

Comparative LCA of 4 types of drinking cups used at events; Eco-efficiency analysis of 4 types of drinking cups used at events

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(Reports can be downloaded from: <http://www.ovam.be/jahia/do/pid/1435>)

Executive Summary (by E. Vink, NatureWorks LLC, January 2007)

In order to outline a well-founded waste management policy for the use of drinking cups at events, OVAM, the Public Waste Agency for the Flemish Region in Belgium, commissioned VITO, the Flemish Institute for Technological Research, to study the current environmental impacts and the costs related to existing systems for drinking cups on small-scale indoor and large-scale outdoor events in Flanders, Belgium. The study was triggered by the introduction of polylactide (PLA) cups in Flemish events. The two-phased study consists of a comparative life-cycle analysis (LCA) comparing the environmental impacts of four existing cup systems and an eco-efficiency analysis in which the total life-cycle costs of the different cup systems are inventoried and related to the environmental aspects. Both studies are discussed in separate reports.

The study compares re-usable Polycarbonate (PC) cups with one-way Polypropylene (PP), Polyethylene (PE)-coated cardboard, and Polylactide (PLA) cups. The functional unit (the basis for the comparison) is defined as the recipients needed for serving 100 litre beer or soft drinks at a small-scale indoor event (2000-5000 visitors) or a large-scale outdoor event (>30,000 visitors). This definition includes the production of the cups, the consumption phase (at the event) and the processing of the waste. The four cup systems were compared in four Basic scenarios, along with a sensitivity analysis to examine the trip rate in the case of the reusable PC cups, as well as the PLA future scenario.

The target audiences for the study are the policymakers at OVAM and the Belgium Government, but both studies were also made available to the general public. The comparative LCA was designed to comply with the international standards for LCA, ISO 14040-14043. The ISO conformity was confirmed during a critical review process. For the second part of the study, the Eco-efficiency analysis, no ISO standards exists. The complete study was guided from the start by a comprehensive stakeholder panel and a peer review team. During the study various external experts were consulted as well. All the involved organizations are specified in the study.

Some key LCA settings for the four Basic scenarios and the PLA future scenario are summarized in Table 1. A detailed overview of the LCA settings is given in the report. For PLA two sets of cradle-to-pellet inventory data, often called "eco-profiles," were used: "PLA" which represents the PLA production system as of May 2005 and "PLA future scenario," which is based on new process technology that is expected to become available within a few years from now.

Parameter	PC Basic	PP Basic	PE carton Basic	PLA Basic	PLA future
Cup weight [g]	45	5	7.7	6.5	5.5
Data pellet production	PlasticsEurope	PlasticsEurope	PlasticsEurope	NatureWorks per May 2005	NatureWorks per May 2005
EOL Small scale	100% incineration	100% incineration	100% incineration	50% incineration 50% composting	90% anaerobic dig 10% incineration
EOL Large scale	100% incineration	50% Incineration 50% Cement kiln	50% Incineration 50% Cement kiln	50% incineration 50% composting	90% anaerobic dig 10% incineration
Pellet production location	Europe	Europe	Europe	US	Europe
Number of trips					
Small scale	45	na	na	na	na
Large scale	20	na	na	na	na

EOL = end of life, the final waste management route selected.

Table 1. Selection of LCA settings for the four Basic scenarios and the PLA future scenario

Comparative LCA of 4 types of drinking cups used at events

Figure 1 presents the general process flow diagram reflecting the most important processes that are taken into account studying the life cycles of the four cup systems. In the inventory phase all the input flows such as materials and energy and all the output flows such as emissions and waste were described and quantified. The data reflect the specific actual situation in Flanders. The data are not case specific but reflect the results within two ranges of visitor numbers that relates either to small scale or large scale events. In the underlying study four basic scenarios were defined, while for the most uncertain and most relevant parameters sensitivity analyses were performed. During the impact assessment the emission and consumption data of the inventory phase were aggregated into nine environmental impact or damage categories: Fossil fuel use, Mineral use, Acidification/Eutrophication, Ecotoxicity, Ozone depletion, Climate change, Respiratory organics, Respiratory inorganics and Carcinogens.

