HOW CIRCULAR IS GLASS?

A report on the circularity of single-use glass packaging, using Germany, France, the UK, and the USA as case studies

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ZERO WASTE EUROPE | eunomia

Executive Summary

Introduction

Glass production, especially from primary sources, is a high energy consuming process. One way to effectively reduce energy consumption and greenhouse gas (GHG) emissions from the repeated production of single-use glass is to retain material in a circular system – e.g. by utilising the cullet from container glass to produce new container glass, i.e. closed-loop recycling, and thereby removing the need to use glass from primary sources.

To understand the current circularity of single-use container glass in different geographical scopes, this study examines the mass flows of single-use glass packaging in four countries: Germany, France, the United Kingdom (UK) and the United States (US). For each case study, the key limitations to circularity are discussed and the potential to improving glass circularity are explored. The study also reviews other limitations and opportunities the single-use container glass industry is facing, and future developments being considered to overcome these challenges.

Current Circularity and Limitations

Current Circularity of Single-Use Glass Packaging

Collection systems vary across countries and even within certain countries. The study uses four key performance indicators to assess circularity in each of the country case studies, as shown in Figure 1. Each of the four indicators is calculated based on glass material only and does not consider caps, labels and other foreign materials that might be classed as contamination. The four indicators used in this study are:

1 Collection rate

The amount of glass packaging collected (excluding any contaminants) vs the amount of glass packaging placed on the market (POM). This indicator shows how much material is collected, thus highlighting how much material is not captured and therefore lost from the system.

2 Overall recycling rate

the amount of glass packaging captured in a sorting and recycling facility, ready for remelt or other recycling end markets vs the amount of glass packaging POM, measured in accordance with EU guidance. This indicator considers all end markets that are considered a recycling route in EU policy. Comparing this indicator to the collection rate highlights any sorting losses that might occur.

3 Closed-loop recycling rate

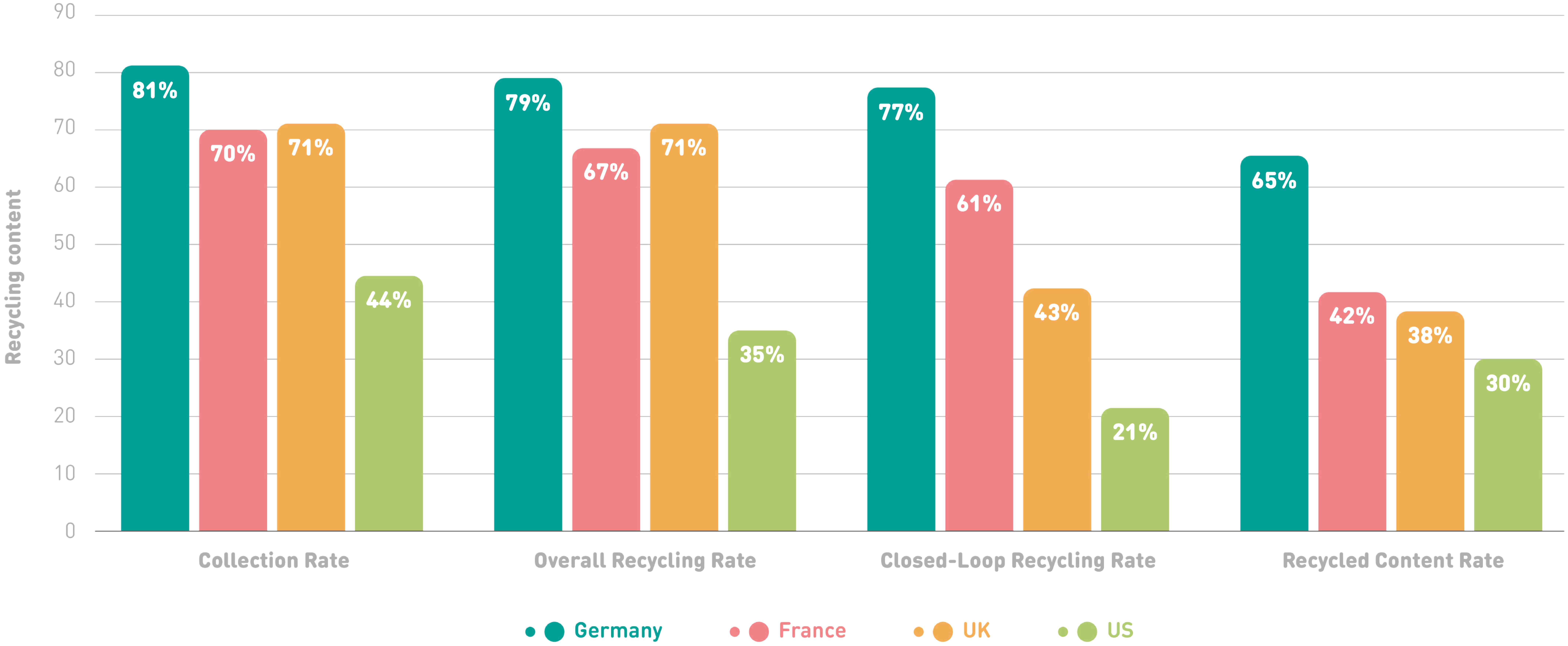
The amount of cullet captured during sorting that is used to manufacture new glass vs glass packaging POM[1]. As opposed to the overall recycling rate measured by the EU, this indicator only considers cullet being used to manufacture new container glass. It is the preferred indicator for the purpose of this study, as this is the only application type that is truly circular. In all other application types, the material is lost from the circular system and from the wider recycling system once its end of life is reached.

