Recycling in the glass packaging industry – part 1

Prof. Vincenzo M. Sglavo and Davide Armoni, Andrea Rossi, Mattia Scottini and Nicholas Paul Sentieri outline the current state of recycling in the glass packaging industry in Italy and Europe and discuss technical and economical limitations to the EU's goals for glass packaging recycling.

In the last three years the European Union has outlined the latest goals and established a standard that the glass packaging industry of all 27 EU member states must meet. By 2030, 90% of all consumed glass packaging must be collected and made available for recycling.[1] Acknowledging that not all glass packaging makes its way through all the recycling process, the EU has also set targets to recycle 70% of packaging by 2025 and 75% by 2030.[1] These values take into account losses during the recycling process and underline how proper education, techniques and procedures appropriate for each individual glass container are more important than ever before.

Figures from 2018 showed that, with a total 'collection for recycling' rate of 76.4%[2] (based on just under 17 million tons of consumed glass packaging over a collected recycling value of just under 13 million tons[2]) the EU as a whole is well on its way towards meeting the 90% goal. Relative to other EU member states, Italy had a total collection recycling rate of 85.2% for 2018.[2] Finland, Sweden and Belgium boasted approximately 98% for 2018, while Portugal could only manage to collect a pitiful 49%.[2]

What holds back some of the member states from improving these collection efforts?

This report seeks to identify the limitations affecting the glass packaging industry in the technical, economic, social, legislative aspects, among others, through the lens of collection and processing in Italy. In addition to identifying the limitations, this work identifies potential solutions to aid in closing the gap on the EU set standards with reference and comparison to other EU members. This may prove difficult as every limitation is interconnected to another in a multitude of ways. The complete and total efforts of every citizen in every nation [must] be set at the forefront of importance if these limitations are to ever be overcome and reach, in the next decade, the EU goal. Yet, even beyond these hollow numbers lies a deeper and more meaningful benchmark of self-sufficient, closed-loop glass packaging systems. These ideas, among others, will be further detailed in the analysis below, specifically referring to the Italian situation.

Restrictive aspects of the glass recycling industry

The EU's ambitious goal of achieving 90% recycling of glass packaging by 2030 is currently held back by limitations in different sectors, not only linked to potential opportunities not exploited in the past, but also to legacies that show enormous inertia to change. In the following sections, a brief analysis of the current situation and its effect on the recycling system are considered and commented on.

Technical limitations

The technical aspect takes into consideration the impact of technology and its development on the recycling industry. The last few years have seen a radical change in technological development, both hardware and software, with a positive impact on productivity and reduction in costs. The current configuration of the glass recycling system envisages the presence of three main entities: the private citizen who carries out separate collection, the industry that processes glass waste in cullet form and the final glass manufacturers. Various bodies can intervene and aid in linking these protagonists together, as shown in the case of CoReVe [the national glass recovery consortium] in Italy, which represents the link between waste collection and the process industry.

The collection system is managed by the municipalities, which usually choose between a centralised bottle bank or a door-to-door collection system. The collection of solely glass packaging, as well as multi-material systems (glass, plastic and metal), can be implemented; single-colour or multi-colour glass collection are additional possible choices. The application of the business model is based on various factors, such as the city structure, political moves or the consolidation of historical actions. An important effect was observed regarding the choice of collection system: the quality of the waste, assessed as the quantity of impurities present, decreases going from a collection of glass only to a multi-material collection, and from the bell-glass [collection] system to the door-to-door system.[3]

Sorting and purification are the ▸

The market for glass packaging recycling in Italy is very different compared to the rest of Europe.

core steps of the glass collection system: they convert waste into cullet, by removing impurities and reducing the pieces to suitable dimensions. Every high-technology production plant is unique and characterised by different machinery along the line, but in general, the process can be boiled down to several phases including the cleaning of the packaging, elimination of metallic impurities, removal of non-metallic contaminants and finally the inspection.[4] The structure of each plant varies according to different factors, most importantly the type and purity of the average incoming waste, which changes greatly from region to region and from state to state. For example, Northern Europe produces glass waste with fewer impurities than Italy and so its plants are characterised by fewer optical detectors and a leaner structure.[4,5]

Separating and sorting

The efficiency of cullet processing is determined by the quantity of recyclable glass that is discharged due to the removal of contaminants. The main impurities that can be recognised are metals, such as bottle caps or cans, plastics, especially plastic bags, and ceramic materials. The latter represents the biggest problem, as porcelain and non-sodium-calcium glasses can be found in the collected product: their glass-like structure and properties make identification difficult and currently account for almost all impurities in the final cullet. Porcelain material usually appears as small particles that do not undergo substantial changes in the melting furnace and are found as infusions in the final glass package. Lead glass danger is related to the presence of the toxic element: an ashtray contains enough lead to exceed the legislative limit of an entire batch! Glasses of other compositions vary the chemical-physical properties during the melting phase, reducing the efficiency of the melting process.

Coloured glass separation is another major role played by optical sorting. The main colours, flint, green and amber, are distinct and sold separately. Their separation is not perfect and this represents the biggest issue for the use of recycled glass, with direct impacts on the aesthetics of the final product. For this reason, the maximum recycled material rate (MRR) adopted by the glass industries is very low in the case of flint glass, while the MRR of amber glass can reach maximum values of 90%, which is currently the technical production limit.[6] An increase in MRR has different advantages: the most important is the reduction of energy used during final production, but a decrease in the raw material costs and equivalent CO_2 into the atmosphere can also be achieved.[7] The drawback of MRR is that it may significantly impact the aesthetic quality, but not mechanical properties, of the final product.

