The carbon footprint of delivering beer to a bar

A comparison of the carbon footprints of various packaging methods, considering the complete chain, producing the packaging, filling, transporting and dispensing

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Abstract

In this whitepaper, we compare the carbon footprint of all major packaging methods from the brewery to the glass, though some packaging methods (such as cans) are not commonly used in bars.

Calculation method

The calculation of the carbon footprint of the production of the packaging is based on the energy needed to produce the main material used. For packaging options that are used multiple times, such as bottles and kegs, the footprint is divided by the number of times the packaging can be reused.

The current average rate of recycling of different materials is taken into consideration to determine the realistic effect on the carbon footprint.

We also have taken into account the carbon footprint of cleaning and filling the packaging and dispensing the beer. This is based on the amount of energy needed to clean the packaging and the amount of CO_2 used during filling and dispensing.

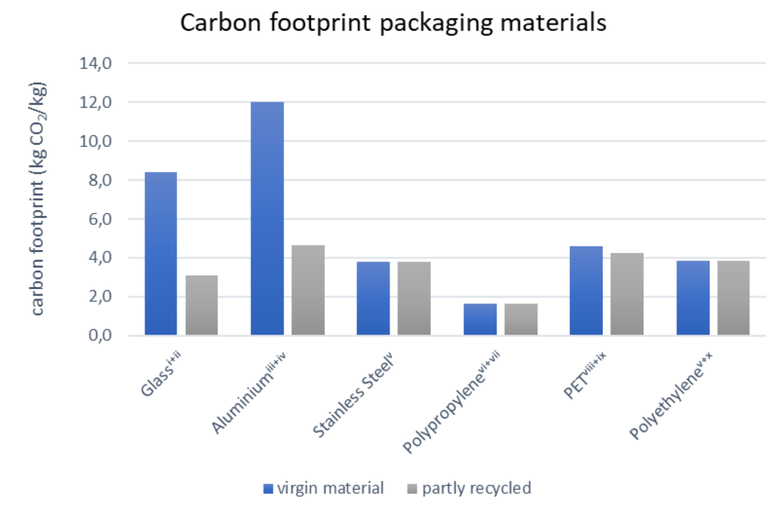
For transportation, we consider the weight of the packaging and, when applicable, the weight of the delivery installation (in case of a tank beer truck). In the calculation, we also consider the weight of the one-way packaging as a return load for the truck, since these materials need to be transported to be recycled as well.

Carbon footprint of the materials used and recyclability

Currently, only glass, aluminium, stainless steel and a part of the PET bottles are really recycled. The standard stainless-steel production already uses 50% scrap metal, so there is no difference between virgin and recycled stainless steel. A lot of plastics are collected as a separate waste stream but are mixed during collection or consist out of different layers of plastic. Therefore, at the moment most of these plastics are not recycled but incinerated.

At the beginning of 2020 a project was launched to completely recycle the plastic bags used in tank beer systems instead of incinerating them.

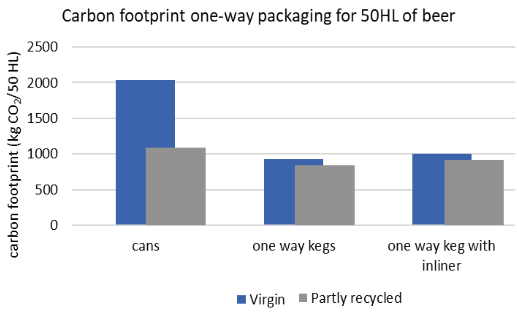
The carbon footprint of the packaging is based on the amount of energy required to produce the different materials (virgin material and partly recycled):

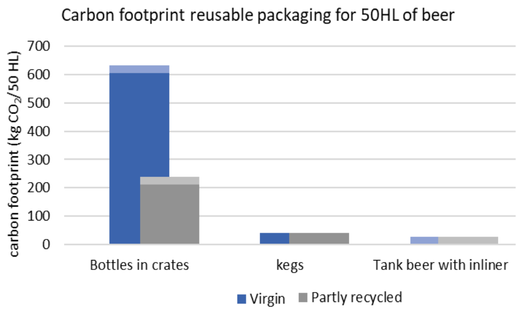


Production of the packaging

There is a big difference in the carbon footprint of reusable packaging methods and one-way packaging methods. The carbon footprint of one-way packaging is up to 5 times larger than that of reusable packaging.

The bag-In-tank system is a combination of both. This is a reusable tank with a one-way plastic bag, called an inliner. Due to this inliner, the tank does not need to be cleaned. Since very little one-way material is used, in comparison to other packaging methods, the carbon footprint is also relatively small.

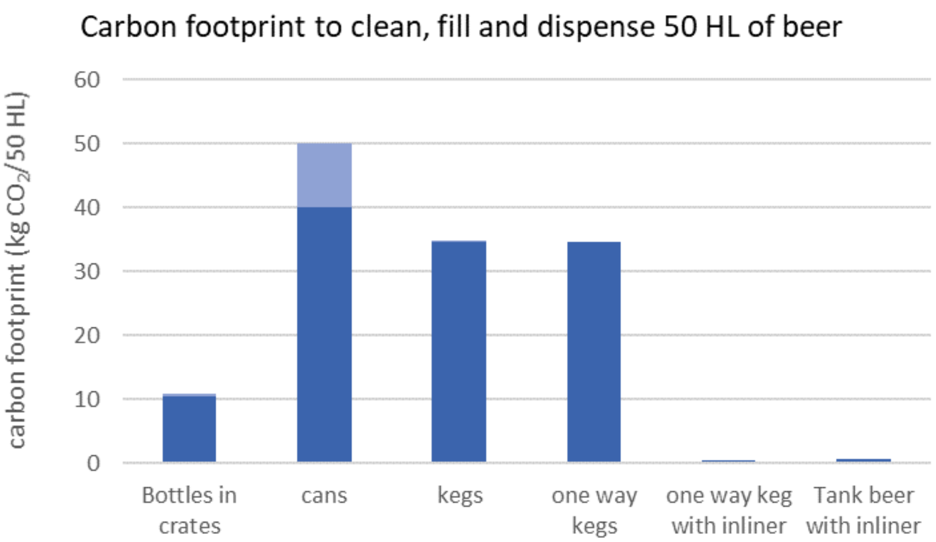




Carbon footprint of filling, cleaning and dispensing

The carbon footprint of cleaning, filling and dispensing is based on the amount of energy used and CO_2 (if applicable) required during filling. The energy or CO_2 needed to dispense the beer is also considered. The carbon footprint of energy is based on the average resources used in Europe.

