Supporting evidence - Environmental performance of beverage cartons

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About the authors

The section ‚Packaging and Resource Management' of the University of Applied Science Campus Vienna (FH Campus Wien) is offering two bachelor programs (Packaging technology, Sustainable Resource Management) and an international master's program (Packaging Technology and Sustainability). The experts of the section have many years of extensive know-how in packaging technology, life cycle assessments, as well in holistic sustainability assessments of packaging. Circular Analytics was founded as a spin-off of the section in 2019.

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Competing interests

The authors declare no conflict of interests.

1. EXECUTIVE SUMMARY

This report focuses on environmental performance of beverage cartons compared to alternative packaging. The authors reviewed life cycle assessment studies commissioned by members of ACE ('The Alliance for Beverage Cartons and the Environment'), as well as further studies identified by conducting a literature search.

A meta-analysis of the selected studies revealed that the global warming potential (given in gram CO_2 equivalents), on average, beverage cartons yield significantly better results (median: 83 g CO_{2eq} per liter) than PET bottles (median: 156 g CO_{2eq} per liter) and single-use glass bottles (median: 430 g CO_{2eq}). While the median global warming potential was also lower than that of reusable glass bottles (100 g CO_{2eq}), the difference was not statistically different due to the small number of LCA studies on reusable glass bottles. However, an additional evaluation of comparative LCA studies showed that beverage cartons yielded better results than reusable glass bottles in all three reviewed studies. Taken together with the meta-analysis, this strongly indicates that beverage cartons indeed have a lower global warming potential than reusable glass bottles.

Next, the reasons for the superior global warming potential were investigated, leading to the development of further environmental benefits of this type of packaging.

Firstly, a meta-analysis on packaging mass revealed that beverage cartons have a significantly greater packaging efficiency (mass of primary packaging per liter) than single-use and reusable glass bottles. While the median packaging efficiency of beverage cartons (31 g including caps) was also better than that of PET bottles (36 g including caps/sleeves/labels), the difference was not statistically significant.

Secondly, the great packaging efficiency also leads to a higher transport efficiency, resulting in lower emissions due to transporting goods. A truck can be loaded with 25% to 41% more milk using beverage cartons compared to glass bottles.

Thirdly, beverage cartons are made mainly from renewable resources, reducing the strain on fossil resources to produce plastic. Even if the entire European Union meets a 90% collection rate of PET bottles by 2030, plastic consumption would still be higher than with beverage cartons.

Finally, beverage cartons are made from wood sourced from sustainably managed forests and even more, are made only from by-products of the timber production or forest management practices, including sawmill chips and wood from thinning. Furthermore, the production of liquid packaging board for beverage cartons primarily uses biotic resources for energy generation. However, not all these aspects are considered in every reviewed study. A more accurate reflection of those issues in LCA methodology would decrease the global warming potential of beverage cartons even further.

2. BACKGROUND

ACE, The Alliance for Beverage Cartons and the Environment, is a European platform of beverage carton manufacturers and their paperboard suppliers. One of ACE's goals is to deliver sound and robust evidence for the environmental benefits of the beverage carton using life cycle approaches. Over the years, ACE members commissioned several life cycle assessment (LCA) studies, which compared their products to alternative packaging types.

2.1. Goal and scope

For the present study, Circular Analytics was asked to deliver sound and robust evidence that can be used by ACE for messaging.

Circular Analytics analyzed LCA studies commissioned by ACE members with European scope. Additionally, publicly accessible LCA reports commissioned by other parties were researched and added to the analysis.

2.2. Methods and results

For the present study, the tasks accomplished can be divided into

1. Meta-analysis of global warming potential in existing LCA studies
2. Analysis of the interpretation of studies which compared beverage cartons to alternative packaging types
3. Investigating the reasons of the global warming potential performance of beverage cartons and identifying improvements leading to a better reflection of beverage carto specific aspects in life cycle assessments

3. LCA META-ANALYSIS

For the LCA meta-analysis, the studies commissioned by ACE and provided to Circular Analytics were analyzed for global warming potential results of beverage cartons and results of alternative packaging if available. To extend the scope, results of further studies were incorporated with the criterion that the LCA study has to be reviewed, thus be either an (i) article published in a peer-reviewed scientific journal ('scientific literature'), (ii) be an LCA report which includes a critical review or (iii) be an environmental product declaration (EPD).

Further, to include the study in the analysis, an individual result for the packaging (in cases where packaging was investigated in combination with its filling good) had to be clearly indicated (or easily derivable) and that the study had to depict the full life cycle of the packaging (including its End-of-Life). The value taken from each study was the Global Warming Potential over 100 years (GWP^{100} in g CO_{2eq}) for 1 liter of packaging or liquid. If the studies did not provide values for 1 liter, the results for the respective volume were scaled accordingly.

For finding and selecting scientific literature, www.sciencedirect.com was used in combination with the keywords (i) lca AND beverage carton (ii) lca AND pet bottle, and (iii) LCA AND glass bottle. Further, snowballing (reviewing the references section of the selected literature) was used to find additional literature missed by the initial review process. In total, 70 GWP^{100} values could be obtained:

- 21 values for beverage cartons
- 25 values for PET bottles
- 13 values for single-use glass bottles
- 11 values for reusable glass bottles

In addition to the GWP^{100} values, information on the type of the respective filling good under study was extracted. In some cases, studies only indicated the filling good as 'beverage' or 'drinks'. Two things should be noted considered the following comparison:

- not all studies indicated if the PET bottles are of mono- or multilayer nature[1], while the functional equivalence to beverage cartons is - more often than not - that of multilayer bottles
- beverage cartons cannot be filled with carbonated beverages or soda

The values extracted from the literature are listed in the following tables (Table 1-Table 4).

