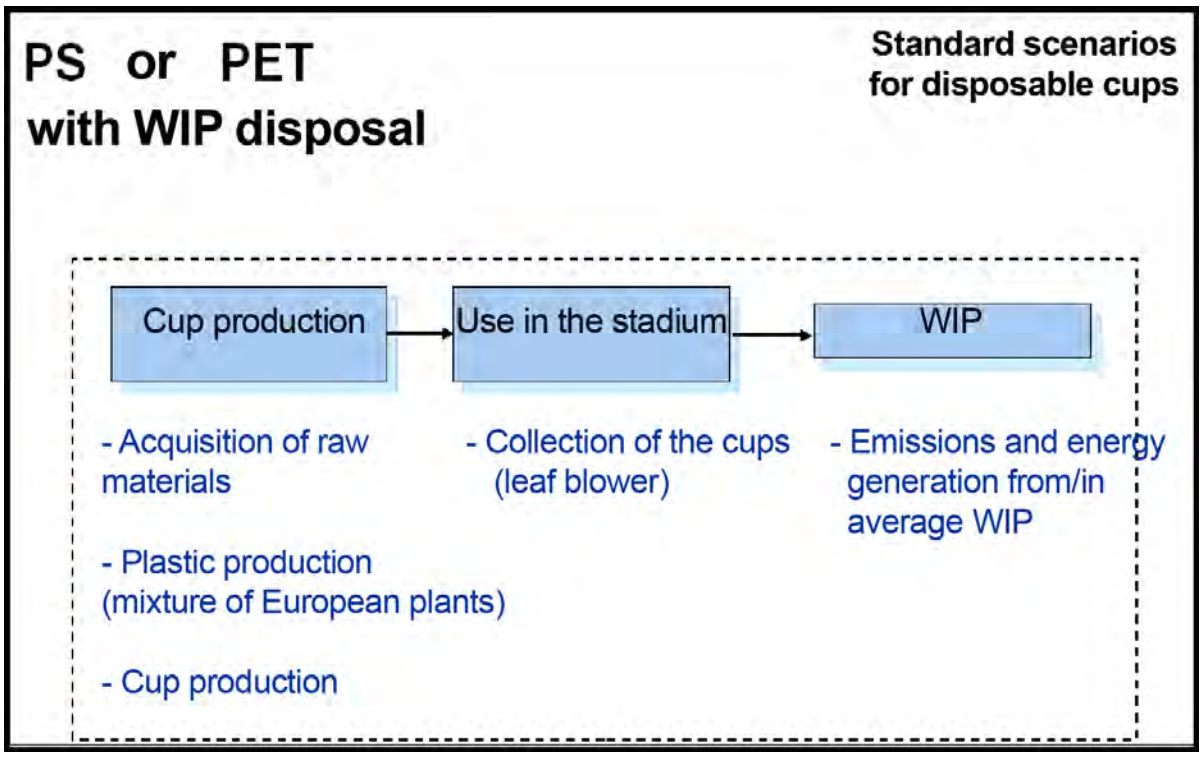



**Figure 12: Standard scenarios: PS or PET in WIPs (use of waste heat in waste incineration plants)**

It was also balanced under sensitivity that the disposable cups are collected separately and transferred into material recycling in the “open loop”. For this sensitivity it is assumed that the regranulate replaces a primary granulate, which is for example used for producing clothes (in the case of PET).

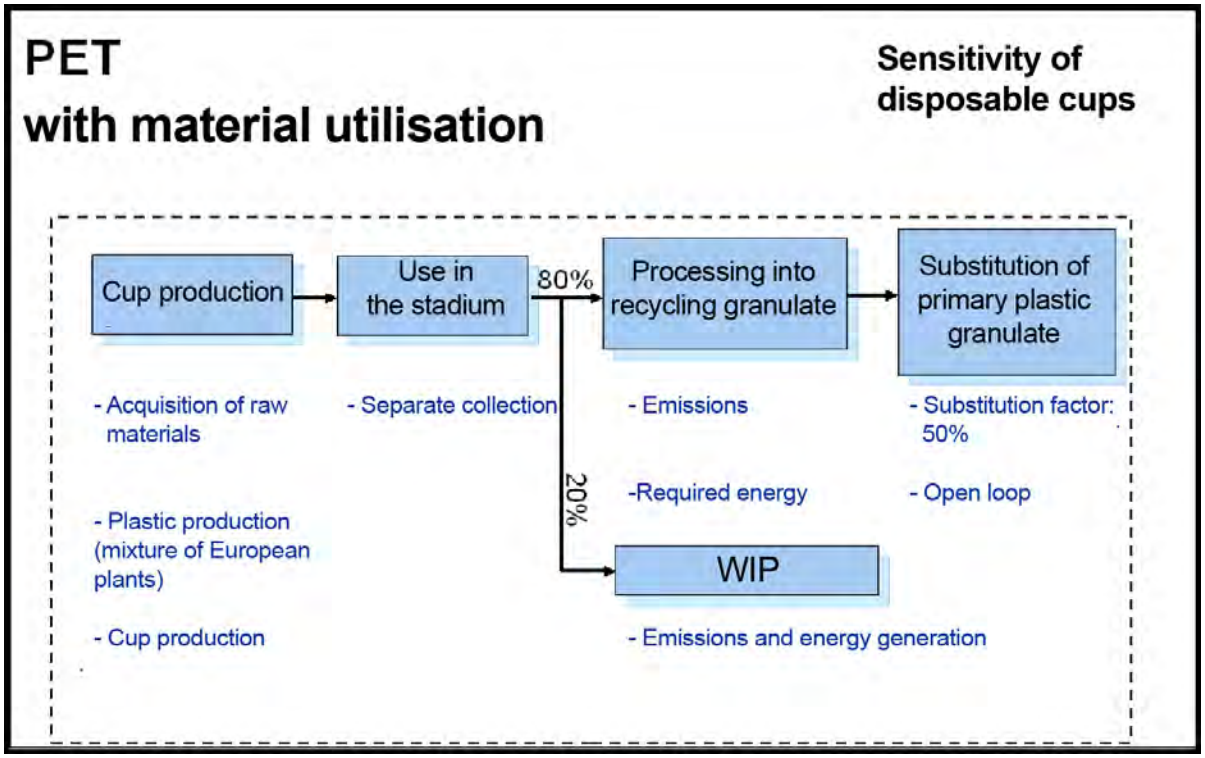


**Figure 13: Sensitivities: material utilisation of PS or PET (recycling if available – open loop)**

For PET bottles closed recycling loops have now also been implemented, which means that drinking bottles are produced from returned (used) drinking bottles. However, research has shown that the respective systems for PET cups are currently not being offered. Therefore, no sensitivity calculation with a closed recycling loop for PET cups has been carried out.

### 6.4.2 Scenario for disposable cups that are coated with cardboard

According to statements by catering companies, customers only accept beer that is served in transparent cups. Therefore, for an event, either only transparent cups or a mixture of on average 70% to 80% transparent cups and 20% to 30% non-transparent cups, such as cardboard cups, have to be used. For this study the above mentioned functional unit of a 0.5 litre cup was specified for serving drinks. Therefore, the cardboard cup is the first cup to be analysed regardless of the acceptance of individual drinks. The effects of the results for a mixture (for example 75:25) can easily be derived from the above.

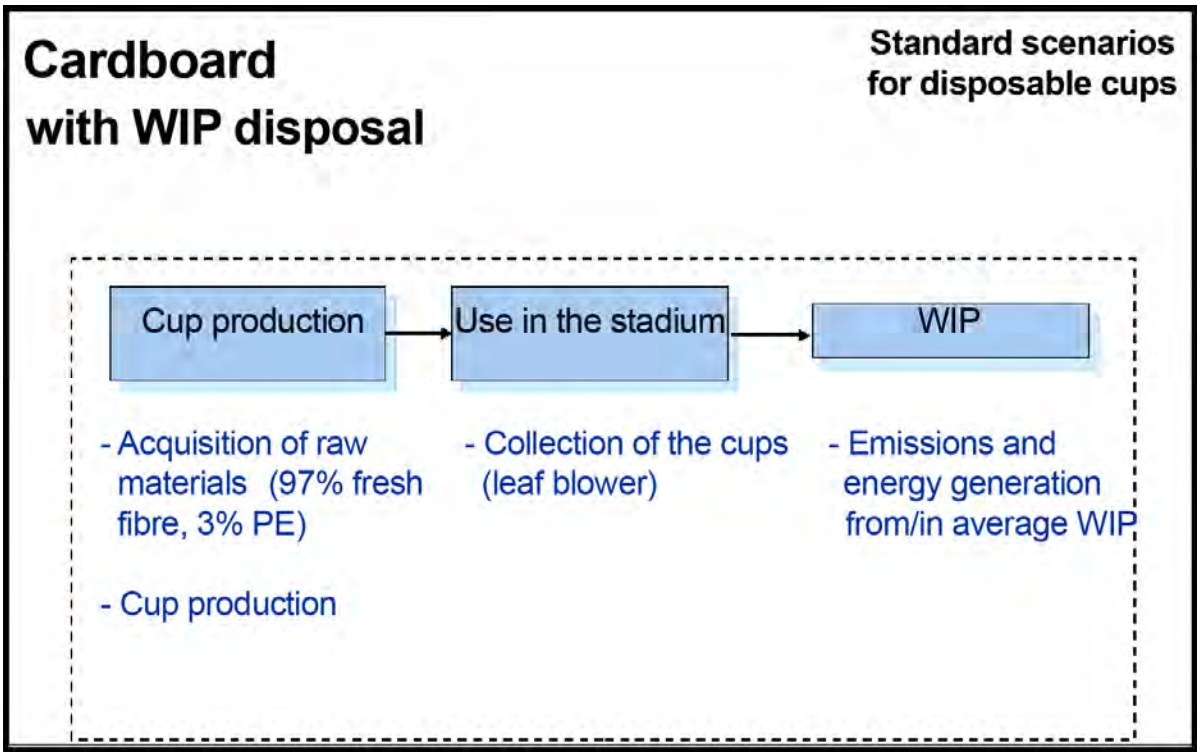



**Figure 14: Standard scenario: cardboard (disposal in waste incineration plants)**

### 6.4.3 Scenarios for disposable PLA cups

For the relevant PLA cups, a material that is manufactured by a US company is used. Further issues regarding the special conditions for plastic made from renewable raw materials and their compostability are discussed in greater detail in chapter 4.2.

Since the PLA material is a regenerative raw material, the $CO_2$ emissions from its disposal are not classified as harmful to the climate, because the $CO_2$ was taken out of the

atmosphere during the growth of the plant. This applies regardless whether the material is disposed of in the WIP or by
composting.

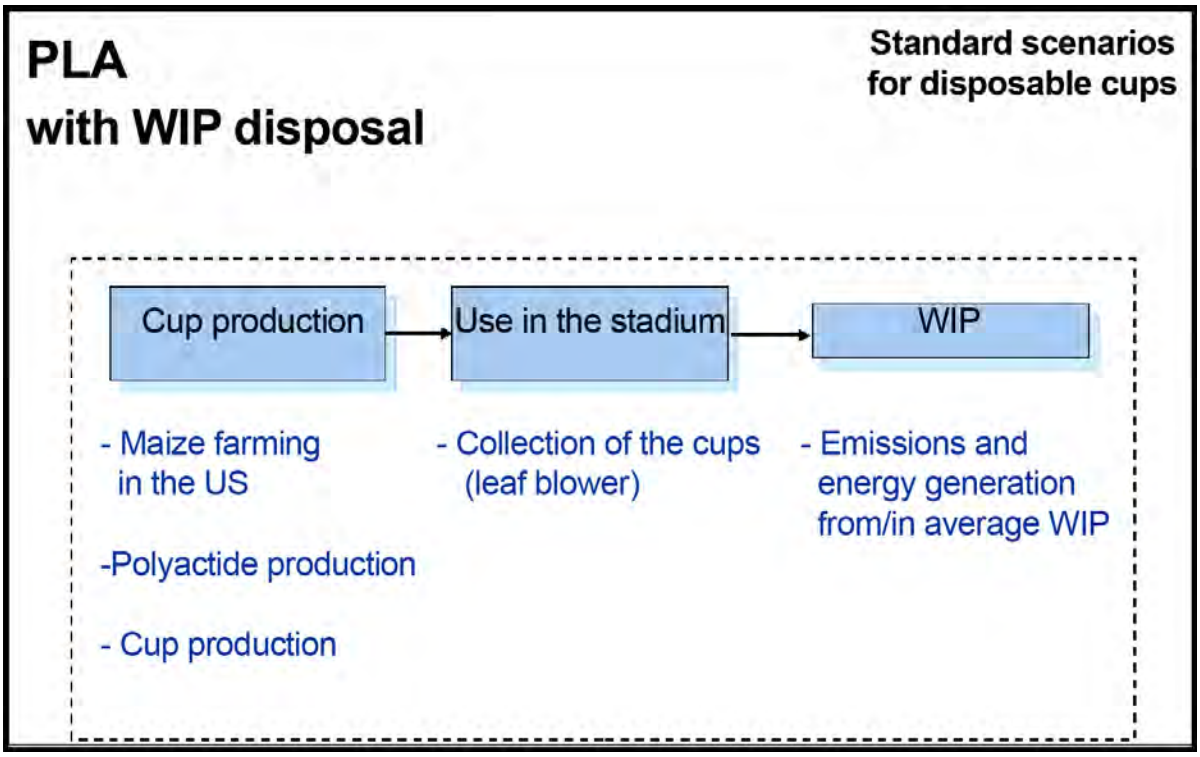



**Figure 15: Standard scenario: PLA in the WIP (disposal in waste incineration plants)**

For composting the cups it is necessary to collect them separately. The additional effort for the collection was not balanced.

Apart from the incineration in WIPs or other plants for thermal utilisation, PLA might also be disposed of in biofermentation plants together with other biowaste. This possible option was not balanced for various reasons:

- The issue was not relevant for EURO 2008 because the appropriate disposal options were not available.
- Various operators of biofermentation plants rejected the processing of PLA materials in their plants to a large extent (example: Vienna composting plant Lobau).
- The fermentation of PLA materials will presumably – in contrast to wet biomasses – not render any more beneficial results in the LCA as compared to the incineration. Due to its high thermal value and the low moisture content in the incineration, fermentation of PLA materials shows much better results than ordinary biowaste. In contrast, during fermentation the fertilizing benefit is missing as is the positive influence on the humus built-up in order to gain further credits from the usage of compost (see chapter 4.2). Previous LCAs have shown that even biowaste with its detrimental incineration conditions is only better placed in fermentation than incineration if apart from the use of biogas the compost is also used to a high degree

(ERZ, 2006).

- Therefore, the energetic use of the PLA material is not just the most probable but also the most ecofriendly
  option.

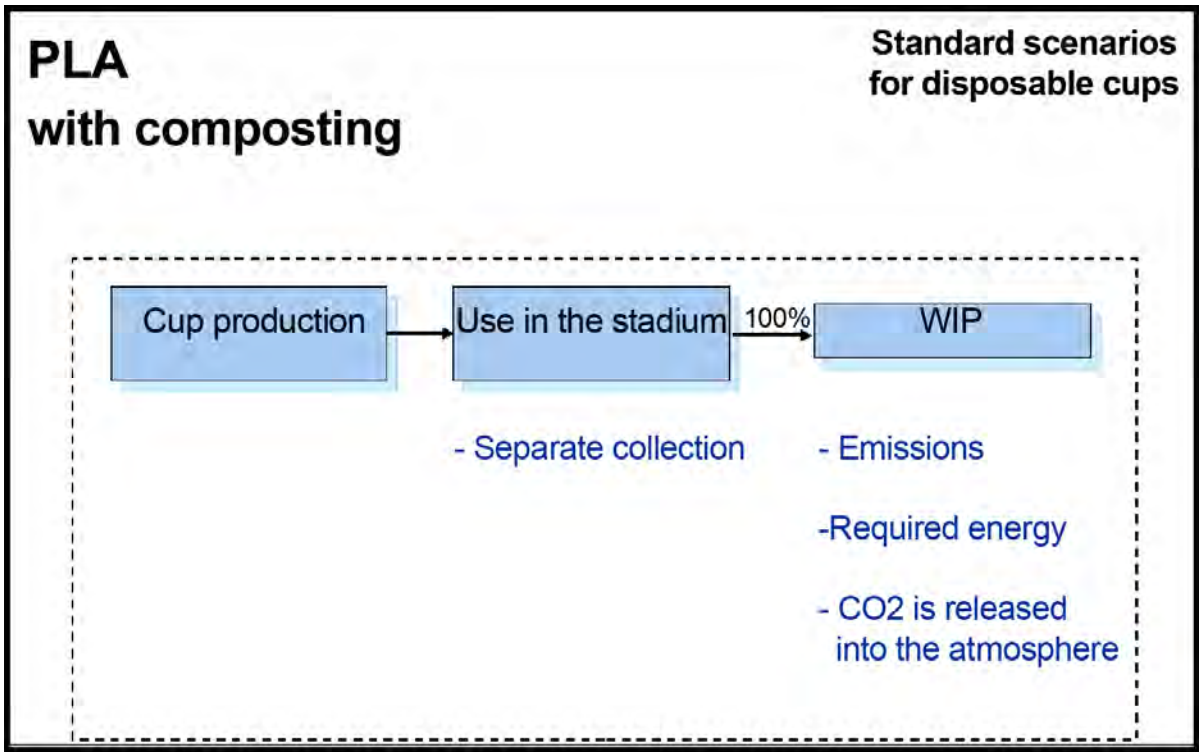



**Figure 16: Sensitivity: PLA with composting**

### 6.4.4 Scenarios for disposable cups made of BELLAND® material

BELLAND® material is a special plastic, which was developed in a similar manner to paper recycling. As for paper, it is designed to be dissolved with little effort and used as a basic material for the production of new goods with a high proportion of recycled material (www.belland.de). This system is currently being developed. The use of recycled material for the production of new goods has been implemented in practical test runs, but not yet in daily production. For this reason, the standard scenario has been chosen in a way that it reflects the system's current stage of development. The collected/returned material is put into intermediate storage. Effort/expenses for storage are not included in the LCA, which means there will be no credits
issuedforthiseither.

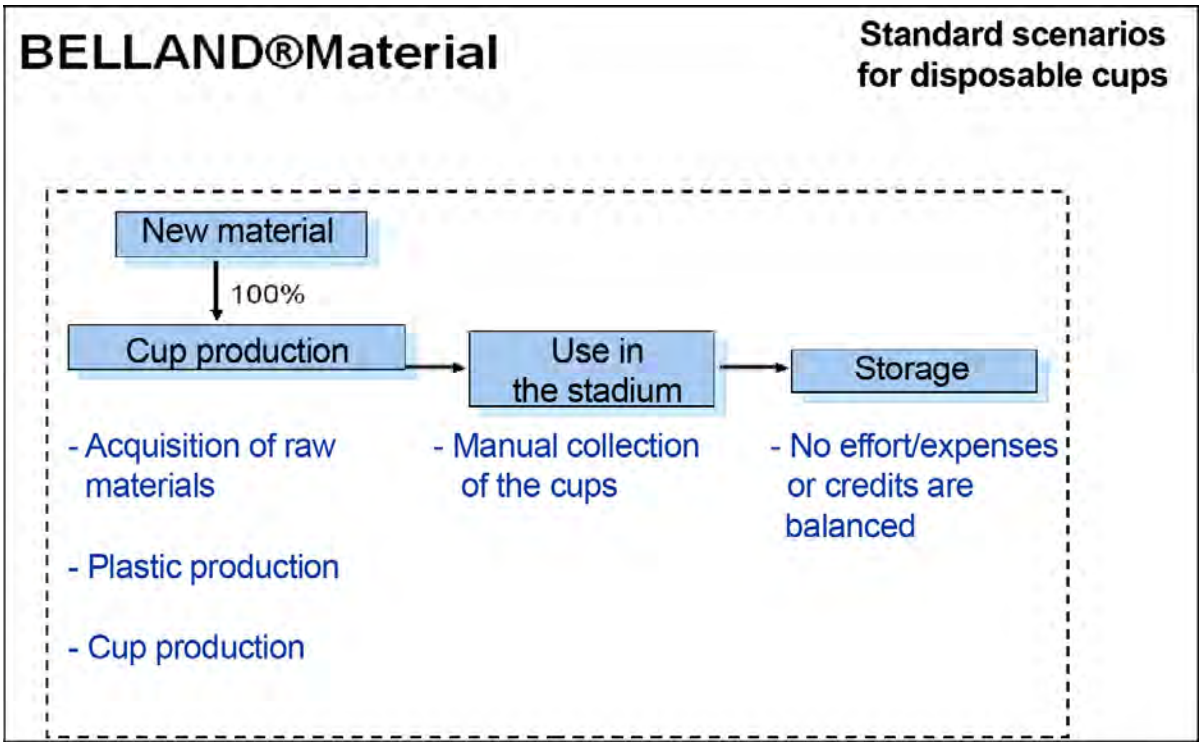



**Figure 17: Standard scenario: BELLAND® material (production from new material, intermediate storage of the collected cups)**

Under the theoretical assumption that BELLAND® material is able to implement a closed loop recycling of 50 percent of recycled material, the sensitivity of BELLAND® material 50 is included in the LCA.

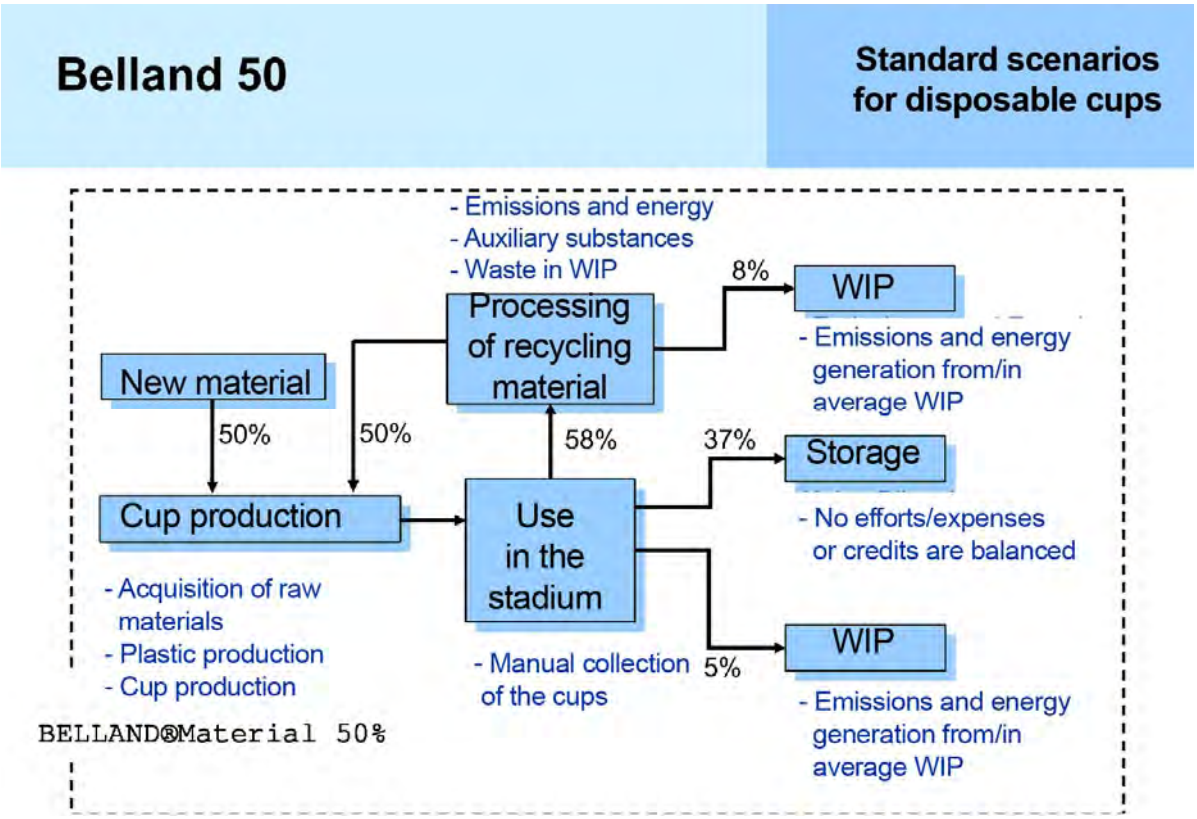



**Figure 18: Sensitivity: BELLAND® material 50% (production using 50% new material and 50% recycled material)**

## 6.5 EURO scenarios for reusable PP cups

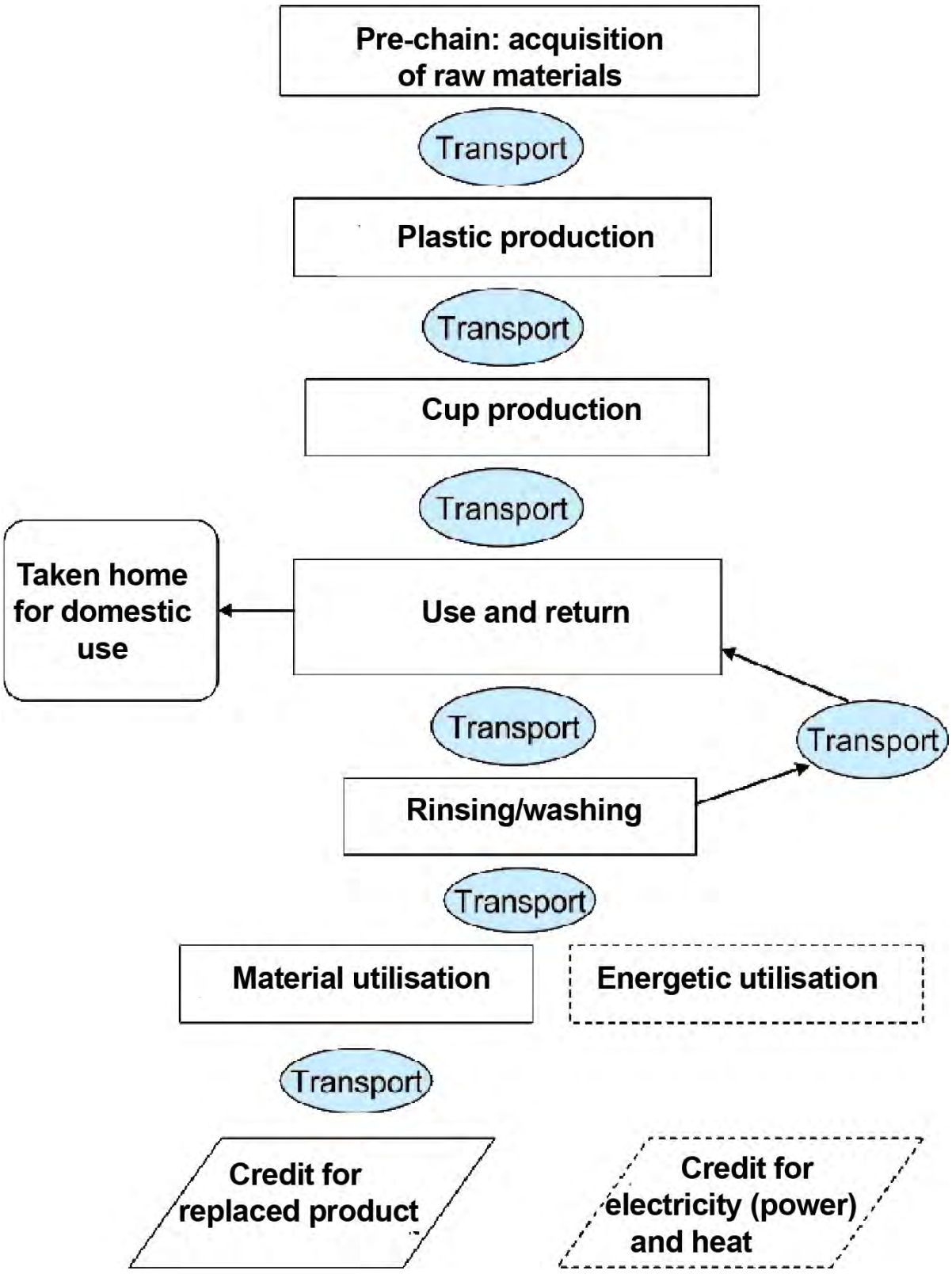



**Figure 19: Basic diagram for reusable cup scenarios (energetic utilisation means an energetic use or the use of waste heat)**

The following sub-chapters contain descriptions of the examined scenarios for reusable cups.

### 6.5.1 Scenario for reusable PP EURO cups with branding (souvenir)

For this scenario, like for all scenarios for reusable cups for EURO 2008, 60 possible usage cycles are assumed. There are eight system cycles based on the total number of 31 matches and the restricted possibility to reuse individual cups due to the nature of the match schedule. If the non-return rate of 25% is taken into consideration, this scenario will have a theoretical 2.9 circulations. This means that 73% of all cups are taken home as souvenirs and will replace another souvenir with the identical production effort in the LCA, which will at some point in the future end up in the domestic waste and be disposed of in a WIP (waste incineration plant). The exact point in time of the cup's disposal does not have any relevance for the LCA.

27% of all cups will be wastage after EURO is over and will be taken to material recycling. This proportion of cups also includes those cups, which were produced in addition as a safety margin. As described in chapter 6.3.2, material utilisation is "open loop" recycling, to which only 50% of all effort (processing: energy, emissions, waste) and credits (substitution of 50% new material) are assigned.

