Viewpoint

Returning glass to the supply chain

Graham Coult and **Rebecca Hartwell** examine the potential for greater recycling, or reuse, of glass and outline actions that the construction industry could take to advance this goal.

There is a tradition of reuse and recycling dating back as long as we have been building. The Roman Empire is known to have had laws relating to demolition in place. Traditionally, the recovery of demolition materials has been driven by material demand to lower fabrication costs. The paradigm shift that we find ourselves in today due to the climate emergency calls for bold action to develop efficient reuse and recycling infrastructure at scale to achieve carbon reductions.

This article will establish the reasons why returning architectural glass to the supply chain at the end of life is beneficial, as well as exploring the factors that make glass recovery more challenging than with other traditional materials and what we can all do to support this goal.

Benefits of recycling

Flat glass accounts for around 24% of the UK glass market **(Figure 1).** Manufacturers have always looked to efficiency as a way to maintain a competitive advantage. This has taken the form of technological improvements to minimise processing yield losses, advances in furnace technologies and fuel-switching, on-site energy efficiency improvments and waste heat recovery processes.

Glass fragments known as cullet are a critical part of the flat glass manufacturing process. Cullet aids the homogenisation of the batch raw materials during the melting phase and can also help to control viscosity levels.

Cullet also brings environmental benefits.

- It lowers the melting temperature of the materials.
- It reduces CO_2 emissions due to a reduction of carbonate raw materials that release a by-product of CO_2 during thermal decomposition.
- It reduces the demand for primary raw materials.

The result is that 530kg of CO_2 is avoided for every tonne of 'post-consumer' glass re-melted into new glass, leading to a 41% reduction in the net embodied carbon of new flat glass products[1].

Current challenges

Glass has been estimated to represent 1.5% of total construction and demolition waste, with metals at 2.5% and concrete at 12%[2]. Deloitte conducted a top-down study of the UK building stock and estimated that in 2014 there was 199 kt of glass waste arising in the UK. This total is likely to be significantly higher; the study only accounts for flat glass rising from insulated glazing units[3]. Current estimates are that less than 1% of post-consumer glass is returned to the flat glass cycle.

Materials that have historically been recovered from demolition 'waste' have been easy to separate and have commanded prices that prove profitable. Now though, we need to look beyond existing market conditions. We need to work towards realising our responsibility in reducing the environmental impact of the flat glass sector and promoting collective action for change.

A key risk that flat glass manufacturers *must* manage is the purity of the batch materials. Low levels of contaminants can cause considerable damage to the float line process and to commercial reputation. As an example, flat glass manufacturers typically stipulate a ferrous content <2ppm and non-ferrous <0.5ppm.

Failures due to nickel sulphide impurities have been greatly reduced over the past decades, although they do still occur. Will a greater amount of recycled content introduced into the batch cause a rise again?