Economic limitations

Regarding the economic limitation, the price of cullet is difficult to estimate, as it varies a lot depending on the timeframe and the region of collection. The first is connected to the cullet availability on the market, while the latter is determined by the cost and quality of waste collection management. Additionally, colours and purity are the two major factors for the final determination of the products final price.

As pointed out before, in the glass recycling industry, the two major types of glass collection systems used are the bottle bank and the door-to-door system. The preferred system is the bottle bank because it is cheaper, more effective and has a higher efficiency. Furthermore, a bottle bank service is one-third the cost when compared to the door-to-door system.[5] In general, the door-to-door system is particularly favourable only in specific and isolated cases (e.g., larger producers such as bars and restaurants or in high populated areas).[5] However, the problematic aspects of the door-to-door system are related to a partial lack of co-operation on the part of citizens or insufficient storage for waste inside homes – often this is due to inadequate collection frequency, causing glass packaging to build up over time. ▸

Industry perspective

From the perspective of industries, the major problem with glass recycling is related to the quality and quantity of cullet. These two factors are among the easiest to identify as not only does quantity have an effect on the fluctuating price of the market, but it also affects costs related to processing industries.[4] Regarding the quality of cullet, the glass collection system plays an important role as the door-to-door system may drastically affect the quality of cullet collected. An example of potentially compromising the cullet quality is the use of plastic bags by citizens as an easier means of separating various materials. This is detrimental to the collection and processing system because these impurities lead to a slowdown in the recycling process and above all, reduce the efficiency of the entire system.[8] In fact, during the treatment process, plastic bags containing recycled glass packaging [have to be] opened manually in order to facilitate the subsequent selection steps.[9] It is also important to remember that a closed bag is treated as a single body, discarded, and that material within the bag is not considered in the final value of recycled glass. A consideration that has not been made up to this point is one of the coveted mono-material,[5] which allows us to avoid problems of contamination from other materials that can lead to the worsening of cullet quality.

Cost comparisons

When considering the economic limitations of glass recycling, an analysis from the point of view of cost is very important. Specifically, a subdivision is made between raw material costs and costs related to processing the recycled material, which includes plant operational costs, waste disposal costs and transportation costs. Production costs are among the simplest to analyse, as the costs of the workers and machinery that are used can be easily parameterized and controlled. With regards to the cost of raw materials, the analysis is more complex because they are strongly influenced by market trends and fluctuations. The costs of raw materials often assume a certain importance relative to the others and can contribute between 20 to 40% of the total cost of generating a new product.[4,6] On the other hand, industries have greater control in managing to reduce the costs associated with the transport of raw materials and finished products, as well as the costs associated with the processing of recycled glass, with one example being an increase in furnace efficiency.[4] Some other interesting strategies that companies can implement to reduce costs include the development of new tools and software to improve performance in the recycling process[4] and the progression of innovative renewable energy sources systems.

Italian market

The market for glass recycling in Italy is very different from the rest of Europe. An aspect that affects the overall percentage of total recycled glass obtained can be linked to the possibility of separating the recycled glass packaging by colour. In Italy, the situation is not as simple as it would seem, especially in the case of using a door-to-door collection system, as this system is unintentionally neglectful of the disproportional use of amber and green coloured glass relative to clear flint glass within each household.[5] Furthermore, as mentioned in the technical limitations, Italy has a higher quantity and quality of optical readers and therefore to achieve the EU 2030 target it has invested heavily in this technology. In Northern and Central Europe (e.g. Germany, Belgium, Sweden) the situation is somewhat different, and there is greater progress towards fully utilising a glass separation system based on colour. However, the main limitation of separating by colour is linked to the final cost of separating the cullet as this separation system is very expensive. The advantage of properly sorting glass packing during collection has a direct influence, not only on the cost, but also on the quality of cullet used in production. ●

This report will be concluded in the March/April 2022 issue of *Glass Worldwide.*

1 European Parliament and the Council of the European Union. "Packaging and Packaging Waste Directive." European Parliament and the Council of the European Union (94/62/EC27). 20 Dec. 1994. Web. 21 June 2021.

2 FEVE. *Year 2018 Glass Recycling Statistics Updated,* 2018. FEVE. Web. 18 June 2021.

3 Testa, M. et al. "Long-Term *Sustainability* from the Perspective of Cullet Recycling in the Container Glass Industry: Evidence from Italy." Sustainability. 1 Oct. 2017. Web 16 June 2021.

4 Vitali, Sara. Interview. By Davide Armoni, Andrea Rossi, Mattia Scottini, and Nicholas Sentieri. 4 June 2021.

5 Avella, Massimiliano. Interview. By Davide Armoni, Andrea Rossi, Mattia Scottini, and Nicholas Sentieri. 14 May 2021.

6 Villotti, Giacomo and Merz, Alessia. Interview. By Davide Armoni, Andrea Rossi, Mattia Scottini, and Nicholas Sentieri. 5 May 2021.

7 Cassano, Stefano. Interview. By Davide Armoni, Andrea Rossi, Mattia Scottini, and Nicholas Sentieri. 4 June 2021.

8 CoReVe. "Come fare la raccolta." *CoReVe.* 2021. Web. 21 June 2021.

9 CoReVe. *Piano Specifico di Prevenzione 2021,* 31 May 2021. CoReVe. Web. 19 June 2021.

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