[1] To provide high barrier properties, PET bottles for liquids other than water are often comprised of additional barrier layers, such as polyamide (PA), polyvinylidenchloride (PVDC) or plasma-coating (SiOx)

Table 1: Literature for meta-analysis, studies and their results for beverage cartons

Type of study	Study	Initial volume of packaging [liter]	Filling good	GWP100 [g CO_{2eq}]
Scientific literature	[1]	1	Milk	186
	[2]	1	Milk	77
	[3]	1	Milk	34
	[3]	1	Milk (UHT)	67
	[4]	1	Drinks	88
	[5]	1	Milk	104
EPD	[6]	1	Milk (UHT)	160
LCA report	[7]	1	Milk	83
	[8]	1	Milk	Redacted (Study under NDA)
	[9]	1	Milk	64
	[10]	1	Juice	128
	[11]	1	Juice	96
	[12]		Wine	139
	[13]	1	Juice	52
	[13]	1	Milk (UHT)	38
	[13]	1	Milk	22
	[14]	1	Milk (UHT)	75 (median of investigated packaging variations)
	[15]	1	Milk (UHT)	85
	[16]	1	Juice	88
Other	[17]	1	Juice	86
	[17]	0.97	Milk	77
Arithmetic average				87
Standard deviation				40
Median				**83**

Table 2: Literature for meta-analysis, studies, and their results for PET bottles

Type of study	Study	Initial volume of packaging [liter]	Filling good	GWP100 [g CO_{2eq}]
Scientific literature	[18]	1	Beverage	187
	[19]	2	Beverage	45
	[20]	0.5	Juice	224
	[5]	1	Milk	165
	[21]	1	Milk	169
	[22]	0.5	Carbonated soft drinks	174
	[4]	1	Drinks	151
LCA report	[7]	0.5	Juice	160
	[7]	1	Milk	117
	[8]	1	Milk	163
	[23]	1	Soda	Redacted (Study under NDA)
	[9]	1	Milk (UHT)	192
	[13]	1	Juice	167 (mean of packaging variations)
	[13]	1	Milk (UHT)	131
	[13]	1	Milk	134
	[16]	1	Non-carbonated soft drinks	121
	[15]	1	Milk (UHT)	155
	[16]	1	Non-carbonated soft drinks	145
	[10]	1	Juice	156
	[11]	1	Juice	154
	[12]	0.75	Wine	351
	[23]	1	Soda	Redacted (Study under NDA)
EPD	[24]	1.5	Soda	160
	[25]	1.25	Soda	294
Other	[17]	1.23	Juice	106
	[17]	1.33	Soda	87
Arithmetic average				161
Standard deviation				61
Median				**156**

Table 3: Literature for meta-analysis, studies, and their results for single-use glass bottles

Type of study	Study	Initial volume of packaging [liter]	Filling good	GWP100 [g CO_{2eq}]
Scientific literature	[2]	1	Milk	448
	[4]	1	Drinks	176
	[21]	1	Milk	430
	[22]	0.75	Carbonated soft drinks	414
	[26]	0.70	Gin	714
LCA report	[7]	0.5	Juice	548
	[7]	1	Milk	335
	[8]	1	Milk	256
	[16]	1	Non-carbonated soft drinks	295
	[12]	0.75	Wine	1173
EPD	[24]	1	Soda	680
	[25]	0.75	Soda	1173
Other	[17]	0.34	Beer	359
Arithmetic average				529
Standard deviation				302
Median				**430**

Table 4: Literature for meta-analysis, studies, and their results for reusable glass bottles

Type of study	Study	Initial volume of packaging [liter]	Filling good	GWP^{100} [g CO_{2eq}]
Scientific literature	[21]	1	Milk	207
LCA report	[7]	0.5	Juice	138
	[7]	1	Milk	114
	[13]	1	Juice	81
	[13]	1	Milk	98
EPD	[25]	0.92	Soda	254
Other	[17]	1	Juice	78
	[17]	0.47	Carbonated soft drink	96
	[17]	0.84	Soda	86
Arithmetic average				123
Standard deviation				56
Median				**100**

To summarize and to facilitate an easier comparison, the results are presented as a box plot chart as follows (Figure 1):