4 Recycled content rate

The amount of processed cullet used in the manufacture of new glass packaging vs the production volume of new glass packaging. This indicator shows how much recycled glass is in fact used to make new container glass.

Figure 1:

Collection, Closed-Loop Recycling and Recycled Content Rates for the 4 Case Studies, 2019 Data



Source: Eunomia modelling using available market data[2]

Losses from the circular glass system occur at three stages: in collections, during sorting and at the point at which cullet is distributed to different recycling end markets. The biggest losses of glass material occur at the collection stage. The country with the highest rate of capture is Germany: only 19% of glass packaging placed on the market is not captured in recycling collections. In both France and the UK, about 30% of glass material is lost. The US over half of its glass packaging placed on the market (56%) is not collected for recycling.

While collection methods do not seem to have a significant impact on collection rates, they do affect the potential for circularity, with some collection methods generating higher losses from a closed-loop system. Comparing each country's overall recycling rate to its closed-loop recycling rate shows that those which rely predominantly on a co-mingled collection system[3] (the UK and US with co-mingled collection rates of 55% and 53% respectively) see less cullet returned into glass manufacturing than countries which mainly use a separate collection stream for glass[4] (i.e. Germany and France, where glass collected co-mingled is less than 1% of the total collected tonnages). In Germany and France, only 2% and 9% of the sorted cullet respectively is used for recycling applications other than container glass. In the UK and US, this figure reaches 40% and 39% respectively.

The sorting and recycling process for glass is relatively efficient across all countries. At this stage only 2% to 3% of glass is lost to landfill, mainly due to misidentification as CSP (ceramic, stone and porcelain), a problem discussed further under the Current Limitations to Circularity. In the US, another significant loss of glass (approx. 7%) occurs where collected glass fails to find a viable route to recycling and is instead sent to landfill. In the UK sorting losses are not separately reported in available data sources. It is likely that loss of glass is relatively low due to CSP typically being sorted to aggregate use. The remaining potential for losses will be where glass is sorted with other contaminants or in mixed collections, with other packaging items.

The estimated recycled content rates for all four countries are shown in Figure 1. The recycled content used to manufacture glass containers in Germany makes up 65% of its total production, while on average recycled content makes up 42% of containers made in France. It is noticeable that the recycled content rates in the UK (36%) and the US (30%) are both higher than their closed-loop recycling rates. Both countries are net importers of glass packaging, meaning more glass packaging is placed on the market in these countries than is produced.