The difference in the carbon footprints of the filling of different types of packaging is mainly due to the added CO_2. Cans need to be flushed with CO_2 during filling. Therefore, their carbon footprint is much higher than that of bottles. Kegs have an even larger footprint than bottles because CO_2 is also added to dispense the beer. Both the one-way kegs and the tank beer system with inliners use compressed air and therefore have a much smaller carbon footprint.



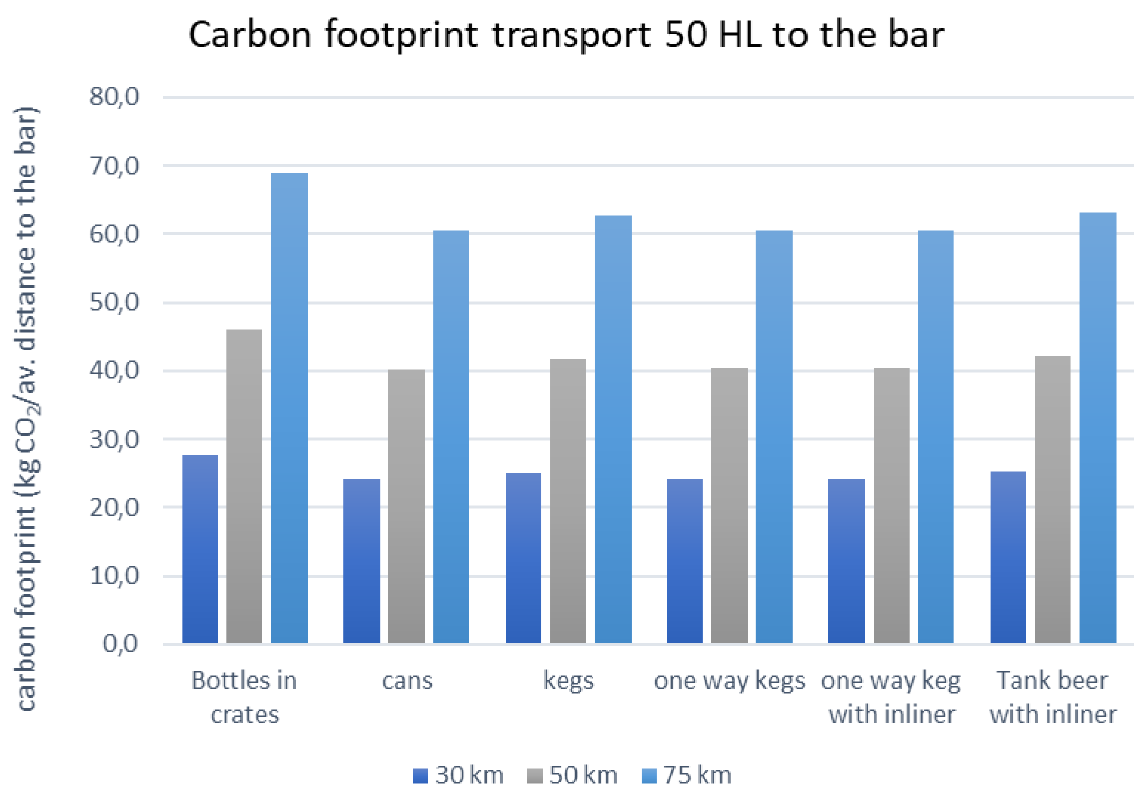
Transport to and from the bar

The carbon footprint of delivering beer to the bar depends on the weight of the beer and packaging that needs to be moved. The more weight, the higher the fuel consumption of the truck and the larger the carbon footprint.

To calculate the carbon footprint, we used the bottom-up emission calculation method developed by the Dutch research organization TNO. It is calculated with full packaging from the brewery to the bar and empty packaging on the way back. The calculation is made for three different average distances from the brewery to the bar: 30, 50 and 75 km.

The difference in the carbon footprint is limited because the packaging is only a small percentage of the total weight. The footprint for bottles is slightly larger because here the packaging weight is much higher. Although the packaging weight of tank beer is low, the weight of the delivery installation to deliver tank beer reduces this advantage.

If a lightweight beer delivery truck (*see case study Heinekens' lightweight beer delivery truck for Utrecht inner-city*) is used, the carbon footprint of beer delivery can be reduced by 30%.

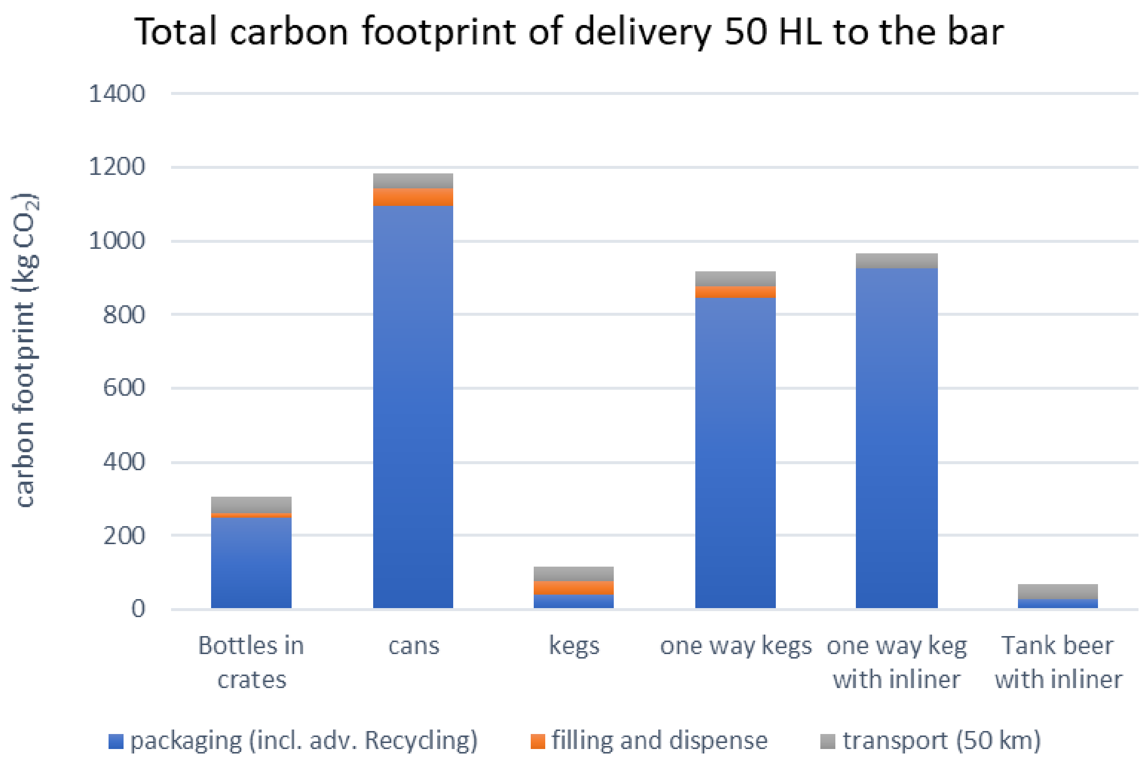


Total carbon footprint

The production of the packaging has the biggest influence on the carbon footprint of the packaging. Therefore, reused packaging has a much smaller footprint.