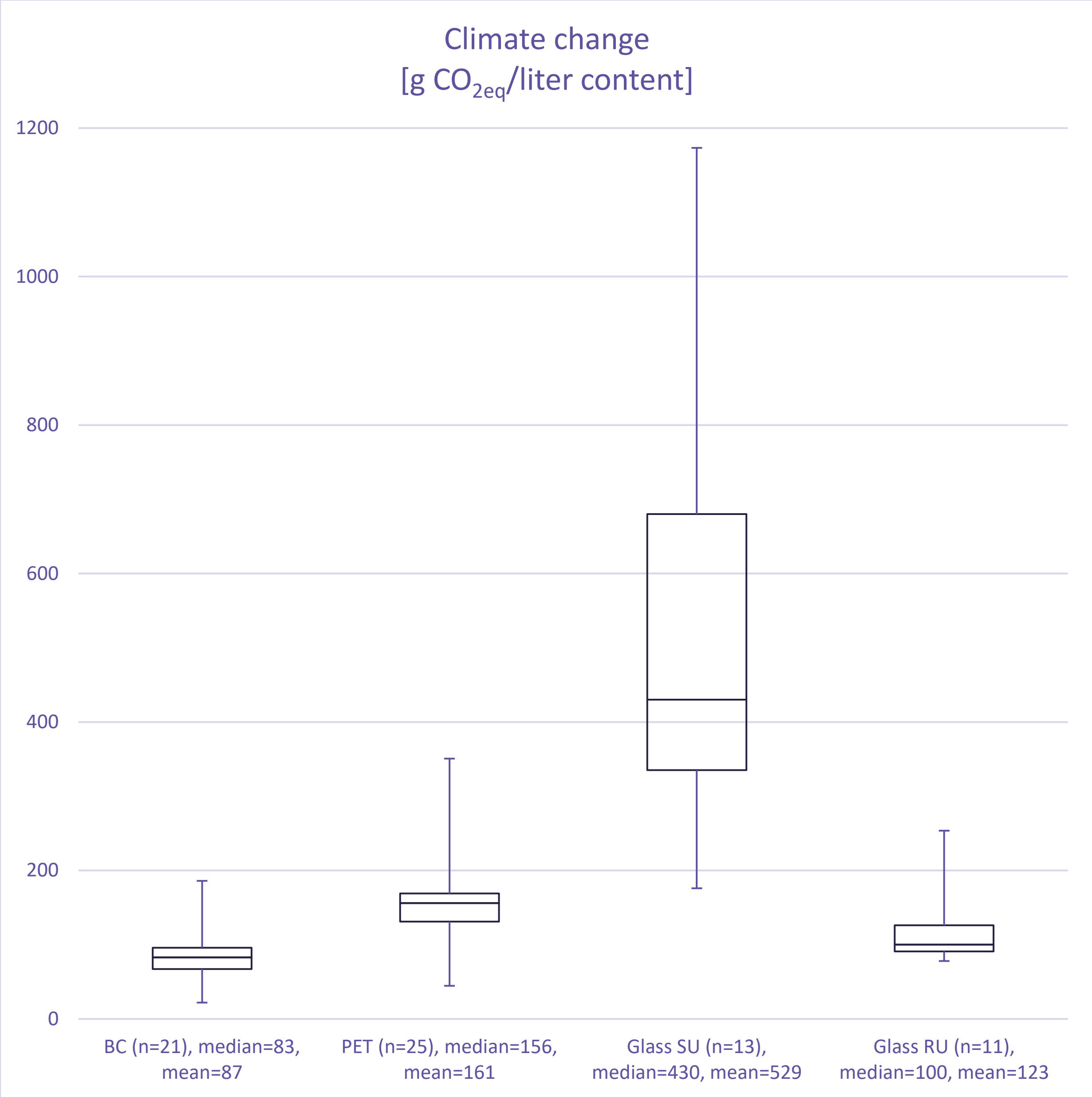


Figure 1: Box plot chart for LCA meta-analysis (BC: beverage carton, Glass SU/RU: glass single use/reusable)

From Figure 1 it becomes apparent, that the median, first and third quartile of global warming potentials for beverage cartons are lower than that of PET bottles and single-use glass bottles. While this also true for the comparison with reusable glass bottles, the difference is substantially smaller. Consequently, GWP^{100} values for the different packaging types were analyzed statistically. Since the extracted values do not fulfill normality, a non-parametric one-way ANOVA (Kruskal Wallis) (Table 5) was used for their comparison, using Jamovi [27] as software for analysis.

Table 5: Results of Kruskal-Wallis test for LCA meta-analysis

Kruskal-Wallis

	χ^2	df	p	ε^2
GWP100	44.1	3	< .001	0.639

As post hoc test, Dwass-Steel-Critchlow-Fligner pairwise comparisons were conducted (Table 6):

Table 6: Results of DSCF pairwise comparison of GWP^{100} values

Pairwise comparisons - GWP100_median

			W	p
BC	PET	PET	6.13	< .001
BC	GLASS_SU	GLASS_SU	6.79	< .001
BC	GLASS_RU	GLASS_RU	3.23	0.102
PET	GLASS_SU	GLASS_SU	6.68	< .001
PET	GLASS_RU	GLASS_RU	-3.42	0.073
GLASS_SU	GLASS_RU	GLASS_RU	-5.69	< .001

From the statistical analysis (Table 6), similar conclusions to that from Figure 1 can be derived, namely that beverage cartons have, on average, a statistically significant lower GWP^{100} than that of PET bottles (median: -47%) and single-use glass bottles (median: -80%). While both mean and median of beverage cartons are lower than that of reusable glass bottles, the difference is not statistically significant (p=0.102), mostly resulting from the small sample size of reusable glass bottles GWP^{100} values.

It should be noted that the outcome of LCA studies is highly susceptible to several parameters, depending on the products or the scope itself (time and geographic scope, transport distances, End-of-Life scenarios, and many more) or the personal choice of the LCA practitioner (methodology, assumptions, and many more). Hence, while the above-mentioned results allow the interpretation that '***on average**, the global warming potential is lower than that of single-use PET bottles and single-use glass bottles*', this does not automatically translate to being true in every single case. Hence, the analysis was extended with an analysis of comparative LCA studies of beverage packaging.

4. ANALYSIS OF COMPARATIVE LCA STUDIES

To further support the results from the meta-analysis, the selected studies which include a comparison of GWP^{100} values for beverage cartons to alternative packaging were used to create a comparison chart. In this chart, every significant difference (> 10%) of GWP^{100} values between beverage cartons were highlighted as either (i) green (beverage cartons had a carbon footprint lower than 10% compared to alternative packaging), (ii) yellow (difference smaller than 10%), or (iii) red (beverage cartons had a carbon footprint greater than 10% than alternative packaging). A distinction was made between PET mono and multi-layer bottles.

The final table is presented as follows (Table 7):

Table 7: Evaluation matrix of comparative LCA studies (BC: beverage carton, Glass SU/RU: glass single use/reusable)

Study	Product	BC vs. PET SU MONO	BC vs. PET SU MULTI	BC vs. GL-SU	BC vs. GL-RU
[15]	Milk	-	better	-	-
[28]	Liquid food	better	better	-	-
[29]	Retorted food	-	-	better	-
[30]	Juice	better	-	better	-
[30]	Milk	better	-	-	better
[31]	Juice	-	-	better	-
[8]	Milk	better	-	better	better
[2]	Milk	-	better	better	-
[9]	Milk	better	-	-	-
[10]	Juice	better	-	-	-
[4]	Beverage	better	-	better	-
[32]	Long-life food	-	-	better	-
[33]	Wine	-	better	better	-
[16]	NCSD	better	better	-	better
[12]	Wine	-	better	better	-
[7]	Milk	better	-	-	-
[34]	Milk	-	better	-	-
[13]	Juice/Milk	better	better	-	-

It is important to repeat that the functional equivalence to beverage cartons is that of multilayer PET bottles. Concerning reusable glass bottles, it should be noted that those are only present in a minority of European countries, representing only a small market volume. Thus, the choice for a consumer is usually only that of different single-use packaging systems.

5. FURTHER ENVIRONMENTAL BENEFITS OF BEVERAGE CARTONS

To better understand, why the beverage cartons has a superior environmental performance compared to alt packaging, the following criteria can be identified.

5.1. Packaging efficiency

One of the key reasons for the low carbon footprint of the beverage carton is its high packaging efficiency, meaning that only low quantities of packaging material are required for packing a product. An evaluation of the amount of packaging material was To compare the packaging efficiency between the types of packaging under study, a meta-analysis similar to the LCA meta-analysis (section 3, p.8) was conducted. For this, packaging mass of 1-liter packaging listed in studies in Table 1 to Table 4 were extracted.

To increase the sample size, product catalogues from glass [35,36] and PET preform/bottle manufacturers [37–42] were used. The total mass of primary packaging per liter beverage includes the mass of the base material, as well as that of (ii) closures, sleeves, labels, and other packaging aids. Since the product catalogues for PET and glass bottles only gave information on the mass of the base material, these values were complemented with the average mass of caps and aids (median) calculated from those studies that indicated those separately.

