LIFE CYCLE ASSESSMENT OF AN ARTISANAL BELGIAN BLOND BEER

Raphaëlle P. Melon (1), Vinciane Wergifosse (2), Roberto Renzoni (1) and Angélique Léonard (1)

(1) Laboratory of Chemical Engineering, Liège University, Belgium

(2) Brasserie des Légendes, Irchonwelz, Belgium

Abstract

In the framework of the Wal-Aid project funded by Wallonia aiming namely at developing valorisation means for co-products of the agro-food industry, a life cycle assessment applied to the production of an artisanal Belgian beer from the ' Brasserie des Légendes' was carried out.

This analysis focuses on the production of a golden triple beer on comparing the packaging in glass bottle or in keg. Six steps are considered for the analysis: (1) culture of barley, malting, grinding and transport to the brewery; (2) brewing of malt flour and water in two steps; (3) boiling wort; (4) guard of the beer at 4°C during 25 days; (5) packaging in brown glass bottle of 33 cl with a crown cap chrome steel or in stainless steel keg of 20 l and then (6) washing of spent grain recovered after brewing. The functional unit is taken as the production of 1 litre of beer. Environmental impacts have been evaluated using the ReCiPe 2008 method with the endpoint hierarchist perspective.

Four packaging scenarios are compared: single use bottle and keg, reused bottle (average 9.2 times) and keg (average 53.5 times). The results show that the most penalizing step is packaging, for single use scenarios, contributing to 86 % of the environmental impact for the keg and 72 % for the bottle. For the reuse scenarios, it's the culture of barley which is the most penalizing step with contribution between 57 % and 70 %. The production of beer remains low with maximum 20 % of contribution. The standardization and single score results show that the most important impacts are fossil depletion and climate change human health due to the energy demand related to the packaging step. These impacts decrease with the reuse of packaging and the keg reused represents the best solution.

Keywords: LCA, ReCiPe, beer, packaging comparison.

1. INTRODUCTION

The Wal-Aid project, funded by Wallonia, aims to develop ways of valorization for co-products of agri-food industry and to assess the environmental potential of these pathways by upgrading the methodology of the life cycle assessment. In this framework, a life cycle assessment of an artisanal Belgian blond beer from the 'Brasserie des Légendes' was performed.

2. METHODOLOGY

This analysis focuses on the production of one liter of triple beer and on two types of packaging: the brown glass bottle and the steel keg. The modeled steps in this study are:

(1) The cultivation of barley, the malting, milling and its transportation by truck to a distance of 12 km to the brewery.

(2) The brewing barley flour mixed with water. This step consists of heating the mixture in two stages with stirring. The mixture is then filtered. Both fractions recovered were wort and spent grain.

(3) The wort boiling for about 90 min and the addition of hops transported by road on 110 km.

(4) The guard of the beer after sedimentation of the wort, its cooling and adding of oxygen and yeast for fermentation. This step must keep the beer to a temperature of 4 ° C for 25 days.

(5) The beer packaging: either brown glass bottle of 33 cl of a mass of 300 g capped with a crown-like ring in chromed steel with a mass of 2 g, or a 20 l stainless steel keg of a mass of 8.8 kg. These two packages can be used for single use or more often be reused. The number of use of a glass bottle

is estimated to an average of 9.2 times. Metal keg are more often reused as bottles, considering that their average number of use is 53.5 times.

(6) The spent grain cake, recovered after filtration of brew, is cleaned with water slightly acidified with 98 % sulfuric acid. Currently, this washed spent grain is intended for animals feed around the brewery.

The chosen functional unit is the production of one liter of beer and environmental impacts are evaluated by the method ReCiPe 2008 with a hierarchist endpoint perspective.

3. INVENTORY AND DATA QUALITY

The data related to the internal boundaries of brewing (mashing, boiling, guard and washing of spent grain) are experimental data coming from the 'Brasserie des Légendes'. The data required to model the steps of malting barley and packaging are obtained from the literature [1, 2]. The modeling study was performed using the SimaPro software from Pré Consultants, associated with Ecoinvent v2.2 database and LCA Food DK.

With regard to electricity consumption, they have been calculated on the basis of energy balances and Belgian energy mix published by the International Agency of Energy on 2008. This mix shows that the Belgian electricity is mainly produced from nuclear (57%), gas (31%) and coal (9%).

4. RESULTS AND DISCUSSION

The results show two trends depending on whether the packaging is reused or for single use. For single use scenarios, Table shows that the worst case is the packaging step with a contribution of 86.59 % of environmental impacts for the keg and 72.17 % for the bottle. In the case of packaging reuse, namely 9.2 times for the bottle and 53.5 times for the keg, the trend is changing and it's the cultivation of barley which represents the worst case with a contribution of 57.52 % and 69.99 % respectively for the bottle and the keg. It is found that the environmental contribution of internal steps at the brewery remains low with a maximum of 20 % of the overall study.