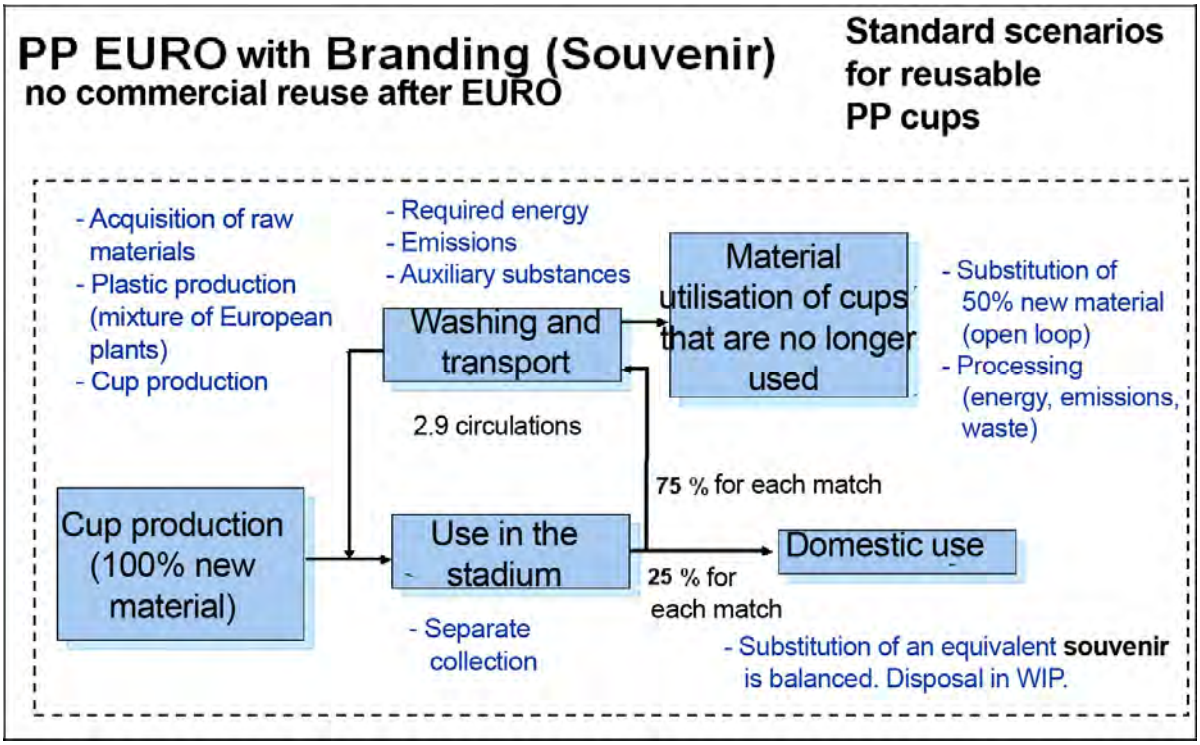



**Figure 20: Scenario for reusable PP EURO cups with branding (souvenir)**

### 6.5.2 Scenario for reusable PP EURO cups with branding (experts)

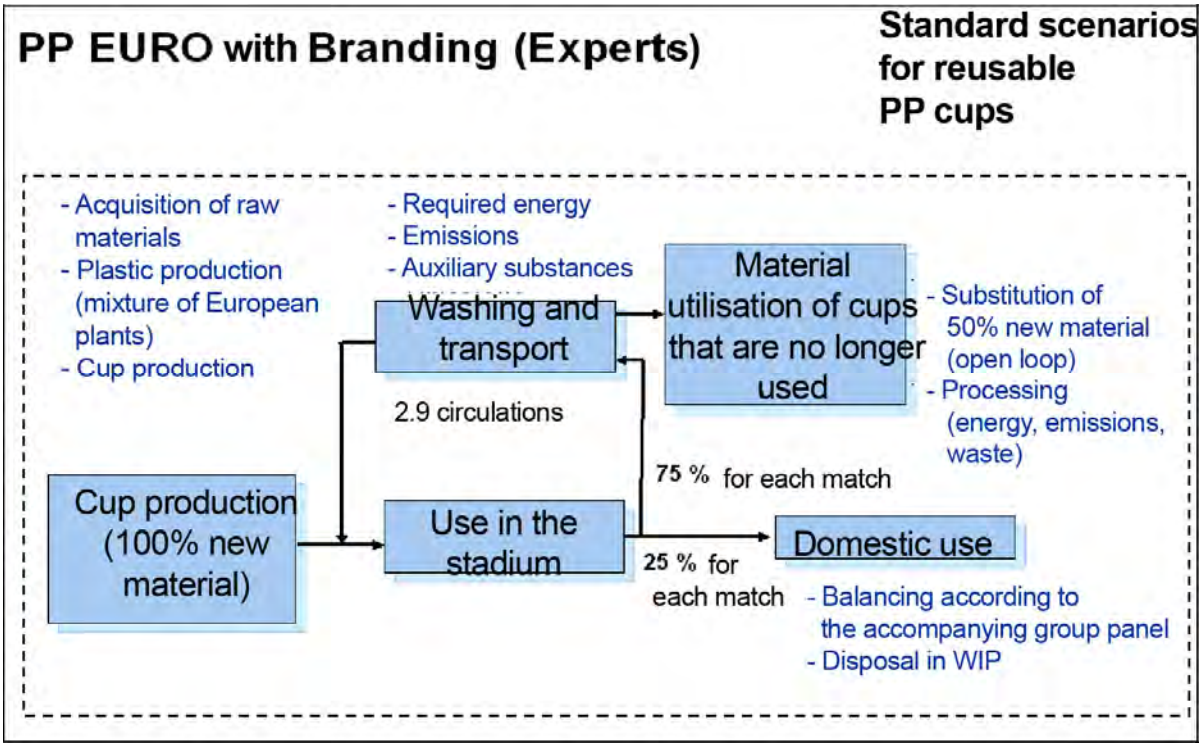



**Figure 21: Scenario for reusable PP EURO cups with branding (experts)**

With regard to circulation numbers, this scenario corresponds exactly to the above scenario “PP EURO cups with branding (souvenir)”. However, for this scenario the domestic use is balanced in accordance with the specifications provided by the experts from the accompanying team (international clients and experts with regard to this LCA) (see chapter 6.3.5).

### 6.5.3 Scenario for reusable PP EURO cups without branding

The standard scenario “PP EURO cups without branding” balances an attractive reusable cup, which is as often not returned, i.e. taken home, as in the previous scenarios for reusable cups. The only assumption is that the cups, which will remain after EURO, can be reused, for example for the Bundesliga operation. However, due to the high non-return rate, the total of all circulations is only just under four circulations. 98% of all cups make their way into domestic use, where they will be used according to the detailed specifications provided by the panel of experts. Only 2% of the cups go into disposal in the form of material recycling.

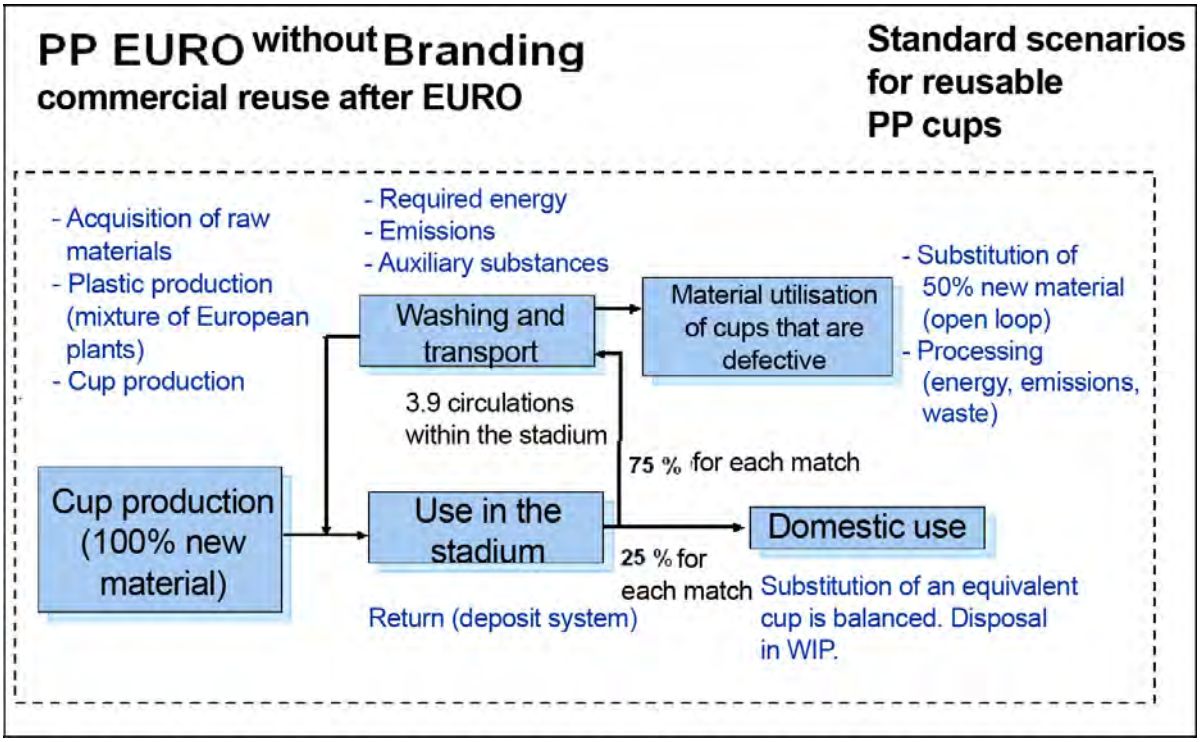



**Figure 22: Scenario for reusable PP EURO cups without branding and with commercial reuse after EURO**

For the sensitivity of the PP cups without printing in Bundesliga (divisional) operations, an LCA for a non-printed cup is prepared, which might either be used during EURO and thereafter for Bundesliga operations or exclusively for divisional operations in Austria and Switzerland. For the maximum circulation number of 60 and with an additional loss rate of 1%, a realistic number of

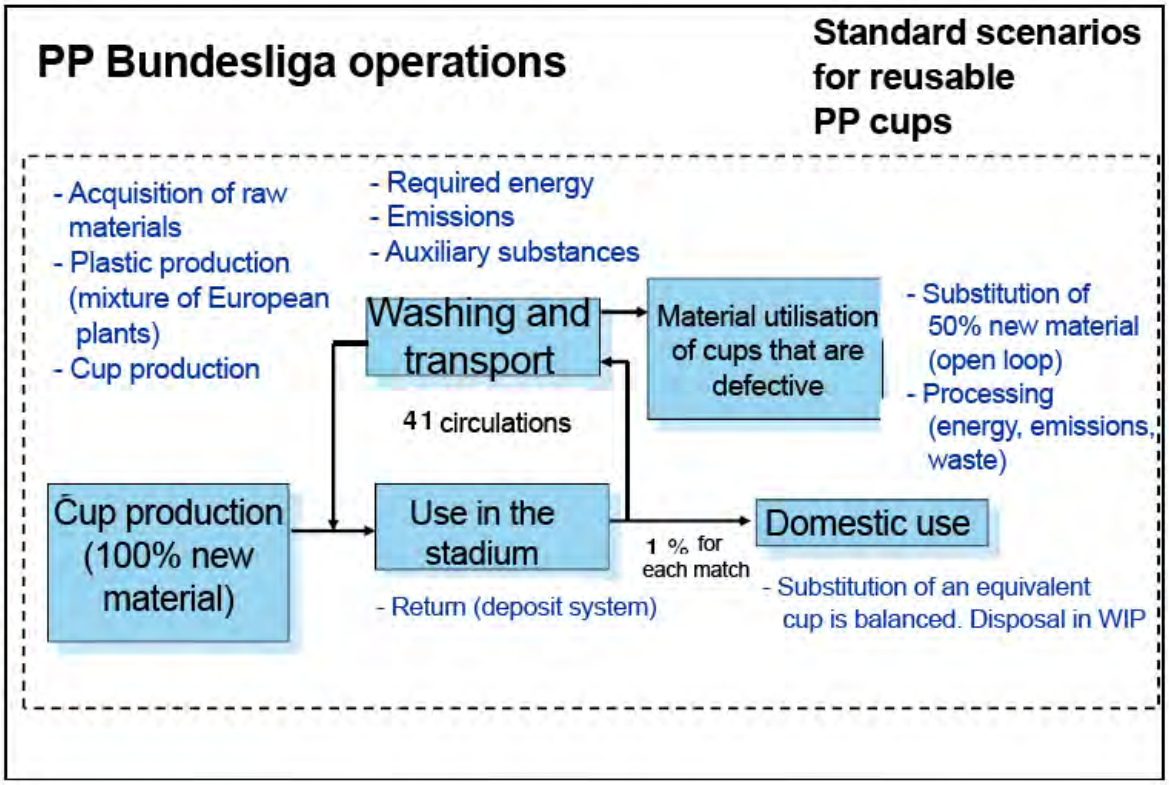


**Figure 23: Sensitivity for the scenario of reusable PP cups for divisional operations**

## 6.6 Divisional operation scenarios for reusable PP cups



For the use of reusable cups, experience from the 2006 world cup as well as surveys in Bundesliga stadiums resulted in a mixture of printed and non-printed cups. For the cups without printing, a combined non-return/breakage rate of 2% is assumed. The specifications provided by the panel of experts are used for a domestic use mixture for the LCA.

The printed cups are collectors' cups (non-return rate of 25%), which carry for example the portraits of players. For the non-return cups, a domestic use according to the panel of experts is assumed. As a variation, the replacement of disposable cups is not assumed because these are not cups for individual events but entire series of collectors' cups, for which the aspect of the additional souvenir is more important than any domestic use. For this purpose the LCA assumes that half of the cups will not get any additional credit and the other half will replace a reusable cup or a souvenir with the same production effort.

The LCA assumes 107 usage cycles (see chapter 6.3.4). The usage cycles result from the breakage rate and correspond to a theoretical number provided that no cups are lost or taken home. The usage cycles and non-return rates were included in the simulation. This resulted in circulation numbers or system cycles, which are reduced according to the non-return rate or breakage rate. The latter was used for the calculations. It was also taken into consideration that the system will not operate indefinitely, but may be replaced by another system after a few years. In case of a possible change of systems, the remaining cups will go into material utilisation of some kind. As a system limit, the maximum number of 500 is assumed for cups without printing. This means that the system will be used at the most for 500 events. For cups with advertising print, the end of the system was assumed after 250 circulations.

For the divisional scenarios, the general data for the German Bundesliga operation was used. This included German energy mixes according to GEMIS not just for the energy demand but also for the release of energy (FRITSCHE et al. 2000 and www.gemis.de). The characteristic WIP values were taken from the average German WIP (see chapter 6.3.2).

### 6.6.1 Scenarios for reusable PP cups for the divisional operations (Bundesliga)

For the normal Bundesliga operations, a mixture of 25% collectors' cups and 75% cups without printing is assumed. This results in 12 real circulations within the system. From this total of all cups in use, 86% remain in domestic use and 14% have to go into material utilisation. The assumption was that the cups from domestic use are disposed of in the residual waste.

### 6.6.2 Scenarios for reusable PP cups for the "Hanover divisional operations"

For this scenario, which reflects the divisional operations in the Bundesliga stadium in Hanover, the following LCA was prepared according to the details provided by the stadium's

operator. They use 87% collectors' cups and 13% cups without printing. This results in 8 real system circulations. 92% of all cups are taken home and go into domestic use or into the residual waste as loss and 8% remain for material utilisation.

The washing station of the Hanover-based system provider is in the city itself.

### 6.6.3 Scenarios for reusable PP cups without printing for divisional operations (Bundesliga)

When only cups without printing are used, the above general data shows 41 real circulations. This value is lower than the value of 60 from table 6. This smaller number of circulations (41) results from the assumption that a non-return rate of 2% applies to cups without printing. In this sense the number that was used tends to be too low for the reusable cups. 82% of all used cups go into domestic use or are lost. For loss and domestic use, disposal in the residual waste is assumed, whereas the remaining 18% of cups go into material utilisation.

### 6.6.4 Scenarios for reusable PP cups for "public viewing" (Vienna)

For the "public viewing" scenario, the situation according to the expectations for EURO 2008 in Vienna is assumed. There will be 300,000 event cups. During peak times, additional cups without printing will be used if required. The cups can be used on 23 days during EURO. Every day, 100,000 to 150,000 drinks will be sold, which means an equal number of rinsing processes for these cups. In total, 2.3 to 3.5 million drinks will be sold during the event.

Assuming that the city of Vienna will be able to use the cups after EURO and that 13% of collectors' cups with a non-return rate of 25% will be used, 27 real cup circulations will result. In total, 80% of the cups will go into domestic use and 20% into material utilisation. For the assessment of the domestic use, the mixture provided by the panel of experts is used.

# 7 Effects balance

In order to specify the effects on the environment the following approach was used:

Classification: Categorising the influences with regard to their effect. The substances are categorised according to their various effects on the environment.

Characterisation: Calculating the effects on the environment

The individual influences, such as emissions or required resources, are balanced against each other with regard to the potential damage they could cause to the environment. This results in the damage potentials regarding a certain effect on the environment.

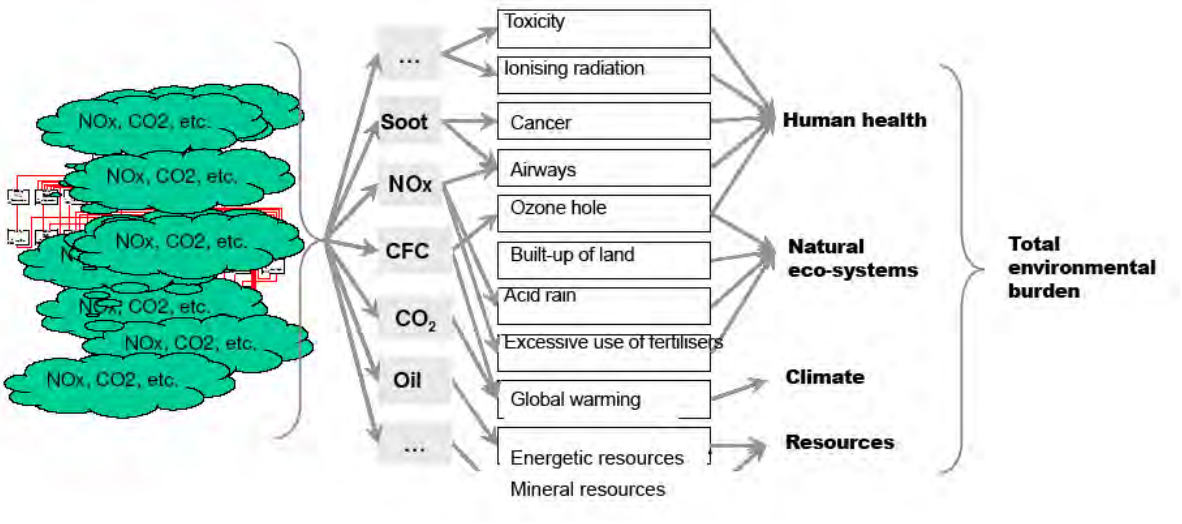



**Figure 24: Criteria for describing the effects of emissions as well as energy consumption and consumption of operating resources**

The effects balance shows the effects of the various material/substance flows on the environment. It focuses on the balance of the various cup systems for the serving of drinks at football matches – for the divisional operations as well as for EURO 2008.

On the basis of comprehensive research of existing ecological evaluations, the relevant cup systems for the serving of water, beer and soft drinks as well as their operating data and effects on the environment with regard to cup production, transport, usage and disposal are described. Then they are balanced in the effects estimation for all environmental criteria, which are important in the context of the examined issue.

In order to get a statement about the significance of the results the data uncertainty is also captured and evaluated.

This study calculates the following effects:

- Global Warming Potential (GWP): Influence on the climate and contribution to the warming

of the climate because of gases such as $CO_2$, methane and nitrous oxide acc. to IPCC 2001.

- Cumulative Energy Demand (CED): Consumption of non-renewable resources such as fossil oil or natural gas (see FRITSCHE et RAUSCH, 2003).
- Ozone Formation Potential: Contribution to the formation of ozone (summer smog) due to the emission of substances such as organic solvents and nitric oxides ($NO_x$). Method: CML, 2001.
- Acid Formation Potential: Contribution to the acidification of the soil and water, for example due to nitric oxides and sulphur dioxide. Method: CML, 2001.
- Toxicity for people (human toxicity): Effects on human health. Method: Impact 2002+.
- Ecotoxicity: Effects on animals and plants due to the emission of certain substances. Method: Impact 2002+.
- Eutrophication or excessive use of fertilisers: Alteration of the nutrient balance in soil and water. Method: CML, 2001.
- Usage of land: Effects on the biodiversity due to usage of large areas of land and their alterations. The calculation is made on the basis of the eco-indicator 99 method (GOEDKOOP, 2000).

# 8 Evaluation

There are numerous methods for describing the effects of a characteristic parameter on the environment. In this case, the following methods were employed:

**a) Method of economic scarcity (environmental burden points, EBP 2006)**

EBP is a method, which was developed in Switzerland and is based on the Swiss environmental policy. For this method, apart from the existing burden, the environmental objectives of Swiss politics are taken into consideration for the evaluation. For this project the revised BAFU version from 2006 was used. Here, the pollutant-dependent criteria have heavier weight than for the eco-indicator.

**b) Eco-indicator 99 (EI 99) method with HA weighing (hierarchist average)**

For the eco-indicator 99, at first the damage to the three objectives in terms of protecting human health, the quality of the ecosystem and resources are calculated. Then this damage is balanced in relation to each other on the basis of society's values. This was prepared and estimated by a scientific panel of experts. For this method, the criterion "non-renewable energetic resources" weighs much heavier than for the EBP.

Both methods are identical regarding the basic approach to the evaluation but vary with regard to the evaluation criteria due to different preferences. Therefore, they are listed together in one sub-chapter. However, the third evaluation method is very different in its approach from the first two methods and is therefore described in its own sub-chapter.

**c) UBA procedure "evaluation in LCAs" (Federal German Ministry of the Environment (Umweltbundesamt) in Dessau)**

The evaluation was carried out according to the UBA method "evaluation in LCAs". The specific contribution is compared to the ecological endangerment and the distance from the environmental objective. The results are evaluated and described.

However, there is no generally applicable method, which can be seen as the "right" one. The word "evaluation" in itself implies that it is about values. Such values will always be subjective and express the value system of the evaluating person or organisation. Therefore, the essential results for all three methods will be demonstrated in the following. It should be noted that the current eco-indicator method does not explicitly take the burden on any kind of water, lake, etc. due to eutrophicating substances into consideration, but only on a flat scale via the agricultural use of land. This effect on the environment is mainly relevant for agricultural products. For this reason, there is a tendency that the results for the cups that are made of renewable raw materials from intensive farming show an insufficient score in the evaluation.

This study employs all three methods in order to substantiate the evaluation's results. This also allows an easier comparability with other studies. The evaluation methods are able to

demonstrate the entirety of all effects on the environment. The evaluations are founded on socially relevant matters and insights. For the description, the method of ecological scarcity is employed as the standard method. The power of its statements is enhanced by the application of further methods (eco-indicator 99, UBA procedure) (sensitivity) and the plausibility is checked using the results of the detailed effects balance. The results were examined for robustness using sensitivity analyses. This means that the influence due to the change of the LCA's specifications or an uncertain data situation in individual modules was recognised and integrated into the final evaluation. Also, the uncertainties were calculated and shown in the graphics, which show the total of all effects on the environment. For the detailed graphics, which show an itemisation according to the various process steps, the uncertainties were not displayed for reasons of maintaining a clear overview. But these can be derived from the graphics for the totals.

The Global Warming Potential (GWP) is not shown separately because the effects on the climate are of an urgent nature. In addition, the results for the CED are listed, which represents a parameter of the calculation but also the consumption (or careful usage) of fossil resources.

# 9 Results

The LCA shows which cup system is the most ecologically beneficial,

1. for normal Bundesliga operations (this also applies to other types of sports with comparable general conditions)
2. for a football tournament over a limited period of time, such as EURO 2008, and
3. for public viewing and fan zones.

The results also apply to major sports events and comparable events.

## 9.1 UEFA EURO 2008™

### 9.1.1 Assessment according to EBP 2006 and eco-indicator 99

The following figures show the effects on the environment for the various cup varieties (measured in EBP and eco-indicator
points).

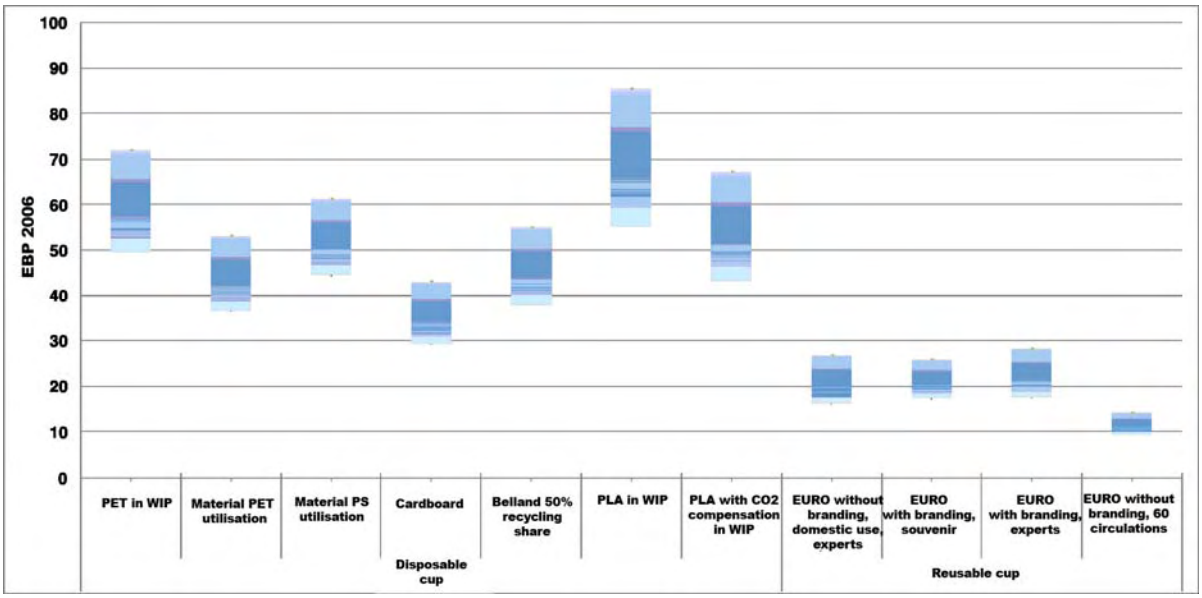



**Figure 25: Comparison of the final results according to the EBP 2006 assessment method (including error ranges)**

For reasons of a clear overview, at first the totals for the various varieties are shown, followed later on by a detailed description of the various causes for the effects on the environment. The uncertainties of the results are shown with the results.

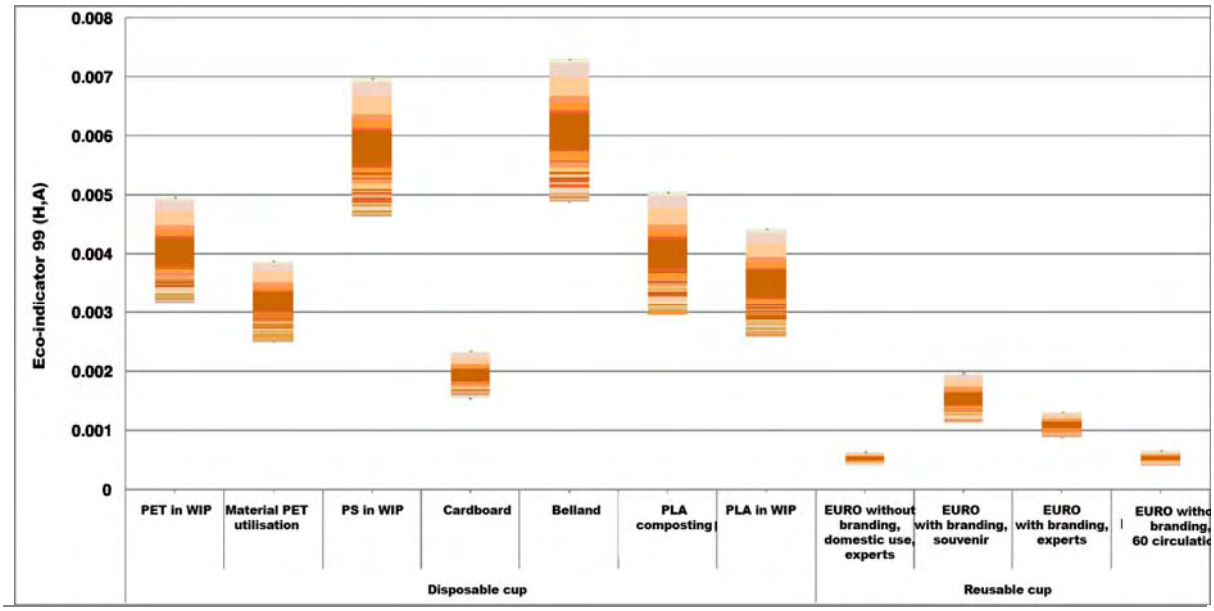



**Figure 26: Effects on the environmental from various drinking cups (assessed using the eco-indicator 99 HA method and including error ranges)**

On the one hand there is a wide range between the various cup types and on the other hand the results have, in parts, high uncertainties.

These ranges result mainly from the following reasons:

- Various basic materials/substances (PS, PET, PLA and PP) are used for cup production.
- The cup weight can vary strongly for identical cup volumes.
- The raw materials can be very different (fossil oil, wood or maize).

The uncertainties of the results stem mainly from the following:

- For the calculations, average values were sometimes used, for example for the weights of the drinking cups.
- For the data acquisition, sometimes assumptions had to be made, for example for the transport distances.

The basic data does carry uncertainties.

Because three methods have been employed, a sensitivity analysis regarding the assessment was carried out.

Despite the differences in the assessment of the individual effects on the environment by the three methods of EBP, eco-indicator and UBA, there are relatively few differences for the overall assessment of the various cup systems.

As a tendency, the assessment using all three methods shows identical results. This means that the results can be regarded as

robust.