Current Limitations to Circularity

When considering the circularity of container glass, we can see key limitations stemming from:

Collection methods

Glass packaging design

Economics of logistics

Collection Methods

The study identified impacts in two aspects of the collection systems:

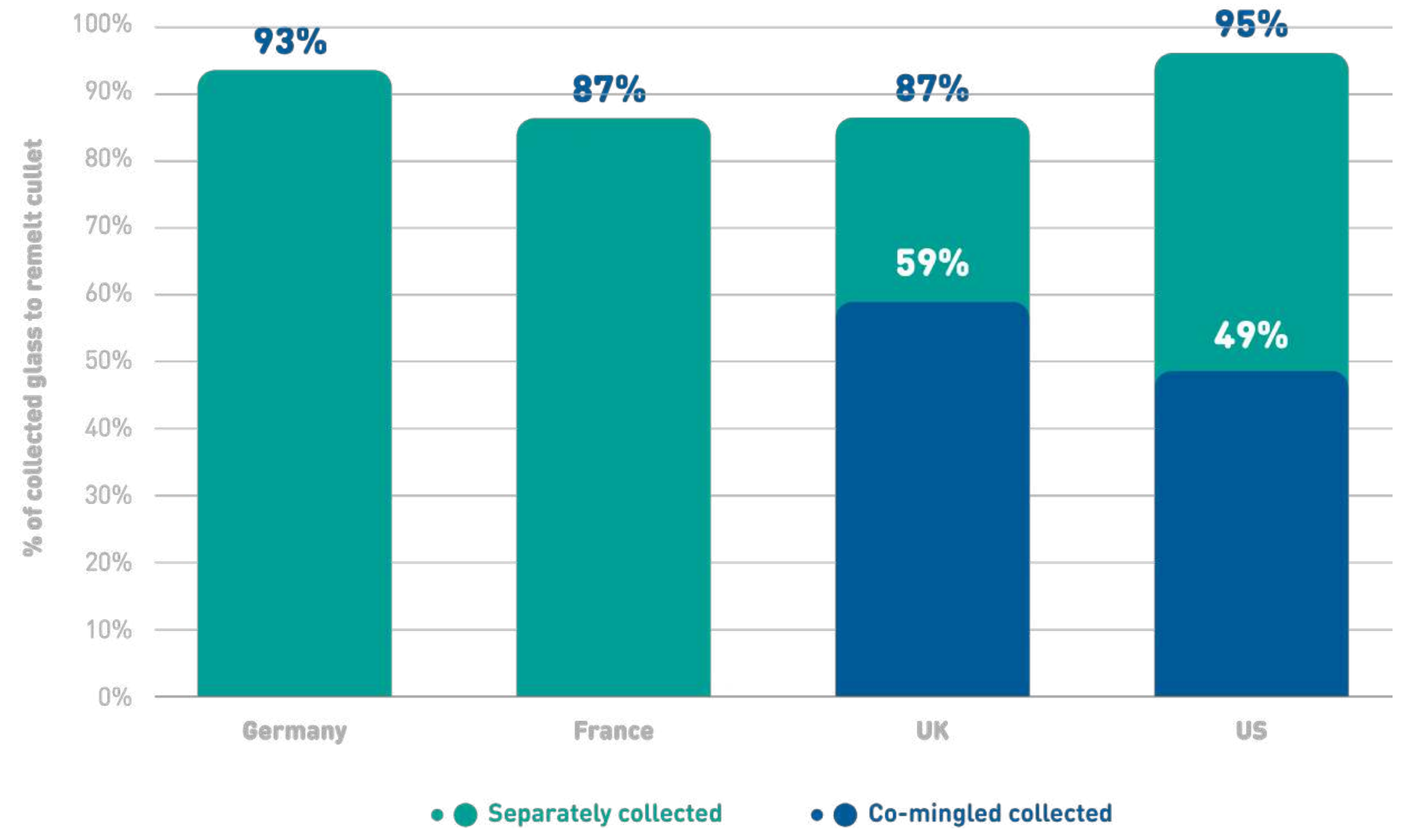
1. Co-mingled collections (glass is collected with other types of packaging) vs separate collections (glass is collected in a separate stream from other packaging); and
2. Colour-separated collections vs mixed colour collections.