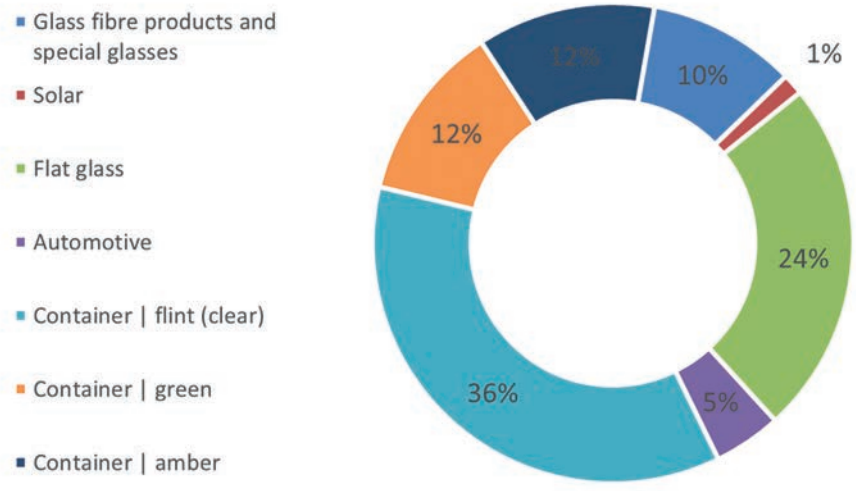

FIGURE 1: UK glass market by volume

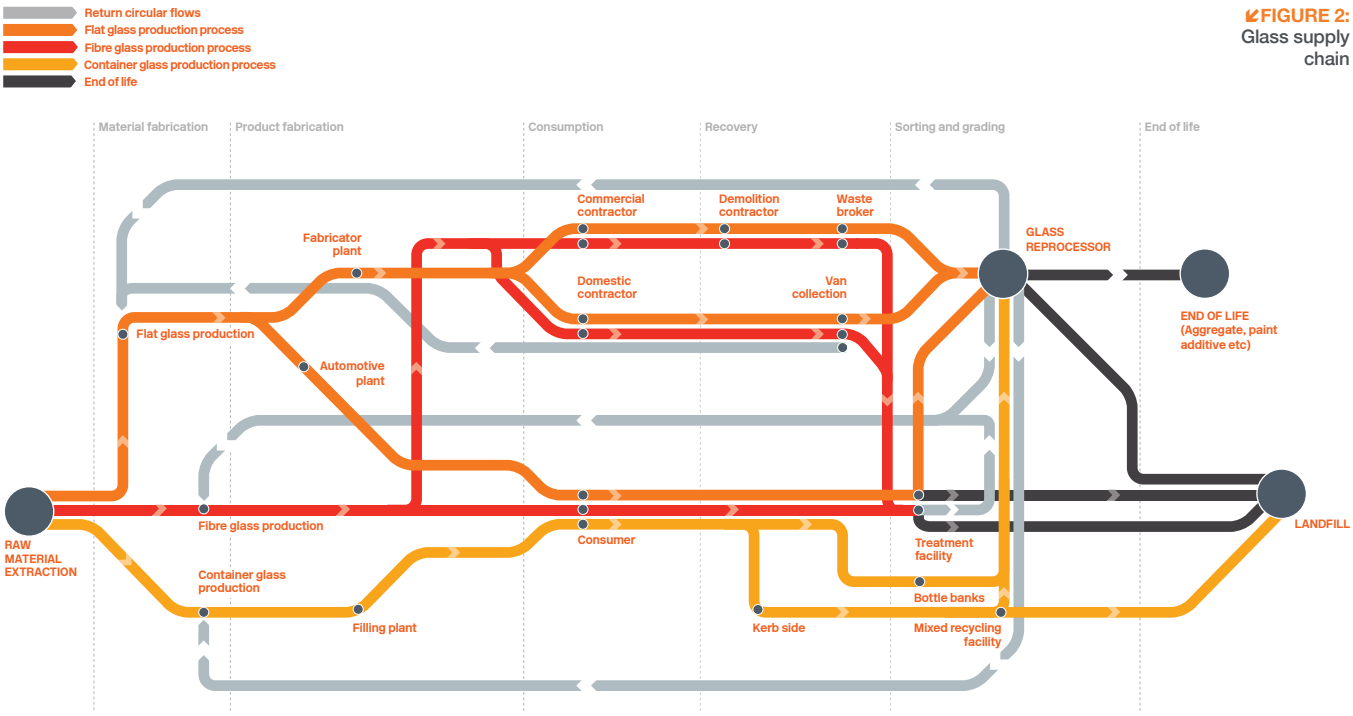

FIGURE 2: Glass supply chain

Reprocessing of glass to remove contaminants should always be secondary to collecting with due care and attention to avoid contamination. Keeping the glass intact is considered to be one key approach in maintaining minimal contamination. Much more care is required to recover intact glass panels due to their fragile nature relative to other construction materials. The process of keeping the glass intact may open up more opportunities for direct glass reuse, e.g. in new insulated glazing units, interior glazing and door frames.

The development of a well-connected supply chain will be key to efficiency. The profit margins in glass are lower than for other materials, but the climate emergency has illuminated opportunities for financial incentives.

How can we encourage a circular approach?

The industry needs to push for better supply chain connectivity **(Figure 2)**. This will involve effort across the board – creating greater opportunity for glass recovery so that material at the end of life can be returned to the supply chain.

Role of industry

To enable rapid development, the industry needs to be open about what the expectations are for each actor and how each can enable development within their sphere of influence.

Where re-processors are involved, they will need to understand to what quality level the glass is processed. A unified glass specification will help to expand the market. Currently, each glass re-processor is working to a specific agreement. While this is not in itself a limitation with relatively low volumes, it could contribute to a less flexible cullet market and stifle expansion.

Further advice needs to be available to those who remove glass on site. There are many ways of framing glass, so an understanding of how to remove the glass efficiently will help to minimise the cost of recovery. This is particularly true for sites where the speed of demolition is an important commercial consideration.

Furthermore, demolition contractors will need to be aware of how to store and manage the glass panels safely on site. Keeping the panels intact is the easiest way to minimise the risk of contamination, leaving the processing of the glass into cullet to experienced glass dismantlers.

Having a demolition specification that requires the segregation and transfer of glass is key to forcing action. A considerate pre-demolition audit should assess with sufficient accuracy the amount of glass on the building, its ease of recovery and potential for recycling or reuse.