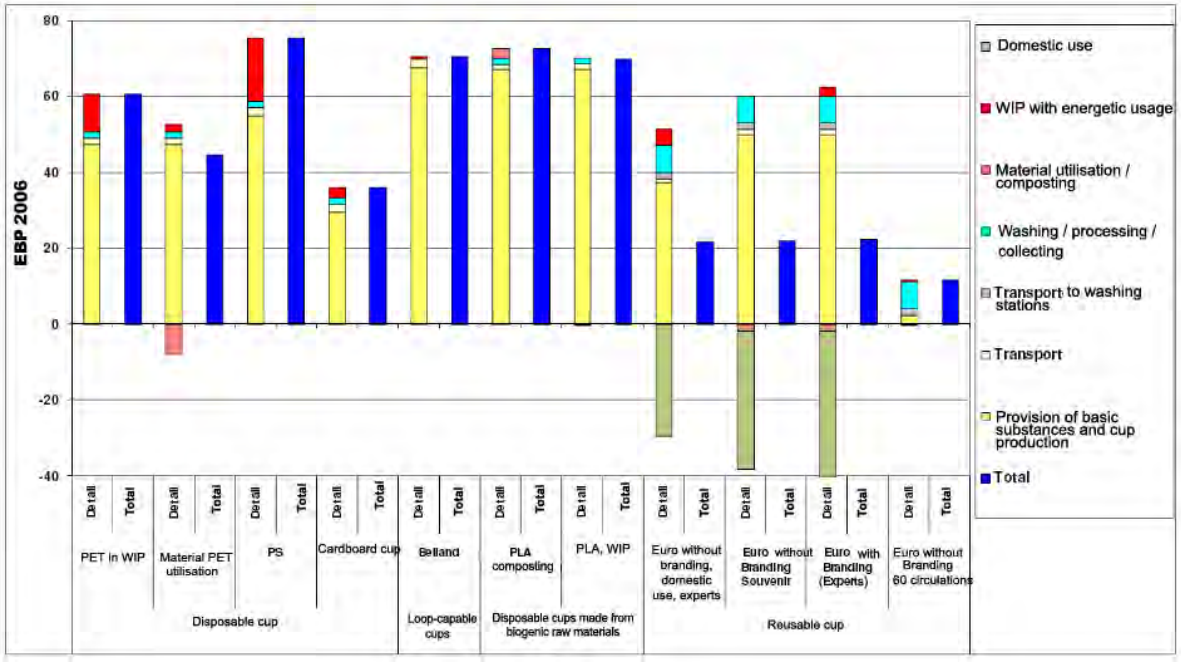



**Figure 27: Detailed analysis of the EURO results with information concerning the various processes according to the EBP 2006 assessment method**

The biggest differences for the cups are with regard to the renewable raw materials, which are basically better assessed using the eco-indicator method. This is mainly down to the high weight of the non-renewable energetic resources. Whereas the EBP 2006 method grants the reusable cups a significantly better assessment than all disposable cups, the eco-indicator 99 method for the cardboard cup only shows a tendency towards a worse assessment in comparison to the worst case scenario for reusable cups. All other disposable cups are given a significantly worse assessment by both methods.

Taking the exactness of the statements and the different assessments into consideration, the following statements can be derived from these
results.

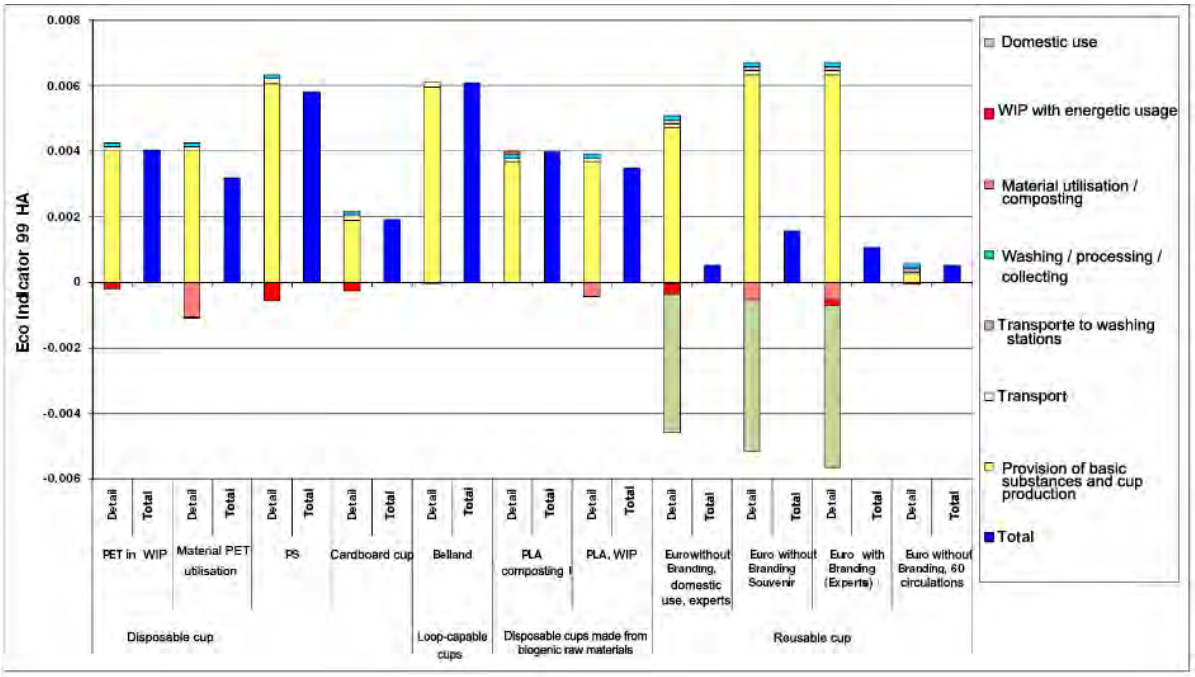



**Figure 28: Detailed analysis of the results with information concerning the various processes according to the eco-indicator 99 assessment method**

The wide ranges for the disposable cups are remarkable. The detailed analysis shows big differences mainly due to the different weights of the cups and the associated effects because of the provision of basic materials and the cup production.

The environmental effects of the biodegradable systems are higher than the effects of the most beneficial variety and lower than the effects of the worst case variety of the conventional disposable cups made of PET or cardboard. A very lightweight plastic cup made from fossil raw materials, which goes into recycling, has a tendency to cause a lower environmental burden than a biodegradable cup made from the renewable PLA raw material.

The spread of the total of all effects on the environment over the various processes shows that the production of disposable cups causes by far the highest contribution to the environmental burden. Since this also applies to biodegradable cups and since the disposal is of minor importance, “composting” even under theoretically optimised conditions (100% compostable) does not result in a reduction of the environmental burden. This means that the characteristic of “compostability” cannot be equalled to a low environmental burden from the cups.

Composting leads to a somewhat worse final assessment because the disposal of the used PLA cups in the WIP results in a credit for the gained energy, whereas for PLA composting no relieving effects will be credited. The reason for the fact that no relieving effects can be credited is that PLA neither contains nutrients, which might serve as fertilisers, nor does it contribute to the built-up of the compost structure.

The biggest PLA manufacturer purchases emission certificates from wind energy in order to compensate for his $CO_2$ emissions. This replaces the electricity from the grid, which is used by the company. This not only results in reductions of $CO_2$ emissions but also of other emissions and of the demand in non-renewable resources. Because this is not an intrinsic characteristic of PLA, the same can be done by any other manufacturer of basic materials/substances such as PET, PS, PP or cardboard. This means that this compensation has not been taken into consideration for the standard scenarios.

The material reutilisation has the strongest effect for the reusable cups. For these, the production does not weigh heavily because of their reuse.

Assessment of standard scenarios

The examined cup systems allow the following conclusions:

- All reusable cup scenarios show a significantly lower environmental burden compared to the examined disposable cup scenarios.
- The best disposable cup scenario is awarded more environmental burden points (EBPs) than the worst reusable cup scenario, for which subsequent reuse is impossible due to branding (PP EURO with branding (souvenir)).
- Amongst the reusable cup scenarios, the scenario with subsequent reuse of the cups (PP EURO without branding) is by far the best in class.
- Biodegradable disposable drinking cups made of PLA (polylactide) are not equal to reusable cups from an ecological point of view. Composting of the cups does not result in a reduced environmental burden because composting of this type of “plastic” does not render any tangible ecological benefit. Also, the effects of disposal are marginal compared to the production of the cups.
- The environmental burden of disposable PLA cups is comparable to that of disposable PET cups and much higher than that of disposable cups made of cardboard.
- The total aggregated environmental burden of disposable cups made of BELLAND® material is at the same level to that of conventional disposable cups such as cups made of PET. The proof for a functioning loop system for BELLAND® material in practical applications has not yet been delivered.

## 9.1.2 Assessment according to the UBA method

### 9.1.2.1 Hierarchical structure of effects categories

The German Federal Ministry of the Environment has developed a method for the hierarchical structuring of LCA results. One of the main objectives is to classify the results of the various effects categories according to their importance. The hierarchical structuring is based on the following statements by the German Federal Ministry of the Environment (Umweltbundesamt (UBA) 1999):

"An effects category ... shall be classified as the more damaging to the environment and shall be given a higher priority,

1. the more serious the potential danger to ecologically sensitive objects in the respective effects category is regarded (regardless of the current state of the environment),
2. the bigger the distance is between the current state of the environment in this effects category and a state of ecological sustainability or another desired state of the environment,
3. the bigger this effects indicator result is in relation to unified reference values, for example the share in the respective total annual emissions in Germany."

These specifications are shown in the criteria for ecological endangerment, "distance to target" and specific contribution.

### 9.1.2.2 Ecological endangerment

This criterion evaluates the seriousness of possible damage to the ecologically sensitive values, such as "human health", "structure and function of ecosystems" and "natural resources", which is connected to the effects categories. In this sense, the ecological endangerment of the examined effects categories is classified as follows[4] (UBA, 1999):

| | |
|---|---|
| Global Warming Potential: | A |
| Acidification: | B |
| Eutrophication: | B |
| Fossil resources: | C |
| Ozone Formation Potential: | D |

[4] A: highest priority; E: lowest priority; the "E" classification was not awarded for any of the examined criteria.

The UBA demands that this classification is checked at regular intervals. For the classifications shown above there have been no essential changes between 1999 and 2007 so that the UBA classification was used for the LCA. This project also uses the effects category “fine dust” for the assessment. The ecological endangerment due to fine dust is classified with a “B” because fine dust has significant effects on human health and can cause irreversible damage. However, this damage only affects the generation, which is directly exposed to the dust, but not any subsequent generations.

Fine dust: B

*9.1.2.2.1 Distance to target (i.e. the environmental objective)*

This criterion compares the current state of the environment to the desired state. The bigger the difference the higher the priority will be. According to UBA (1999) the “distance to target” for the examined effects categories is classified as follows:

Global Warming Potential: A

Acidification: B

Eutrophication: B

Fossil resources: B

Ozone Formation Potential: B

Also for the “distance to target” regarding the environmental objective there are no significant changes as compared to the classifications from 1999 so that the UBA classification can be used. The “distance to target” for fine dust is classified with a “B” because a reduction requires changes in the energy politics, traffic politics and economic politics apart from requiring the discussion of definite reduction targets.

Fine dust: B

**9.1.2.3 Specific contribution**

The criterion of the specific contribution compares the standardised LCA results of the individual effects categories. They are called the specific contribution. In order to recognise the relative importance of the various environmental contributions that have been found and to be able to weigh opposing results against each other, the determined LCA results of the individual effects categories are compared to the overall burden within the examination period.

For the EURO varieties, Austria and Switzerland are the examination area, and for the divisional operation varieties, Germany is the examination area.

This standardisation can show to which degree the individual effects categories contribute to the current environmental situation.

The total emissions for Germany were collected from publications by the German Federal Ministry

of the Environment (UBA 2006a and UBA 2006) and aggregated within the individual effects categories (ÖKO-INSTITUT, 2007). The total emissions for Austria and Switzerland were calculated according to FRISCHKNECHT et al. (2006) as well as GUINÉE et al. (2001 and 2004) with the help of further data from the Austrian and Swiss environment statistics.

The result of an LCA is regarded as the more important the higher it is compared to the annual total burden that is measured in Germany. The variety with the highest specific contribution is set to 100%. The results of the other varieties are compared to the variety with the highest specific contribution. This ranking results in the following class categorisation: A (80-100%); B (60-80%); C (40-60%); D (20-40%); E (0-20%).

This means that the specific contribution is no fixed standardisation. Rather it is determined from the LCA data and also depends on the total emissions within the examination area. For this reason, the estimations for this criterion for the divisional operations in Germany differ from those for the EURO in Switzerland and Austria (see also tables 9 and 11).

#### 9.1.2.4 Combination of the three criteria

Once the classes for the criteria “distance to target”, “ecological endangerment” and “specific contribution” have been determined, they are composed according to the following table for each effects category, and then an ecological priority is derived.

**Table 8: Determining the ecological priorities according to the UBA method**

| Individual assessments of the criteria “specific contribution”, “distance to target” and “ecological endangerment” | | | Ecological priority |
|---|---|---|---|
| A | A | A | Very high |
| A | A | B | Very high |
| A | A | C | High |
| A | A | D | High |
| A | A | E | High |
| A | B | B | High |
| A | B | C | High |
| A | B | D | High |
| A | B | E | Medium |
| A | C | C | High |
| A | C | D | Medium |
| A | C | E | Medium |
| A | D | D | Medium |
| A | D | E | Medium |
| A | E | E | Low |
| B | B | B | High |
| B | B | C | High |
| B | B | D | Medium |
| B | B | E | Medium |
| B | C | C | Medium |
| B | C | D | Medium |
| B | C | E | Medium |
| B | D | D | Medium |
| B | D | E | Low |
| B | E | E | Low |
| C | C | C | Medium |
| C | C | D | Medium |
| C | C | E | Low |
| C | D | D | Low |
| C | D | E | Low |
| C | E | E | Low |
| D | D | D | Low |
| D | D | E | Low |
| D | E | E | Very low |
| E | E | E | Very low |

The LCA results were hierarchically structured according to the UBA method. Table 9 shows the classification of the effects categories according to the described criteria “distance to target”, “ecological endangerment” and “specific contribution” as well as the derivation of the ecological priority for the LCA results of the EURO varieties within the examination area of Austria and Switzerland.

**Table 9: Hierarchical structuring of the LCA results for EURO in Austria and Switzerland**

| | Specific contribution | Distance to target | Ecological endangerment | Ecological priority |
|---|---|---|---|---|
| Global Warming Potential | D | A | A | High |
| Acidification | E | B | B | Medium |
| Eutrophication | B | B | B | High |
| Ozone Formation Potential | E | B | D | Low |
| Fine dust | B | B | B | High |
| Fossil resources | A | B | C | High |

The effects categories of GWP, eutrophication, fine dust and fossil resources show high ecological priority. For the effects category of acidification a medium ecological priority and for the ozone formation potential a low ecological priority results.

**Summary**

Figure 29 shows the relative LCA results for the individual effects categories in relation to the best value of each individual effects category. For an improved display, the effects categories of GWP and acidification were not assigned the best value of 1 but the second best and third best value.

The reusable variety “PP without branding”, for example, shows the best values for all effects categories apart from fossil resources and GWP. Therefore, all effects categories for this variety apart from fossil resources and acidification (see above) are given the value 1. All other varieties are shown in relation to the above.

For fossil resources the cardboard cup shows the best result. There is only a small distance to the best reusable cup scenario. The two other reusable cup scenarios (PP with branding) show approximately three times the value. However, the overall result is clear:

For all other effects categories, the worst reusable cup scenario is still much ahead of the best disposable cup scenario.

In the direct comparison of the disposable cup scenarios, the cardboard cup is best in class for all criteria.

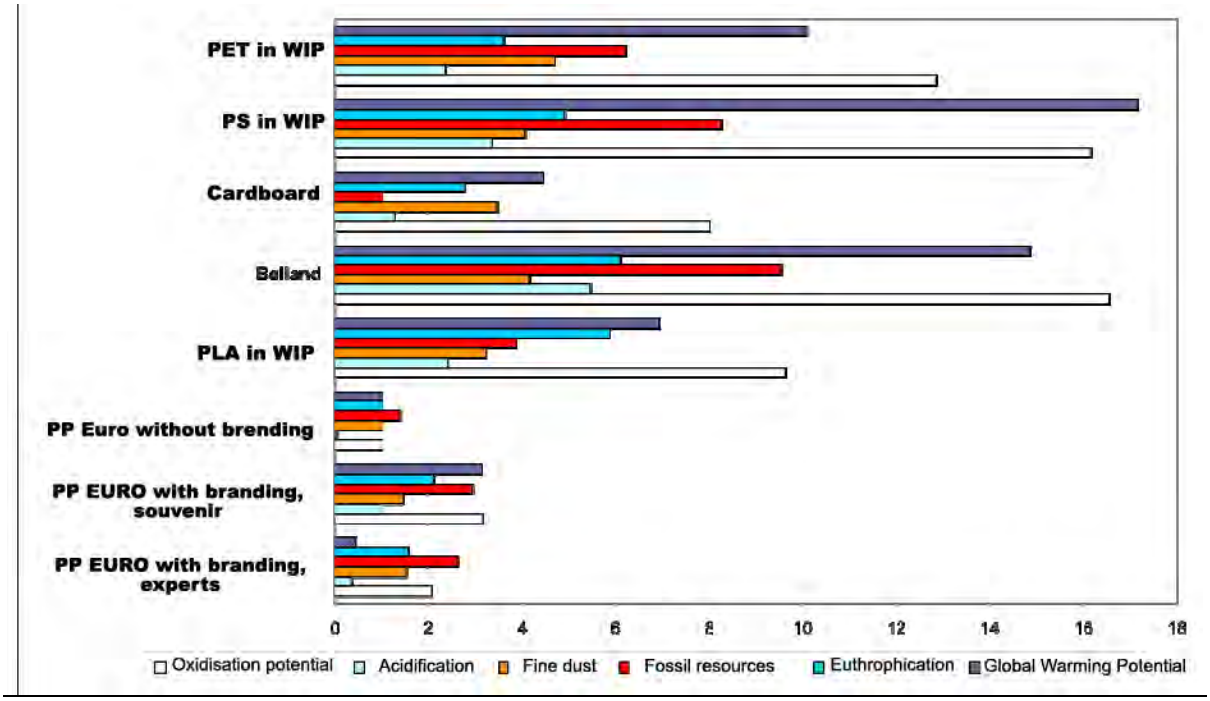



**Figure 29: Summary of the LCA results for EURO in Austria and Switzerland**

This confirms the results from the two aggregated assessment methods for the EURO varieties.

### 9.1.3 Individual assessments for GWP and CED

GWP: All reusable cup scenarios also showed to be more climate-friendly than disposable cup scenarios in the individual effects category of global warming potential (GWP).

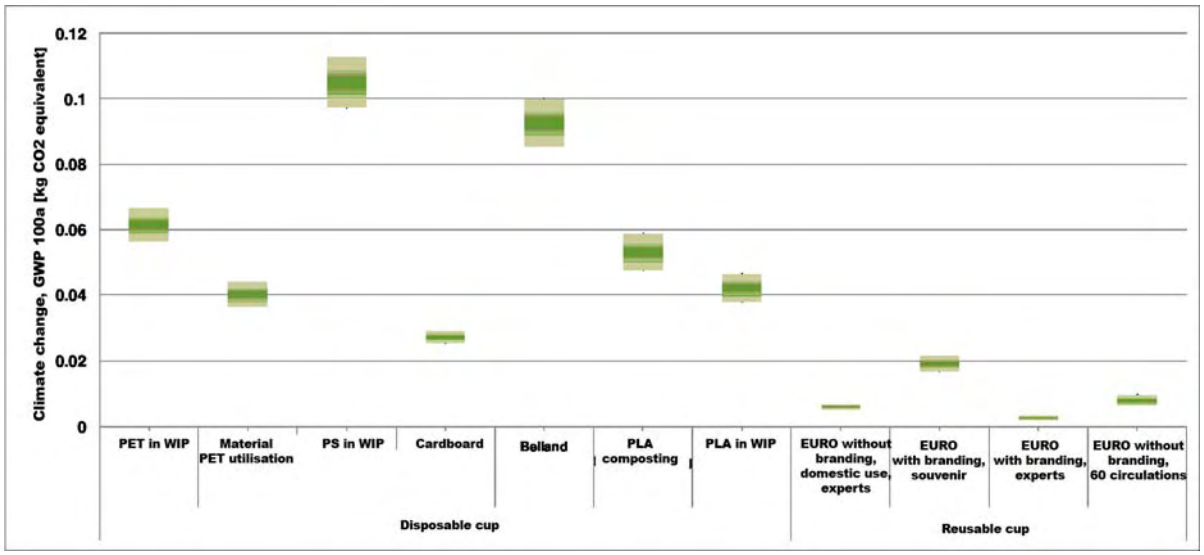



**Figure 30: Effects of various drinking cups on the climate (including error ranges)**

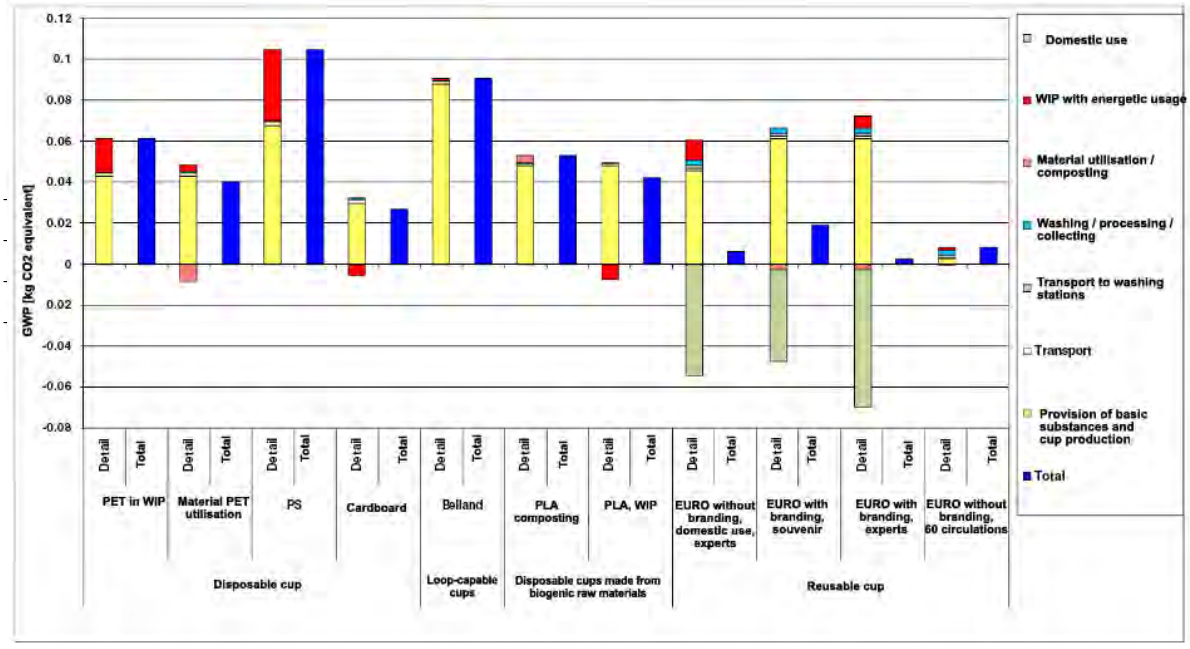



**Figure 31: Detailed analysis of the EURO results with information concerning the various processes for the GWP**

The comparison between the disposable cup scenarios shows the cardboard cup as being responsible for the least burden on the environment (for both aggregating assessment methods and for the influence on the climate due to GWP). However, according to expectation the distance between the best disposable system (cardboard cup) and the reusable cups is smaller for this individual criterion.

For the climate-relevant emissions from the WIP, the influence of the raw material is particularly tangible for the disposable systems. The WIP incineration of cups made from fossil raw materials leads to additional emissions, whereas in the country mix electricity and heat are produced more effectively, i.e. with lower $CO_2$ emissions. This is not surprising because the WIP has to fulfil other tasks, such as pollutant separation, within waste disposal and has a higher own demand for exhaust gas cleaning. In contrast, the use of cardboard and PLA cups results in a reduction of climate-changing gases because the direct $CO_2$ emissions from the incineration of renewable raw materials are per definition not classified as harmful to the climate. However, these credits are rather small compared to the emitted climate-changing gases due to the effort for the acquisition of raw materials and the cup production.

For the reusable cup scenarios, the credits for domestic use result in another hierarchical structure than for both summarising assessment methods of EBP 2006 and eco-indicator 99. Here, the replacement of disposable cups with high credits has a particularly high impact. However, the reusable cup scenario with the highest GWP “PP EURO with branding (souvenir)) with a difference of 30% is still significantly below the best disposable cup scenario.

CED: With regard to the cumulated energy demand, which represents the consumption of fossil energy resources, the scenario of disposable cardboard cups scores better than the best reusable cup scenario (EURO without branding). This is especially due to the intensive use of regenerative resources for the production of cardboard cups.

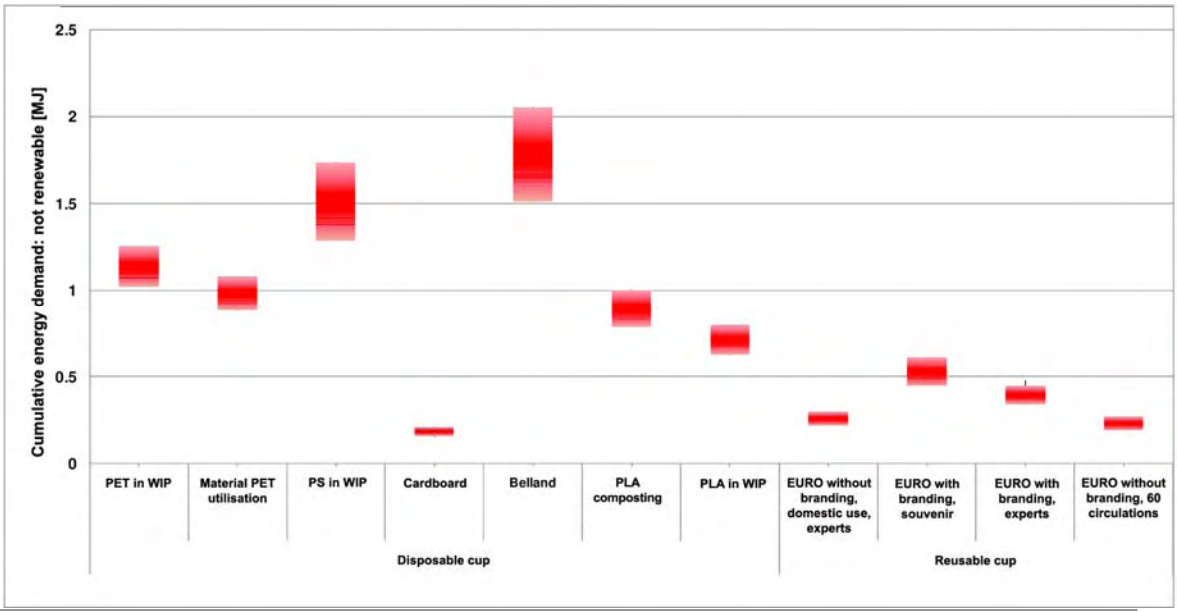


**Figure 32: Results for the various EURO varieties for CED including details about uncertainties**

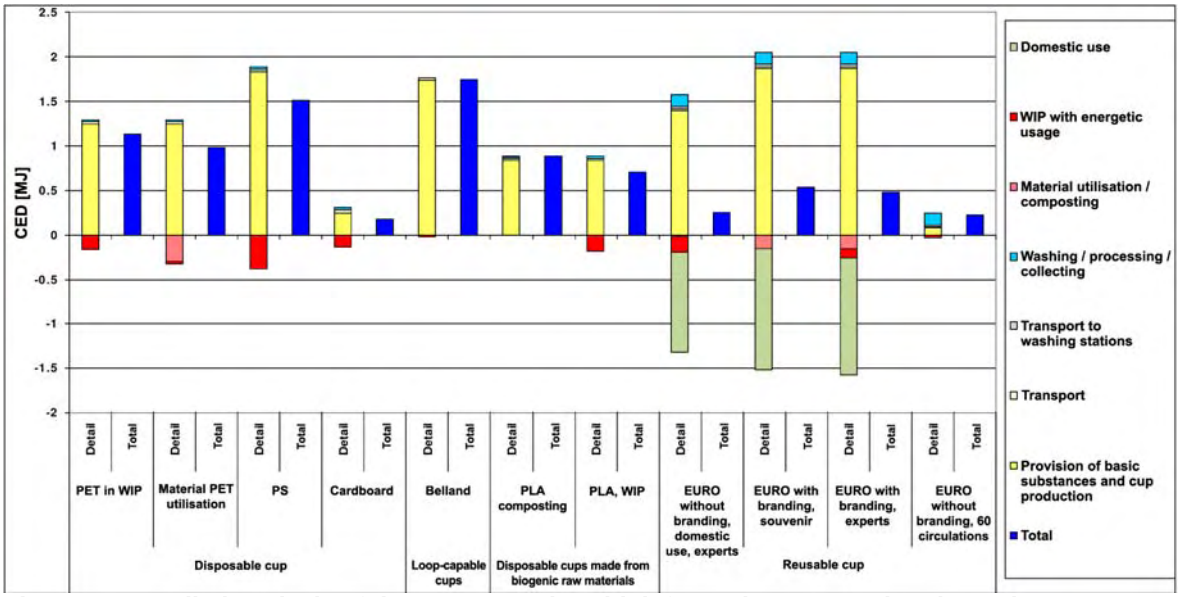



**Figure 33: Detailed analysis of the EURO results with information concerning the various processes for the CED**

### 9.1.4 Influence of domestic use

Figures 27, 28, 31 and 33 show that the domestic use has a significant influence on the results. The domestic use needs to be taken into consideration for methodical reasons in order to balance the entire cup life span. The non-return of “collectors’ cups” has a significant influence on the system circulations, which are essential for the result. Therefore, it is important to achieve a proper balancing of the domestic use; otherwise, there would be much higher circulation cycles, which would lead to the results of the scenario “EURO without branding, 60 circulations” with its lower impact on the environment. In this sense the scenarios for domestic use show a tendency to be worst-case scenarios. For reasons of transparency the circulation cycles were determined, which are necessary for achieving the same environmental effects for the reusable cups as for the respective disposable cups.