Collecting materials in a co-mingled collection system results in a lower yield of cullet suitable for remelt applications than when glass is collected in a separate stream (see Figure 2). It is likely that glass collected in a co-mingled system requires more handling, which reduces particle sizes to an extent that further sorting of colours and contaminants becomes uneconomical. Tight glass manufacturing specifications limit both contaminants and small particle sizes, and so these smaller particle fractions are likely used in other applications than the manufacturing of glass packaging.

Collections of mixed coloured container glass require a positive sort on clear glass to generate a cullet fraction suitable for clear glass production. Usually, this positive sort does not capture all the clear glass and some pieces are left behind in the green and amber cullet, which could lead to an oversupply of amber and green cullet and an undersupply of clear cullet for local manufacturing.

This might become an issue when collection rates increase to a point where demand for green and amber cullet in container glass production is fully met, leaving no circular recycling routes for the surplus.

Figure 2: Estimated Yield to Remelt Cullet by Collection Method



Source: Eunomia modelling

Economics of Logistics

By comparing average disposal fees to average material revenue for material recovery facility (MRF) glass in the US, this study concludes that disposal fees need to be considerably higher than material revenue to ensure it is feasible to transport material to recycling plants – even if these are located some distance away. In the Northeast and Pacific, where disposal tipping fees are relatively high, MRF operators can transport their glass commodities to recyclers over 500 km (310 miles) further than they can transport the glass to disposal facilities. Conversely, in the South-Central region, it is only possible for MRF operators to transport glass to recyclers at a distance of around 116 km (72 miles) more than disposal facilities before it becomes more costly to do so.

This economic limitation might explain why, in the US, some glass that is collected through recycling programs still ends up in landfill (7% of total single-use glass POM). In some cases, the cost of disposing material may be too low to offset the relatively low material value of co-mingled glass sorted at MRFs.

In Europe, net glass packaging exporters such as Germany and France see a considerable discrepancy between their closed-loop recycling rates and their recycled content rates. When glass packaging is exported before it is placed on the market, it will not be captured in the local collection system. The material is essentially lost from the local circular system to an overseas recycling system. In these countries, only small quantities of cullet are imported and exported – either prior or post sorting – reportedly over short land distances (bordering countries) or transported by sea. Thus, it is unlikely to be economically feasible to import large amounts of cullet from far destinations to fill the deficit in local recycled content left by exporting glass packaging.

Design

Cement, stones and porcelain (CSP) is a critical contaminant, and, in the optical sorting process, some perfectly good glass is sorted out to ensure all CSP is removed. In addition, glass that is lacquered or has difficult-to-remove labels fails the optical test and gets ejected together with CSP. The misidentification of fragments at CSP removal stage accounts for the highest loss of glass in Germany. Glass misidentified as CSP represents around 40-50% of the CSP fraction, which is equivalent to approximately 2% of total glass collected.

Future Potential

Each limitation discussed above forms a potential lever to increase circularity of single-use glass in the future. As part of this study, Eunomia investigated this potential in each of the country case studies. The study differentiates between the two regions – Europe (including the UK) vs the US, due to the variances in drivers as shown in Table 1. While in Europe the Commission has set targets in policy, in the US targets are voluntary and agreed within industry, so there is no real incentive to achieve them.

While Germany has already reached the PPWD's recycling target, it sets its own target of 90% for material collected (including contamination) in local packaging law. Currently, this rate is reported at just under 85%. All other case study countries need to increase their collection rates to achieve recycling rate targets, but none of the countries analysed have strategic pathways in place to achieve this. Collection rates could be improved by implementing behaviour change interventions, such as educational measures or expanding the nationwide coverage of bottle bring banks or kerbside collection systems to increase convenience. It is unlikely, however, that even these measures will bridge the large gaps between what is currently being collected and the increase in collections needed to meet future targets.

In the US, improvements to glass sortation at MRFs are underway, but this change would not meet the voluntary recycling targets set by the glass industry.