For both types of events it can be concluded that none of the cup systems has the highest nor the lowest environmental score for all environmental categories. Based on these results it was not possible to make straightforward conclusions for the selection of the most favorable cup system since the different environmental impact categories do not have the same denominator and can therefore not be compared directly with each other. If the small-scale indoor results are compared with the large-scale outdoor results for the individual cup systems the environmental burden for the PC cups increase significantly moving to larger scale events, while the burden stays the same for the three one-way cup systems. Further the LCA sensitivity analysis confirms that the trip rate for the PC cups is a very determining factor for the PC cup results. For both small indoor and large outdoor events the trip rate has a clear effect on the ranking of the different cups.

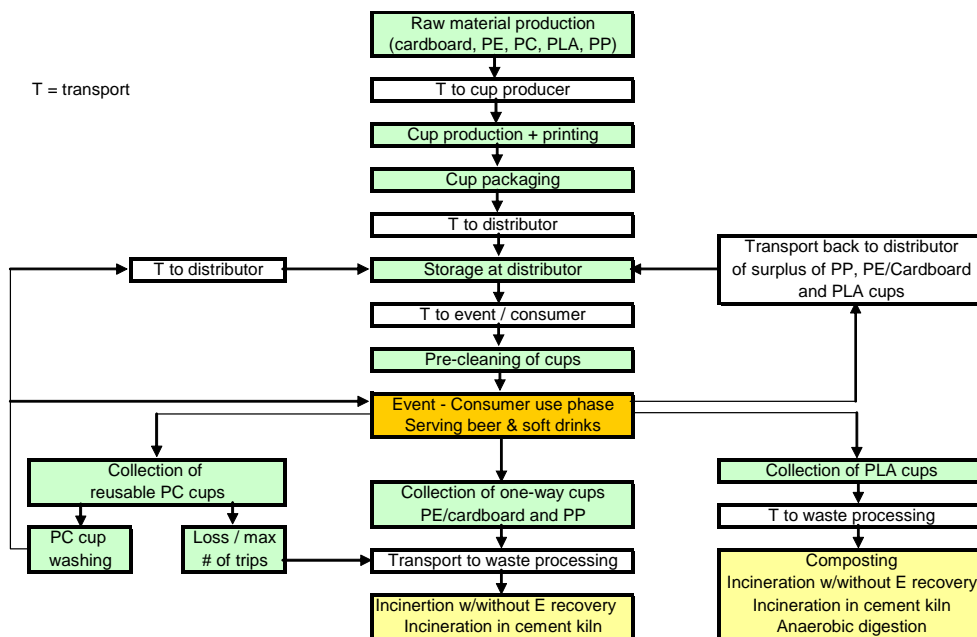


Figure 1. General process flow diagram of four cup systems

Eco-efficiency analysis of 4 types of drinking cups used at events

To get a more complete picture of the overall performance of the four cup systems an Eco-efficiency analysis was performed in which the environmental aspects are combined with the economic aspects. The economic aspects are especially important since the PC cup systems are subsidized by the Belgium Government. The environmental assessment is based on the above-

described LCA and the Eco-indicator 99 methodology is used to aggregate all impacts into one single indicator. The economic aspects were assessed using Life Cycle Costs analysis. Both methodologies are described in detail in the reports.

Figure 2 shows the Eco-indicator 99 scores for the use of cups at small events for the four Basic scenarios and the sensitivities. Figure 3 shows the scores for the large scale events.