These results show that with regard to the overall environmental burden (measured in EBP or eco-indicator) already after 3 to 5 circulations (6 for material recycling of the disposable cups) the environmental burden from the reusable cups is equal to or lower than that of the transparent disposable cups. For cardboard cups, which only pose a restricted alternative, 6 to 10 circulations are required. For the indicators GWP and CED, 3 to 7 circulations are required in order to cause the same effects on the environment as are caused by transparent disposable cups. The cardboard cups show an excellent score with regard to these indicators so that in comparison to these cups circulations of 10 to 60 plus cycles are necessary.

**Table 10: Number of circulation cycles of reusable cups that are necessary to produce the same effects as for the respective disposable cups. *: higher values apply if the cups are materially utilised, **: higher values apply to the incineration in a WIP**

| | EBP 06 | Eco-indicator 99 | GWP | CED |
|---|---|---|---|---|
| PET | 3 – 4.5* | 5– 6* | 5 – 7* | 4– 5* |
| PLA | 3 | 5 | 5 – 7** | 4– 5** |
| PS | 3 | 3 | < 3 | 3 |
| Cardboard | 6 | 10 | 10 | 60 |

### 9.1.5 Sensitivity assessments

Both the disposable systems and reusable systems have an optimisation potential. Sensitivity calculations were carried out in order to check whether optimisation for the disposal systems might lead to other results for the reusable systems. For this purpose, optimisation for the reusable system was deliberately not taken into consideration. The sensitivities regarding the material utilisation of disposable PET cups and the composting of PLA cups (collected separately) have already been integrated into the standard scenarios in the previous figures (see figures 27 to 33) because these were varieties, which had already been realised, which results in an improved comparability. For theses sensitivity calculations, the following scenarios are examined in addition:

- BELLAND® material with a 50% share of recycled material: This is a future scenario because it has not yet been realised in practical applications.
- PS cup in material recycling: This is possible in principle, but is not as widespread as PET recycling.
- PLA with $CO_2$ compensation: The biggest PLA manufacturer purchases emission certificates from wind energy in order to compensate for his CO2 emissions. This replaces the electricity from the grid, which is used by the company. This not only results in reductions of CO2 emissions but also of other emissions and of the demand in non-renewable resources. Because this is not an intrinsic characteristic of PLA, the same can be done by any other manufacturer of basic materials/substances such as PET, PS, PP or cardboard. This means that this compensation has not been taken into consideration for the standard scenarios.

The possibility to cover the electricity demand for washing with eco-power, as this is done in some washing plants in Germany, was not taken into consideration for the reusable varieties.

All of the sensitivity examinations confirm the trend of the results from the standard scenarios:

- Material recycling of the collected disposable PET and PS cups leads to a clear environmental relief as compared to thermal utilisation in a WIP but does not offer an ecological alternative to reusable systems. Due to the higher cup weight, the credit for PS is slightly higher than for the PET cups. In this variety, the PS cup shows a similar good score as the lighter PET cup for WIP disposal.
- Technically "PET to PET" drinking cup recycling is equally possible as for PET bottles (bottle to bottle). It might be possible to reduce the environmental burden even further using this method. However, whether this is logistically sensible remains to be proven.
- A functioning loop system for the BELLAND® material has not yet been realised. Assuming that the BELLAND® material was able to implement a closed loop recycling with up to 50% of recycled material, as has been assumed for the sensitivity as an example, the environmental burden would be significantly reduced. It would be on the scale of the best transparent cups. However, the cups made from BELLAND® material would still show a much higher environmental burden than all other examined reusable varieties. The cup made from BELLAND® material would still not be able to compete with the disposable varieties of the cardboard cup.
- All reusable cup scenarios show the least environmental burden throughout. No disposable cup can be called an ecologically comparable container because it will always have a significantly higher environmental burden

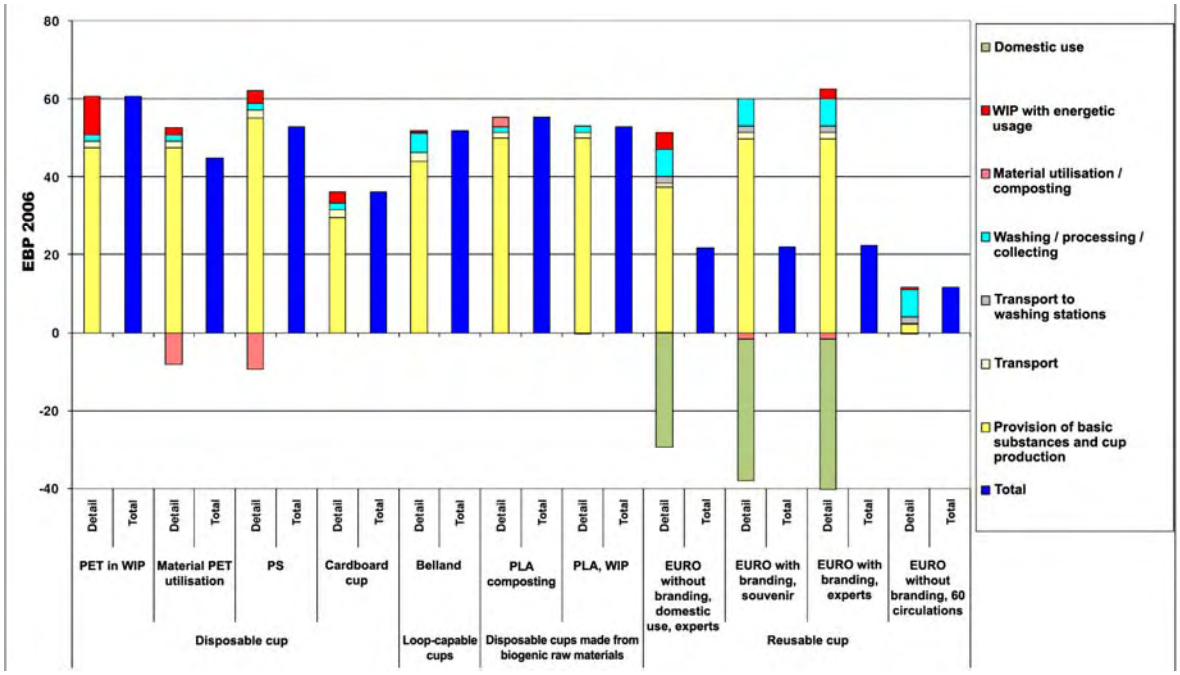



**Figure 34: Sensitivity assessments of EURO for EBP 2006: BELLAND® material with 50% recycled material, PLA with compensation of CO2 emissions, PS with material utilisation of 80%.**

**Cups made from renewable and biodegradable raw materials**

Despite the consideration of the $CO_2$ compensation for the provision of basic materials/substances and the production of disposable cups made of PLA, these do not have the qualities of reusable cups when measured using the EBP. The better disposable cup systems, especially the cardboard cup, also remain superior. The life span of a drinking cup made from renewable PLA raw material carries a relatively high environmental burden even if it is biodegradable (compostable). Disposable cups made of PLA are on the same scale as the cups that are made from fossil resources.

Detailed analysis shows the reason for the high environmental burden to be down to intensive maize farming and the production of lactic acid and polylactic acid (PLA). It should be noted that the PLA production has not yet been fully optimised. The manufacturers of compostable PLA cups suggest that the coming years will show optimisation with regard to the type of energy provision for PLA production and the use of agricultural by-products for the replacement of maize. Current data was used because of the lack of respective basic data as well as the future realisation, which is still to come, and the relevance of this study to today's state of affairs. On the basis of experience with the evaluation of fuels from biogenic raw materials, reductions can be expected mainly from the use of agricultural by-products and the optimisation of the starch production. Nobody can predict today whether the results will significantly change because the above optimisation is also possible for other systems. It may be that the calculations have to be redone at some point in the future.

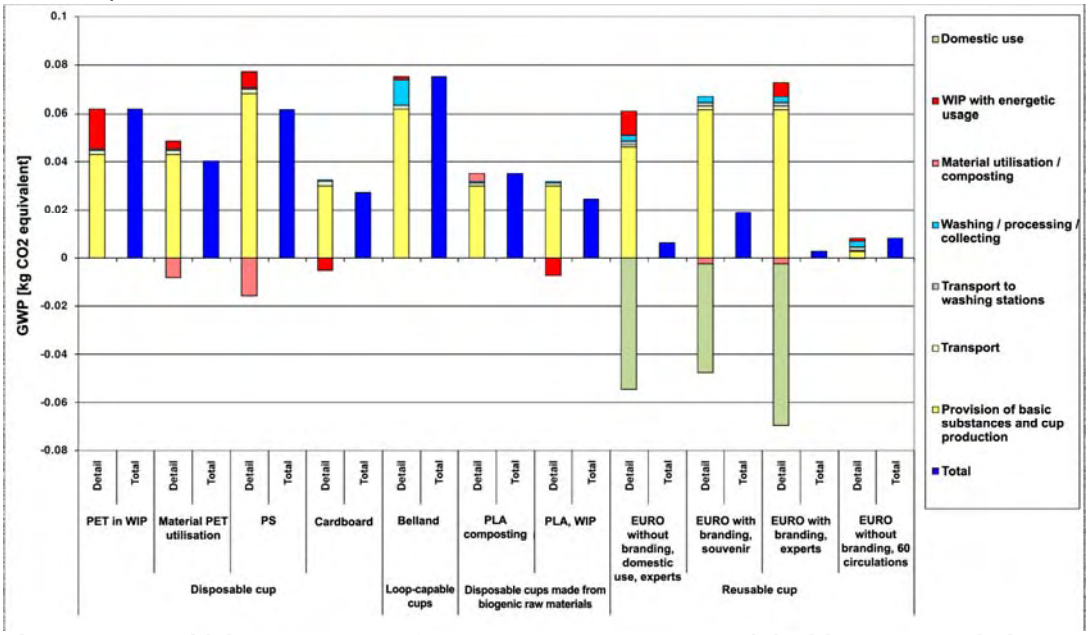



**Figure 35: Sensitivity assessment for GWP: BELLAND® material with 50% recycled material, PLA with compensation of CO2 emissions, PS with material utilisation of 80%**

As expected, the consideration of the $CO_2$ compensation for the PLA production has a bigger impact on the individual analysis of the GWP. However, the consideration of compensation cannot be included in the final assessment because this is not a quality of the examined scenario. It is not a quality of PLA as such but based on the willingness of a certain manufacturer to purchase the respective certificates. In principle, this option of impacting on the $CO_2$ balance

exists for all examined systems. It is for the same reason that the use of ecopower for reusable cup system was not included in the LCA.

## 9.2 German Bundesliga operations and public viewing

### 9.2.1 Assessment according to EBP 2006 and eco-indicator 99

For normal Bundesliga operations, a mixture of 25% collectors' cups and 75% cups without printing is assumed. This results in 12 real system circulations in the stadium. From this total of all cups in use, 86% remain in domestic use and 14% have to go into material utilisation. For the scenario, which reflects the divisional operations in the Bundesliga stadium in Hanover, the following LCA was prepared according to the details provided by the stadium's operator. They use 13% collectors' cups and 87% cups without printing. This results in 8 real system circulations in the stadium. 92% of all cups are taken home and go into domestic use or into the residual waste as loss and 8% remain for material utilisation. The washing station of the Hanover-based system provider is in the city itself. When only cups without printing are used, the above general data shows 41 real circulations. 82% of all used cups go into domestic use or are lost and end up in the residual waste and 18% are materially utilised.

For the "public viewing" scenario, the situation according to the expectations for EURO 2008 in Vienna is assumed. There will be 300,000 event cups. During peak times, additional cups without printing will be used if required. The cups can be used on 23 days during EURO. Every day, 100,000 to 150,000 drinks will be sold, which means an equal number of rinsing processes for these cups. In total, 2.3 to 3.5 million drinks will be sold during the event. The city of Vienna will continue to use the cups after EURO. This results in 27 system circulations in the stadium. In total, 80% of the cups will go into domestic use and 20% into material utilisation. For the assessment of the domestic use, the mixture provided by the panel of experts is used.

According to the aggregated assessment methods, the reusable cup scenarios with the most circulations (Bundesliga operations with cups without printing and public viewing) show the highest score. However, even the two scenarios of Bundesliga operations and divisional operations (Hanover), both of which achieve a significantly lower number of real circulations in the stadium because of the non-return of collectors' cups, remain superior to the best disposable cup system (cardboard cup).

The reusable cups score highest even for the general Bundesliga conditions and especially for the Hanover stadium with the German energy mixes.

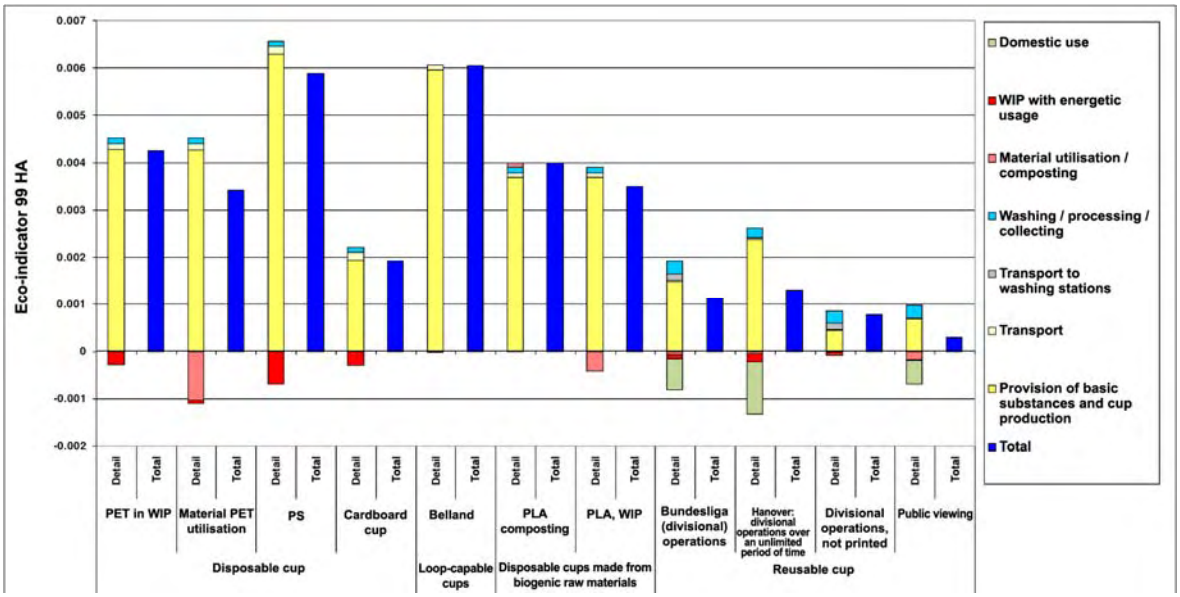



**Figure 36: Detailed analysis of the results for divisional operations and public viewing with information concerning the various processes according to the EBP 2006 assessment method**

According to the eco-indicator 99 assessment method, the disposable cups made from renewable raw materials (PLA and cardboard) score slightly higher than those made from fossil resources (PET, PS and BELLAND® material) because the energetic resources are given a higher weight than for EBP 2006. The difference between the reusable cups and disposable cups remains significant.

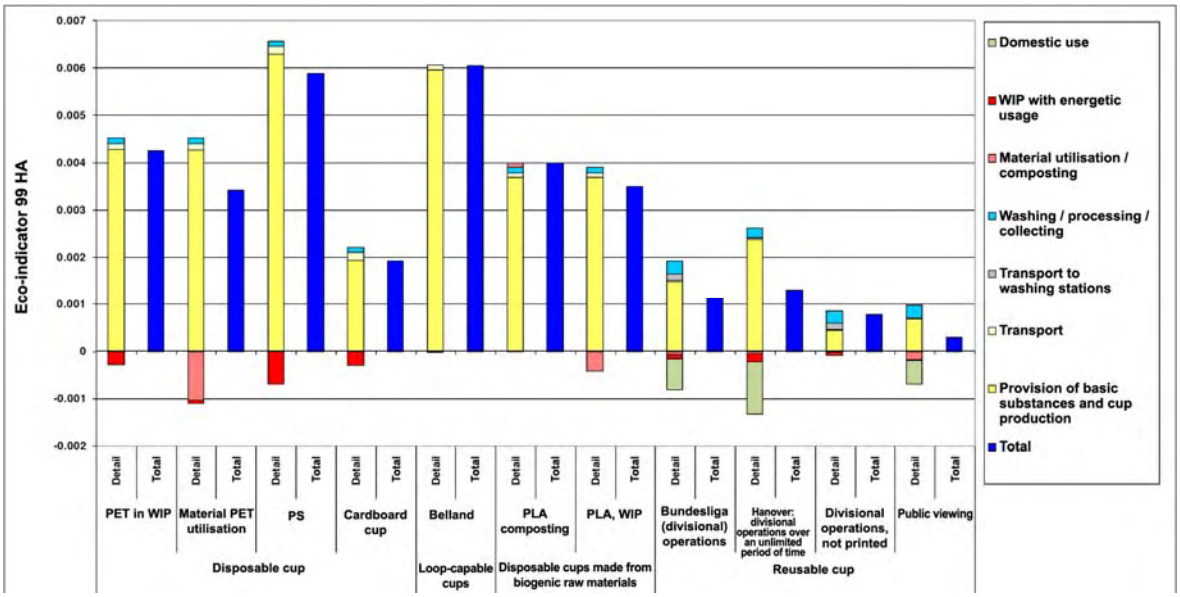



**Figure 37: Detailed analysis of the results for divisional operations and public viewing with**

**information concerning the various processes according to the eco-indicator 99 assessment method**

### 9.2.2 Assessment according to the UBA method

The UBA method is described in chapter 9.1.1. The results for the German Bundesliga operations are not very different from those for EURO, apart from the fact that the hierarchical structuring due to the new examination area leads to other priorities (see tables 9 and 11).

**Hierarchical structuring**

The following table shows the classification according to the described criteria of "distance to target", "ecological endangerment" and "specific contribution" as well as the derivation of the ecological priority according to the prescriptions by the UBA method for the effects categories for the varieties of the German Bundesliga operations.

**Table 11: Hierarchical structuring of the LCA results for the German Bundesliga operations**

| | Specific contribution | Distance to target | Ecological endargerment | Ecological priority |
|---|---|---|---|---|
| GWP | A | A | A | Very high |
| Acidification | C | B | B | High |
| Eutrophication | D | B | B | Medium |
| Ozone Formation | E | B | D | Low |
| Fine dust | C | B | B | High |
| Fossil resources | A | B | C | High |

For the examination area of Germany the ecological priority of the GWP effects category is estimated as very high because of its "A" classification for all criteria. Acidification, fine dust and fossil resources show high ecological priority. These four categories are highlighted in yellow. The eutrophication has been classified with medium priority and the ozone formation potential with low priority (see table 11).

**Summary**

The summary of the LCA results according to the UBA method for German divisional operations and public viewing is shown in figure 38, where the relative LCA results for the individual effects categories are depicted in relation to the respective best value. Only public viewing shows the best values for fossil resources (CED), together with the disposable cardboard cup. The second-best result for almost all effects categories is achieved by the divisional operations with reusable cups that are not designed as collectors' cups. However, there is only a small distance to the other two reusable scenarios.

For the GWP, the cardboard cup is in the same range of both reusable scenarios with collectors' cups with printing. For all other effects categories, all reusable scenarios show better results than the best disposable scenario throughout.

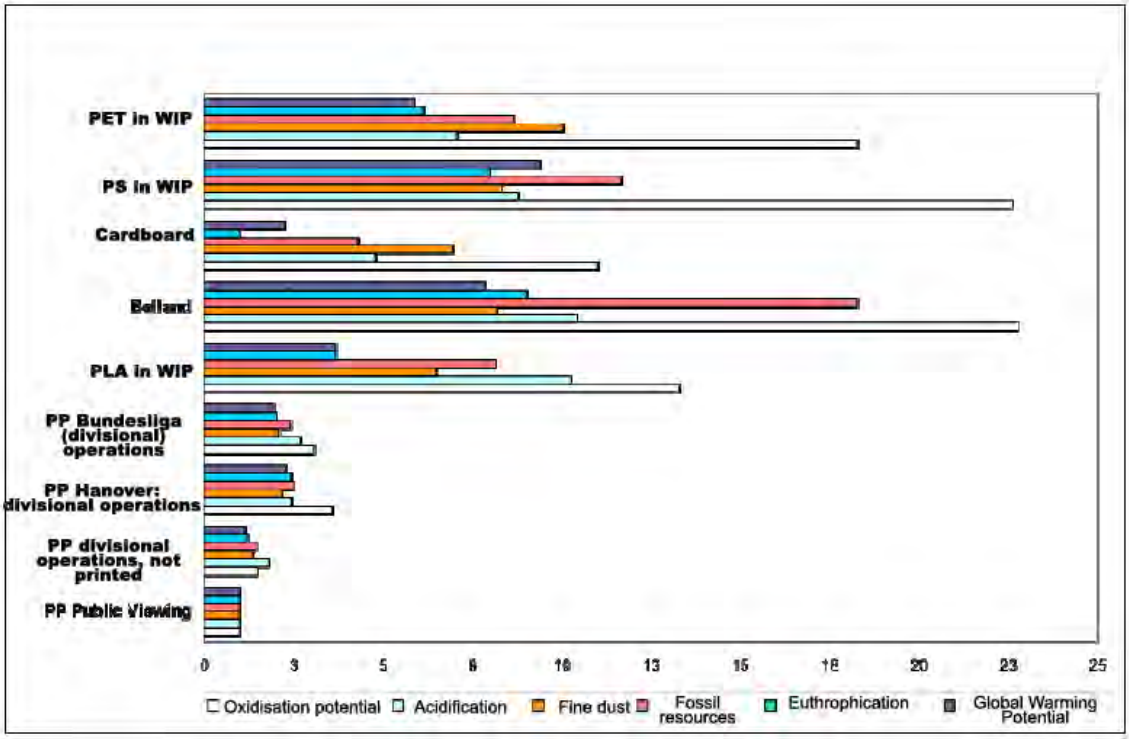



**Figure 38: Summary of the LCA results for the German Bundesliga operations and public viewing**

This clearly confirmed the results of both aggregated assessment methods by the UBA method, also for the German Bundesliga operations.

### 9.2.3 Individual assessments for GWP and CED

The individual assessments show the GWP and CED once again separately. Since these criteria are particularly dependent on the question whether regenerative or fossil raw materials are being used, the disposable cups that are made from renewable raw materials are even closer to the reusable systems than for the eco-indicator 99. For the GWP, the cardboard cup is a very close second to the less beneficial reusable cup systems. However, the PLA cups cause a significantly higher additional burden because of climate-changing gases.

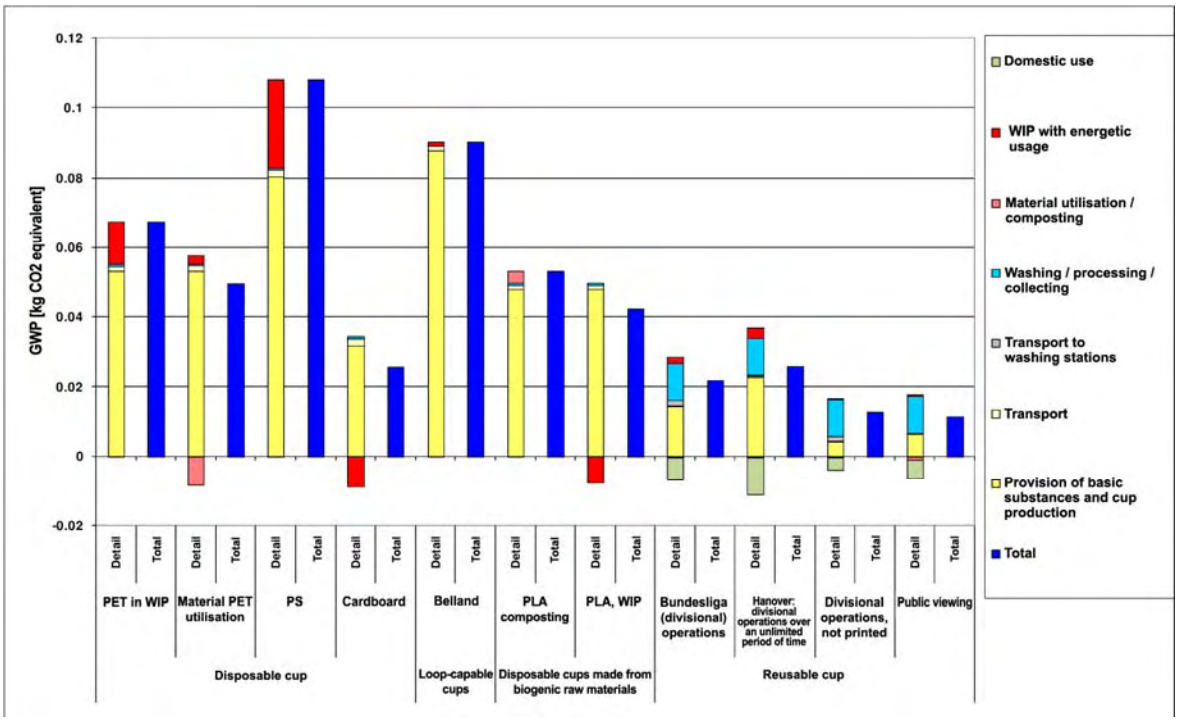

GWP [kg CO2 equivalent]
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
Detail
Total
PET in WIP
Material PET utilisation
PS
Cardboard
Belland
PLA composting
PLA, WIP
Bundesliga (divisional) operations
Hanover: divisional operations over an unlimited period of time
Divisional operations, not printed
Public viewing
Disposable cup
Loop-capable cups
Disposable cups made from biogenic raw materials
Reusable cup
Domestic use
WIP with energetic usage
Material utilisation / composting
Washing / processing / collecting
Transport to washing stations
Transport
Provision of basic substances and cup production
Total

**Figure 39: Detailed analysis of the results for divisional operations and public viewing with information concerning the various processes for the GWP**

For the CED the cardboard cup is even able to come close to the better reusable cup scenarios (as it has done for the EURO scenarios). This is especially down to the fact that the cardboard production mainly uses regenerative energy such as waterpower and biomass. The same applies to the cumulative energy demand, for which the other disposable cup systems remain well behind all reusable cup systems.

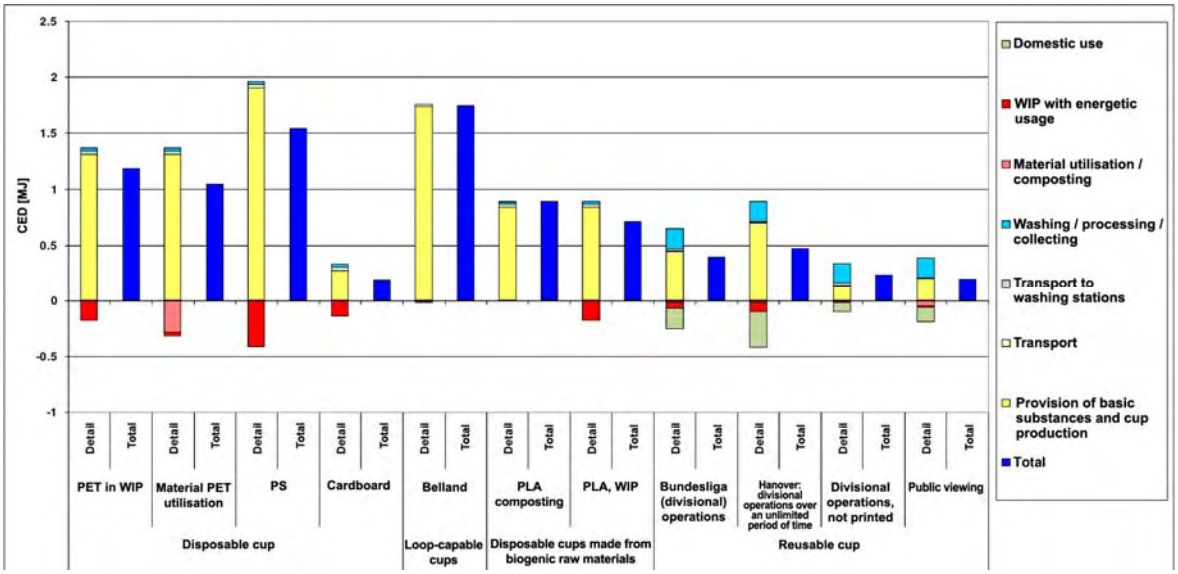



**Figure 40: Detailed analysis of the results for divisional operations and public viewing with information concerning the various processes for the CED**

## 9.2.4 Sensitivity assessments

With regard to the EBP 2006, the reusable cups remains clearly superior, even for the described assumptions of the sensitivity analysis. Although the credits for domestic use for reusable cups without printing have been completely disregarded, this scenario scores very highly. Because of the high number of circulations, the effect is of no great importance.

One of the German providers of reusable cup systems purchases ecopower with very low $CO_2$ emissions for the operation of his washing plants. The sensitivity shows that the effort for washing for the EBP is almost halved and the overall burden is again reduced by a further 30% and for public viewing even by 50%.