Other measures such as improving existing deposit return schemes (DRS) is another potential solution, but it is still fairly unlikely that the recycling target could be met without wide-spread change.

A well-designed nationwide DRS program could see significant improvements to the collection and therefore recycling rate for single-use glass packaging. The better performing bottle bill states (states that operate a DRS) in the US achieve collection rates between 75% and 59%. Similarly, existing DRS systems for glass in Europe are currently achieving between 84% and 89%[5] collection rates for glass beverage bottles in 2019 and have since improved in some cases (e.g. Finland reported a 98% glass collection rate in 2021[6]). It is therefore likely that the introduction of a DRS system, which includes single-use glass packaging in its scope, charges a reasonably high deposit and offers a well-developed infrastructure, is a way of improving the overall container glass collection rates, particularly in underperforming countries such as the US and UK.

Increasing collection rates and therefore recycling rates will not necessarily achieve high levels of glass packaging circularity in some countries without a change in the method of glass collection. This would be the case in the UK or US, where much of the cullet is not currently used in a closed-loop. It is unlikely that cullet quality will change without a considerable change to current collection methods. A nationwide, separate collection system, as is the case in France and Germany would likely improve cullet quality and therefore circularity, but it is unlikely that the UK or US will see such large-scale change in the foreseeable future. Alternatively, a DRS system, as described above, would see an increase in separately collected beverage containers, improving the collection quality in countries that currently rely on co-mingled collections.

Table 3: Current Modelled Recycling Rates and Future Recycling Rate Targets

	Germany	France	UK	US
Predominant collection method	By colour separate collection	Mixed colours separate collection	Mixed colours co-mingled collection	Mixed colours co-mingled collection
Current Recycling Rate (overall)	79%	67%	71%	35%
Targets	Target recycling rate (2030): 75%[7]			Voluntary industry target: 50%[8]
	Target rate for material sent for recycling (2022): 90%[9]		Proposed recycling rate target (2030): 83%[10] Current remelt target: 72%; proposed remelt target (2030): 80%[11]	

Source: Recyclingmarkets.net, Environmental Research & Education Foundation (EREF)

Wider Impacts

As well as the circularity of glass packaging, the wider environmental impact of glass must be considered; this is mainly linked to greenhouse gas (GHG) emissions from manufacturing and transport. To identify and evaluate opportunities to reduce the impact of glass packaging on the environment, this study reviewed how single-use glass performs in life cycle assessments (LCAs), the industry's decarbonisation plans, developments in glass design and the potential of refillable glass bottles in this context.

Past LCA studies generally show that single-use glass packaging has the highest associated GHG emissions compared with other single-use beverage packaging materials, such as aluminium cans, PET bottles, HDPE bottles and multi-layer beverage cartons. Minimising the amount of glass from primary sources in the production of container glass is one way to reduce this impact. Other ways include using renewable or other alternative low energy sources or designing lighter-weight products that use less material. The latter might be hindered by consumers' quality expectations – a heavier bottle feels more premium than a lighter bottle – or by technical barriers, such as the need for investment in new production and quality inspection facilities.

Rising energy costs and increased pressure to reduce carbon footprint could encourage this capital investment, as well as lower running costs when set up. There are significant opportunities for decarbonising the manufacture of container glass, as well as reducing associated GHG emissions by lightweighting products. Meanwhile, other beverage packaging material industries are making considerable efforts to reduce GHG emissions. While further LCAs are needed to assess whether decarbonising the glass manufacturing process provides a competitive advantage, a scenario in which single-use glass outperforms its alternatives in single-use applications is unlikely.

Refillable packaging options offer another important circular material flow opportunity, reducing GHG emissions. Generally, switching to refillable glass packaging cuts down on the environmental impact significantly by avoiding the high GHG emissions associated with new production. This effect is more significant in the early cycles of reuse. While most LCAs conclude that refillable glass has lower overall GHG emissions than its single-use alternative, the results highly depend on a number of factors, such as number of refill cycles, transport distances, packaging weight, recycled content and energy sources for the manufacture and/or cleaning.[12] Particularly transport distances for the take back and redistribution of glass bottles are a key factor in the results of LCAs,[13] which, together with the effects of washing, repeatedly occur at each cycle[14] and become a constant, recurring impact.