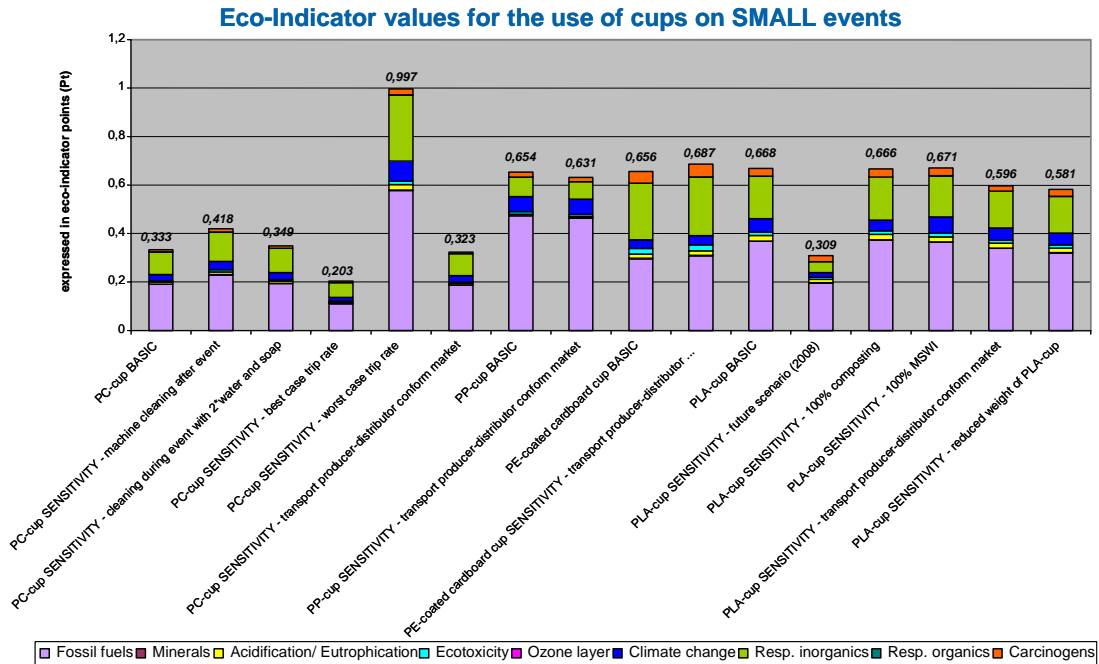


Figure 2. Indicator scores for small scale events

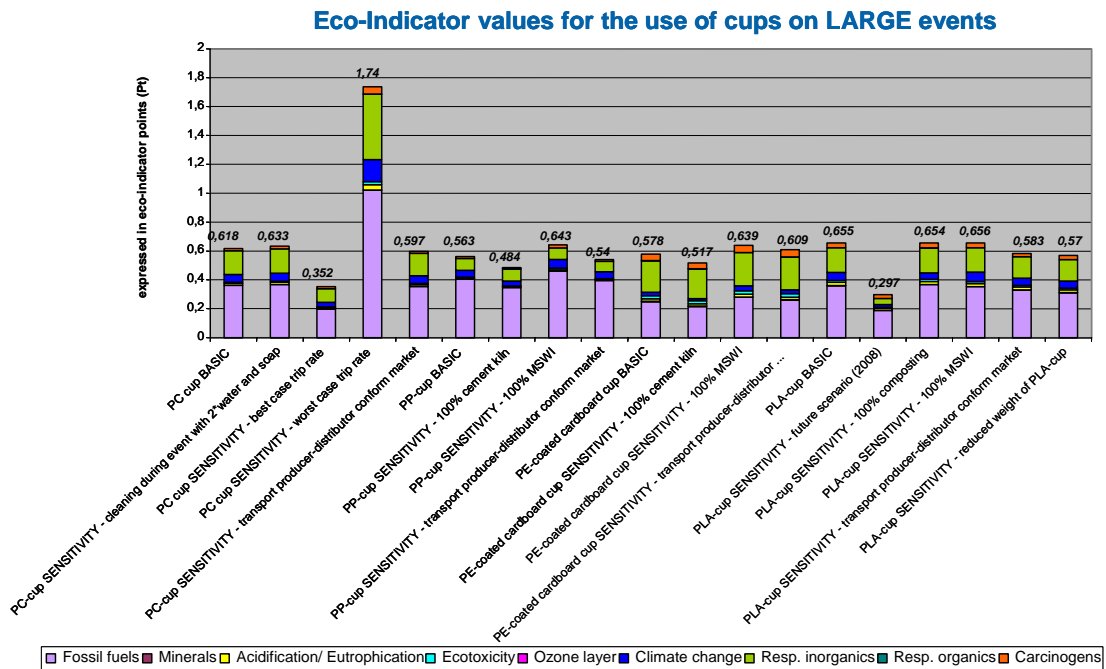


Figure 3. Indicator scores for the large scale events

From the results shown in Figure 2 and 3 the following conclusions can be drawn:

- For each scenario studied the fossil fuel use and human health effects of inorganics (dust, NOx, SOx) are the biggest contributors.
- 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.
- The trip rate for the PC cup is the dominating factor for the results of the study. The effect on the Basic scenarios is significant.
- The choice for PLA composting or incineration has no significant influence.
- 15% PLA cup weight reduction shows 13% reduction in indicator score, so reduction of cup weight is an important optimization parameter.
- For the *small* events the PLA future cup is comparable with the PC Basic cup and is significant better than the PP and PE-coated carton cups.
- For the *large* events the PLA future cup is significantly better than the PC, PP, and PE-coated carton Basic cups.

Figure 4 shows the results of the Eco-efficiency analysis for the small scale events. Figure 5 shows the results for the large scale events.