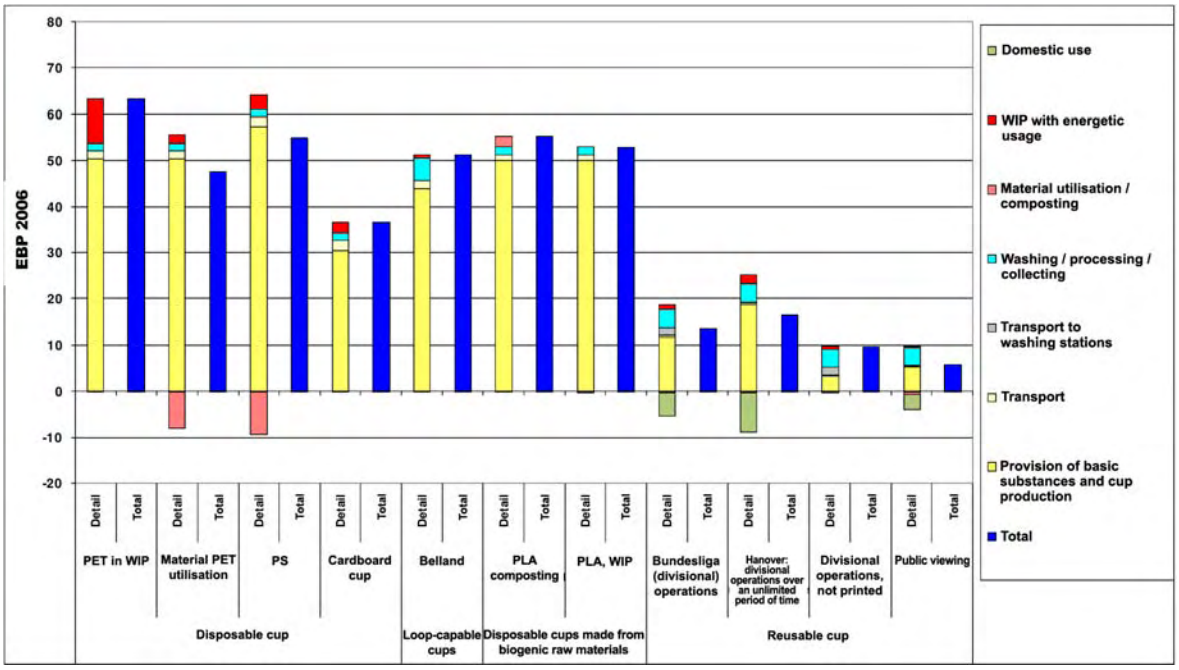



**Figure 41: Sensitivity assessments for divisional operations and public viewing for EBP 2006: BELLAND® material with 50% of recycled material, PLA with compensation of the $CO_2$ emissions, PS with material utilisation of 80%; all reusable scenarios use ecopower for washing; divisional operations with cups without printing and without consideration of domestic use**

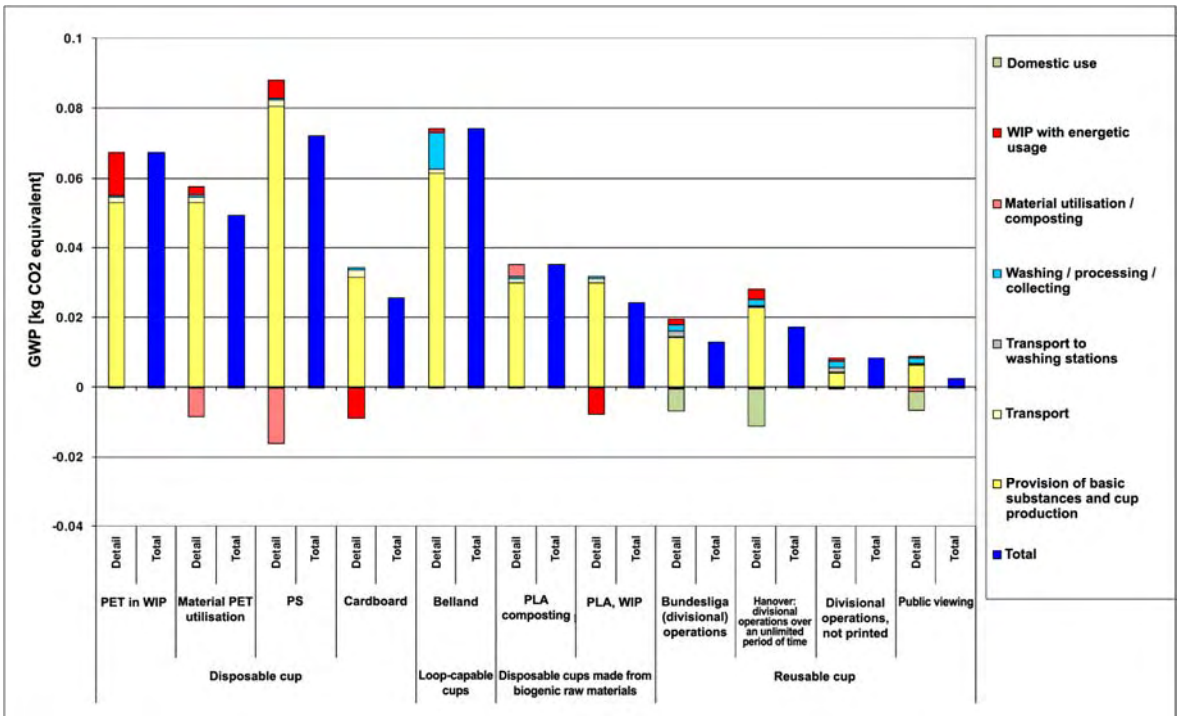


**Figure 42: Sensitivity assessments for divisional operations and public viewing for GWP: BELLAND® material with 50% of recycled material, PLA with compensation of the $CO_2$ emissions, PS with material utilisation; all reusable scenarios use ecopower for washing; divisional operations with cups without printing and without consideration of domestic use**

Naturally, this effect has an even bigger impact on the GWP. Here, the overall reduction is 40% and for public viewing even as much as 75%. This shows that the use of ecopower for reusable cup systems is beneficial in order to improve the LCA and especially the climate balance (see also http://www.ecotopten.de/produktfeld_strom.php or http://www.topten.ch). The same effect can be achieved using solar energy for the heating of water.

All sensitivity assessments confirm the statements of the standard scenarios: The reusable cup systems are clearly superior to the disposable cup systems for all examined general conditions.

# 10 Conclusions

This study examined various disposable and reusable cups that are available on the market and are relevant for UEFA EURO 2008™. It analysed cups that are made from fossil resources as well as renewable raw materials, biodegradable materials and loop-capable materials.

As with all LCAs, the results only apply to the examined systems or products. Any conclusions regarding other applications are only possible with restrictions even if these applications have similar situation parameters. In order to achieve reliable results, the necessary adaptations must be made. In accordance with the issue, only those cup systems and materials were examined, which were relevant for use during EURO 2008. The new materials from renewable raw materials (PLA) or recyclable materials (BELLAND® material) are at an early stage of development and warrant the expectation of future improvements, which were not investigated. The classic disposable systems or reusable systems also give rise to expectations of further optimisation, for example PET recycling for disposable cups or weight reductions/savings for reusable cups. Such optimisation was also not included in our LCAs because it is not relevant for the application during EURO 2008.

To be precise, the results only refer to the application of the examined materials at their current stage of development. The LCAs also refer to the waste management situation in the examined countries (Switzerland, Austria, Germany), which mainly use incineration as the procedure of choice for disposing of residual waste. For countries, which are still championing landfill methods for residual waste, the results might be very different.

In general, the use of the cups at major events was examined. The examined cup systems allow the following conclusions:

- On the basis of the results of the study by the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), the German Institute of Ecology (Deutsches Öko-Institut e.V.) and Swiss company Carbotech AG and taking ecological aspects into consideration, reusable cups are recommended for major events such as UEFA EURO 2008™.
- The same recommendation is given for the German Bundesliga operations as well as divisional operations in Austria and Switzerland and for other major events such as public viewing.
- Any subsequent reuse of the cups after UEFA EURO 2008™ by the Bundesliga or other organisers is recommended. This would result in a further reduction of the negative environmental burden as well as the avoidance of additional waste. In this way it would be possible to implement one of the demands from the catalogue of the Austrian and Swiss sustainability concept for UEFA EURO 2008™.

- The sensitivity examinations show that even the excellent reusable cup systems can be

optimised further if certified ecopower is used for operating the washing plants.

- The recommendations are based on clear and significant results, which were confirmed by the sensitivity analysis and, despite the rather conservative assumptions regarding the reusable cup scenarios, display clear benefits in comparison to all disposable cup systems.
- An important influence on the results is due to the number of cups that are taken home, their influence on the circulation numbers and the type of domestic use, which has been specified for the LCA. The latter cannot be excluded because of the principle of the LCA, which is to examine the entire life cycle of the products. For this reason, these

# 11 Critical review report

This report was reviewed by an external reviewer: Mr Paul W. Gilgen from the Swiss Materials Testing and Research Facility (Eidgenössische Materialprüfungs- und Forschungsanstalt (Empa)) in CH-8600 Dübendorf. On the basis of his review, Mr Gilgen drew the following conclusions (extract from the review report; for the complete review report please see the enclosure):

"The critical review of the study concluded the following:

The modification of the parameters that are essential for the result has led to the upkeep of the study's recommendations (pages 92/93). These recommendations are as follows:

> «On the basis of the results of the joint study by the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), the German Institute of Ecology (Deutsches Öko-Institut e.V.) and Swiss company Carbotech AG and taking ecological aspects into consideration, reusable cups are recommended for major events such as UEFA EURO 2008™.»
>
> «The same recommendation is given for the German Bundesliga operations as well as divisional operations in Austria and Switzerland and for other major events such as public viewing.»
>
> «The recommendations are based on clear and significant results, which were confirmed by the sensitivity analysis and, despite the rather conservative assumptions regarding the reusable cup scenarios, display clear benefits in comparison to all disposable cup systems.»

**The recommended action is robust to such a degree that it still applies even if the extreme values of the parameter spreading range are employed for the LCA calculations.**

- This result is based on current situations and realities within the examined system. Future conditions may lead to other results and consequently to recommended action of a different nature.
- The study provides a practical answer to the question by the joint clients (BMLFUW in Austria and BAFU in Switzerland), which containers for the serving of drinks at major events such as UEFA EURO 2008™ will result in an overall reduced environmental burden: the reusable cup.
  The study provides authorities and administrative bodies with a robust data collection for justifications of possible legislative requirements and regulations with regard to mandatory containers for the serving of drinks at major events.
- It also provides practical recommendations for action for the organisers of such major events with regard to containers, which are to be preferred for reasons of a low environmental burden: the use of the reusable cup.
  The study provides organisers with a robust data collection for further improvement of the ecological aspects of logistics.

**To summarize:**

**The three bodies that prepared the study «Comparative LCA of various cup systems for the serving of drinks at events» (from 24/9/2008) on behalf of the Austrian Federal Ministry of Agriculture and Forestry, the Environment and Water management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW) and the Swiss Federal Environment Authority (Bundesamt für Umwelt, BAFU) have delivered a good piece of work.**

The reviewer:

**Paul W. G i l g e n**

CH-8600 Dübendorf, 3rd April 2009

# 12 Appendix

## 12.1 References and sources

BAUER (2006): Umlaufzyklen von Mehrwegbechern: Eine Umfrage im Zoologischen Garten Basel zum privaten Gebrauch der Zolli-Mehrwegbecher (Circulation cycles of reusable cups: A survey at Basel zoo regarding the private use of Zolli cups), January-February 2006, Building Department of the Canton of Basel city, Environment and Energy Authority, Department for Waste Water and Waste (Baudepartement des Kantons Basel-Stadt Amt für Umwelt und Energie, Abteilung Abwasser und Abfall), Basel February 2006

BASF (2003): Ökoeffizienzanalyse Serviceverpackungen im Kantinenvergleich (Comparative LCA of service packaging in canteens), Ludwigshafen 2003

BÄTTIG (2002): Ökobilanz Einwegbecher – Mehrwegbecher (LCA of disposable cups and reusable cups), INFRAS, Zurich 2002

BUSCH (2001): Environmental assessment of plastic cups, Environmental assessment of plastic cups, Environmental project no.625, Danish EPA, Copenhagen 2001

DALMATINER (2007): Das österreichische Innenministerium (BM.I) zum Einsatz von Getränkebechern bei der EURO 2008, GD für öffentliche Sicherheit, Zentrum für Sportangelegenheiten (Projektbüro EURO 2008), (The Austrian Ministry of the Interior on the use of drinking cups for EURO 2008, GD for Public Safety, Centre for Sports Affairs (EURO 2008 project office)), written notice

DEHOUST et al. (2002): Der Beitrag der thermischen Abfallbehandlung zu Klimaschutz, Luftreinhaltung und Ressourcenschonung (The contribution of thermal waste processing to climate protection, air protection and the saving of resources), Öko-Institut e.V. on behalf of ITAD, Darmstadt 2002

DEHOUST/SCHÜLER (2004): Review zur Ökobilanz „Bewertung von Szenarien der Bioabfallverwertung in Berlin“ (Review of the LCA “Assessment of scenarios for biowaste utilisation in Berlin”); Öko-Institut e.V. on behalf of Berlin City Cleaning Authority (Berliner Stadtreinigungsbetriebe, BSR), Darmstadt 2004

DEHOUST et al. (2005): Statusbericht zum Beitrag der Abfallwirtschaft zum Klimaschutz und mögliche Potentiale (Status report regarding the contribution of waste management to climate protection, and possible potential); study by the Öko-Institut on behalf of the BMU, UBA, BDE and NABU, Darmstadt 2005

DINKEL (2001): Ökologische Beurteilung verschiedener Geschirrtypen mit Empfehlungen (Ecological assessment of various crockery types including recommendations) – update, Basel, October 2001

DINKEL (2004): Ökologischer Vergleich: Einweg – Mehrwegbecher (Ecological comparison

between disposable and reusable cups), Carbotech, Basel 2004

DINKEL (2005): Ökologisch orientierte Geschirrwahl (Ecologically oriented selection of crockery), on behalf of Swiss Olympic, CARBOTECH, Basel, August 2005

EBNER and GUPFINGER (2007): Ökologisierung von Veranstaltungen (Ecological sustainability of events), Vienna, February 2007

ERZ (2006): Verwertung der biogenen Abfälle in der Stadt Zürich, Bericht mit besonderer Berücksichtigung der biogenen Abfälle aus Haushalten (Utilisation of biogenic waste in the city of Zurich, report with special consideration of biogenic household waste), ERZ Entsorgung + Recycling Zürich, Hagenholzstrasse 110, Postfach, 8050 Zurich

FRITSCHE et al. (2000): GEMIS 4.0 Gesamt-Emissions-Modell Integrierter Systeme. Umwelt- und Kostenanalyse von Energie-, Transport- und Stoffsystemen (Total emissions model for integrated systems. Environmental and costs analysis of energy, transport and material systems.), Öko-Institut e.V. on behalf of the Hessian Ministry of the Environment, Agriculture and Forestry (Ministerium für Umwelt, Landwirtschaft und Forsten), Darmstadt/Berlin 2000

FRITSCHE et al. (2004): Stoffstromanalyse zur nachhaltigen energetischen Nutzung von Biomasse (Materiel flow analysis for the sustainable energetic use of biomass), Öko-Institut e.V on behalf of the Federal German Ministry of the Environment and Nuclear Plant Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit), Darmstadt 2004

FRITSCHE/RAUSCH (2003): Anwendung und Kommunikation des kumulierten Energieaufwands als praktikabler Entscheidungsindikator für nachhaltige Produkte und Dienstleistungen hinsichtlich Reduzierung des Ressourcen- und Energieverbrauchs (KEA II) (Application and communication of the cumulated energy demand as a practical decision indicator for sustainable products and services regarding the reduction of resources and energy consumption), Öko-Institut e.V. on behalf of the German Federal Ministry of the Environment, Darmstadt 2003

FRISCHKNECHT R., R. STEINER, N. JUNGBLUTH (2006): Methode der ökologischen Knappheit Ökofaktoren 2006 (Method of ecological scarcity eco-factors 2006), BAFU and ÖBU, 2006

GOEDKOOP M.J und SPRIENSMA, R.S (1999): The Eco-indicator 99, Methodology report, A damage oriented LCIA Method; VROM Report -------, Den Haag, 1999, eco-indicator 99 method

GUINÉE J. B., GORRÉE M., HEIJUNGS R., HUPPES G., KLEIJN R., DE KONING A., VAN OERS L., WEGENER SLEESWIJK A., SUH S., UDO DE HAES H. A., DE BRUIJN H., VAN DUIN R., HUIJBREGTS M. A. J., LINDEIJER E., ROORDA A. A. H. & WEIDEMA B. P., (2001): Life cycle assessment - An operational guide to the ISO standards. Ministry of Housing, Spatial Planning and Environment (VROM) and Centre of Environmental Science (CML), Den Haag and Leiden, Netherlands

HACKEL (2004): Innovatives Mehrwegsystem im Kino (Innovative reusable system for cinemas), selected in the course of the “waste avoidance in Vienna” initiative (Abfallvermeidung in Wien), Vienna 2004

HAUER (1993): Wiener Filmfestival 1993: Einsatz von Mehrweggeschirr, Auswirkungen und Akzeptanz (Vienna Film Festival 1993: Use of reusable crockery – effects and acceptance), Vienna, August 1993

HAUSCHILD M &. WENZEL H. (1998): Environmental Assessment of Products: Scientific background., Chapman&Hall, London, 565 p.

HOCKING (1994): Summary of ”Reusable and Disposable Cups: An Energy-Based Evaluation”; Environmental Management 18(6), 1994, pp.889-899, 1994

IPCC, 2001. Climate Change 2001: The Scientific Basis. In: Houghton, J. T. et al. (eds.), Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). IPCC, Intergovernmental Panel on Climate Change, Cambridge University Press, The Edinburgh, Building Shaftesbury Road, Cambridge, UK

JOLLIET OLIVIER, et al., Impact 2002+ : A new life cycle impact assessment methodology, J. of LCA 8 (6) 324 – 330 (2003)

MATHIES (2007): Public Viewing während der Fußball-Weltmeisterschaften 2006 in Deutschland bei der Enquete „EURO 2008 Public Viewing - Das ganze Land wird Stadion“ (“Public Viewing during the Football World Cup 2006 in Germany” on the occasion of the meeting “EURO 2008 Public Viewing – The whole Country becomes a Stadium”), by Jürgen Mathies, Director of the North-Rhine Westfalia County Authority for Central Police Services (Landesamt für Zentrale Polizeiliche Dienste), 28th August 2007, Modul Hotel, Peter-Jordan-Strasse 78, 1190 Vienna

ÖKO-INSTITUT (2007): Methodenentwicklung für die ökologische Bewertung der Entsorgung gefährlicher Abfälle unter und über Tage und Anwendung auf ausgewählte Abfälle (Development of methods for the ecological assessment of the disposal of hazardous waste (incl. landfill and underground disposal) and application to selected waste types), BMBF research project, Darmstadt 2007

OBERSTEINER and SCHNEIDER (2006): Analyse des Tests von Bechern aus nachwachsenden Rohstoffen im Tiergarten Schönbrunn (Analysis of the test of cups made from renewable raw materials in the Schönbrunn zoo), Vienna, August 2006

PIRINGER T., FISCHER T.: Kreislaufwirtschaft mit Produkten aus nachwachsenden Rohstoffen. Voraussetzungen und Strategien. (Loop management with products made from renewable raw materials – conditions and strategies), on behalf of the Austrian Federal Ministry of Transport, Innovation and Technology (Bundesministerium für Verkehr, Innovation und Technologie) [publisher], Berichte aus Energie- und Umweltforschung (reports from energy and environment research) 14/2003, Vienna 2003

ROSENTHAL (2006): WM-Nachlese: Wie ist es gelaufen? Welche Erkenntnisse gibt es für zukünftige Großveranstaltungen! (World Cup review: How was it? Which insights can be gained for future major events?) 29th-30th August 2006, Frankfurt/M.

SCHNEIDER (2005): WieNaWARO - Beschreibung und praxisgerechte Planung von Umsetzungsprojekten zum Einsatz von Werkstoffen aus nachwachsenden Rohstoffen (Description and practical planning of implementation projects for the use of materials made from renewable raw materials), April 2005

SCHWAGER (2006): Energie aus Abfall – Beitrag zum Klimaschutz, Situation in der Schweiz (Energie gained from waste – contribution to climate protection; the situation in Switzerland), workshop by the German Federal Ministry of the Environment (Umweltbundesamt), Berlin, November 2006

STAHL (2007): Green Goal – Das Umweltkonzept zur FIFA WM 2006 (Green Goal – The environmental concept for the FIFA World Cup 2006), Legacy Report, publisher: Horst R. Schmidt, Organisational Committee of the FIFA Football World Cup 2006, Frankfurt/Main, and Gertrud Sahler from the German Federal Ministry of the Environment and Nuclear Plant Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU), Berlin; authors from the Öko-Institut: Dr. Hartmut Stahl, Christian Hochfeld, Martin Schmied, Ralph O. Harthan, Martin Cames, Regine Barth, Dr. Matthias Buchert, Veit Bürger, Günter Dehoust, Jan Ferenz, Kirsten Havers, Marion Schäfer, Beate Schmitt, Angelika SpiethAchtnich, Christof Timpe, Jutta Ungemach, Kristina Vesper

UBA 1999: Bewertung in Ökobilanzen – Methode des Umweltbundesamtes zur Normierung von Wirkungsindikatoren, Ordnung (Rangbildung) von Wirkungskategorien und zur Auswertung nach ISO 14042 und 14043 (Assessments in LCAs – method of the German Federal Ministry of the Environment for the standardisation of effects indicators, (hierarchical) structuring of effects categories and evaluation acc. to ISO 14042 and 14043), version 99, Berlin 1999

UBA (2006a): Schwermetalleinträge der Flussgebiete Deutschlands (Heavy

metals input into German rivers),

http://www.umweltbundesamt.de/wasser/themen/ow s5 3.htm, August 2006

UBA (2006b): http://www.umweltbundesamt.de/uba-info-daten/daten/tba.htm

VERCALSTEREN and SPIRINCKX (2006a): Life Cycle Assessment of 4 types of drinking cups used on events, Flemish Institute for Technological Research (VITO), Integral Environmental Studies and Public Waste Agency for the Flemish Region (OVAM), Belgium, February 2006

VERCALSTEREN and SPIRINCKX (2006b): Eco-Efficiency Analysis of 4 types of drinking cups used on events, Flemish Institute for Technological Research (VITO), Integral Environmental Studies and Public Waste Agency for the Flemish Region (OVAM), Belgium, February 2006

VINK (2002): Applications of life cycle assessment to NatureWorks™ polylactide (PLA) production, November 2002

VINK (2003): The Sustainability of NatureWorks™ Polylactide Polymers and Ingeo™ Polylactide Fibersa: an Update of the Future Initiated by the 1st International Conference on Bio-based Polymers (ICBP 2003), November 12–14 2003, Saitama, Japan 2003

VINK (2007a): Executive Summary of the Comparative LCA of 4 types of drinking cups used at events; Eco-efficiency analysis of 4 types of drinking cups used at events January 2007

VINK (2007b): Comparative LCA of Four Types of Drinking Cups used at event venues, OVAM, Mechelen, Belgium, January 2007

VINK (2007c): Benchmarking NatureWorks® Polylactide Polymers with traditional polymers using Gross Energy Use and Climate Change as indicators, 2007

WOLF (2005): Entwurf eines Abfallvermeidungskonzeptes für die FIFA WM 2006 in Leipzig (Design of a waste avoidance concept for the FIFA World Cup 2006 in Leipzig), dissertation at Merseburg university, Merseburg, September 2005

## 12.2 Abbreviations and glossary

**BELLAND® material:** Chemically speaking, BELLAND® material is based on a co-polymer made from styrene and acrylate monomers. Its application characteristics are comparable with those of polystyrene.

**Closed-loop recycling:** A type of reuse with the renewed use of materials/substances and products in the same production process incorporating shape dissolution and alteration (e.g. used glass for glass production, metal for metal production).

**EDIP**: Environmental Assessment of Products: Scientific background. Chapman&Hall, London, 565 p., Hauschild M &. Wenzel H., 1998

**Eutrophication or excessive use of fertilisers:** Alteration of the nutrients balance in soil and water. The method is EDIP.

**Disposable:** Disposable products.

**Usage of land:** Effects on the biodiversity due to usage of large areas of land and their alterations. The calculation is made on the basis of the eco-indicator 99 method (GOEDKOOP, 1999).

**Usage cycles:** The total number of uses of a reusable cup over its entire life cycle. It corresponds to the system analysis of the LCA. The usage cycles contain both the use at events and domestic use.

**GWP:** Gobal Warming Potential: The influence on the climate and contribution to the warming of the climate because of gases such as $CO_2$, methane and nitrous oxide acc. to IPCC 2001.

**Domestic use:** Reusable drinking cups may be taken home by the user. In this case, the user waives his deposit and he/she may use the cup for another purpose. This means that reusable drinking cups can replace other drinking cups (both reusable and disposable ones) but also other objects such as souvenirs.

**CED:** Cumulative Energy Demand: The consumption of non-renewable resources such as fossil oil or natural gas.

**WIP:** Waste Incineration Plant

**Reusable:** Reusable cups.

**Ecotoxicity:** The effects on animals and plants due to the emission of certain substances. The method is EDIP.

**Open-loop recycling:** A type of reuse with the use of materials/substances and products for new production processes and their conversion into other new materials/products (e.g. cardboard from used paper, liquid fuel from plastic waste by means of pyrolysis).

**Ozone Formation Potential:** A contribution to the formation of ozone (summer smog) due to the

emission of substances such as organic solvents and nitric oxides ($NO_x$). The method is EDIP. Hauschild/ Wenzel, 1998.

**PET:** Polyethyleneterephthalate (polyester)

**PLA:** Polylactic acid: A biodegradable material based on starch. Today, this material is produced from maize and can be processed using conventional procedures for plastic processing.

**PP:** Polypropylene

**PS:** Polystyrene

**Acid Formation Potential:** A contribution to the acidification of the soil and water, for example due to nitric oxides and sulphur dioxide. The method is EDIP.

**Circulation cycles/system cycles:** The number of uses of a reusable cup within a certain system, for example the reusable system of a caterer in a stadium.

**Toxicity for people (human toxicity):** Effects on human health. The method is CML. 2001.

**EBP:** Environmental Burden Points

**World Cup:** The FIFA Football World Cup.

## 12.3 List of tables

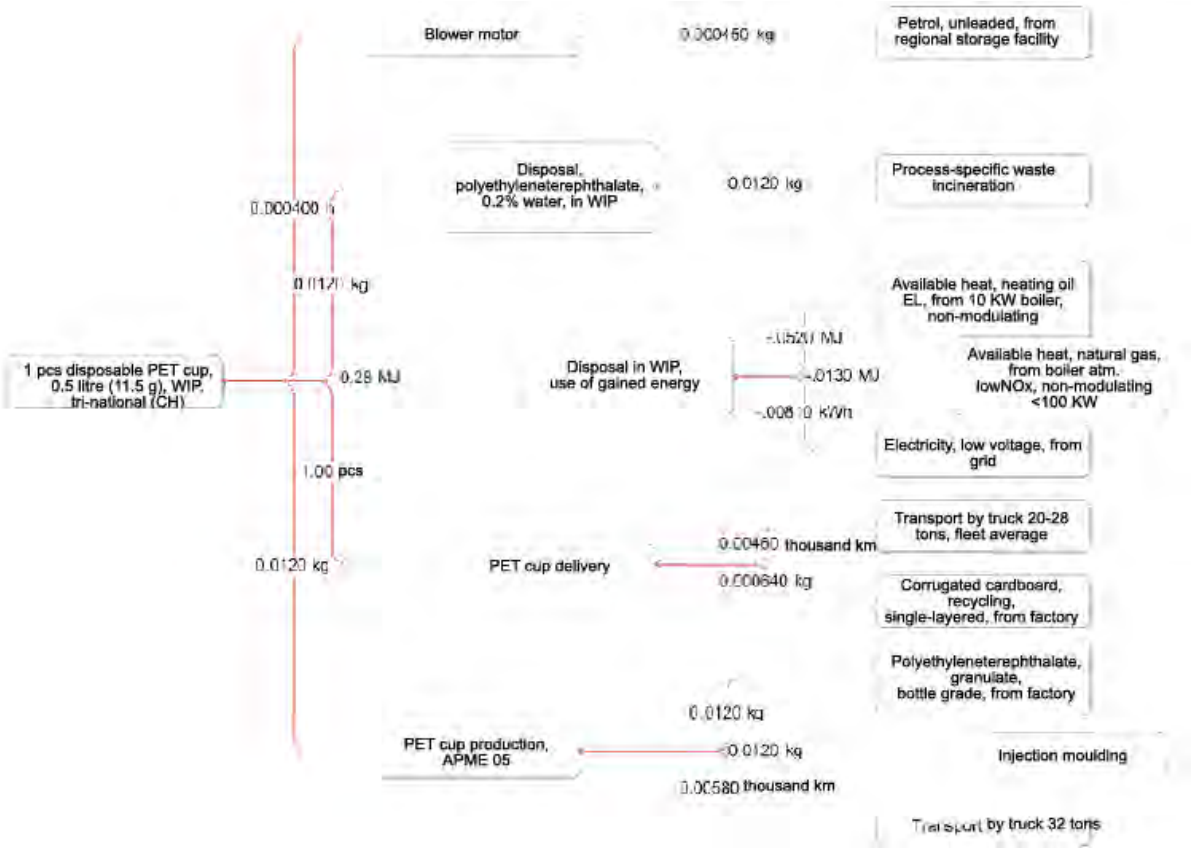
## 12.4 List of figures

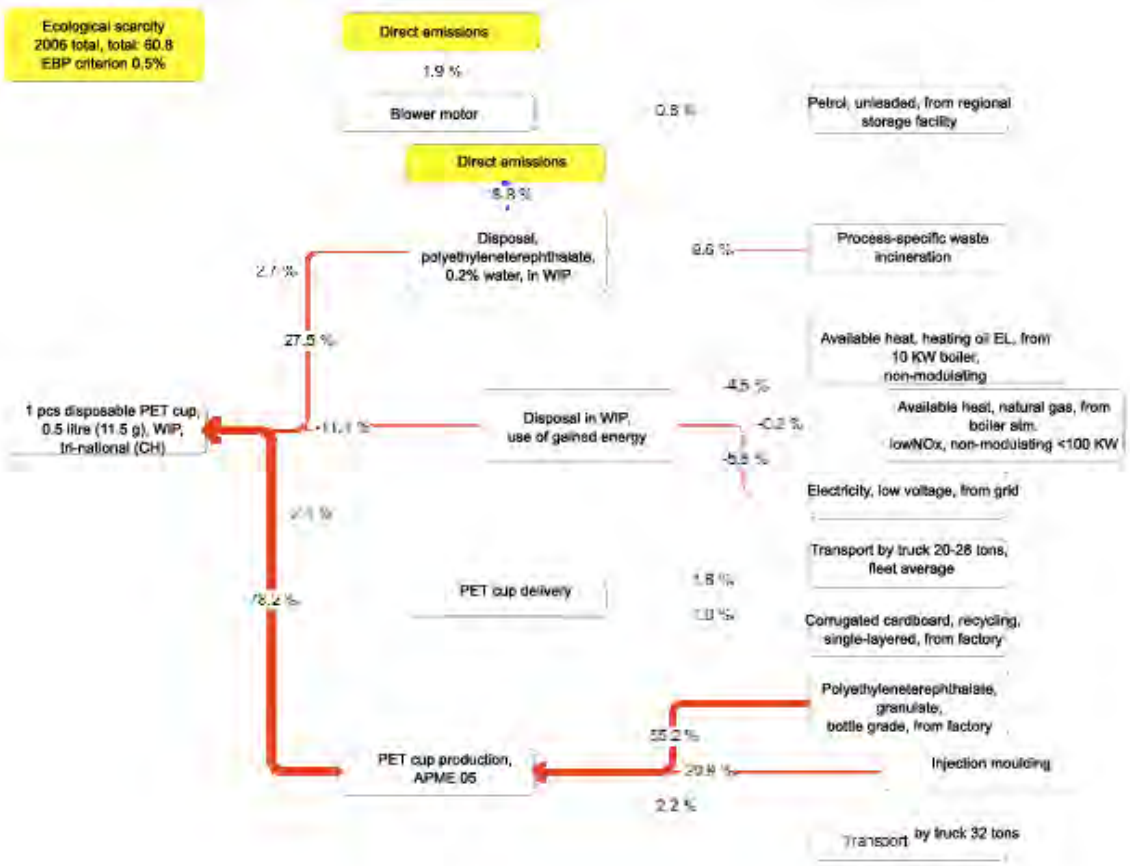
## 12.5 Flow charts of the examined scenarios

The most important scenarios have two flow charts each. First, the essential mass flows and energy flows including details regarding time and distance are shown, followed by the percentage share in the EBP.