Pool systems, in which multiple bottlers use a few standardised bottle designs, allow optimised transport distances. Individually designed bottles, on the other hand, always need to be returned to one specific bottler, generating much further transport distances than a pool system. For glass packaging to provide an effective refillable option that minimises GHG impacts along the entire life cycle, it would be necessary to move towards a pool system with a limited number of design options to optimise logistical flows.

Conclusion

So, to answer the question as to how circular single-use glass packaging is –the study found that circularity, measured by four key performance indicators (the respective rates of collection, recycling, closed-loop recycling and recycled content) varies from country to country. The ability to achieve high circularity depends primarily on the effectiveness and methods of collections. The more glass packaging is collected through a high-quality separate collection system, such as a DRS, the more glass is likely going to flow back into the manufacture of new single-use glass. To retain material in a closed-loop, an efficient refillable system with optimised transport distances and high number of refill cycles could also offer a potential solution as an alternative to single-use glass.

Notes

1 COMMISSION IMPLEMENTING DECISION (EU) 2019/ 665 - of 17 April 2019 - amending Decision 2005/ 270/ EC establishing the formats relating to the database system pursuant to European Parliament and Council Directive 94/ 62/ EC on packaging and packaging waste - (notified under document C(2019) 2805)

2 Collection and recycling rates are based on single-use glass packaging placed on the market; recycled content rate is based on production of single-use glass packaging

3 Different packaging materials collected together (e.g. glass collected with paper, plastic and/or metal packaging)

4 Glass collected separately without any other packaging materials

5 Reloop (2020) Global Deposit Book 2020 https://www.reloopplatform.org/wp-content/uploads/2020/12/2020-Global-Deposit-Book-WEB-version-1DEC2020.pdf

6 PALPA, Deposit-Based System https://www.palpa.fi/beverage-container-recycling/deposit-refund-system/#who-pays-for-the-recycling-of-beverage-packages

7 EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE 94/62/EC- of 20 December 1994- on packaging and packaging waste https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01994L0062-20150526&from=EN

8 Glass Packaging Institute (GPI), A Circular Future for Glass, https://www.gpi.org/a-circular-future-for-glass

9 Gesetz über das Inverkehrbringen, die Rücknahme und die hochwertige Verwertung von Verpackungen (2017), https://www.verpackungsgesetz.com/wp-content/uploads/gesetz_verpackg_final_fassung_ab_20220101.pdf

10 DEFRA (2022) Extended Producer Responsibility for Packaging, Summary of consultation responses and Government Response https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063589/epr-consultation-government-response.pdf

11 Ibid.

12 Megale Coelho, P., Corona, B. and Worrell, E., 2020. Reusable vs single-use packaging. A review of environmental impacts. [online] Zero Waste Europe and Reloop. Available at: <https://zerowasteeurope.eu/wp-content/uploads/2020/12/zwe_reloop_report_reusable-vs-single-use-packaging-a-review-of-environmental-impact_en.pdf.pdf_v2.pdf> [Accessed 29 June 2022].

13 Schonert, M., Motz, G., Meckel, H., Detzel, A., Giegrich, J., Ostermayer, A., Schorb, A. and Schmitz, S., 2002. Ökobilanz für Getränkeverpackungen II / Phase 2. [online] Berlin: Umweltbundesamt. Available at: <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2180.pdf> [Accessed 29 June 2022].

14 Megale Coelho, P., Corona, B. and Worrell, E., 2020. Reusable vs single-use packaging. A review of environmental impacts. [online] Zero Waste Europe and Reloop. Available at: <https://zerowasteeurope.eu/wp-content/uploads/2020/12/zwe_reloop_report_reusable-vs-single-use-packaging-a-review-of-environmental-impact_en.pdf.pdf_v2.pdf> [Accessed 29 June 2022].

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