The second biggest influence on the carbon footprint is the use of CO_2 to fill and dispense beer. Especially with kegs, this is approximately 30% of the total footprint. Here one-way kegs with inliners and tank beer have a big advantage because compressed air is used instead of CO_2.

Tank beer has the smallest carbon footprint. It's footprint is 4.4 times smaller than that of bottles and 13 to 17 times smaller than that of single-use packaging.



"Tank beer has the smallest footprint!"

"We must remember our duty to nature and reduce our CO_2 footprint."

Hop plant – main ingredient of a quality beer

What do we compare?

In this whitepaper, we compare the carbon footprint of all major packaging methods from the brewery to the glass, though some types of packaging (such as cans) are not commonly used in bars. We look at the footprint of producing, filling, transporting and serving beer. We also take into account the influence of recycling on the carbon footprint.

Calculation method

To make a uniform calculation, we consider the amount of packaging needed for a volume of 50 HL.

The calculation of the carbon footprint of the production of the packaging is based on the energy needed to produce the main material used. For packaging methods that are used multiple times, such as bottles and kegs, the footprint is divided by the number of times the packaging can be reused.

The current average rate of recycling of different materials is taken into consideration to determine a realistic carbon footprint.

We have also considered the carbon footprint of cleaning and filling the packaging and dispensing the beer. This is based on the amount of energy needed to clean the packaging and the amount of CO_2 used during filling and dispensing.

For transportation, we consider the weight of the packaging and, when applicable, the weight of the delivery installation (in case of a tank beer truck). In the calculation, we also consider the weight of the one-way packaging methods as a return load for the truck, since these materials need to be transported to be recycled.

Figurative image of a carbon footprint

To be able to compare the packaging itself, we unified the influence of the transport solutions. Bottles and cans, for instance, can be delivered through many different supply chains. Kegs can go directly from the brewery or through a distribution centre. Tank beer normally goes directly from the brewery to the bar. For the comparison, we will assume that all the packaging options go directly from the brewery to the bar, and empty packaging goes back to the brewery. For re-usable packaging, this is necessary, but for single use it is not. However, it does have to be shipped to a recycling company and in this model this is considered to be the same distance as to the brewery.

Production of the packaging

Carbon footprint of virgin and recycled materials

The carbon footprint of the packaging is based on the energy needed to produce the different materials (virgin material and partly recycled):

Glass

Virgin material has a carbon footprint of 8.4 kg CO_2 per produced kg.[i]

In 2017, 76% of all glass in Europe was recycled.[ii] The carbon footprint of 100% recycled glass is 1.4 kg CO_2 per kg. Based on 76% recycled material, the carbon footprint of recycled glass is 1.4*76% + 8.4*24% = 3.1 kg CO_2 per produced kg.

Aluminium

Virgin material has a carbon footprint of 12 kg CO_2 per produced kg.[iii]

In 2019 74.5% of all cans in Europe were recycled.[iv] The carbon footprint of 100% recycled aluminium is 2.1 kg CO_2 per kg. Based on 74.5% recycled material, the carbon footprint of recycled aluminium is 2.0*74.5% + 12*25.5% = 4.6 kg CO_2 per produced kg.

Stainless steel

Stainless steel has a carbon footprint of 3.78 kg CO_2 per produced kg.[v]

Although 90% of the stainless steel is recycled, to make stainless steel, a maximum of around 50% scrap is added. The carbon footprint of stainless steel is therefore already based on partial use of recycled material.

Polypropylene

Virgin material has a carbon footprint of 1.63 kg CO_2 per produced kg.[vi]

Although polypropylene is very often used and is a very recyclable plastic, only 1%[vii] of the polypropylene is actually recycled. This is because the majority of pp is not yet collected separately. The carbon footprint of 100% recycled polypropylene is 0.45 kg CO_2 per kg. Based on 1% recycled material, the carbon footprint of recycled polypropylene is 0.45*1% + 1.63*99% = 1.62 kg CO_2 per produced kg.