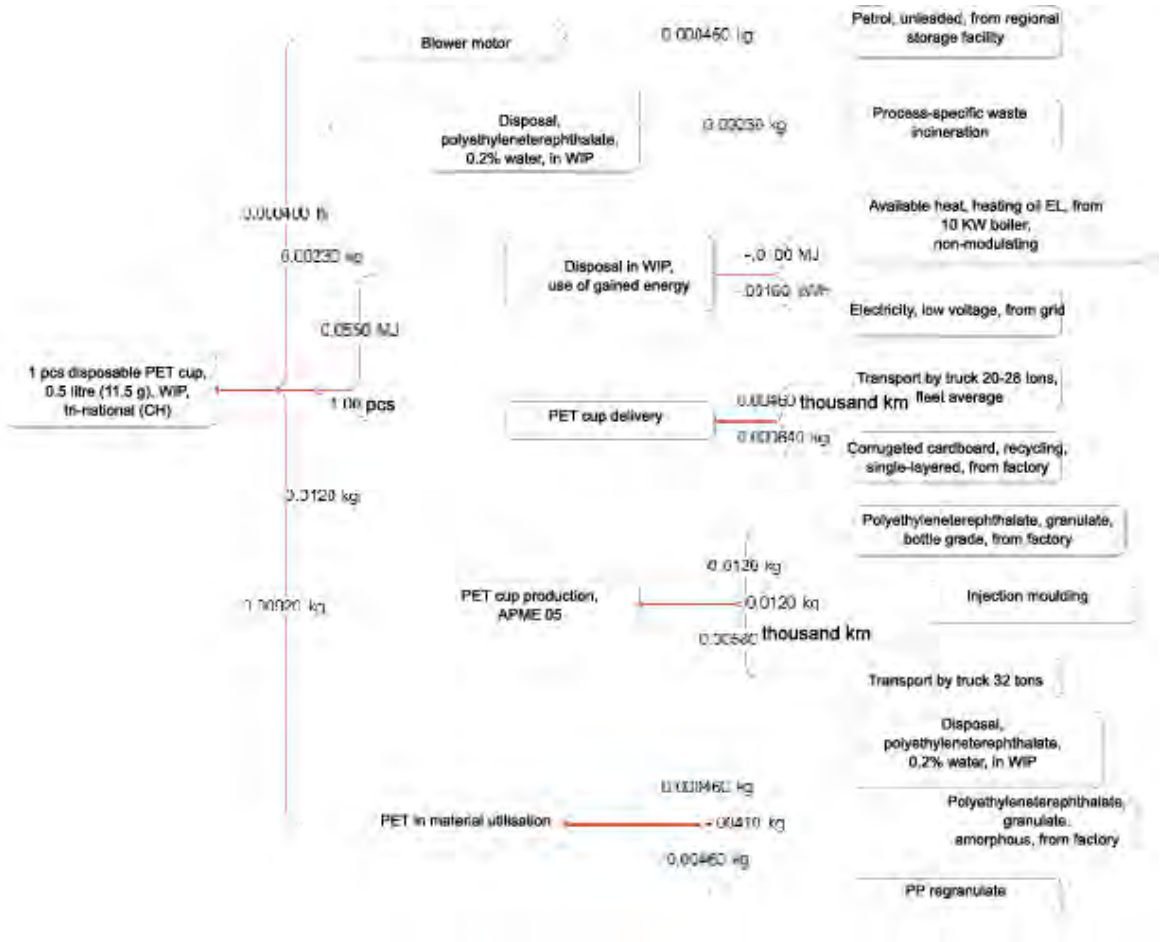
### 12.5.1 Disposable scenarios

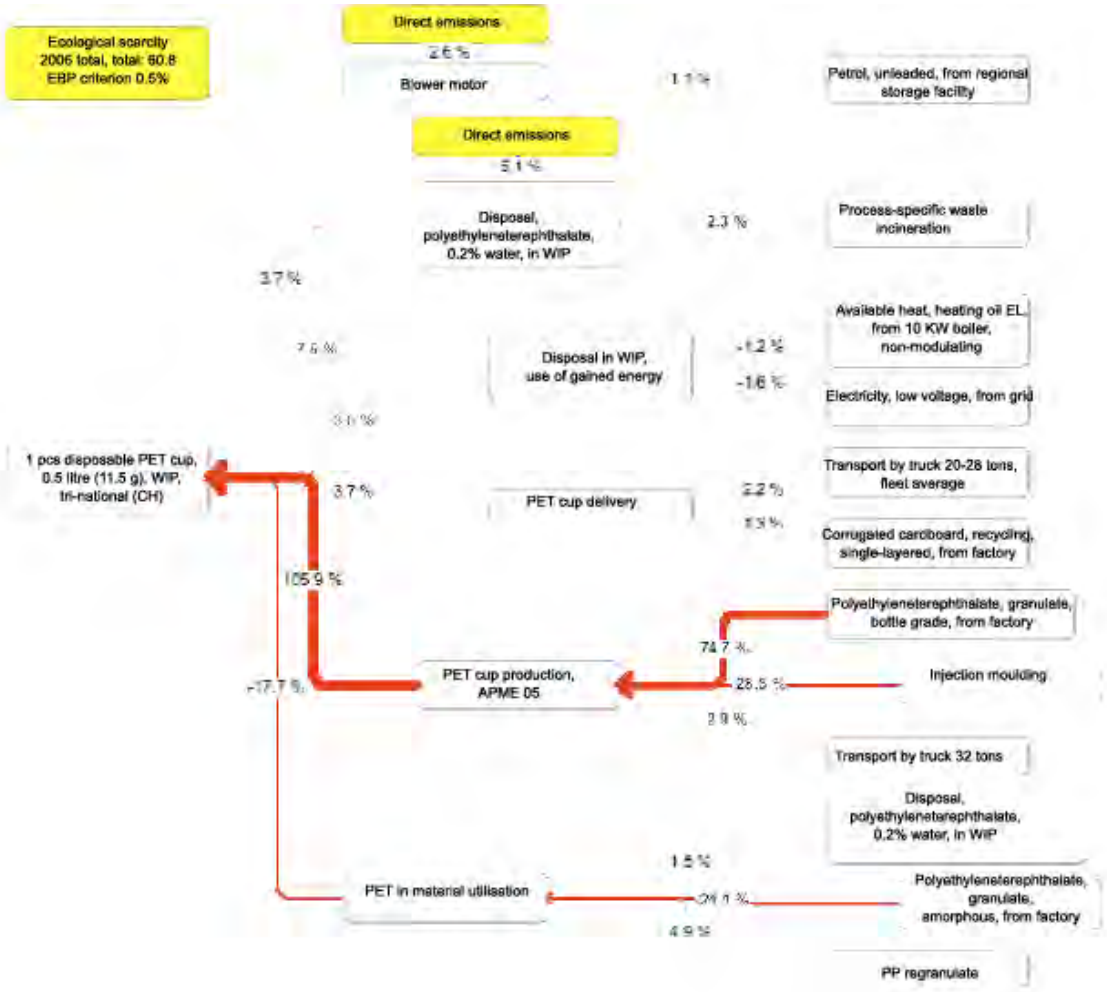
#### 12.5.1.1 PET cups in WIP



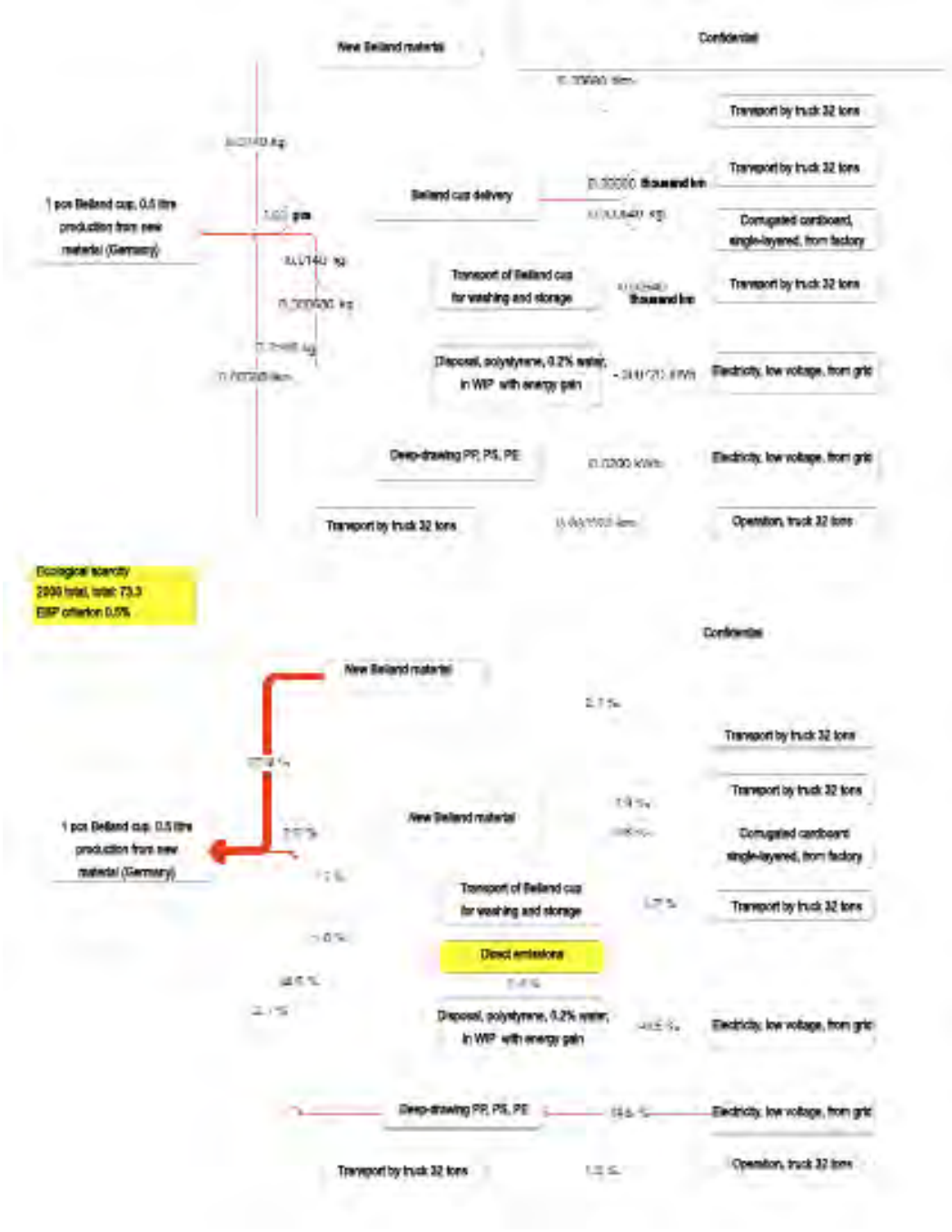

Ecological scarcity 2006 total, total: 60.8 EBP criterion 0.5%
Direct emissions
1.9 %
Blower motor
0.8 %
Petrol, unleaded, from regional storage facility
Direct emissions
6.8 %
Disposal, polyethyleneterephthalate, 0.2% water, in WIP
9.6 %
Process-specific waste incineration
2.7 %
27.5 %
Available heat, heating oil EL, from 10 KW boiler, non-modulating
45 %
1 pcs disposable PET cup, 0.5 litre (11.5 g), WIP, tri-national (CH)
11.1 %
Disposal in WIP, use of gained energy
0.2 %
Available heat, natural gas, from boiler stm. lowNOx, non-modulating <100 KW
5.5 %
Electricity, low voltage, from grid
2.1 %
Transport by truck 20-28 tons, fleet average
78.2 %
PET cup delivery
1.8 %
1.0 %
Corrugated cardboard, recycling, single-layered, from factory
Polyethyleneterephthalate, granulate, bottle grade, from factory
55.2 %
PET cup production, APME 05
29.8 %
Injection moulding
2.2 %
Transport by truck 32 tons

### 12.5.1.2 PET cups with material utilisation

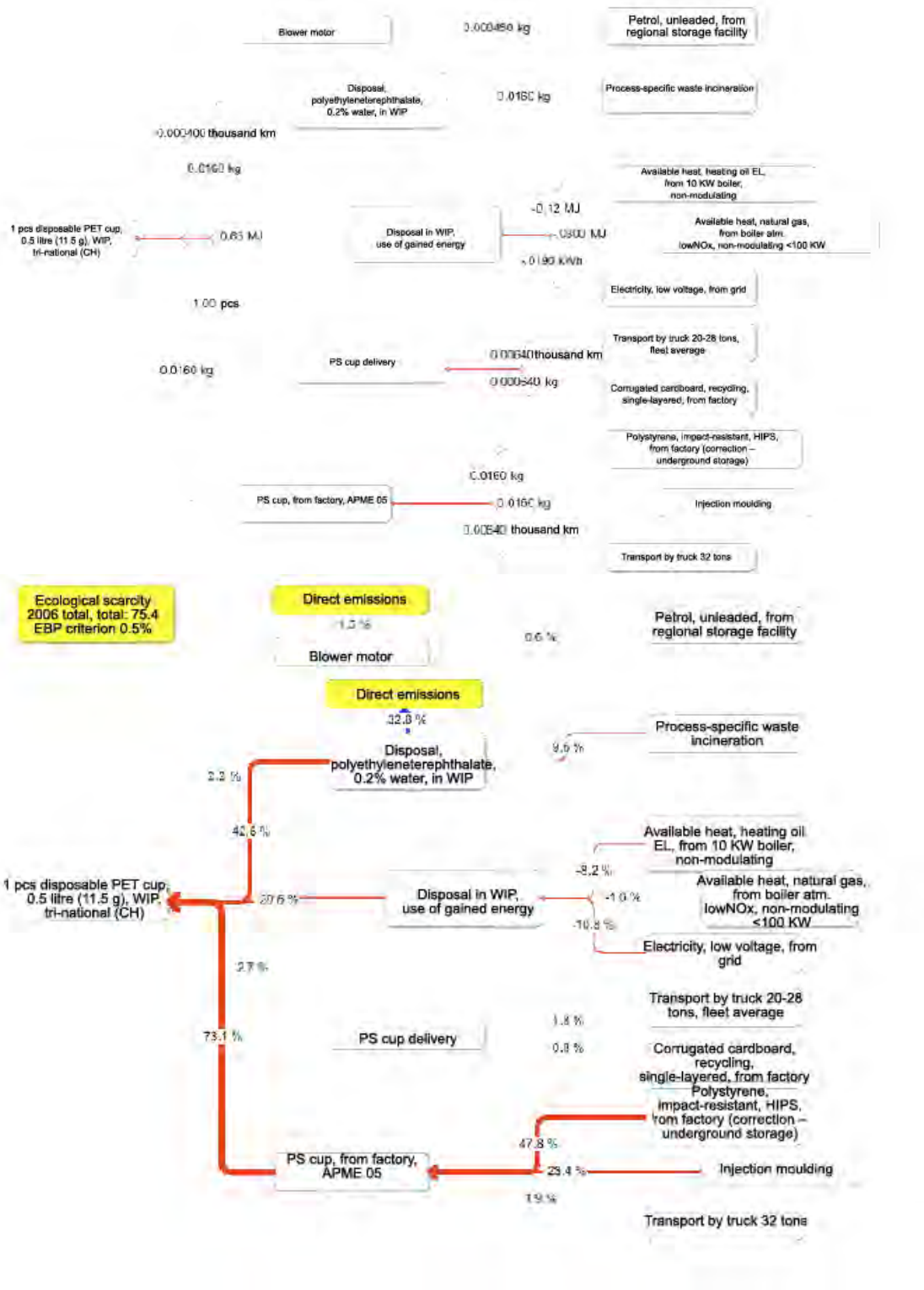



Ecological scarcity 2006 total, total: 60.8 EBP criterion 0.5%
Direct emissions
2.6 %
Blower motor
1.1 %
Petrol, unleaded, from regional storage facility
Direct emissions
5.1 %
Disposal, polyethyleneterephthalate, 0.2% water, in WIP
2.3 %
Process-specific waste incineration
3.7 %
7.5 %
Disposal in WIP, use of gained energy
-1.2 %
-1.6 %
Available heat, heating oil EL, from 10 KW boiler, non-modulating
Electricity, low voltage, from grid
1 pcs disposable PET cup, 0.5 litre (11.5 g), WIP, tri-national (CH)
3.7 %
PET cup delivery
2.2 %
1.5 %
Transport by truck 20-28 tons, fleet average
Corrugated cardboard, recycling, single-layered, from factory
105.9 %
Polyethyleneterephthalate, granulate, bottle grade, from factory
74.7 %
-17.7 %
PET cup production, APME 05
28.5 %
Injection moulding
2.9 %
Transport by truck 32 tons
Disposal, polyethyleneterephthalate, 0.2% water, in WIP
1.5 %
PET in material utilisation
-24.1 %
Polyethyleneterephthalate, granulate, amorphous, from factory
4.9 %
PP regranulate

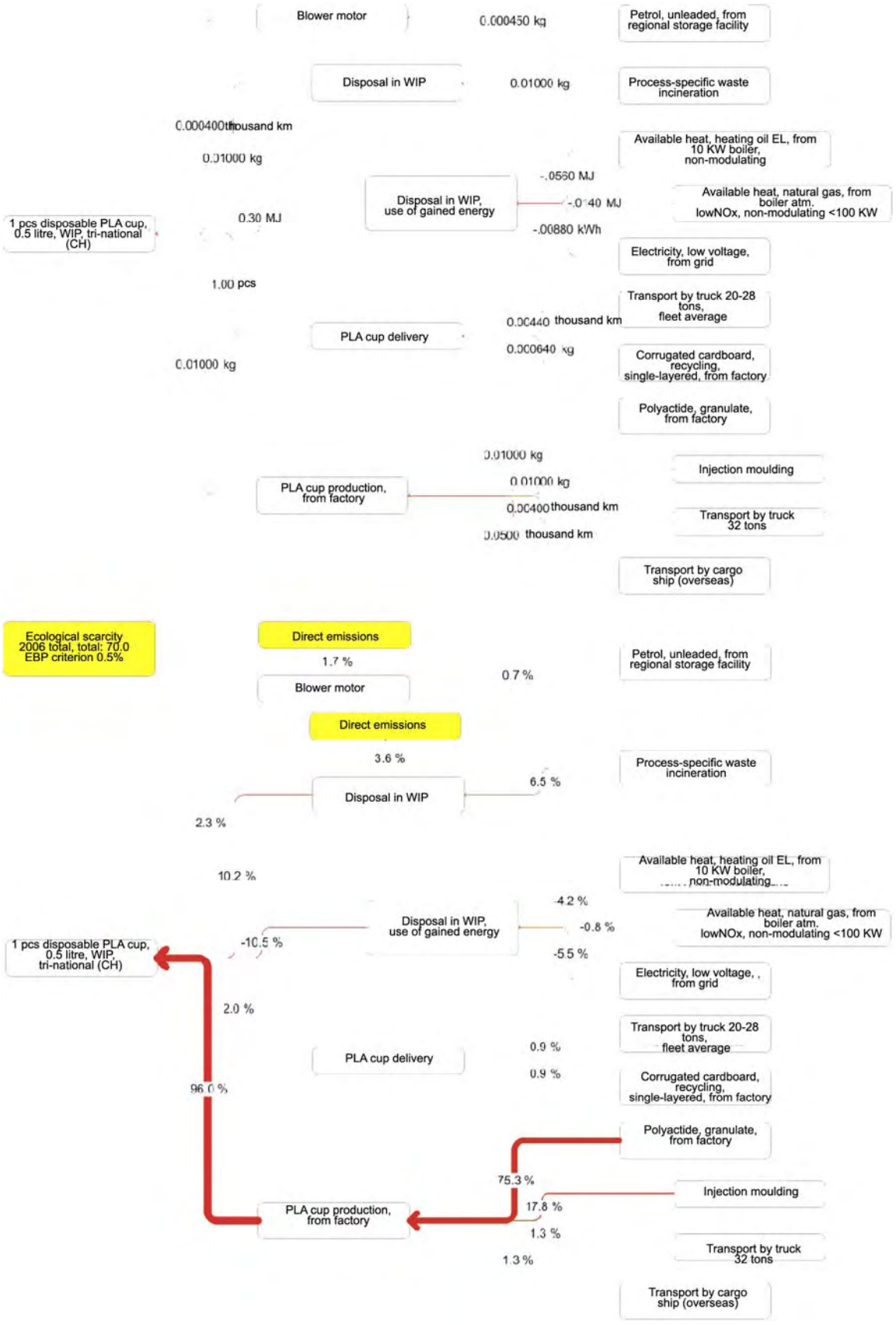
### 12.5.1.3 BELLAND® material cups with a 0% reuse