The results are depicted as a boxplot chart in Figure 2:

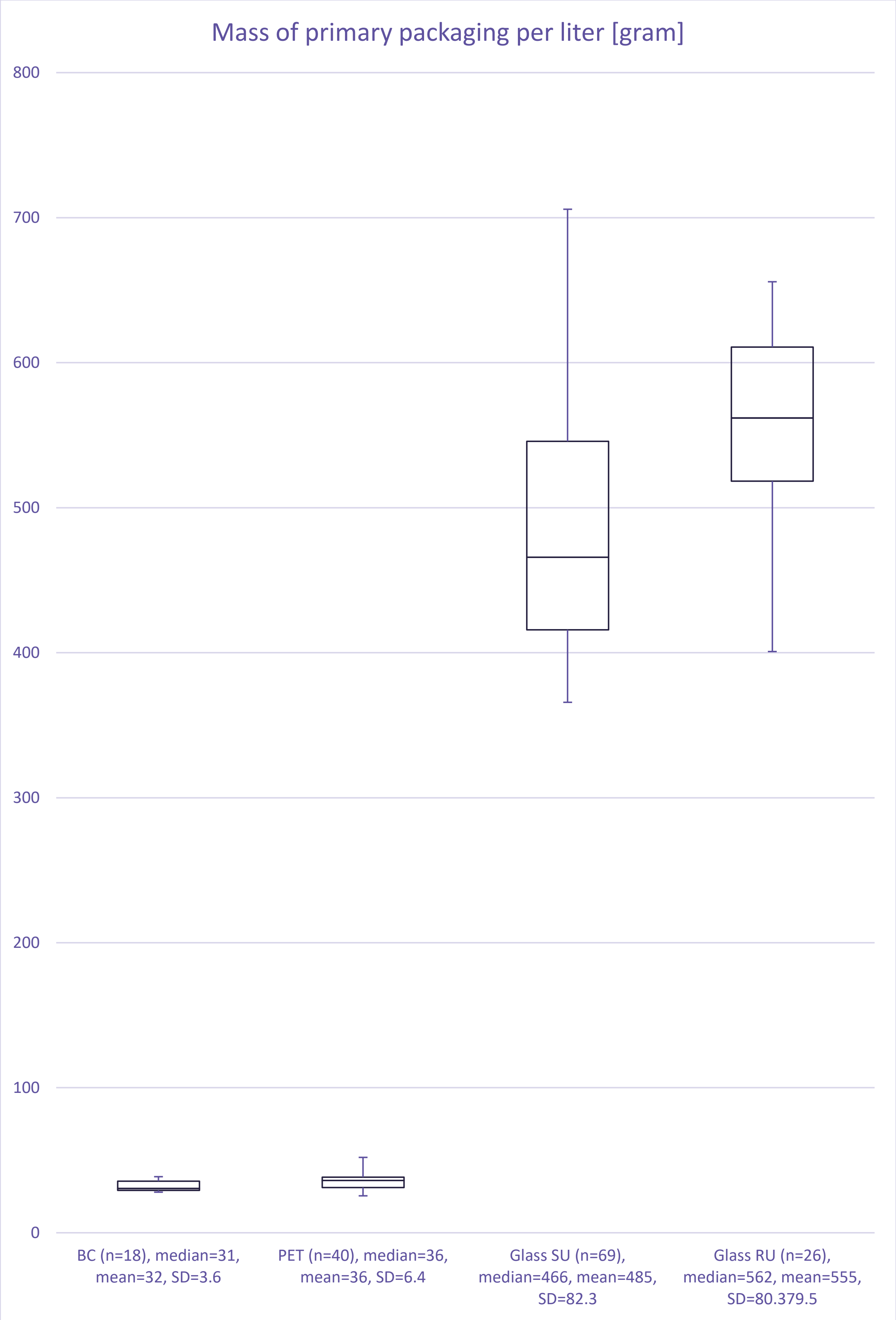


Figure 2: Boxplot chart of packaging mass per liter beverage (BC: beverage carton, Glass SU/RU: glass single use/reusable)

It is obvious from Figure 2 that beverage cartons and PET bottles have a substantially greater packaging efficiency than glass bottles. The average (median) packaging mass of beverage cartons with a size of 1 liter is 31 g, compared to 36 g for PET bottles, 466 g for single-use and 562 g for reusable glass bottles. To further analyze the comparison, particularly between beverage cartons and PET bottles, the results were statistically analyzed. Since the extracted values do not fulfill normality, a non-parametric one-way ANOVA (Kruskal Wallis) was used (Table 8):

Table 8: Kruskal-Wallis test for packaging efficiency results

Kruskal-Wallis

	χ^2	df	p
Mass	114	3	< .001

As post hoc test, Dwass-Steel-Critchlow-Fligner pairwise comparisons were conducted (Table 9):

Table 9: DSCF pairwise comparisons for packaging efficiency results

Pairwise comparisons - Mass

		W	p
BC	PET	3.45	0.07
BC	GLASS_SU	9.2	< .001
BC	GLASS_RU	7.96	< .001
PET	GLASS_SU	12.27	< .001
PET	GLASS_RU	9.76	< .001
GLASS_SU	GLASS_RU	5.04	0.002

As expected from Figure 2, the difference between all types of packaging is significant ($p<0.05$) except between beverage cartons and PET bottles ($p=0.07$).

A low packaging to product mass ratio is not only good itself is one of the key reasons for the environmental performance, not only leading to a reduced use of resources but only a lower transport intensity (see section 5.2).

5.2. Transport efficiency

Resulting from its packaging efficiency, less trucks must be placed on the road to transport beverages or liquid food when using beverage cartons instead of glass bottles. Assuming a truck of 22 tons payload and an example of milk, the amount of transported milk per truck can be calculated as follows (Table 10):

Table 10: Calculation example of transport efficiency for milk in beverage cartons and alternative packaging (lower bound: first quartile, upper bound: third quartile)

Packaging mass per liter milk, in gram	Beverage cartons, lower bound	Beverage cartons, upper bound	PET bottles, lower bound	PET bottles, upper bound	Glass bottles, lower bound (single-use)	Glass bottles, upper bound (reusable)
Primary packaging	29	36	31	38	416	611
Secondary packaging[2]	20	27	20	27	20	183
Milk	1 035	1 035	1 035	1 035	1 035	1 035
Payload (minus mass of 30 pallets)	21 250 000	21 250 000	21 250 000	21 250 000	21 250 000	21 250 000
Liter of milk per truck	**19 606**	**19 359**	**19 567**	**19 324**	**14 446**	**11 616**

Compared to glass bottles, the use of beverage cartons facilitates loading a truck with 25% to 41% more milk, while there is no significant difference for the comparison with PET bottles.