PET

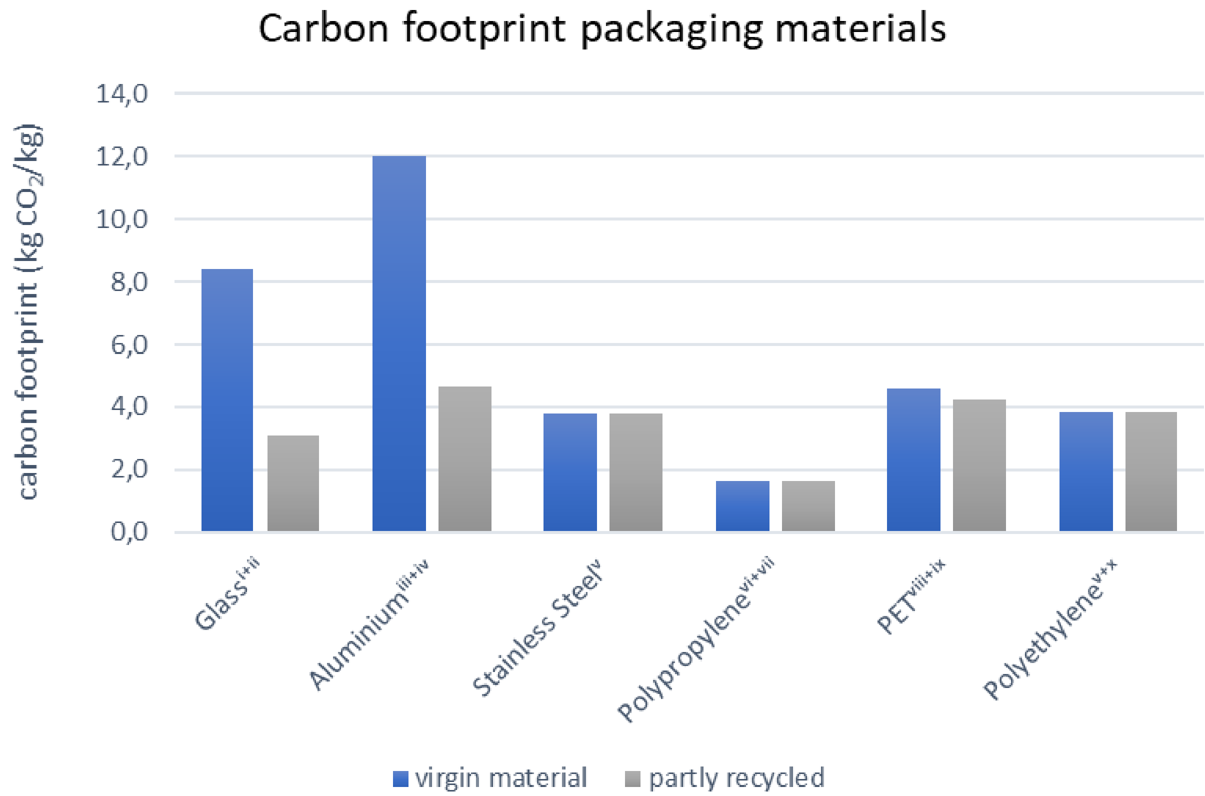
Virgin material has a carbon footprint of 4.62 kg CO_2 per produced kg.[viii]

Although the targets in Europe for recycling PET bottles are very high, currently only around 11%[ix] of the PET bottles are recycled. A large part is still collected as part of the mixed plastics waste stream. The carbon footprint of 100% recycled PET is 1.0 kg CO_2 per kg. Based on 11% recycled material, the carbon footprint of recycled PET is 1.0*11% + 4.62*89% = 4.2 kg CO_2 per produced kg.

Polyethylene

Virgin material has a carbon footprint of 3.83 kg CO_2 per produced kg.[v]

Polyethylene is commonly used to package foodstuffs and for plastic bags. To package foodstuffs, multi-layered plastics are often used. These have an EVOH barrier or aluminium layer to prevent oxygen from penetrating through the package. These plastics are collected as mixed plastics[x] together with one-way PET bottles, plastic bags and foodstuff packages. Currently, this plastic stream is incinerated and not recycled. Therefore, in this calculation we only consider virgin materials.



Carbon footprint per packaging

The carbon footprint per material combined with the weight of the packaging gives a good overview of the CO_2 released during production.

BOTTLES + CRATE 250.5 kg CO_2 per 50 HL

- The weight of a bottle is based on a German NRW bottle of 0.5 litres, 0.36 kg.
- The packaging weight of 50 HL in bottles is 50 HL/0.5 L = 10,000 x 0.36 kg = 3600 kg.
- A bottle can be reused 50 times.[xi]
- The carbon footprint of bottles of virgin material is (3,600*8.4)/50 = 604.8 kg CO_2.
- Taking into consideration the current recycling ratio of glass, the carbon footprint is (3600*3.1)/50 = 221.8 kg CO_2.
- A crate is usually made of polyethylene and the weight is 2 kg (20 bottle crate). The packing weight for crates to support 50 HL of beer is 50 HL/0.5 L/20*2 kg = 1000 kg.
- If 0.5-1% is not reusable due to damage, theft etc., the average carbon footprint for crates is 1,000*3.8*0.75% = 28.7 kg CO_2.

CANS – 1,096 kg CO_2 per 50 HL

- The weight of a 0.5-litre can is 0.017 kg.
- The packaging weight of 50 HL in cans is 50 HL/0.5 L = 10,000*0.017 kg = 170 kg.
- The carbon footprint of virgin material is 170*12 = 2,040 kg CO_2.
- Taking into consideration the current recycling ratio of aluminium, the carbon footprint of cans is 170*4.6 = 1,096 kg CO_2.

STAINLESS-STEEL KEG - 41 kg CO_2 per 50 HL

- The weight of a 50-litre keg is 13 kg.[xii]
- The packaging weight of 50 HL in 50L-kegs is 50HL/50L = 100*13 kg = 1300 kg.
- The keg can be reused 120 times.[xiii]
- To make stainless steel, already 50% scrap is added. The carbon footprint of stainless steel is therefore already based on the partial use of recycled material.
- The carbon footprint of stainless-steel kegs is 1,300*3.78/120 = 41.0 kg CO_2.

ONE-WAY PET KEG (NO INLINER)

844 kg CO_2 per 50 HL

- The weight of a PET keg of 30 litres is 1.2 kg.[xiv]
- The packaging weight of 50 HL in 30L-kegs is 50HL/30L = 167*1.2 kg = 200 kg.
- The carbon footprint of virgin material is 200*4.62 = 924 kg CO_2.
- Taking into consideration the current recycling ratio of PET, the carbon footprint of one-way PET kegs is 200*4.2 = 844 kg CO_2.
- In order to recycle this packaging, it needs to be collected separately. Currently, it is still collected as mixed plastics and will be incinerated.

ONE-WAY PET KEG (BAG-IN-KEG)

925 kg CO_2 per 50 HL

- The weight of a PET keg with inliner of 30 litres is 1.5 kg.[xv] 80% is made of PET and the rest is mainly made of PP.
- The packaging weight of 50 HL in 30L-kegs is 50HL/30L = 167*1.5kg = 250 kg.
- The carbon footprint in virgin material is 250*80%*4.62+250*20%*1.63 = 1,005 kg CO_2.
- Taking into consideration the current recycling ratio of PET and PP, the carbon footprint of one-way PET kegs with a bag-in-keg system is 250*80%*4.6+250*20%*1.6 = 925 kg CO_2.
- In order to recycle this packaging, it needs to be dismantled and collected separately. Currently, it is still collected as mixed plastics and will be incinerated.