Steps	Bottle		Keg	
	Single use	Reuse	Single use	Reuse
Cultivation barley	21.83	57.52	10.52	69.99
Brewing	0.2	0.52	0.1	0.64
Wort boiling	3.79	9.98	1.82	12.14
Guard	1.97	5.2	0.95	6.32
Washing spent grain	0.04	0.11	0.02	0.13
Packaging	72.17	26.67	86.59	10.78
Total	100.00	100.00	100,00	100,00

Table 1: Environmental contributions of the process.

The standardization and single score graphs (Figure and Figure) show that the concerned impacts are, in descending order of importance: fossil depletion, climate change affecting human health, particulate matter formation, human toxicity, agricultural land occupation and climate change affecting ecosystems. Of course, the importance of agricultural land occupation is independent of the proposed packaging scenario and involves only the cultivation of barley and hops. This impact, low relative to fossil depletion and climate change for single use scenarios, is the third largest impact in the scenarios with reuse of packaging. Whatever the scenario, depletion of fossil resources and climate change with effect on human health are the two most worrying impacts of this study. They are mainly due to energy demand, especially that related to the manufacturing stage of packaging. In case of stainless steel keg, an additional impact appears, the metals depletion as raw material for the manufacture of the keg. However, it is minimal in case of reuse of the keg. As for human toxicity, this impact is mainly for single use scenarios.

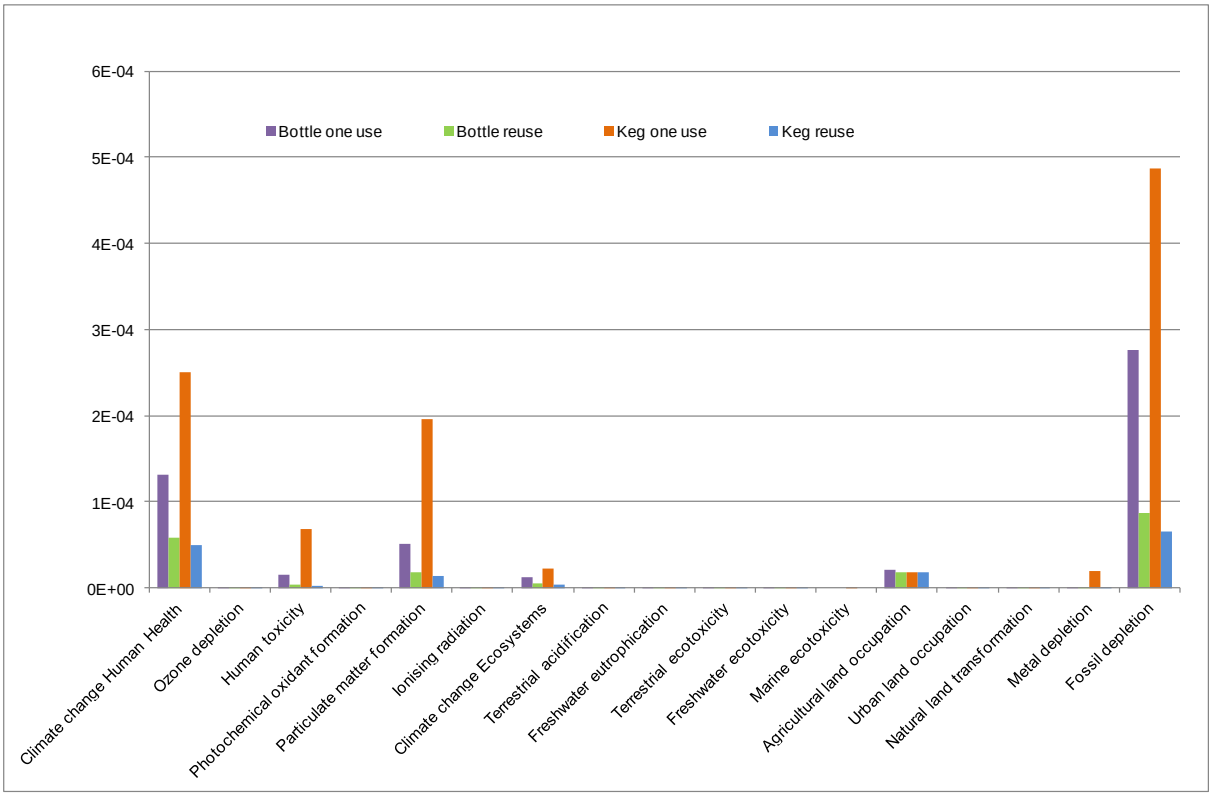

Figure 1: Standardization graph for the production of beer with packaging.