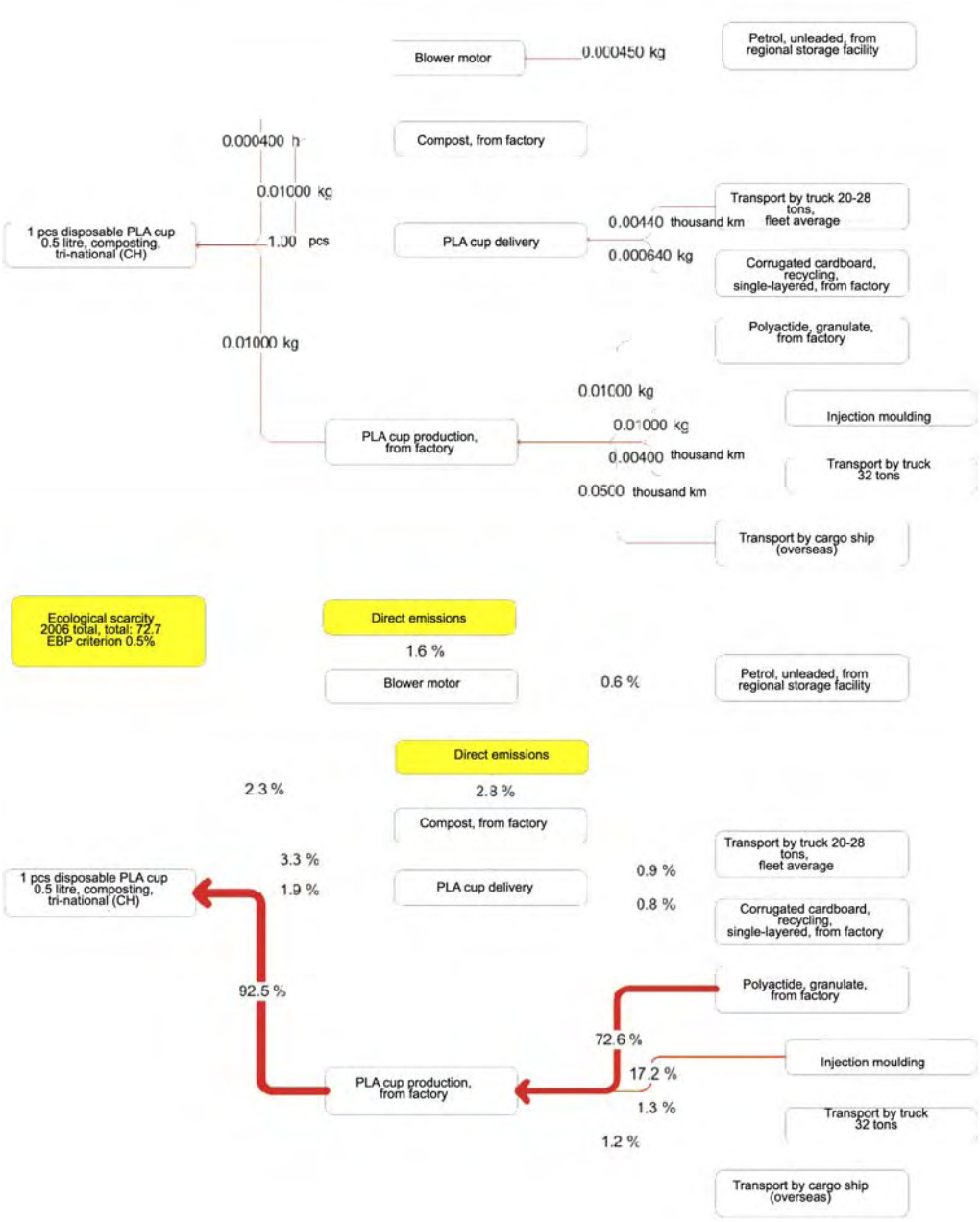
### 12.5.1.4 PS cups



### 12.5.1.5 PLA cups in WIP

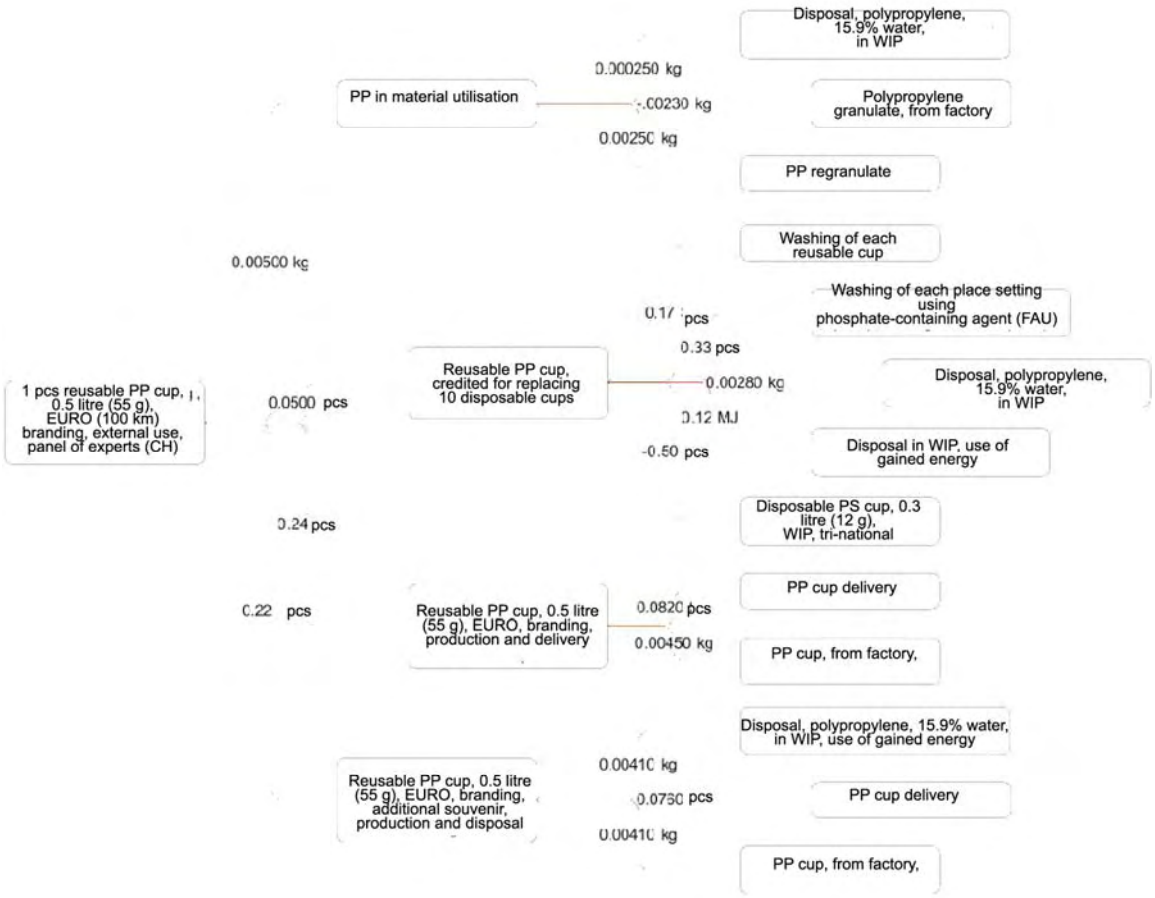


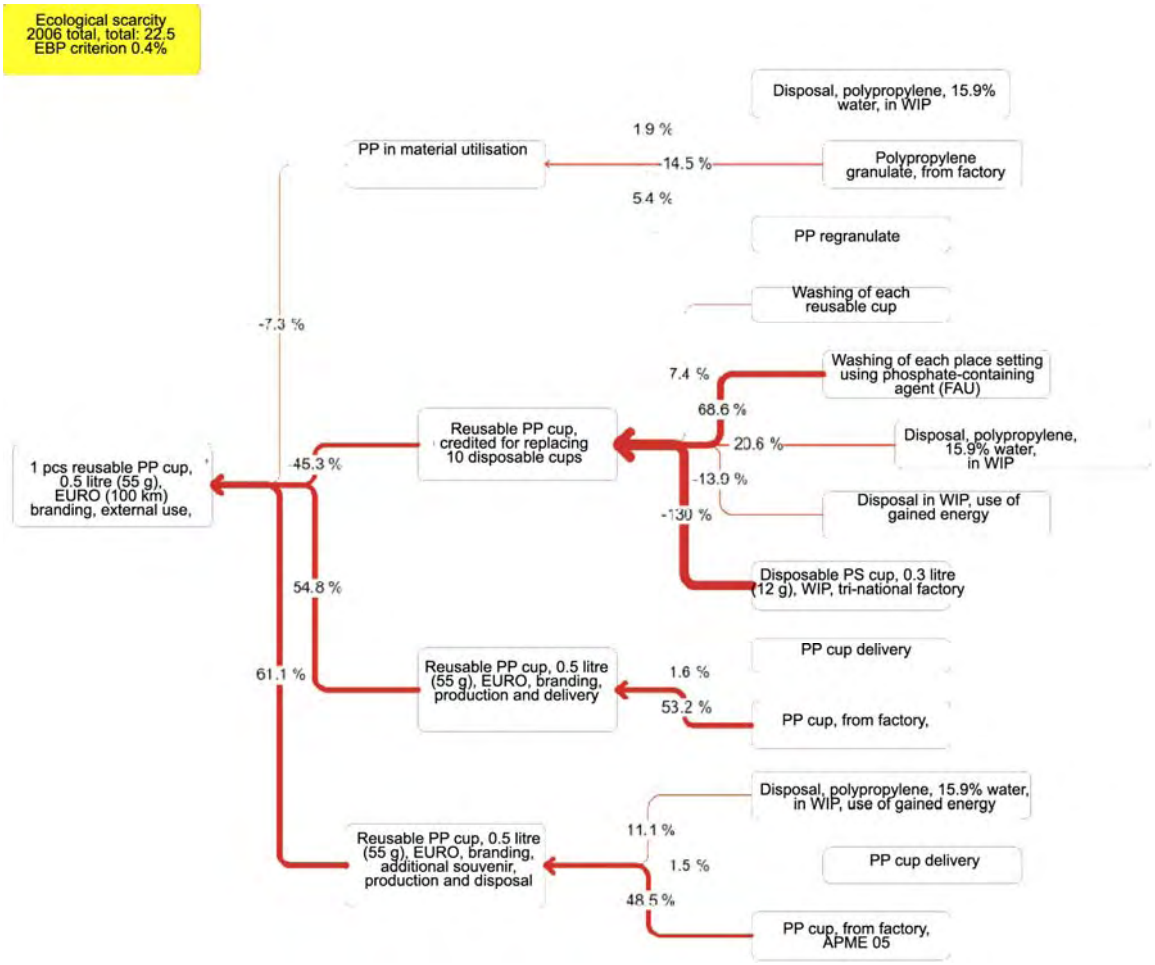
### 12.5.1.6 PLA cups in composting



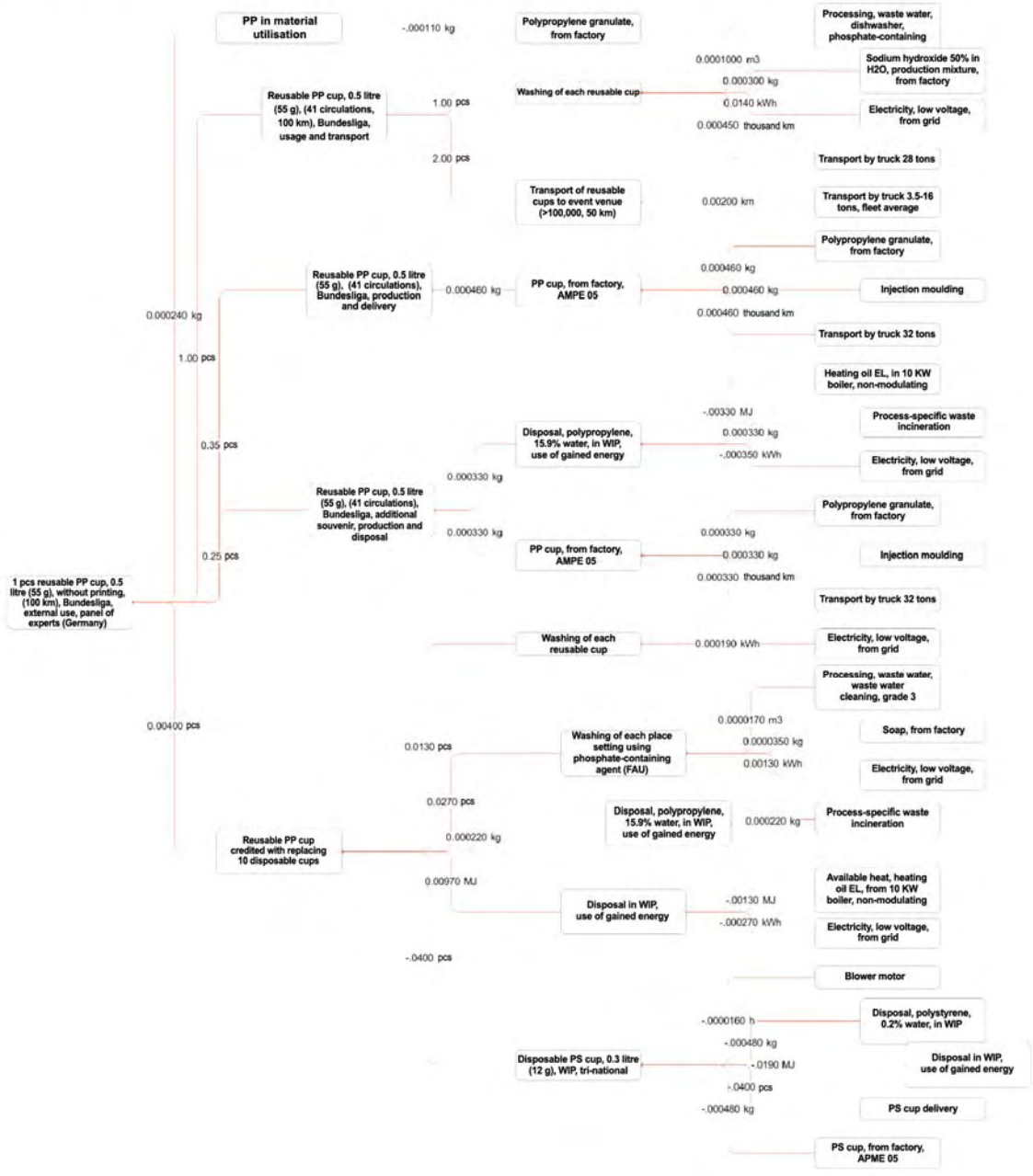
## 12.5.2 Reusable cup scenarios

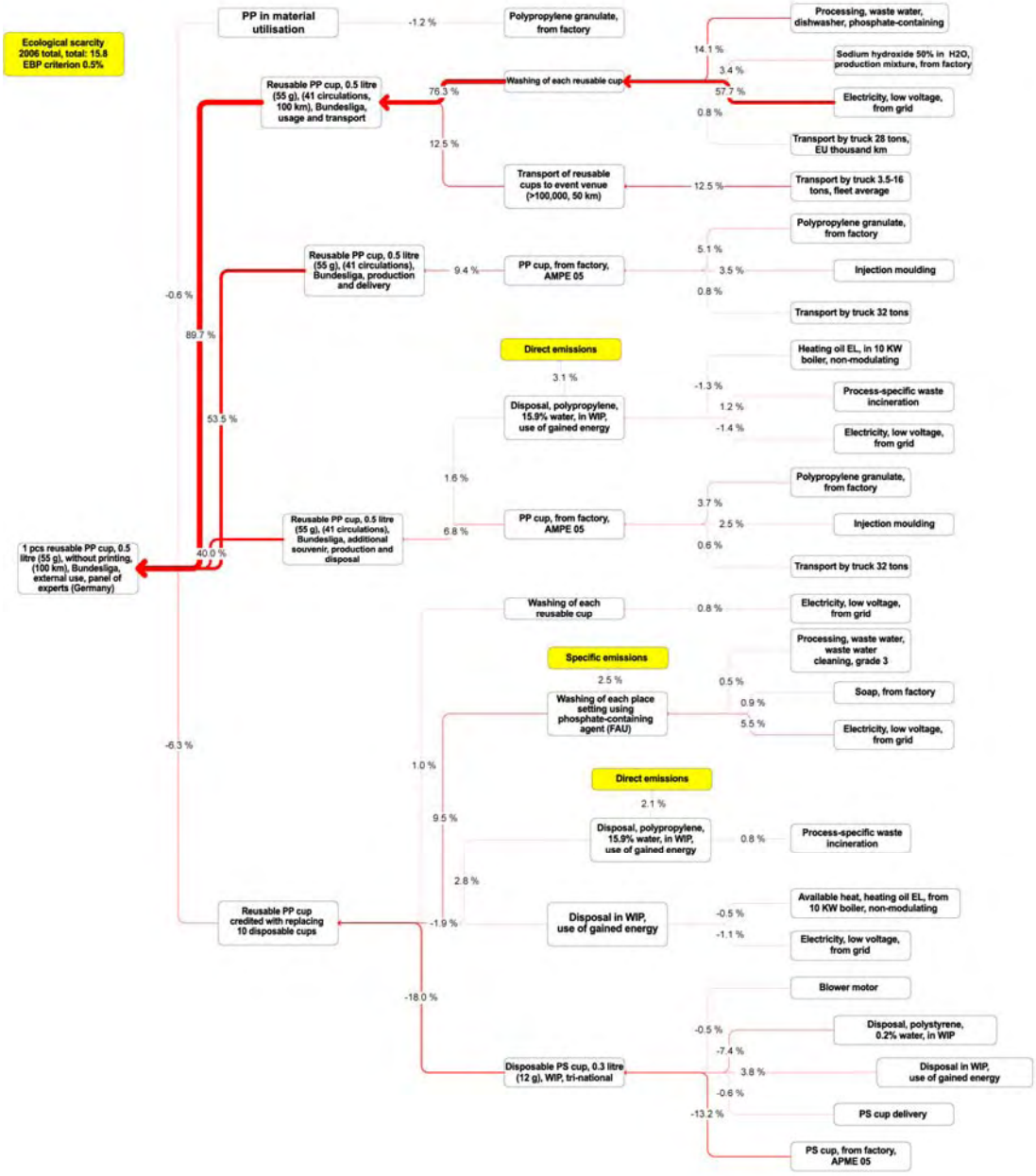
### 12.5.2.1 Reusable EURO cups with branding, panel of experts



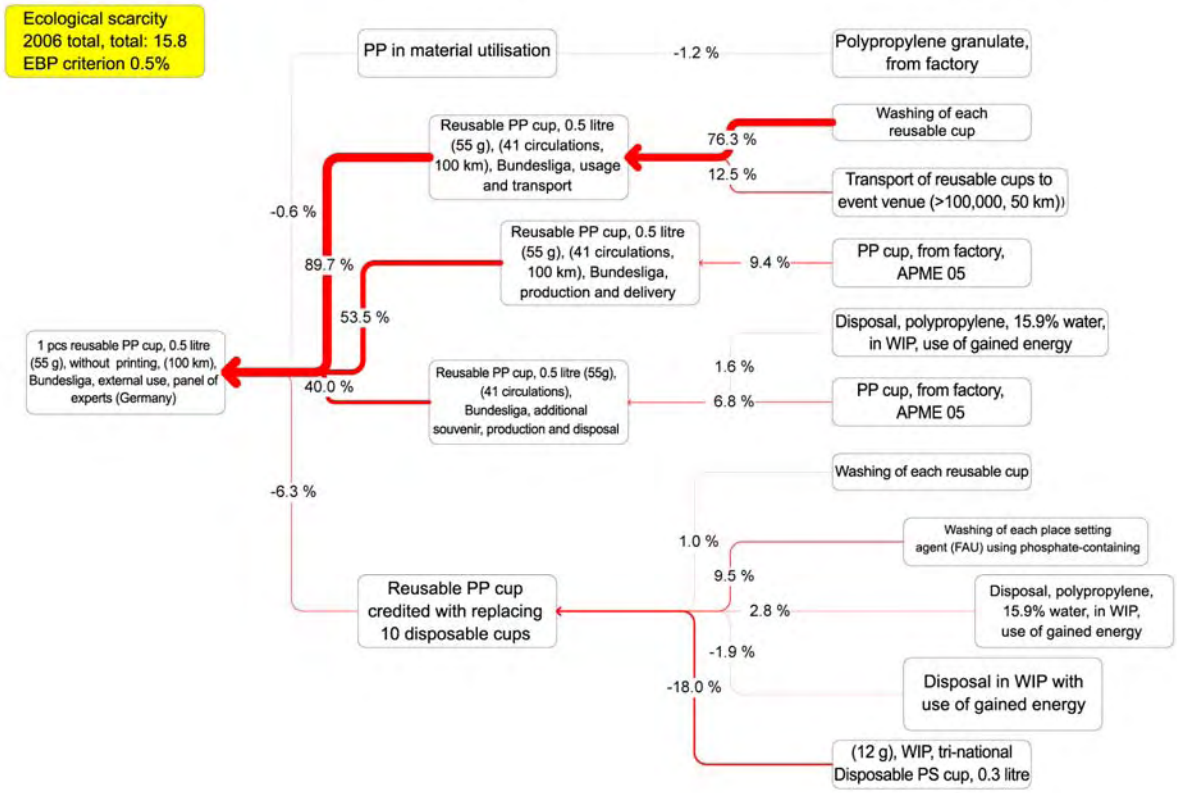

Ecological scarcity 2006 total, total: 22.5 EBP criterion 0.4%
1 pcs reusable PP cup, 0.5 litre (55 g), EURO (100 km) branding, external use,
45.3 %
-7.3 %
54.8 %
61.1 %
Reusable PP cup, credited for replacing 10 disposable cups
Reusable PP cup, 0.5 litre (55 g), EURO, branding, production and delivery
Reusable PP cup, 0.5 litre (55 g), EURO, branding, additional souvenir, production and disposal
PP in material utilisation
1.9 %
14.5 %
5.4 %
Disposal, polypropylene, 15.9% water, in WIP
Polypropylene granulate, from factory
PP regranulate
Washing of each reusable cup
7.4 %
68.6 %
20.6 %
13.9 %
13.0 %
Washing of each place setting using phosphate-containing agent (FAU)
Disposal, polypropylene, 15.9% water, in WIP
Disposal in WIP, use of gained energy
Disposable PS cup, 0.3 litre (12 g), WIP, tri-national factory
1.6 %
53.2 %
PP cup delivery
PP cup, from factory,
11.1 %
1.5 %
48.5 %
Disposal, polypropylene, 15.9% water, in WIP, use of gained energy
PP cup delivery
PP cup, from factory, APME 05

# 12.5.2.2 Reusable cups, Bundesliga operations, without printing, panel of experts

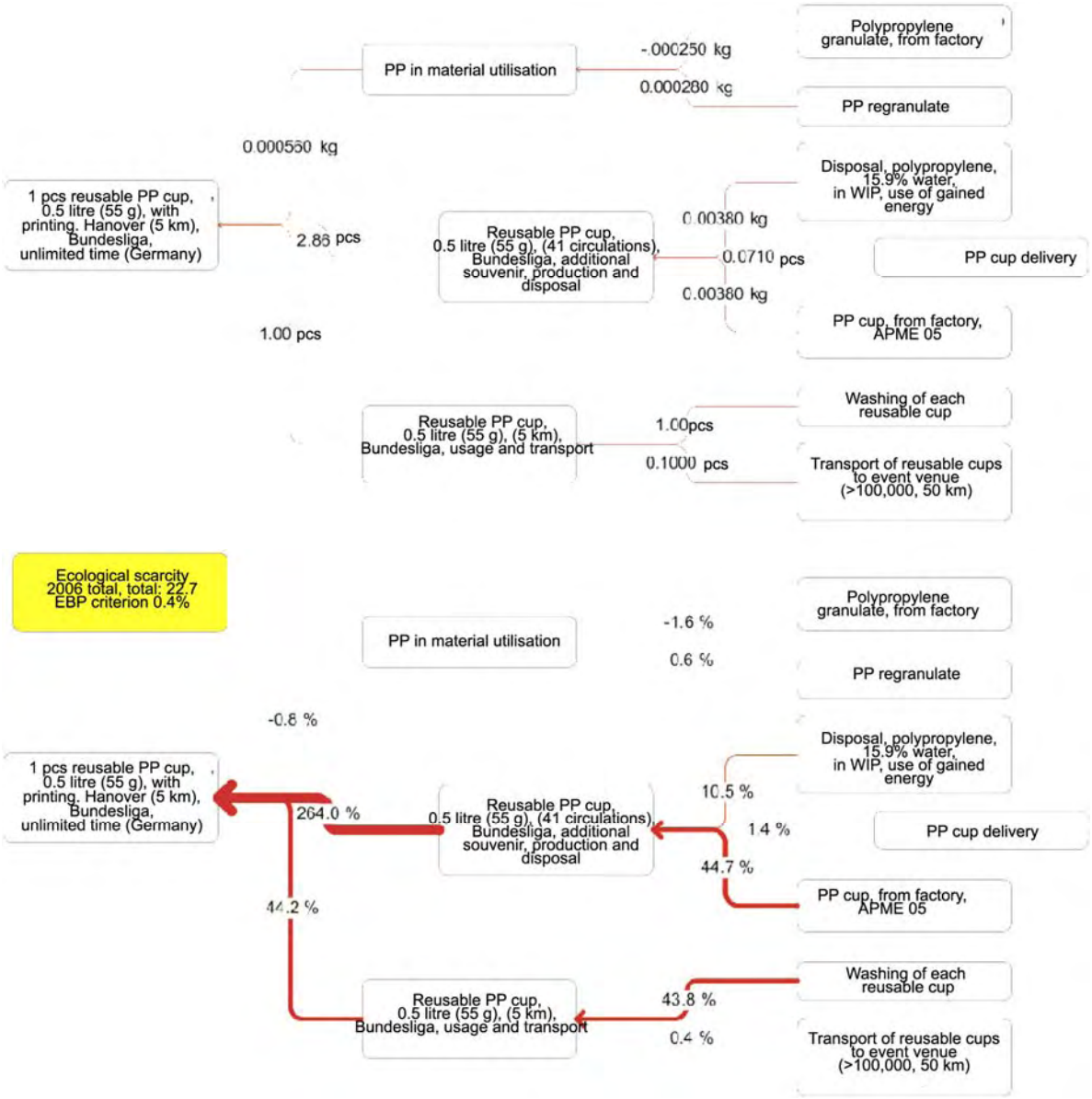



Ecological scarcity 2006 total, total: 15.8 EBP criterion 0.5%
1 pcs reusable PP cup, 0.5 litre (55 g), without printing, (100 km), Bundesliga, external use, panel of experts (Germany)
40.0 %
-6.3 %
-0.6 %
89.7 %
53.5 %
PP in material utilisation
-1.2 %
Polypropylene granulate, from factory
Reusable PP cup, 0.5 litre (55 g), (41 circulations, 100 km), Bundesliga, usage and transport
76.3 %
Washing of each reusable cup
14.1 %
3.4 %
57.7 %
0.8 %
Processing, waste water, dishwasher, phosphate-containing
Sodium hydroxide 50% in H2O, production mixture, from factory
Electricity, low voltage, from grid
Transport by truck 28 tons, EU thousand km
12.5 %
Transport of reusable cups to event venue (>100,000, 50 km)
12.5 %
Transport by truck 3.5-16 tons, fleet average
Reusable PP cup, 0.5 litre (55 g), (41 circulations), Bundesliga, production and delivery
9.4 %
PP cup, from factory, AMPE 05
5.1 %
3.5 %
0.8 %
Polypropylene granulate, from factory
Injection moulding
Transport by truck 32 tons
Direct emissions
3.1 %
Disposal, polypropylene, 15.9% water, in WIP, use of gained energy
-1.3 %
1.2 %
-1.4 %
Heating oil EL, in 10 KW boiler, non-modulating
Process-specific waste incineration
Electricity, low voltage, from grid
1.6 %
Reusable PP cup, 0.5 litre (55 g), (41 circulations), Bundesliga, additional souvenir, production and disposal
6.8 %
PP cup, from factory, AMPE 05
3.7 %
2.5 %
0.6 %
Polypropylene granulate, from factory
Injection moulding
Transport by truck 32 tons
Washing of each reusable cup
0.8 %
Electricity, low voltage, from grid
Specific emissions
2.5 %
Washing of each place setting using phosphate-containing agent (FAU)
0.5 %
0.9 %
5.5 %
Processing, waste water, waste water cleaning, grade 3
Soap, from factory
Electricity, low voltage, from grid
1.0 %
Direct emissions
2.1 %
9.5 %
Disposal, polypropylene, 15.9% water, in WIP, use of gained energy
0.8 %
Process-specific waste incineration
2.8 %
Reusable PP cup credited with replacing 10 disposable cups
-1.9 %
Disposal in WIP, use of gained energy
-0.5 %
-1.1 %
Available heat, heating oil EL, from 10 KW boiler, non-modulating
Electricity, low voltage, from grid
-18.0 %
Blower motor
-0.5 %
-7.4 %
3.8 %
-0.6 %
-13.2 %
Disposal, polystyrene, 0.2% water, in WIP
Disposal in WIP, use of gained energy
PS cup delivery
Disposable PS cup, 0.3 litre (12 g), WIP, tri-national
PS cup, from factory, APME 05

## 12.5.2.3 Reusable cups, Bundesliga operations, without printing, panel of experts (simplified scheme of ecological scarcity)



### 12.5.2.4 Reusable cups, Hanover, 25,000 without printing, 15,000 collectors' cups



## 12.6 Further selected results charts for sensitivities of the EURO scenarios

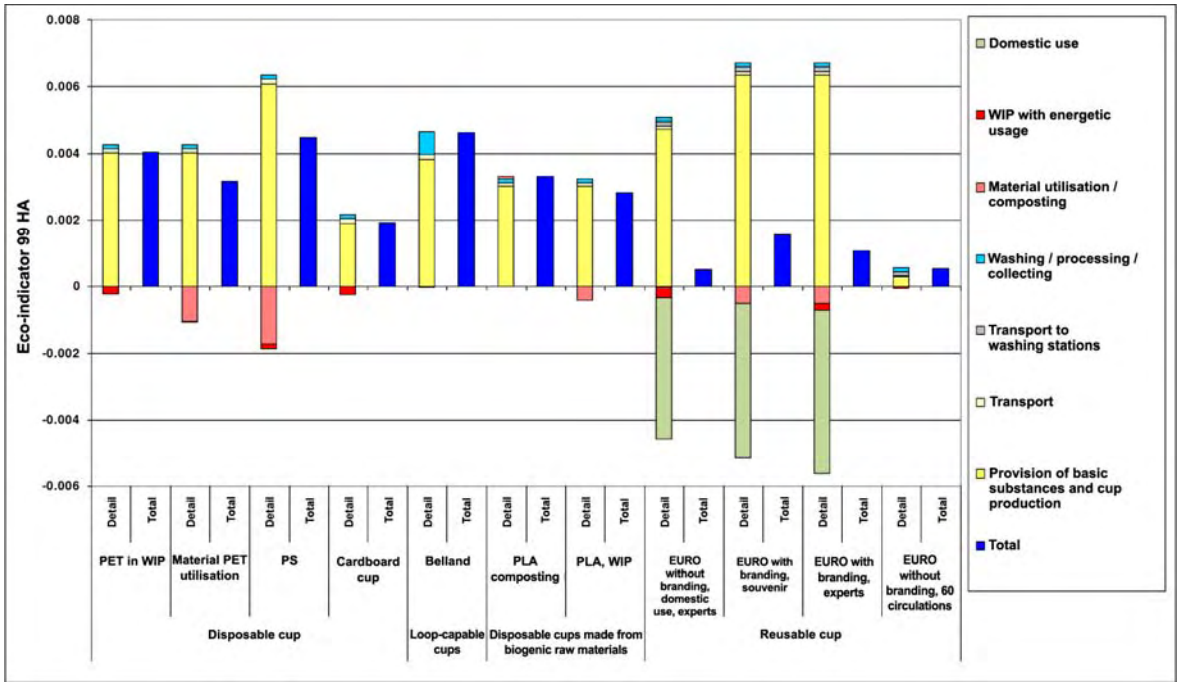



**Figure 43: Sensitivity assessment of EURO for eco-indicator 99: BELLAND® material with 50% recycled material, PLA with compensation of $CO_2$ emissions, PS with material utilisation**

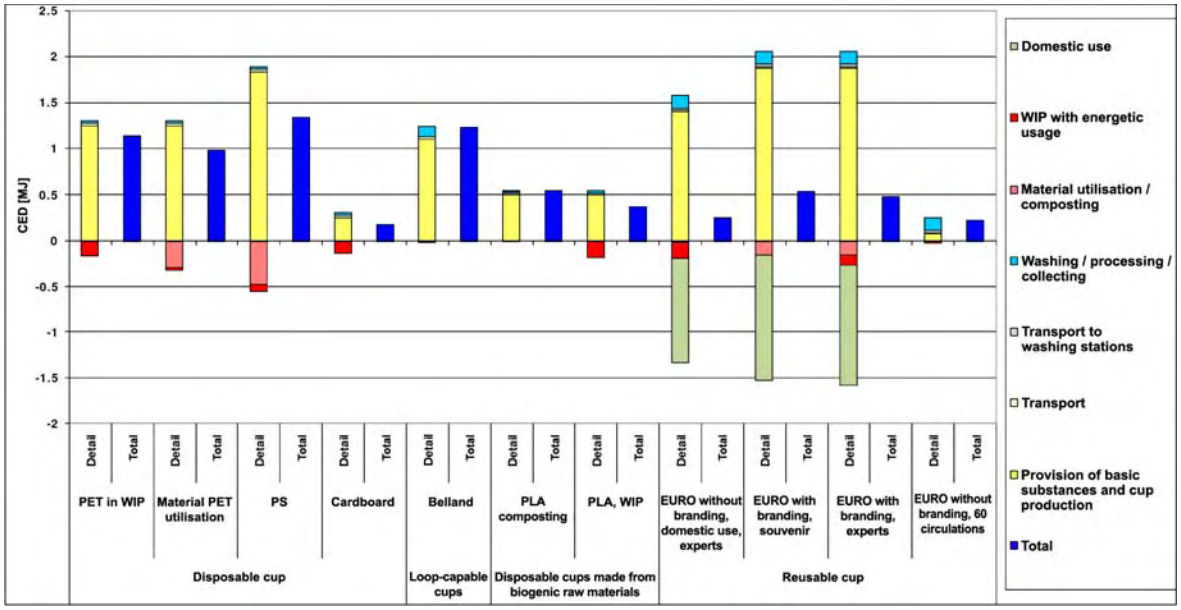



**Figure 44: Sensitivity assessments of EURO for CED: BELLAND® material with 50% recycled material, PLA with compensation of $CO_2$ emissions, PS with material utilisation**