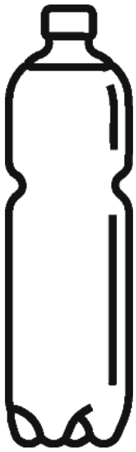
[2] Mass of secondary packaging for single-use systems in literature were found to be between 120 and 160 g for a tray of 6 pieces of primary packaging. Secondary packaging for the reusable glass bottle was assumed to weigh 1 100 g for 6 bottles.

5.3. Reduced plastic consumption

An increasing number of EU member states, as well as retailers, set goals for the reduction of plastic packaging. This led to the fact that the amount of plastic in packaging is now a key performance indicator in several countries and sectors. While e.g. PET bottles are comprised of 100% plastic, beverage cartons are mainly made from wood fibers, requiring only a plastic liner. In most cases, beverage cartons use a plastic cap in addition. However, the plastic liner as well as the cap can be produced from bio-based raw materials such as sugarcane or tall oil. Thus, beverage cartons have a high share of renewable material already and can be manufactured with materials of 100% biogenic origin.

The Single Use Plastics Directive by the European Union set the mandatory goal that PET bottles must meet a 90% collection rate by 2029 in every member state. If more bottle are recycled, then the increased volume of recycled materials could help reduce the production of new plastic, which could lead to a reduced plastic consumption overall. While it is not yet clear if the 90% collection rate can be met, it is important to consider that even if 90% of all PET bottles will eventually be collected, this would not automatically result in the production of 90% recycled materials. According to a report by Deloitte [43], the assumption of a 90% pre-treatment and a 78% recycling efficiency by 2030 is plausible, leading to a recycling output rate of 63% for a 90% collection rate. Depending on the mass of a PET bottle, this will result in a plastic consumption of 11 to 14 g per liter (Figure 3)[3], more than beverage cartons which require between 5 and (maximum) 12 g of plastic per liter (Figure 4).

[3] Not considering a reduction of the average mass of a PET bottle by 2030



90%

Collection by 2030

PET bottle
(mass: upper bound)

38 g total

-24 g recycled material

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14 g plastic consumption

per liter

PET bottle
(mass: lower bound)

31 g total

-20 g recycled material

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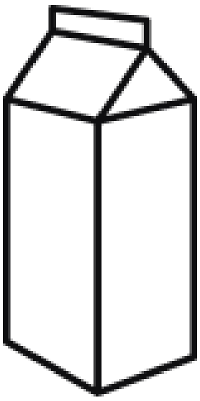
11 g plastic consumption

per liter

Figure 3: Plastic consumption of PET bottles



Beverage carton

29-36 g mass (incl. cap)

Fibre content: 70-90%

5-12 g plastic consumption

per liter

Figure 4: Plastic consumption of beverage cartons

5.4. Use of biogenic resources

A typical beverage carton consists of liquid packaging board (LPB), polyethylene, and in the case of aseptic packaging, of aluminum. Fibers for LPB are sourced from wood from sustainably managed forests, ensuring sustained yields. Moreover, LPB is not produced using primary pulpwood, thus not directly responsible for the extraction of wood mass from forests. Instead, the production of LPB is supporting a cascading use of wood by using by-products from the timber industry or wood from thinning forests. Yet, countries were wood products for LPB are procured from see a growth of wood mass year after year. As a result, the storage of carbon increases. Yet, in the majority of LCA studies on beverage cartons, an allocation of forest land use or wood mass (meaning attributing only a share of the total land use) is omitted.

Yet, to better understand the theoretical magnitude of the use of biotic resources for beverage cartons, official data on wood extraction and growth from FAOSTAT were combined with (estimated) market data on beverage cartons and their recycling rate.

With the estimate of 1 million tons of beverage cartons placed on the EU-28 market (no change of production volume over the years was known) and an average fiber content of 70%, 700 000 tons of fibers are used every year for this type of packaging. Using the value provided in Ecoinvent of 2.85 kg wood per kg liquid packaging board[4], this results in approx. **2 million tons** of wood which are required for its production. However, it should be emphasized again that this approach heavily and arguably unfairly disadvantages beverage cartons, since LPB is made from wood from forest management practices and by-products of the timber industry.

Finally, 49% of all beverage cartons are sent to recycling plants, where around 275 000 tons of fibers are recovered and placed on the market again.

Using the share concerning the countries of origin for wood provided by the suppliers of LPB, the following chart (Figure 5) was derived:

[4] This value seems too high and implausible; however, no other value could be found according to one supplier. Average densities of 650 kg/m³ for hard wood and 450 kg/m³ for soft wood were used for converting wood given in volume to wood mass. Carbon content of wood was assumed to be 50% for the conversion of carbon stock to wood mass.