For the *small* scale events the following conclusions can be drawn:

- The PC cups have the lowest environmental indicator of the 4 Basic scenarios. However, it has to be guaranteed that the PC cups are at least reused 32 times. Below this trip rate the advantage for PC cups disappears. A clear disadvantage of the PC cups is that the life cycle costs are 3-5 times higher.
- If the PLA future scenario becomes reality and the other cup systems are not able to improve their environmental indicators, PLA becomes similar to PC with respect to the environmental indicator but with a significant lower cost indicator, resulting in a higher eco-efficiency.
- An environmental policy to promote the use of reusable PC cups (e.g. by subsidies) at small events is not justified in the PLA future scenario, according to this study.

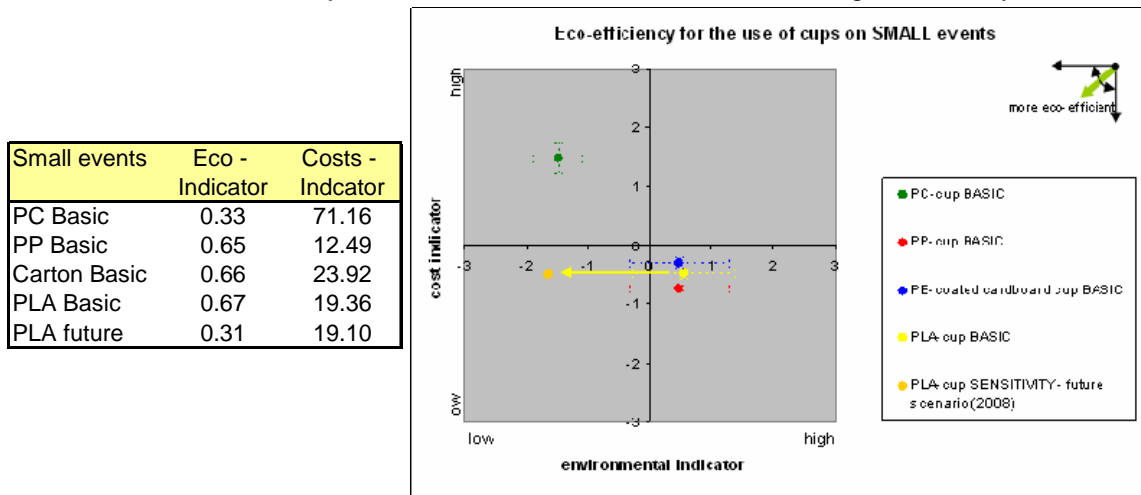


Figure 4. Eco-efficiency results for small scale events

Large events	Eco - Indicator	Costs - Indicator
PC Basic	0.62	49.17
PP Basic	0.56	13.30
Carton Basic	0.58	24.51
PLA Basic	0.66	17.15
PLA future	0.30	17.01