TANK BEER BAG-IN-TANK

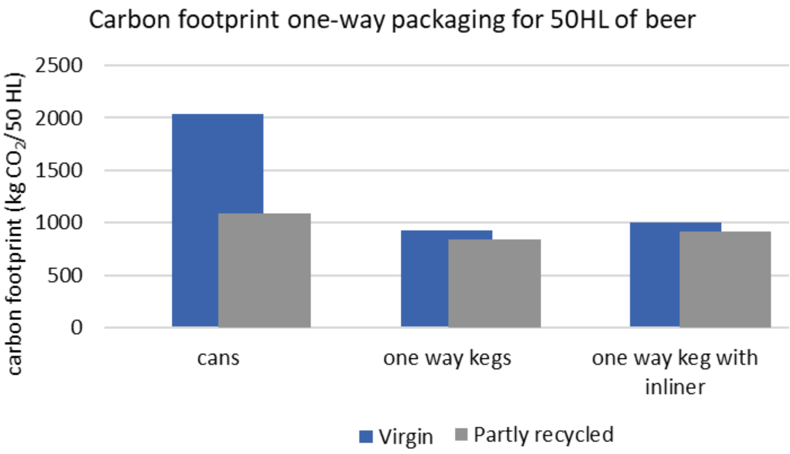
23.9 kg CO_2 per 50 HL

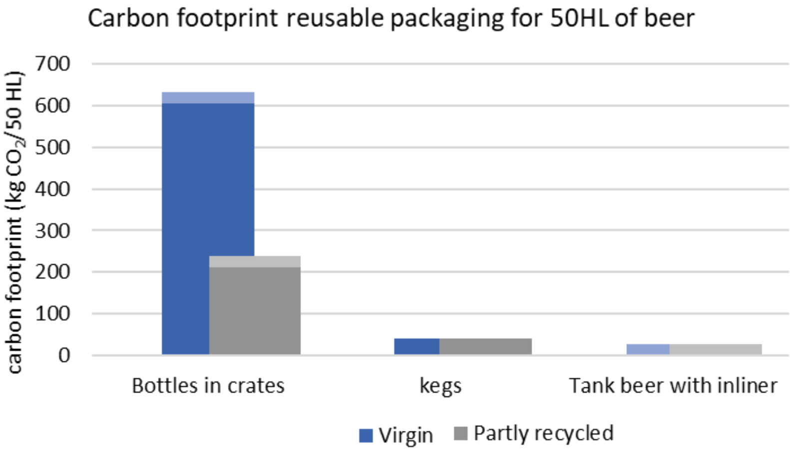
- The weight of a 10 HL serving tank is 98 kg.[xvi]
- The packaging weight of 50 HL in 1000L-tanks is 50HL/10HL = 5*98 kg = 490 kg.
- The tank can be reused for at least 25 years. With an average filling interval of two weeks, the tanks can be reused 650 times. This results in a carbon footprint of 490*3.78/650 = 2.8 kg CO_2.
- For each fill, an airtight bag needs to be inserted into the tank. This is called the bag-in-tank system. These bags (inliners) are made of LDPE and weigh 1.25 kg for a 10 HL tank.
- The packaging weight to fill 50 HL in 10 HL tanks is 50HL/10HL = 5*1.25 kg = 7.5 kg.
- The carbon footprint of virgin material is 7.5*3.83 = 23.9 kg CO_2.
- The packaging is currently not separated for recycling.
- In order to recycle this packaging, it needs to be dismantled and collected separately. Currently, it is still collected as mixed plastics and will be incinerated.

Overview of the carbon footprint of packaging materials

There is a big difference between the carbon footprint of reusable packaging materials and that of one-way packaging materials. The carbon footprint of one-way packaging materials is up to 5 times larger than that of reusable packaging materials.

The bag-in-tank system is a combination of both types, as there is a reusable tank with a one-way plastic bag (inliner). Due to this inliner, the tank does not need to be cleaned. In comparison with other packaging options, very little one-way material is used, which results in a small carbon footprint.





Innovation

At the beginning of 2020, a project was launched to recycle the inliners used in tank beer systems. Together with a recycling company, Duotank has set up a specialized recycling program to completely recycle inliners into re-useable products. This process includes the collection of the inliners at the brewery and optimized transport to the recycling plant. This will further decrease the carbon footprint of inliners.

For more information, see press release:

"Tank beer inliners from Heineken 100% recycled"

"The carbon footprint of one-way packaging materials is up to 5 times larger than that of reusable packaging materials."

Carbon footprint of cleaning, filling and dispensing

The carbon footprint of cleaning, filling and dispensing of the packaging is based on the amount of energy used and CO_2 (if applicable) required during filling. Moreover, the energy or CO_2 needed to dispense the beer is considered. The carbon footprint of the energy used is based on the average resources used in Europe.[xvii]

Electric energy:	0.23 kg CO_2 per produced kWh (average Europe 2018)
Energy to heat 1 kg of water 1 degree = 4.184 KJ, which results in 4.184/3600 = 0.001167 kWh.	
This results in:	
Hot water (90°C):	0.026 kg CO_2 per produced kg (based on average CO_2 per kWh of energy)
3 Bar steam (133°C):	0.036 kg CO_2 per produced kg (based on average CO_2 per kWh of energy)

The energy needed for filling depends on the energy needed to pressurize beer. The speed of filling depends on many factors, which are not related to the type of packaging but mainly the brewery itself. Therefore, only the energy needed to pressurize the beer is taken into account. The energy needed to pressurize beer to 1 Bar in order to fill under counterpressure is the same for all packaging methods. Approximately 0.1 KJ of energy is needed to pressurize 1 kg of beer to 1.0 Bar. This results in 5,000*0.1/3600*0.23 = 0.03 kg CO_2 to pressurize 50 HL of beer for filling.

The energy needed to compress air is approximately 0.1 kWh per m3. Based on the average energy needed for a small air compressor.[xviii] With the average footprint of energy in Europe, this results in:

1.0 Bar compressed air:	0.02 kg CO_2 per produced m3 or 1,000 litres
2.5 Bar compressed air:	0.06 kg CO_2 per produced m3 or 1,000 litres

Weight of CO_2 at 1.0 Bar: 1.97 kg CO_2 per m3 or 1,000 litres

Filling, cleaning and dispensing

BOTTLES

A large automated bottle-cleaning line consumes 1.0-1.2 kWh and 15-22 kg of steam per 1,000 bottles.[xi] The carbon footprint of cleaning 50 HL of bottles is 15-22*0.036 kg + 1.0-1.2*0.23 kg = 0.77-1.07 kg CO_2.

To fill the bottles, they need to be pressured with CO_2 at approximately 1.0 Bar. The carbon footprint of filling 50 HL is 5,000/1,000*1.97 + 0.03 (pump) = 9.88 kg CO_2.