Currently, glass can be crushed on site for fill or other purposes. Being an inert material, it does not pose a threat to the environment (although it should be noted that some secondary components of insulated glazed units are not inert). We should aim to do more with what we have.

One key circular recovery strategy is to reuse the glass panel itself, rather than returning it as a bulk material for recycling, thereby utilising the embodied carbon for a longer time. The approach is in its infancy, but GSF, a glazing company in the Netherlands, has been making vast strides in this area[4]. There is a growing field of research in this area to investigate the technical feasibility of reuse (residual strength, thermal performance, ability to redimension). Items such as internal glass partitions lend themselves well to reuse.

Role of legislation

Legislation will tend to lag behind those leading the change, but there are some simple steps that could be taken. For example, in the UK, glass falls into the lower landfill tax rate of £3.25 per tonne, while the standard rate is £102.10 per tonne. Increasing the glass tax rate to the standard rate could help redirect that 'waste glass' as a useful resource.

Role of consultants

The principal action anyone involved in a demolition or refurbishment project can take is to consider the glazing that is due to be replaced as a useful resource. Companies have been providing glass collection for architectural glazing for a number of years.

Larger commercial buildings require a survey of the glazing to be recovered. Certain framing types, or the presence of films, will cause greater difficulty in recovery, but monolithic glass partitions are particularly easy to recover.

If it is practical to remove the glass, then early engagement with the demolition contractor and glass waste carrier is essential.

Communication with the client is of paramount importance, so that they are aware of the benefit of glass recovery.

If space on site is generous, then the glass panel should be stored intact on a stillage. This will help to minimise the risk of contamination from other materials.

If conditions are more compact, as is typical on urban sites, then alternative measures will need to be taken. In such cases, the glass recovery specialist's advice will be needed at the earliest opportunity. With the use of specialist tools and sorting equipment, it is possible to destructively dismantle glass on site, thus enabling the collection of high-quality cullet for use in new flat glass.

On the smaller scale of residential and domestic glazing, the individual unit volumes are smaller, but in total the sector surpasses commercial construction.

In the UK, Eckersley O'Callaghan is working with the Glass and Glazing Federation and FENSA to encourage the replication of end-of-life glass recovery that has been carried out for years by pioneers such as Morley Glass in conjunction with Saint-Gobain Glass. Morley Glass produces new glass units and allows glazing installers to return old units when collecting new ones, saving transport costs and waste disposal. In total, this one processor has diverted 1500t of glass from landfill.

Information sharing

To support this effort, Eckersley O'Callaghan is launching a website (www.glazingrecovery.org) to support glazing recovery. It will initially be populated with the firm's research, but others will be invited to collaborate. As well as providing contacts for glass recovery, it will host useful information such as guidance on removing and storing glass on site.

There is an opportunity to achieve a significant reduction in the carbon emissions of glass by taking practical steps at the right time. This has been technically achievable for some time – effectively scaling these practices relies on increased awareness and action.

This is the kind of collaboration that signatories of Structural Engineers Declare have committed to, so please submit any resources that would be useful. We all stand to gain.

Graham Coult
BEng (Hons)

Graham Coult is a Technical Director at Eckersley O'Callaghan in London, with a particular passion for the development of structural glass design using sophisticated analysis and modelling tools.

Rebecca Hartwell
MEng, PhD

Rebecca Hartwell is a Postdoctoral Researcher at TU Delft in the Netherlands, with a particular interest in promoting the effective reuse and high-value recycling of building envelopes.

REFERENCES

1) Hartwell R., Coult C. and Overend M. (2022) 'Mapping the flat glass value-chain: a material flow analysis and energy balance of UK production', *Glass Struct. Eng.*, 8, pp 167-192; https://doi.org/10.1007/s40940-022-00195-9

2) del Río Merino M., Izquierdo Gracia P. and Weis Azevedo I.S. (2010) 'Sustainable construction: construction and demolition waste reconsidered', *Waste Manag. Res.*, 28 (2), pp. 118–129; https://doi.org/10.1177/0734242X09103841

3) Hestin M., de Veron S. and Burgos S. (2016) *Economic study on recycling of building glass in Europe* [Online] Available at: https://glassforeurope.com/economic-study-on-recycling2/ (Accessed: December 2023)

4) van Nieuwenhuijzen E.J., Tetteroo J.I.A., van de Vliet M. and Melet E. (2023) 'In situ detection of product age and argon concentration as measure of the re-use potential of insulating glass units in buildings', *Glass Struct. Eng.*, 8, pp. 211–233; https://doi.org/10.1007/s40940-023-00225-0