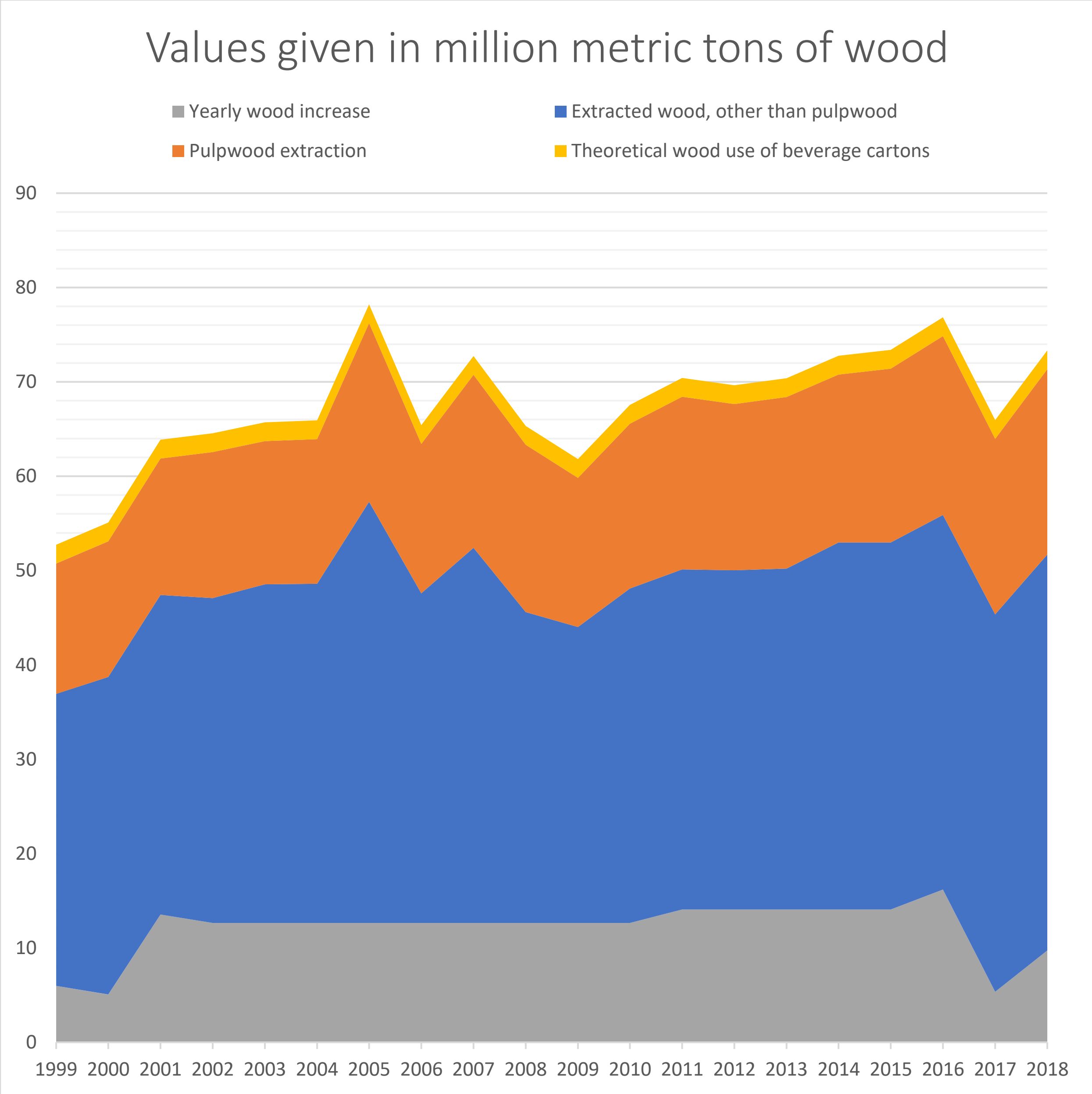


Figure 5: Extraction and growth of wood in forests of selected countries. Comparison of extracted wood, extracted wood for the pulp and paper industry, the theoretical wood consumption of beverage cartons and the surplus of wood each year after extraction

Compared to the total wood mass standing, the theoretical wood use for beverage cartons is 0.017%. Substantially more wood grows back each year than is theoretically required for liquid packaging board, amounting to 4.3% (or 3.0% considering the recycling of beverage cartons) compared to the wood mass which is put on top of the standing wood mass.

6. CONCLUSION

Deriving from the results of the LCA meta-analysis, as well as the interpretation of the comparison of the investigated comparative studies, the authors found strong supporting evidence of a superior performance concerning the global warming potential of beverage cartons compared to alternative packaging types. The median values of all studies included in the meta-analysis yielded median values as follows.

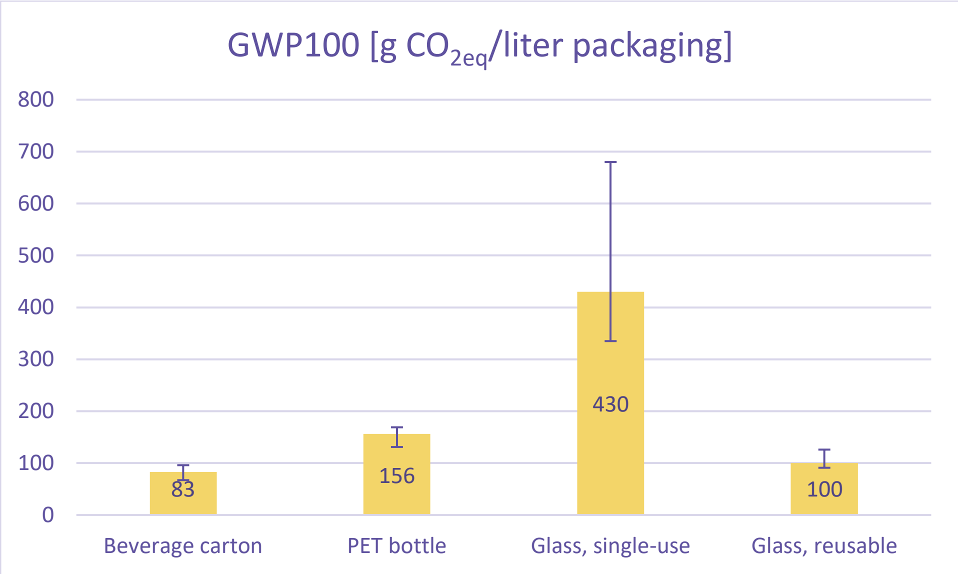


Figure 6: Global warming potential over 100 years for the containment of 1 liter liquid. Results taken from meta-analysis as depicted in Section 3. Bars represent median values, while error bars represent the first and third quartile respectively.

The superior performance of the beverage cartons is a result of its packaging and transport efficiency, as well as the fact they are mainly comprised of a renewable material. The methodology for modelling biogenic carbon, the assumption of recyclability, recycling rates and many more study parameters varied greatly. Nonetheless, the superiority of beverage cartons concerning their global warming potential is significant compared to that of PET and single-use glass bottles. While mean and median value of the global warming potential for the beverage carton were lower compared to the reusable glass bottle, the difference is not significant due to the small number of studies investigating the latter packaging system. However, the evaluation of comparative LCA studies (see section 4, p. 15) gives further indication that beverage cartons have a superior global warming potential than reusable glass bottles.

Moreover, only few reusable glass bottle systems exist on today's markets in Europe, thus their market relevance is low. In practice, a consumer has to the choice of products being packed in different types of single use packaging, for which products packed in beverage cartons should be preferred. Presumably, this may also be true for the choice between products packed in beverage cartons or reusable glass bottles, but more studies investigated the latter would have to be conducted for a sound and scientifically accurate argument.