CANS

Cans are delivered clean, so no extra CO_2 emission for cleaning is added.

To fill the cans, they need to be flushed with CO_2. For this, 0.8-1.0 kg per HL is needed.[xi] The carbon footprint of filling 50 HL is 50 HL*0.8-1.0 kg + 0.03 (pump) = 40-50 kg CO_2.

STAINLESS STEEL KEGS

A large automated keg-cleaning line consumes 0.4-0.5 kWh and 1.7-2.1 m3 of heated water per 100 kegs[xi] (50 HL). The carbon footprint of filling 50 HL is 1.7-2.1*0.02 kg + 0.4-0.5*0.23 kg = 0.1-0.2 kg CO_2.

To fill the kegs, they need to be pressurized with CO_2 at approximately 1.0 Bar. The carbon footprint of filling 50 HL is 5,000/1,000*1.97 + 0.03 (pump) = 9.88 kg CO_2.

To dispense a keg, pressurized CO_2 is needed again. An average pressure of 2.5 Bar is required. The carbon footprint of tapping 50 HL is 50 HL/1,000L*2.5*1.97 = 24.6 kg CO_2.

ONE-WAY PET KEG (no inliner)

One-way kegs are delivered clean, so no extra CO_2 emission for cleaning is added.

To fill the kegs, they need to be pressurized with CO_2 at approximately 1.0 Bar. The carbon footprint of filling 50 HL is 5,000/1,000*1.97 + 0.03 (pump) = 9.88 kg CO_2.

To dispense a keg, pressurized CO_2 is needed. An average pressure of 2.5 Bar is required. The carbon footprint of tapping 50 HL is 50 HL/1,000 L*2.5*1.97 = 24.6 kg CO_2.

ONE-WAY PET KEG (bag-in-keg)

One-way kegs are delivered clean, so no extra CO_2 emission for cleaning is added.

To fill the kegs, they need to be pressurized at approximately 1.0 Bar. Because the keg has an inner bag, this can be done with compressed air. The carbon footprint of filling 50 HL is 5,000/1,000*0.02 + 0.03 (pump) = 0.13 kg CO_2.

To dispense a keg, pressurized air is needed again. An average pressure of 2.5 Bar is required. The carbon footprint of tapping 50 HL is 50 HL/1,000 L*0.06 = 0.3 kg CO_2.

TANK BEER (bag-in-tank)

Bag-in-tank inliners are delivered clean, so no extra CO_2 emission for cleaning is added.

To fill the tanks, they need to be pressurized at approximately 1.0 Bar. Because the tank has an inner bag, this can be done with compressed air. The carbon footprint of filling 50 HL is 5,000/1,000*0.02 + 0.03 (pump) = 0.13 kg CO_2.

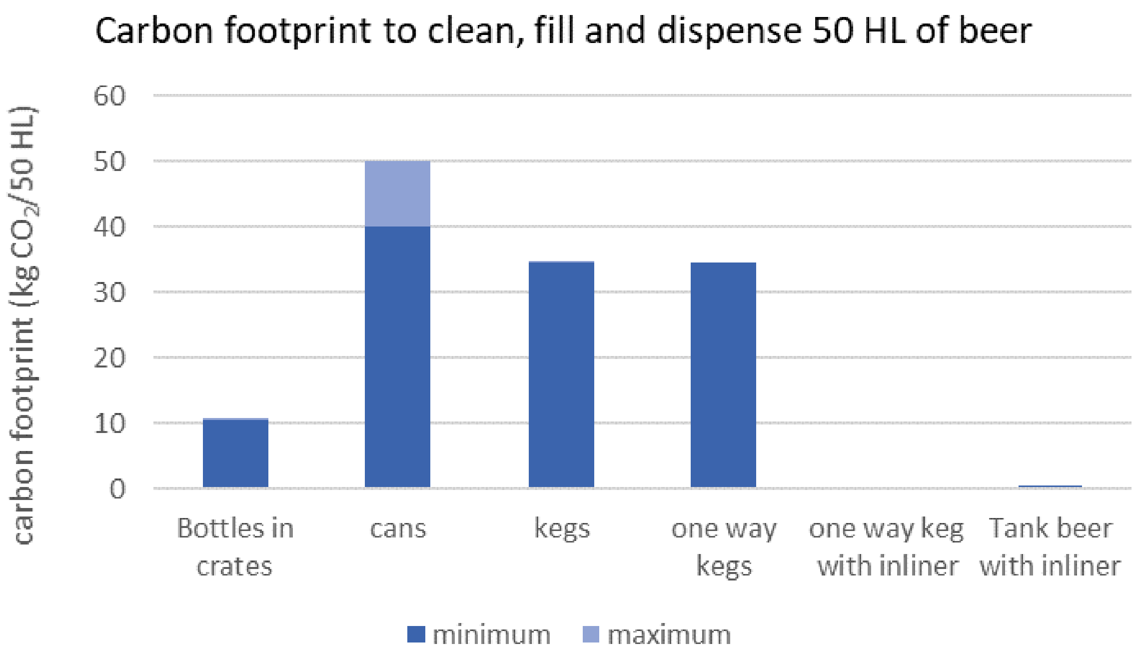
Because the tanks are filled by a tank truck, the tank(s) in the truck first need to be pressurized at approximately 1.0 Bar and then filled. The transport tank also has an inner bag, so this can be done with compressed air. The carbon footprint of filling 50 HL is 5,000/1,000*0.02 + 0.03 (pump) = 0.13 kg CO_2.

To dispense a tank, pressurized air is needed again. An average pressure of 2.5 Bar is required. The carbon footprint of making pressurized air of 2.5 Bar is 0.06 kg CO_2 per m3 (1,000 litre). The total carbon footprint of tapping 50 HL is 50 HL/1,000 L*0.06 = 0.3 kg CO_2.

Overview of the carbon footprint of filling, cleaning and dispensing

The difference between the carbon footprints of the packaging methods is mainly due to the added CO_2. Cans need to be flushed with CO_2 during filling and therefore their carbon footprint is much larger than that of bottles.

Kegs have a larger footprint than bottles because here also CO_2 is added to dispense the beer. Both the one-way kegs and the tank beer system with inliners use compressed air and therefore have a much smaller carbon footprint.