# 12.7 Further results charts for sensitivities of the scenarios for "German Bundesliga operations and public viewing"

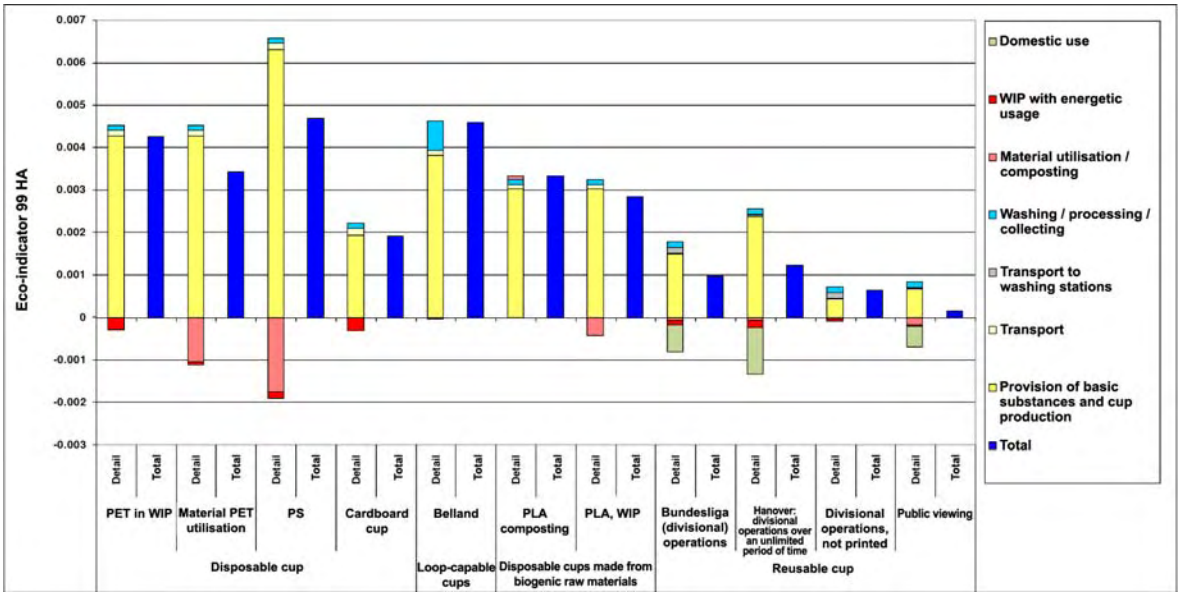



**Figure 45: Sensitivity assessments of divisional operations and public viewing for eco-indicator 99: BELLAND® material with 50% of recycled material, PLA with compensation of the $CO_2$ emissions, PS with material utilisation; all reusable scenarios use ecopower for washing; divisional**

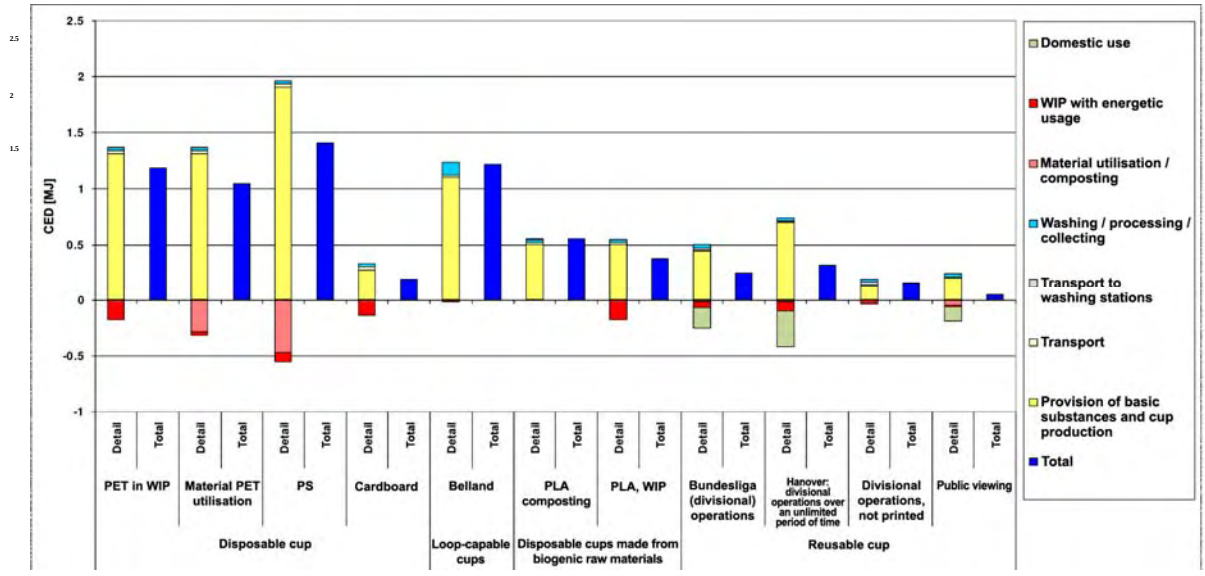



**Figure 46: Sensitivity assessments of divisional operations and public viewing for CED: BELLAND® material with 50% of recycled material, PLA with compensation of the $CO_2$ emissions, PS with material utilisation; all reusable scenarios use ecopower for washing; divisional operations with cups without printing and without consideration of domestic use**

EMPA
Materials Science &Technolog y

**Critical Review (Peer Review)**
**of the tri-national LCA study**

# ”Comparative Life Cycle Assessment of various Cup Systems for the Serving of Drinks at Events”

## Focussing on major events such at the European Football Championships UEFA EURO 2008™ in Austria and Switzerland as well as the German Bundesliga operations

Jointly prepared by:

Austrian Institute of Ecology (Österreichisches Ökologie-Institut), Seidengasse 13, A-1070 Vienna
Carbotech AG, Eulerstrasse 68, CH-4051 Basel
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Date: 24th September 2008

# Critical Review Report

by

**P a u l W . G i l g e n**

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**F.A.O. the collective clients:**

**Austrian Federal Ministry of Agriculture and Forestry, the Environment and Water Management (Österreichisches Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW)**
**and**
**Swiss Environmental Authority (Schweizerisches Bundesamt für Umwelt, BAFU)**

s u p p o r t e d b y
German Federal Ministry of the Environment and Nuclear Plant Safety (Deutsches Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU)
and the counties/cities of Basel, Bern, Hanover, Kärnten, Salzburg, Vienna and Zurich

**3rd April 2009**

# Table of contents

# 1 Preliminary comments

This critical review (peer review) of the LCA study "Comparative LCA of various cup systems for the serving of drinks at events", jointly prepared by

- from Austria, Österreichisches Ökologie-Institut, Vienna,
- from Switzerland, Carbotech AG, Basel,
- from Germany, Öko-Institut e.V., Darmstadt,

was prepared during February and March 2009. The subject of this review was the 116-pages final report, which had been completed in autumn 2008. A pre-presentation (consisting of 45 PowerPoint slides), which was presented on 12th October 2007 by representatives of the three joint authors on the occasion of a meeting of the Associations Européennes de Football (UEFA) in Nyon in Switzerland, served as a complementary document. Of the two options for a critical review – i.e. to be carried out parallel to the development of an LCA study or after its completion – the latter had to be chosen: the assessment of a completed LCA.

The reviewer met Dr. Fredy Dinkel from the Swiss authoring company on three separate occasions: on 13th March 2009 at the headquarters of Empa in Dübendorf as well as on 31st March 2009 and 3rd April 2009 at the headquarters of Carbotech AG in Basel. The initial meeting was intended as a basic exchange of ideas with regard to the critical review, and the second and third meetings focused on the sensitivity analyses and their respective calculations (see chapter 2.8). None of these discussions involved any kind of influencing of the peer review or the reviewer who prepared this critical review on his own accord.

The reviewer whose job it is to assess a completed LCA (such as this LCA study) can approach his task as follows:

- He either

  checks long rows of figures in great detail for their exactness. The LCA author had to select a representative value for almost all parameters from their various spreading ranges, and some of these specifications may be subject to other weighing as well as concerns or other kinds of objections.

  b Therefore, the reviewer focuses on the indicated factual balances and effects balances.

- or

  The reviewer checks the LCA's recommended action (which is what really matters in practical terms) for the issue whether these recommendations will remain unchanged even if the full range of calculating variation for the key parameters is employed in the LCA software.

  b In this case the reviewer focuses on the indicated sensitivity analyses.

This peer review of the tri-national cup study will follow the second option, which is the critical review of the indicated sensitivity analyses.

Here, the focus on the sensitivity analyses for the purpose of checking the robustness of the recommended action subject to the variation of key parameters is the appropriate approach – for another reason.

As for all modern LCAs – and in general for many scientific and engineering papers – the figures in the results (output) are the functional result of the figures and numerical values from the input values (input). This transformation is not based on any kind of assumption but on carefully weighed and comprehensibly displayed factual specifications. This applies to all influencing factors, not just for the key parameters (such as the system boundary because it defines what is to be taken into consideration and what is excluded). Therefore, the computer using the LCA software calculates with the help of these values. This means that the critical review of LCAs – and especially of completed LCAs – requires a great degree of care regarding the variation of those input values, which strongly determine the result via the above transformation and of course the derived recommendation for action.

For this detailed review the following five key parameters have been chosen:

- –Non-return rates for reusable cups
- –Circulation cycles for reusable cups
- –Domestic use of reusable cups
- – Washing of reusable cups
- – Transport of reusable cups

The above is applied to the following categories of reusable cups (if applicable and if data is available):

- – Reusable cups with branding UEFA EURO 2008™
- – Reusable cups without branding UEFA EURO 2008™

# 2 Detailed review of the following sections: Sensitivity analyses – How robust is the recommended action if key parameters are modified?

## 2.1 Conclusion and recommended action by the study

The study's summary from page 7 states the following conclusions:

- "All reusable cup scenarios show lower environmental burden compared to the examined disposable cup scenarios. The differences for all examined cups are significant, with the exception of the cardboard cup, for which the differences are only significant to a certain extent."
- "The best disposable cup scenario has twice as many environmental burden points (EBP) than the worst reusable cup scenario."

This conclusion is repeated on page 79 (chapter 9.1.5 "Sensitivity assessments") as follows:

- "All reusable cup scenarios show the least environmental burden throughout. No disposable cup can be called an ecologically comparable container because it will always have a significantly higher environmental burden."

The study's summary from page 11 gives the following recommended action:

- "On the basis of the results from this study and taking ecological aspects into consideration, the authors recommend reusable drinking cups for major events such as UEFA EURO 2008™ as well as divisional operations (e.g. German Bundesliga) and other major events (e.g. public viewing)."
- "Any subsequent reuse of the cups after UEFA EURO 2008™ by the Bundesliga or other organisers is recommended."

The detailed examination of the sensitivity analyses is to show the robustness of this recommended action subject to a variation of the figures for key parameters:

If

the reusable cups prove to be the more eco-friendly container even for the spreading over a wide variation range,

the reality is reflected by the study in an appropriate manner, which means that the study's conclusions are correct and reliable.

## 2.2 Comments regarding the assumptions for reusable cups

The three parameters of “non-return rates”, “circulation cycles” and “domestic use of the reusable cups” (material: polypropylene (PP), weight *G* = 55 g (the heaviest of the three reusable varieties was used, the other two weighed 30 g and 46 g respectively)) are linked with each other. The more cups that are taken home (i.e. withdrawn from the total volume of all cups that remain in the stadium), the more cups that must be provided in addition in order to have sufficient numbers for UEFA EURO 2008TM or for the divisional spectators in the stadiums. After EURO has ended, the remaining UEFA EURO 2008™ cups must be destroyed for licensing reasons, which means that the planned additional production should not be overly generous in terms of cup numbers.

For these values, the study uses the following figures for the non-return rate as an assumption:

- After each EURO match, 25% of the reusable cups with the printed UEFA EURO 2008™ logo are taken home by fans;
- After each EURO match, 75% of the reusable cups with the printed UEFA EURO 2008™ logo remain in the stadiums.

This assumption (as well as the assumptions regarding the linked circulation cycles and domestic use) is based on two sources:

- Experience and data from the Football World Cup 2006 in Germany (FIFA World Cup 2006 Germany™);
- The details provided by a reusable system operator and his definite proposal for UEFA EURO 2008™.

For the German Bundesliga operations, the following assumptions apply:

- After each Bundesliga match, 1% of the reusable cups without printed logo are either taken home or break, which results in 41 circulations;
- After each Bundesliga match, 100% - 1% = 99% of these reusable cups without printing remain in the stadiums.
- Note regarding the non-return rate:
  Acc. to figure 23, the non-return rate is 1%, but according to the text on page 59 it is 2%; the review of this calculation resulted in the figure of 1%, which has been used.
  The basis for all reusable scenarios for UEFA EURO 2008™ is the data from table 6 (which stems from the German Bundesliga) with regard to the usage and breakage rates of reusable cups. Their circulations can be calculated from this data, i.e. 60 to 217. These figures represent the (theoretical) life span until the end of the system (for example because of the introduction of a new reusable system), which in general has been assumed as 300 circulations.

This corresponds to reality and is correct.

The weighed average circulation cycle is 107.

From this wide range, 60 circulations (also called usage cycles) have been chosen, which is clearly a conservative assumption. The European Football Championships comprised a total of 31 matches in the stadiums at eight venues in Austria and Switzerland. The match schedule for these wide-apart venues limits the theoretically possible usage cycles to eight so-called system cycles. Considering the assumed non-return rate of 25%, the figure of 2.9 circulations for a reusable cup in the stadiums was calculated.

Based on these details, the joint study authors created logically linked model calculations, from which the figures (including spreading widths) result that have been used for the study. This has all been described concisely and in a shortened format.

A panel of 12 experts formulated the type and scope of domestic use and reached a consensus. The study uses their weighed assumptions in the form of percentages. This is plausibly and comprehensibly described.

Reviewer's note regarding the critical review of the reusable cups (exclusively):

The critical review of the reusable cups (exclusively) is justified because the LCA for the disposable cups always uses the most beneficial value for all specifications (i.e. "best case" assumptions to the benefit of the disposable cups throughout). Opposed to that, the LCA for the reusable cups always uses the least beneficial values (i.e. "worst case" assumptions to the debit of the reusable cups throughout). Despite this, the reusable cups display a significantly lower environmental burden.

## 2.3 Non-return rates for reusable cups

The tri-national cup study bases the non-return rates for the reusable cups on the following two assumptions:

2.3.1 For UEFA EURO 2008™ in Austria and Switzerland:

The non-return rate for the reusable cups with printed UEFA EURO 2008™ logo is 25%. (Because of the above data the highest rate for the value range from 10% to 25% is used.)

2.3.2 For German Bundesliga operations: The non-return rate or breakage rate for reusable cups without printing is 1 %.

## 2.4 Circulation cycles for reusable cups

Due to the plausible description of the non-return rates, the circulation cycles for the reusable cups for four scenarios are as follows:

### 2.4.1 Scenario 1

UEFA EURO 2008™ cup, which is taken home as a souvenir after use in the stadium and becomes a so-called fan item. (At home, the cup replaces a souvenir in the display cabinet, which has been produced with the same effort and which will at some point end up in the household waste and go into the waste incineration plant.)

- 2.92 circulations in the stadium.

### 2.4.2 Scenario 2

UEFA EURO 2008™ cup as under 2.4.1.

However, in addition, the domestic use as a reusable cup has been defined by a panel of experts, and this will be taken into consideration in the LCA.

- 2.92 circulations in the stadium.

### 2.4.3 Scenario 3

Attractive cup without printed UEFA EURO 2008™ logo, which can be used for UEFA EURO 2008™, for divisional operations and also commercially.

An average of 107 circulations is assumed. There are also a non-return rate of 1% and a breakage rate of 0.93%. This results in a total of 2.9 circulations in the stadium and 57.1 circulations in subsequent use.

- 6060 circulations.

### 2.4.4 Scenario 4

Neutral cup without a UEFA EURO 2008™ logo, which can be used for divisional operations in Austria and Switzerland (as well as for Bundesliga operations).

- 4141 circulations in the stadium.

Experience from six German Bundesliga venues has provided the following circulation figures (using special calculations): 60 to 217 circulations, with a weighed average of 107 (chapter 6.3.4, especially table 6).

Chapter 6.6.3 states the non-return rate and breakage rate as reasons for the even lower circulation rate of this scenario compared to the empirically determined lower value of 60 circulations: The non-return rate/breakage rate is 1% and 1.7% respectively.

This means that the assumption of a mere 41 circulations of the reusable cup is a “worst case” assumption for the purpose of the LCA.

## 2.5 Domestic use of reusable cups

The study's result is strongly influenced by the domestic use, which is why its specification is important. Therefore, a panel of experts from the accompanying group has determined the rates of domestic use. The 12 members of the panel stated four scenario assumptions for domestic use of all non-returned reusable cups ( = 100%) as follows:

2.5.1 A reusable cup, which is taken home as a souvenir after use in the stadium and becomes a so-called fan item. (At home, the cup replaces a souvenir in the display cabinet, which has been produced with the same effort and which will at some point end up in the household waste and go into the waste incineration plant.)

- Applies to 20% of all cups, which are taken home. There is no effort for cup production applicable.

2.5.2 A reusable cup as under 2.5.1.

However, at home the cup does not replace a souvenir but another drinking container with equal usage. (This other drinking container was produced with the same effort and will at some point be disposed of in a waste incineration plant.)

- Applies to 30% of all cups, which are taken home.
  No credit is given.

2.5.3 A reusable cup, which – after use in the stadium – is used at home, for example for a barbecue, where it replaces 10 disposable cups made from various materials. (This reusable cup will at some point be disposed of in a WIP.)

- Applies to 20% of all cups, which are taken home. There is no credit for the replacement of 10 disposable cups.

  For this scenario, the lightest disposable cup is assumed (i.e. made of PET with a weight of $G$ = 11.5 g). This leads to the smallest credit in the LCA of the reusable cup. This is again a «worst case» assumption.

2.5.4 A reusable cup, which – after use in the stadium – is taken home

and replaces a reusable cup of equal value, which was bought in a department store.

- Applies to 30% of all cups, which are taken home.
  No effort for cup production is applicable.

The indicated spread (in percent) of all reusable cups, which are taken home, is the weighed average of the experts' views regarding the assumed domestic use. On

page 46, the study displays the significant variation range of the estimations by the accompanying group.

## 2.6 Washing of reusable cups

Washing the reusable cups has a big influence on the extent of the total environmental burden. For the LCA, not just the washing process itself but also the manner, in which the required thermal energy and electricity are produced, is important. According to the details given on page 40, the cleaning of the reusable cups is carried out in Vienna and Munich as well as Interlaken and Basel. The study balanced the actual situation, unfortunately without any mention of explicit details.

In chapter 9.2.4 “Sensitivity assessments” the study states that one of the German providers of reusable cup systems uses certified ecopower for the operation of his washing plants. The resulting, very low CO2 emissions reduce the environmental burden from the life cycle section of washing by almost half and that of the entire life cycle by almost a third – a surprisingly high proportion, but absolutely correct (see figure 41 vs. figure 36). This of course only applies to scenario ® and the divisional operations (although the text does not make this clear). For the other three scenarios, the improvements are much more modest.

Therefore, the ecological effects of the use of certified ecopower for the life cycle section of washing is examined in greater detail in the following:

– Proportion of certified ecopower: 0% (This is the value, which was used in the study and which corresponds to the examined reality.)

– Proportion of certified ecopower: 50%

– Proportion of certified ecopower: 100%

## 2.7 Transport of reusable cups

The details from page 39 regarding the transport of reusable cups for UEFA EURO 2008™ and for divisional operations are plausible:

- 4 0 0 k m a rounded weighed average for the distance between production site and stadiums
- 1 0 0 k m a rounded weighed average for the distance between stadiums and washing station
- 3 0 k m a rounded weighed average for the distance between stadiums and WIP

The transport has a significant influence on the results, which is why conservative estimates should be used. The study has done exactly that, and the corresponding figures are on the "safe side". As an example, the balanced transport distance for the reusable cups to the washing stations and back are examined: The reviewer shares the authors' opinion that the distance, which has been used for the LCA (2 x 100 km = 200 km) can be regarded as the upper value.

The distance between the production site and the stadiums is on average 400 km. The environmental burden that results from this transport has been correctly considered in the study, but has almost no influence on the result: The numerous washing processes for reusable cups and the respective transport distance of 2 x 100 km are totally dominating. This fact has been plausibly described in the study.

## 2.8 Overview of selected results of the sensitivity analyses (table)

The following sensitivity analyses including the corresponding calculations were prepared on 31st March 2009 and 3rd April 2009 at Carbotech AG headquarters in Basel. This was done by Dr. Fredy Dinkel and in the presence of the reviewer. The review used the same computer with the same LCA software and data status, which had been used for the study itself.

On the occasion of these two meetings in Basel, the reviewer carried out spot checks of some of the study's LCA calculations – with a highly satisfactory result.

| Parameters | | Reusable cup made of polypropylene, weight G = 55 g, volume V = 0.5 litre | | | |
|---|---|---|---|---|---|
| The percentage values and figures in **bold** print are the average values of the respective parameters (incl. the justification of their specification) that have been used for the study.<br><br>The percentage values and figures in normal print are the lower and upper limits for the respective parameters that have been used for the sensitivity analyses of the critical review. | | **with branding** and printed label "EUFA EURO 2008™" | | **without branding** and without printed label "EUFA EURO 2008™" | |
| | | **Use in the stadium** only during "EUFA EURO 2008™" | | **Use in the stadium** | |
| | | | | Attractive cup: for UEFA EURO 2008TM or Bundesliga or commercial Rate of cups that are taken home (not returned) during UEFA EURO 2008TM: 25% (domestic use: acc. to panel of experts) Rate of cups that are taken home (not returned) during Bundesliga operations: 1% | Neutral cup: only for Bundesliga operations<br><br>Rate of cups that are taken home (not returned) during Bundesliga operations: 1% |
| | | **Subsequent domestic use** | | | |
| | | Used as a souvenir | Used as a reusable cup; domestic use; acc. to panel of experts | Used as a reusable cup | Used as a reusable cup |
| | | Scenario ① | Scenario ② | Scenario ③ | Scenario ④ |
| **Non-return rate** (scenarios 1 and 2) | 35% | 25,2 EBP | 25,7 EBP | 25% non-return rate: **25,3 EBP** | 1% non-return rate: **10,6 EBP** |
| | **25%** | **24,9 EBP** | **25,3 EBP** | | |
| | 10% | 24,8 EBP | 24,9 EBP | 1% non-return rate: **9,7 EBP** | |
| **Circulation cycles** (scenarios 1 and 2) | 2,3 | 25,2 EBP | 25,7 EBP | 2,9 circulation cycles: **25,3 EBP** | 41 circulation cycles: **10,6 EBP** |
| | **2,9** | **24,9 EBP** | **25,3 EBP** | | |
| | 4,7 | 24,8 EBP | 24,9 EBP | 60 circulation cycles: **9,7 EBP** | |
| **Domestic use** (scenarios 2, 3 and 4) | 20/30/10/40% | data not applicable | 31,0 EBP | For non-return at UEFA EURO 2008TM: see scenario 2 | data not applicable |
| | **20/30/20/30%** | | **25,3 EBP** | | |
| | 20/30/30/20% | | 19,4 EBP | | |
| **Washing** (partly eco-electricity; scenarios 1, 2 and 4) | 100% | 21,7 EBP | 22,0 EBP | data not applicable | 9,8 EBP |
| | **0%** | **24,9 EBP** | **25,3 EBP** | | **15,8 EBP** |
| | 50% | 23,3 EBP | 23,7 EBP | | 12,8 EBP |
| **Transport** (to the washing station and back) | 300 km | 25,7 EBP | 26,1 EBP | data not applicable | 16,7 EBP |
| | **200 km** | **24,9 EBP** | **25,3 EBP** | | **15,8 EBP** |
| | 100 km | 24,1 EBP | 24,5 EBP | | 15,0 EBP |

Note: The colouring for the four scenarios has been chosen at random and only serves graphical purposes. It does not have any other meaning.

Paul W. Gilgen, c/o Eidgenössische Materialprüfungs- und Forschungsanstalt (Empa), CH-8600 Dübendorf, Switzerland. 3rd April 2009

Critical review (peer review) of the reviewer concerning the LCA study «Comparative LCA of various cup systems for the selling of drinks at events», which was jointly prepared by three countries.

Client:

Austrian Ministry of Agriculture and Forestry, the Environment and Water Management (Österreichisches Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW) and the Swiss Federal Environment Authority (Schweizerisches Bundesamt für Umwelt, BAFU); supported by the German Federal Ministry of the Environment and Nuclear Plant Safety (Deutsches Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU), the Austrian county of Kärnten as well as the cities of Basel, Bern, Hanover, Klagenfurt, Salzburg, Vienna and Zurich

As a comparison:
According to chapter 12.5.1.2, the lightest disposable cup (made of PET, weight $G$ = 11.5 g, volume $V$ = 0.5 litre; calculated for “best case” assumptions throughout, such as the most beneficial material recycling and without WIP disposal) causes an environmental burden of 44.9 EBPs – much higher than that of a reusable cup (see flow charts on pages 102 and 103).

## 2.9 Comment on the result of the detailed review

The study plausible explains (e.g. page 42) that the number of the cups, which are taken home and are therefore taken out of the total amount of cups that is to be produced, as well as their further use are the essential influencing values with regard to the study’s results. The assumptions concerning the non-return rate and breakage rate are based on experience from the Football World Cup 2006 in Germany (FIFA World Cup 2006 Germany™), which showed very similar conditions. Also, the type of usage has been carefully defined by a panel of 12 experts from the accompanying group, and both form a solid and reliable data basis for this important parameter.

The table overview of the environmental burden, which is stated in environmental burden points (EBP), shows that the reusable cups – for all parameter variations – have a significantly lower environmental burden than disposable cups, even if the latter are calculated using the most beneficial assumptions throughout.

Therefore, reusable cups are indeed the ecologically more beneficial type of container for the serving of drinks at major events, which means that the study’s recommendation is correct.

# 3 Summary of examined sections

The specification of the issue/question as well as the determination of the system boundaries and the functional unit and also the description of the general conditions have all been carried out with a high degree of functionality. The derivation of the factual balance and effects balance, the interpretation of the results as well as the use of two assessment methods [i.e. ecological scarcity 2006 (environmental burden points, EBP 2006) and eco-indicator 99 (EI 99) with HA (hierarchist average) weighing] do not pose any reason for objections as the authors' knowledge of LCAs and their special requirements is clearly visible.

The ecological basic data has been taken from the "ecoinvent" database (data stock version: ecoinvent 1.3), and the LCA software "EMIS" has been used for calculating the factual balance and effects balance. The excellent quality and reliability of these two tools is unquestionable and their competent handling by the experienced authors of the LCA is obvious.

RE disposal:

The experience gained from preparing LCAs for many products has resulted in a general 90/10-rule:

- 90% of the determined environmental burden of an entire life cycle result from the production (and for certain products also including their use);
- 10% of the determined environmental burden results from disposal.

Sometimes this spread shifts to a ratio of 80/20 or higher. However, almost always a minor proportion of the total environment burden stems from the disposal section of the life cycle. Therefore, the utilisation of the cups can be omitted because of its negligible influence and cancelled from the list of the key parameters, which require detailed reviewing.

Also, the reviewer shares the following opinion of the authors (see study page 38):

- "The type of utilisation or disposal of the drinking cups after their usage phase has an influence on the results, which must not be neglected. Whereas incineration is often used as the disposal option of choice, for cups that are sorted according to definite types (e.g. disposable cups with deposit), high-quality material recycling should be balanced as standard."

The allocation rule of “accreditation of 50% of the credit” (page 38) for the avoidance of double accrediting of benefits for “open-loop” recycling is correct, as is the allocation rule of “accrediting of 100% of the credit” for “closed-loop” recycling.

As a variation parallel to its derivation from the effort for primary and secondary plastic granulate, the allocation rule from the price relation between new goods and regranulate is mentioned. It seems credible that their application (as described on page 38) only has a marginal effect on the results.

The heating values of the materials from page 39 (in MJ/kg), which can be granted for the credits from the thermal use of the cups in the WIP, are the commonly used figures.

The weighed averages for incineration and use of heat and electricity for the WIP have been used correctly.

## 4 Further comments

In the reviewer’s opinion, the graphic presentation and linguistic description of various parts of the study show definite room for improvement. (“Working on the language is working on thought.”) Various sections require repeated reading in order to be understandable – not a defect in itself, but something that would have been avoidable by using more precise language and visually more expressive graphics. Two examples regarding the above:

– The complicated, interlinked and partly interdependent conditions for non-return and circulation of cups as well as their domestic use could have been described with much greater clarity.

– Figure 23 is titled “divisional operations”. If this refers only to Austria and Switzerland or to the German Bundesliga as well is not clearly understandable from the corresponding text.

These notes concern possible improvement of the form because this has not consistently been prepared with the same degree of care as the contents as such.

# 5 Conclusion

The critical review of the study concluded the following:

– The modification of the parameters that are essential for the result has resulted in the upkeep of the study's recommendations (pages 89 and 90). These recommendations are as follows:

> "On the basis of the results of the joint study by the Austrian Institute of Ecology (Österreichisches Ökologie-Institut), the German Institute of Ecology (Deutsches Öko-Institut e.V.) and Swiss company Carbotech AG and taking ecological aspects into consideration, reusable cups are recommended for major events such as UEFA EURO 2008™."
>
> "The same recommendation is given for the German Bundesliga operations as well as divisional operations in Austria and Switzerland and for other major events such as public viewing."
>
> "The recommendations are based on clear and significant results, which were confirmed by the sensitivity analysis and, despite the rather conservative assumptions regarding the reusable cup scenarios, display clear benefits of the reusable cups in comparison to all disposable cup systems."

The recommended action is robust to such a degree that it still applies even if the extreme values of the parameter spreading range are employed for the LCA calculations.

– This result is based on current situations and realities within the examined system. Future conditions may lead to other results and consequently to recommended action of a different nature.

– The study provides a practical answer to the question by the joint clients (BMLFUW in Austria and BAFU in Switzerland), which containers for the serving of drinks at major events such as UEFA EURO 2008™ will result in an overall reduced environmental burden: the use of the reusable cup.
The study provides authorities and administrative bodies with a robust data collection for justifications of possible legislative requirements and regulations with regard to mandatory containers for the serving of drinks at major events.

- It also provides practical recommendations for action for the organisers of such major events with regard to containers, which are to be preferred for reasons of a low environmental burden: the use of the reusable cup.
The study provides organisers with a robust data collection for further improvement of the ecological aspects of logistics.

**To summarize:**

**The three bodies that prepared the study "Comparative LCA of various cup systems for the serving of drinks at events" (from 24/9/2008) on behalf of the Austrian Federal Ministry of Agriculture and Forestry, the Environment and Water management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW) and the Swiss Federal Environment Authority (Bundesamt für Umwelt, BAFU) have delivered a good piece of work.**

The reviewer:

**Paul W. G i l g e n**

CH-8600 Dübendorf, 3rd April 2009

**Reviewer's address:**

Paul W. G i l g e n

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