Additionally, several limitations in the available LCA studies could be identified, such as the choice of modelling biogenic carbon or land use, as well as generation of energy for/in the production of LPB. Concerning recommendations for future LCA studies of beverage cartons, more focus should be put on the correct modelling of biogenic carbon and forest occupation. Further, the high share of biogenic resources should be considered when modelling the energy consumption of LPB production. Finally, the global warming potential of beverage cartons would improve even further if the sourcing of wood, from either forest management practices (such as thinning) or by-products from the timber production, were reflected more accurately in a broader range of studies.

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ANNEX – COMMUNICATION MEDIA

In the course of the project, sketches were produced to illustrate a possible communication to interested parties. These sketches could be used as a basis for graphically and verbally refined communication media, such as presentations, folders, or websites.

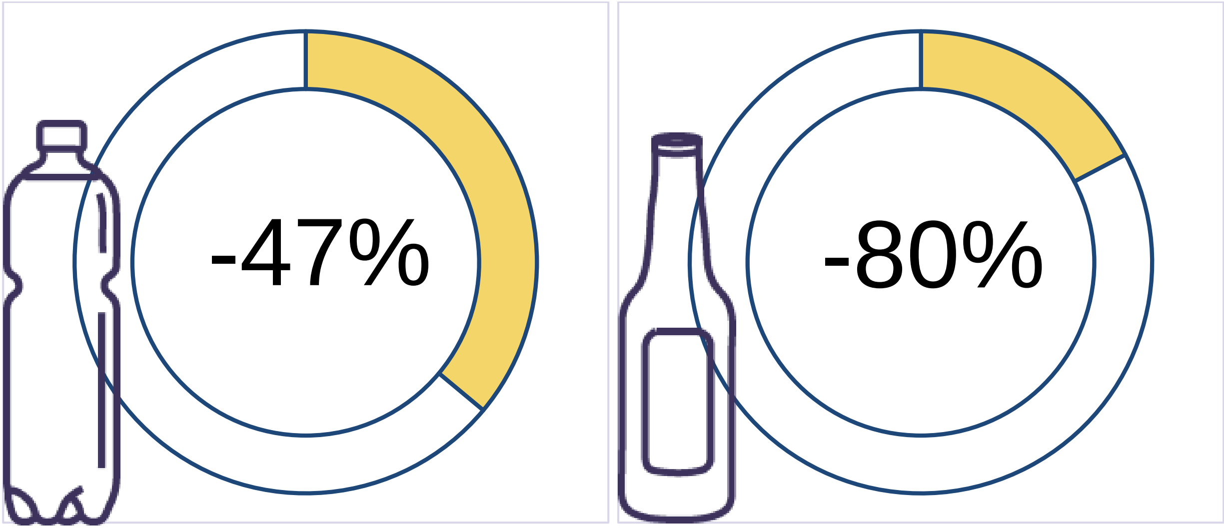
Products are linked to global warming

In the manufacturing process of a product, the emission of greenhouse gas emissions is unavoidable. Resources are consumed, fuels are burned.

Using a method such as life cycle assessment, the footprint left on the planet by a product can be quantified.

Less carbon

The beverage carton has a lower global warming potential in comparison to every other single use packaging. While they are similarly as good as reusable glass bottles, they save on average[5]:



Compared to PET bottles

Compared to single-use glass bottles

[5] Results of LCA meta-analysis

Protection of goods

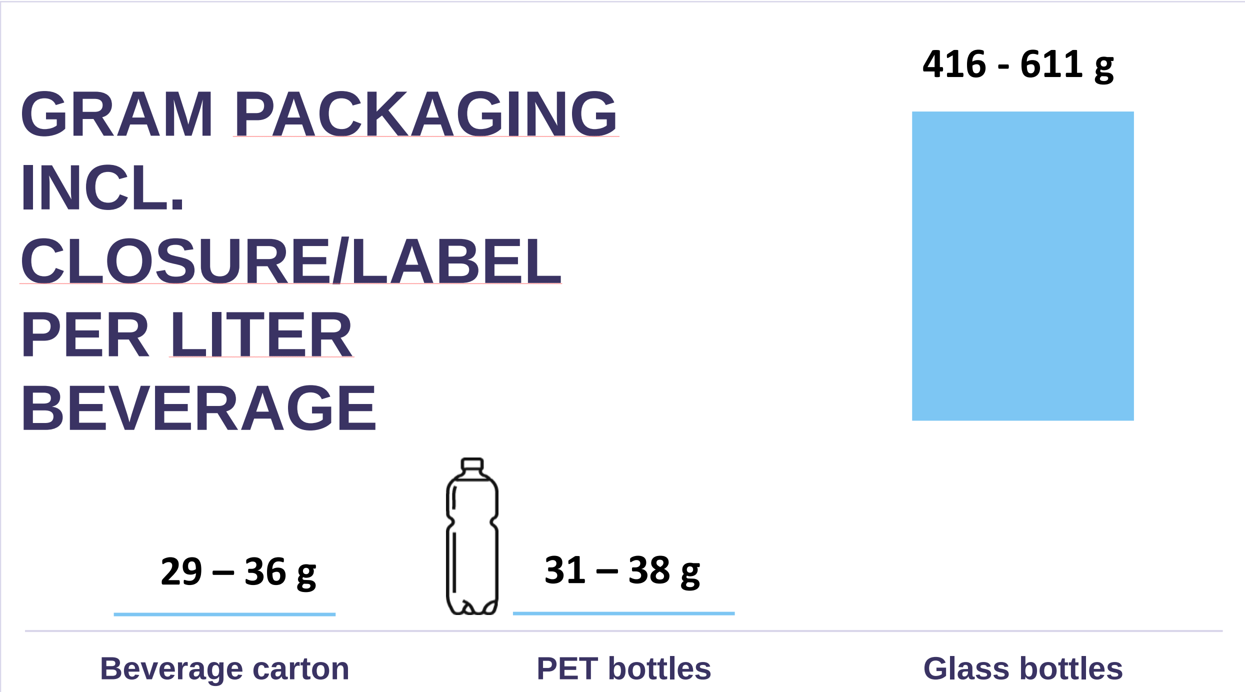
Compared to milk[6], the global warming potential of beverage cartons is very small. For the global warming potential of 1 liter milk, 14 beverage cartons can be produced and disposed of. Good thing that beverage cartons have great protective properties, thus enabling a long shelf life and minimizing food loss and waste.