The single score graph, Figure , facilitates comparison of several scenarios. Thus, we see that the reuse of packaging can totally reverse the trend. Indeed, for scenarios for single use packaging, the keg packaging represents the worst option with a score of 324 mPt against 156 mPT for single use of bottle. The trend is totally reversed for scenarios with reuse. The score for a keg is 48.6 mPt while the bottle is 59.2 mPt. The keg appeared to be an option to avoid for single use and is ultimately the best option in case of reuse.

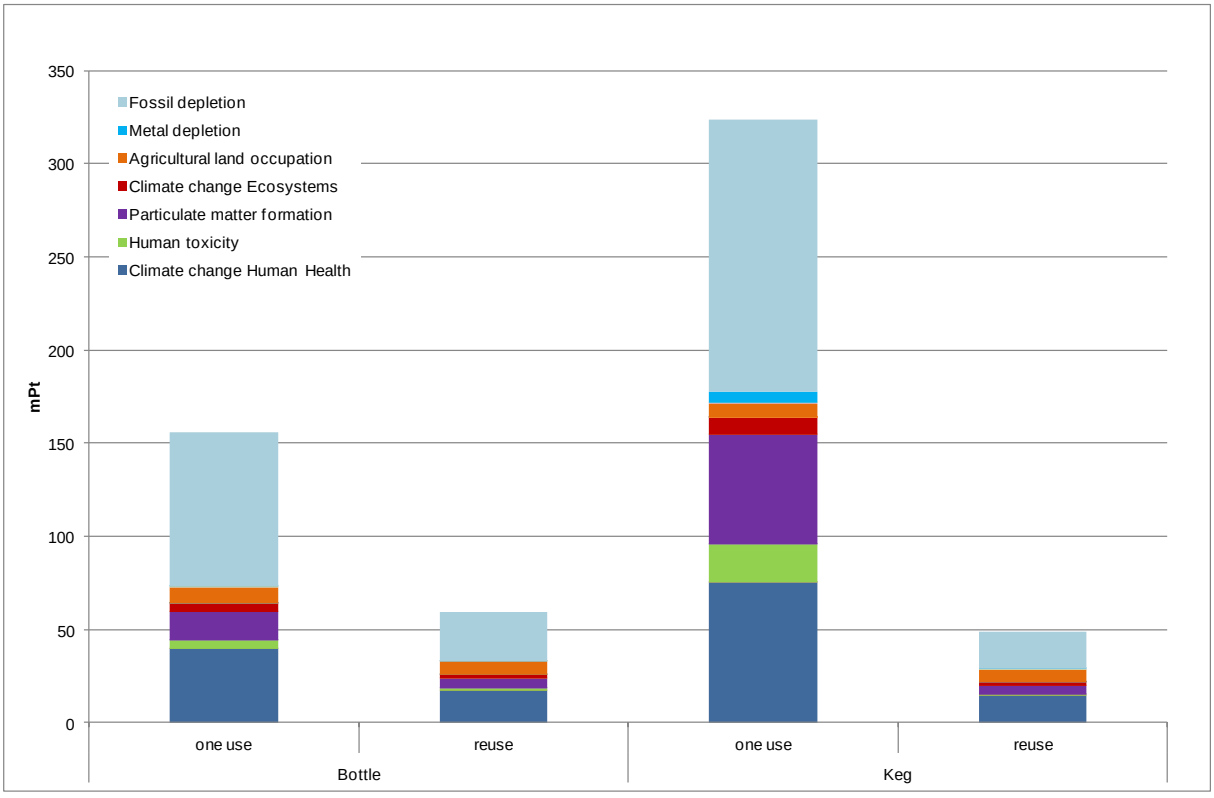

Figure 2 : Single score results of the production of beer with packaging.

5. CONCLUSIONS

This study focused on the production of an artisanal Belgian blond beer and on two methods of packaging, the brown glass bottle or the steel keg. The analysis showed that the internal steps of the brewery represent only maximum 20 % of the environmental contributions related to overall system boundaries. Moreover, it appeared that the packaging step is the most damaging in the case of single use packaging. Indeed, this step is the most energy and induces a significant impact in terms of fossil depletion and climate change. On the other side, in case of reuse of packaging, this is the stage of growing barley, malting and grinding which has the greatest impact with the associated agricultural land occupation. This study allowed us to highlight the interest of reuse the packaging.

6. ACKNOWLEDGEMENTS

This project is financially supported by Wallonia. Grant agreement n° 6089.

7. REFERENCES

[1] Kloverpris, J.H., Elvig, N., Nielsen, P.H., Nielsen, A.M., Ratzel, O. and Karl, A., 'Comparative life cycle assessment of malt-based beer and 100 % barley beer', Novozymes A/S, 2009.

[2] Pasquier, S. and Laurent, E., 'Emballages industriels: évaluation environnementale, économique et sociale de l'intérêt comparé entre réutilisation et usage unique. Emballages consignés en cafés hôtels et restaurants', ADEME, synthèse, 2010.