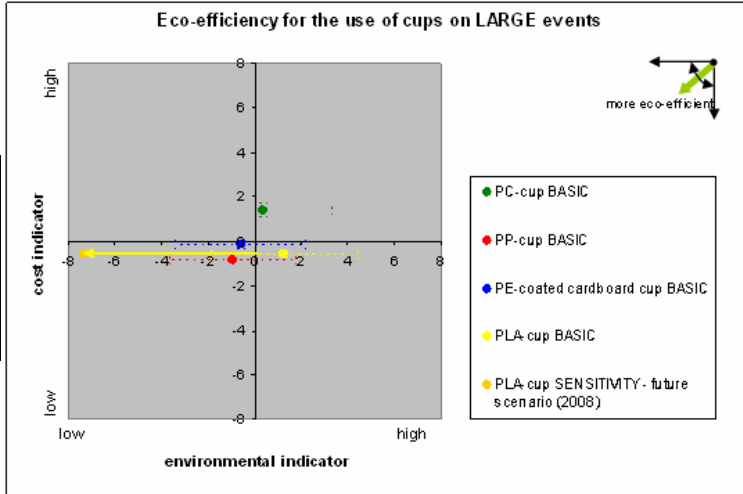


Figure 5. Eco-efficiency results for large scale events

For the *large* scale events the following conclusions can be drawn:

- The cup systems modeled in the 4 Basic scenarios have a similar environmental indicator. However, the costs for the PC cups are significantly higher. One-way cups are therefore more eco-efficient.
- The effect of the PLA future scenario at large scale events is identical to the small scale events. The cost indicator remains the same; the environmental indicator improves significantly, causing an increase in eco-efficiency of this future system.
- If the PLA future scenario becomes reality and the other cup systems are unable to improve, the PLA cup system becomes the environmentally best option.

The comparative LCA and the following Eco-efficiency study was performed in 2005 and is based on NatureWorks® PLA production data as available in May 2005. Since then NatureWorks LLC decided to utilize wind energy to drive its processes and continued optimizing its processes. From Figure 2 and 3 it can be concluded that fossil energy use and human health effects of inorganics (NOx and SOx) are the biggest contributors. In Table 2 the data used in the underlying reports and the currently (Jan. 2007) available data for those two impact / damage categories are compared.

	PLA future scenario Data per May 2005	PLA6* Data per January 2007	PLA/NG** Data per January 2007
Fossil energy use (MJ/kg)	35.6	27.4	16.6
NOx (g/kg)	5.9	2.1	2.0
SOx (g/kg)	8.2	7.4	5.9

*PLA6 represents the current, 2006/2007, cradle-to-pellet PLA production system. It includes the purchase of wind-based renewable energy certificates to offset the environmental burden of the electricity used in the PLA production system with the environmental burden of electricity produced by wind mills.

**PLA/NG represents the future or next generation (NG) cradle-to-pellet PLA production system. This PLA is expected within a few years. It is based on the implementation of new process technology, which will reduce energy and raw material use and co-product creation. Green Power is expected to be used to supply electricity in the Cargill/NatureWorks controlled production processes.

Table 2. Comparison of fossil energy use and NOx and SOx emissions.

From Table 2 it can be concluded that many of the environmental benefits of the “PLA future scenario,” as used in the underlying study, are indeed already available today via the utilization of wind energy, as modeled in the PLA6 case.