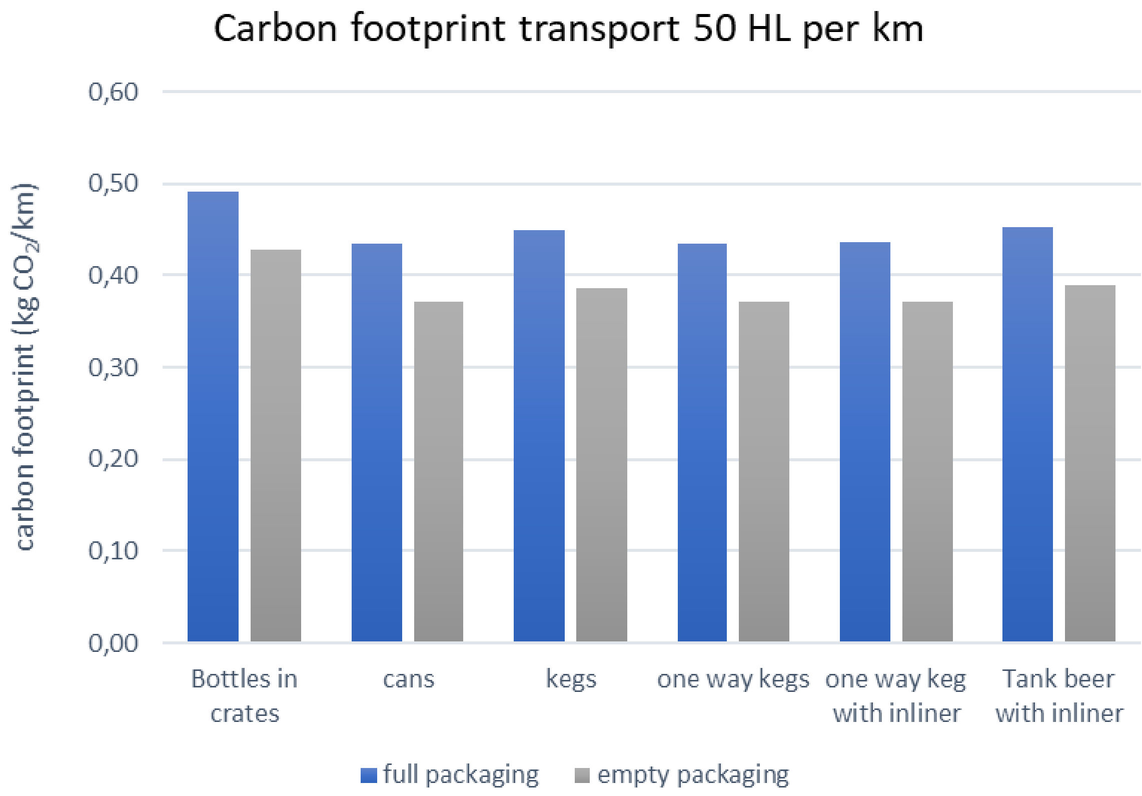


Transport to and from the bar

Carbon footprint per kilometre

The carbon footprint of delivering beer to the bar depends on the weight of the beer and packaging that needs to be moved. The more weight, the higher the fuel consumption of the truck and the larger the carbon footprint.

Based on the formula on the next page and the packaging weight, the carbon footprint per km is calculated:



Calculation method

To calculate this, we used the bottom-up emission calculation method[xix] developed by the Dutch research organisation TNO.

The formula is based on the following variables:

Weight of vehicle:	We have taken an average truck weight for city distribution of 8-10 tons of cargo. We assume the empty truck weight is 9 tons.
Cargo weight:	The cargo weight depends on the different packaging. For the weight calculation, see the paragraph “Production of the packaging”.

This results in:		
Bottles + crates	3,600 kg + 1,000 kg + 5,000 kg (50 HL beer)	9,600 kg
Cans	170 kg + 5,000 kg (50 HL beer)	5,170 kg
Stainless-steel kegs	1,300 kg + 5,000 kg (50 HL beer)	6,300 kg
One-way kegs	200 kg + 5,000 kg (50 HL beer)	5,200 kg
One-way kegs (inliner)	250 kg + 5,000 kg (50 HL beer)	5,200 kg
Tank beer	7.5 kg + 1,580 kg (Delivery unit + tank[xx]) + 5,000 kg (50 HL beer)	6,588 kg

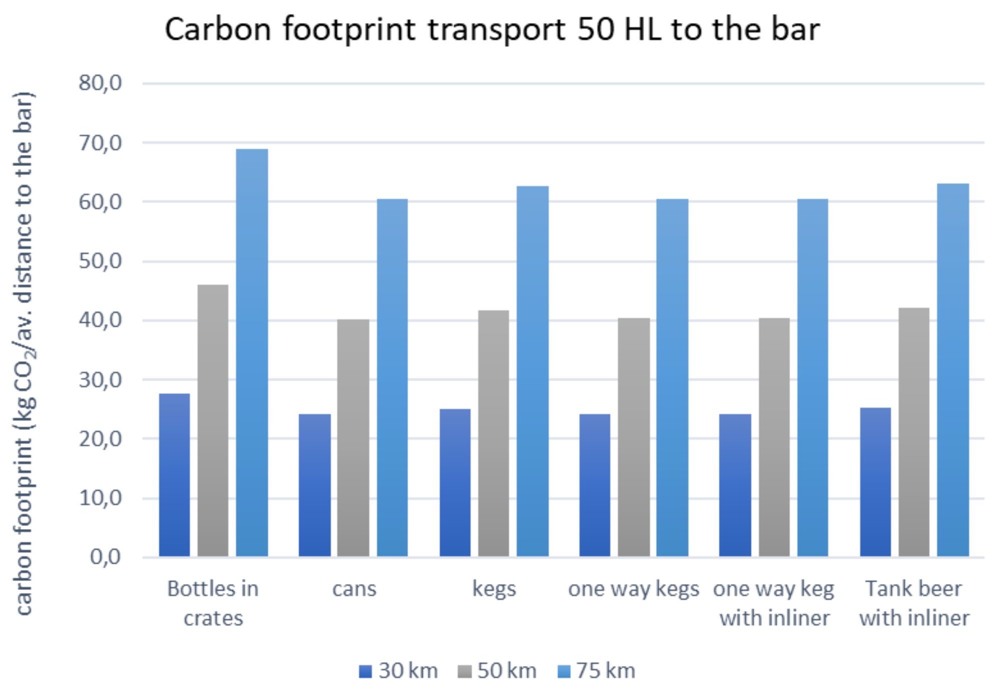
Power of the truck:	For this calculation, we have used an average truck engine power of 200 kW.
Correction:	The formula is based on fuel consumption data from 2011, but it can also be adjusted for other years. For 2012 there is no correction, each year a truck is older a correction of +1% is applicable. If this also is applicable, for each year a truck is newer a correction of -1% would be needed. The calculation method, however, does not mention this. Therefore, this correction is based on tests performed by “Last Auto Omnibus” together with DEKRA and Mercedes Benz in 2016[xxi] and another test performed by DAF trucks. In these tests, the fuel consumption of Euro 3 trucks (2003) is compared with that of Euro 6 trucks from 2016 (Current emission standard) with similar cargo loads and engine power. The test from DAF concluded a reduction in fuel consumption of 14%, and the test from Auto Omnibus and Mercedes showed a reduction of 15%. As the tested trucks both had the latest engine specifications (Euro 6), we used this data for the correction factor F: 9% (correction for 2003) -15% (result from test) = -4%
The formula is:	CO_2 emission (gr/km) = correction factor F* (13.25* (weight truck + cargo (1,000kg)) + 1.325*engine power (kW)