[6] 1 kg milk (exkluding packaging) 44: 1240 g CO_{2eq}

4 REASONS FOR THE LOW GLOBAL WARMING POTENTIAL OF BEVERAGE CARTONS

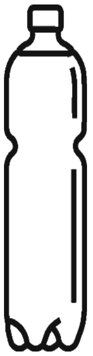
1. Packaging efficiency

The great environmental performance of beverage cartons has several reasons. For once, the beverage carton is very efficient and requires only low amounts of packaging material.



2. Plastic reduction

Beverage cartons are less dependent on plastic. Even if 90% of all PET bottles are collected eventually, they will still consume more plastic compared to beverage cartons.



90%

Collection by 2030

Heavy PET bottle

38 g total

-24 g recycled material

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14 g plastic consumption

Lightweight PET bottle

31 g total

-20 g recycled material

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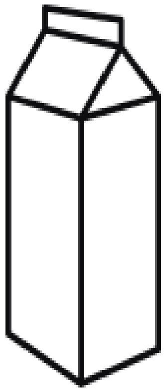
11 g plastic consumption



Beverage carton

5-12 g plastic consumption

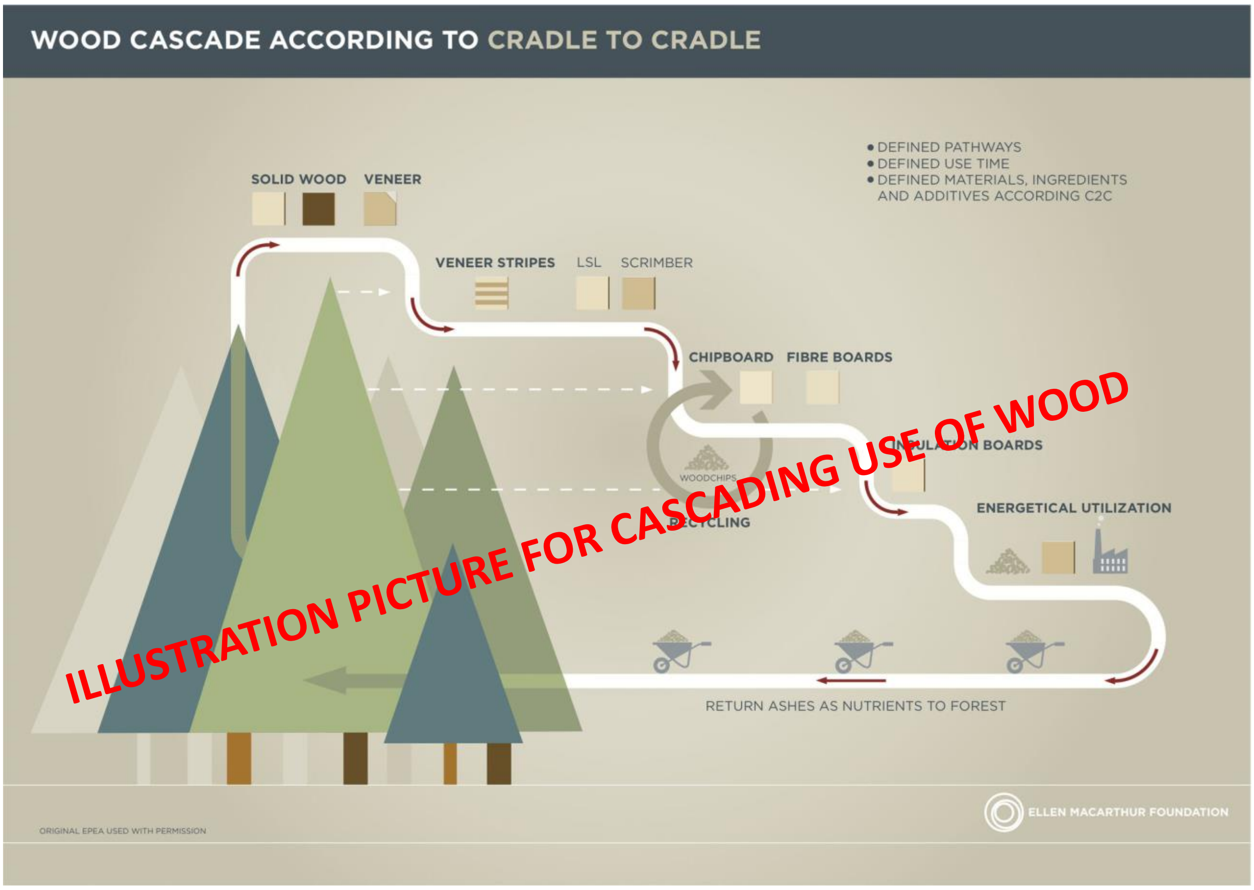
3. Transport efficiency

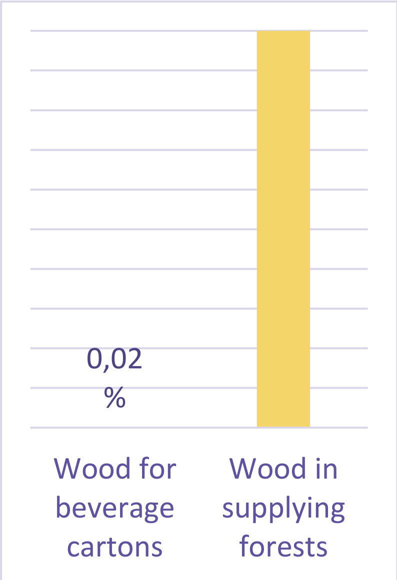
Resulting from its great packaging efficiency, more beverage can be loaded onto a truck using a beverage carton, which in turn leads to a reduction of trucks on the road[7].

[7] Averages of upper and lower bounds

4. Renewability and circularity

The cardboard in beverage cartons is made from wood, a renewable resource which stores removes carbon from the air. Furthermore, in a circular economy, focus should be put on the cascading use of wood. This is already practice for beverage cartons since they only use residual wood in their production.





This wood only comes for sustainably managed forests, meaning that in the same period of time more wood grows back than has been removed. Substantially more wood grows back each year than is theoretically required for liquid packaging board, amounting to 4.3% (or 3.0% considering the recycling of beverage cartons) compared to a wood mass which is put on top of the standing wood mass.

Compared to the total wood mass standing, the theoretical wood consumption for beverage cartons is only a fraction.