Total carbon footprint of transport to and from the bar

Based on the carbon footprint per km, a comparison can be made between the different packaging methods. Below we have calculated the carbon footprint for three different average distances from the brewery to the bar: 30, 50 and 75 km. We calculate with full packaging from the brewery to the bar and empty packaging on the way back.

The difference between the carbon footprints is limited because the packaging is only a small percentage of the total weight. The footprint of bottles is slightly higher because there the packaging weight is higher.

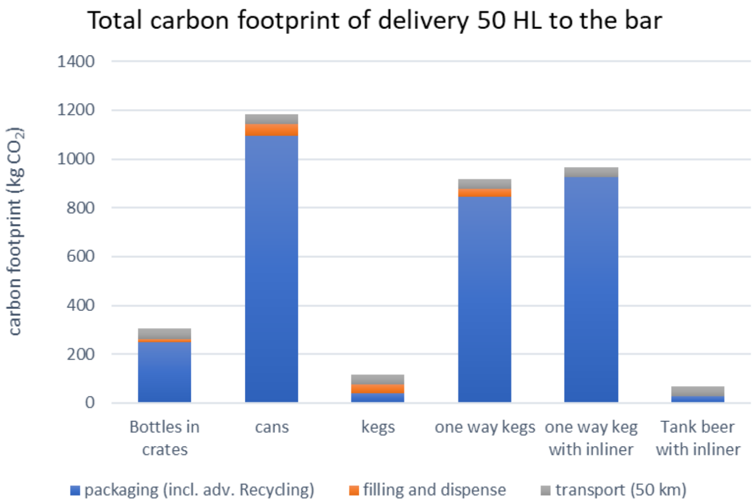
Although the packaging weight of tank beer is low, the installation to deliver tank beer partly reduces this advantage. If a lightweight beer delivery truck (see *whitepaper: "Trends & Technology report")* is used, the carbon footprint of beer delivery can be reduced by 30%.



Total outcome

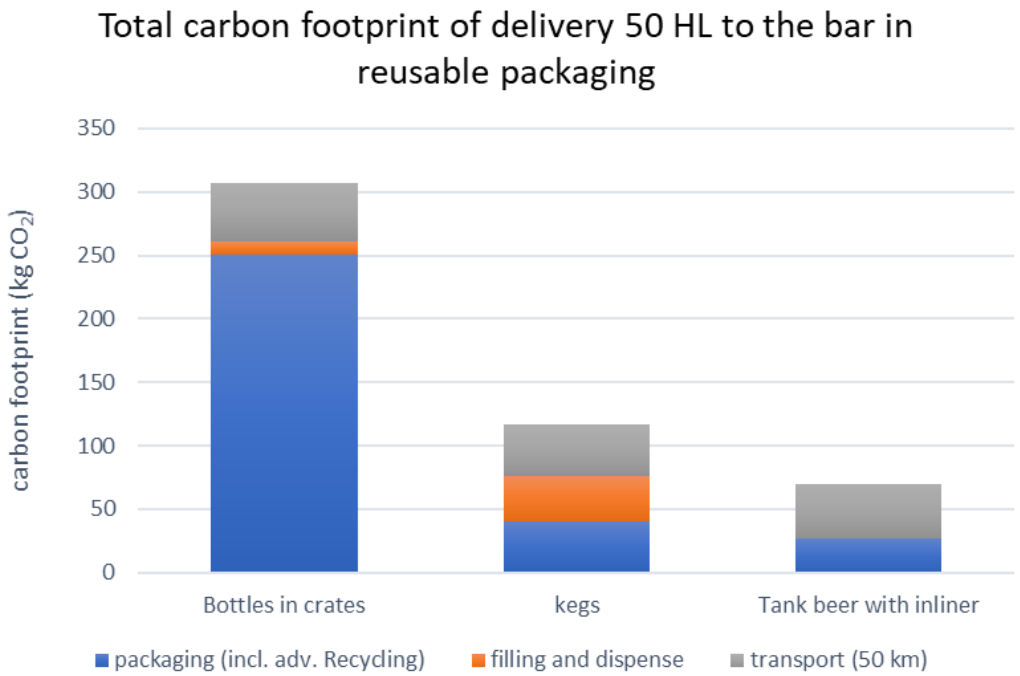
It is the production of the packaging that has the biggest influence on the carbon footprint of the packaging. Therefore, reusable packaging has a much lower footprint.

Looking specifically at the carbon footprint of reusable packaging, the filling and dispensing method becomes important.



The use of CO_2 to fill and dispense beer has the second biggest influence on the carbon footprint. With kegs, the CO_2 used for filling and dispensing accounts for approximately 30% of the total footprint. Tank beer has a big advantage because compressed air is used instead of CO_2.

The total carbon footprint of tank beer is 4.4 times smaller than that of bottles and 13 to 17 times smaller than the footprint of single-use packaging methods.



“The carbon footprint of tank beer is 4 to 17 times smaller than that of other packaging methods.”

Resources:

i. Website Greenrationbook, the cost of everyday living - 2020
http://www.greenrationbook.org.uk/

ii. Glass recycling at 76% in the EU - Food Packaging Form - Ksenia Groh - 2019
https://www.foodpackagingforum.org/news/glass-recycling-at-76-in-the-eu

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Duotank Beverage Solutions b.v.
Petunialaan 5
5582 HA Waalre, The Netherlands

Telephone: +31 (0)40 221 22 72

E-mail: info@duotank.nl

Website: www.duotank.com

More information: