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Building glass into the circular economy

How to guide

UK GBC

VERDEXTRA

British Glass

ARUP

CONTEXT

Glass is a highly recyclable material, despite which, end-of-life building glass is almost never recycled into new glass products. In the UK alone, almost 200,000 tonnes of glass is currently sent to landfill each year. In the EU, the proper recycling of all building glass waste could avoid 925,000 tonnes of landfilled waste every year and save around 1.23 million tonnes of primary raw materials annually.

When a building is refurbished, end-of-life façade glass is usually crushed and used as aggregates in road construction. Whilst this is better than sending glass to landfill, the most effective use is to turn glass into new glass products: it can be recycled in this 'closed loop' indefinitely.

The process of turning waste flat glass into cullet (crushed waste glass for recycling) is classified as a waste recovery operation and is therefore subject to waste management legislation. This creates a significant burden for the industry, resulting in very little waste glass being recovered.

There are a range of opportunities to recycle and reuse glass; this guide gives an overview of the options and opportunities available.

CIRCULAR ECONOMY

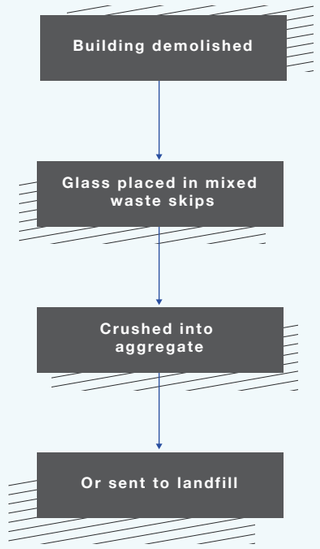
Circular economy practices offer the potential to capture the lost value from recycling of glass, creating opportunities for the reuse of materials and saving of raw materials, energy and carbon emissions.

A circular economy approach provides a framework for designers and engineers to work and build greener, more sustainable, buildings and infrastructure projects, decoupling economic growth from finite resource consumption. Figure 2 shows how glass is currently treated under the existing linear economy, and how it could be recycled and reused under a circular economy. Figure 2 shows more specifically how processes could be adapted to create a circular value chain for glass recycling.

FIGURE 1

Shifting from a linear to a circular economy (Tishman Speyer, Verde case study)

STANDARD PRACTICE | LINEAR



IMPROVED APPROACH | CIRCULAR

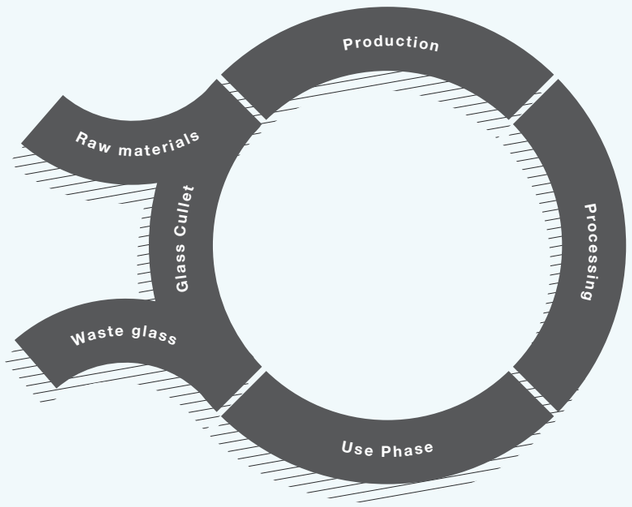
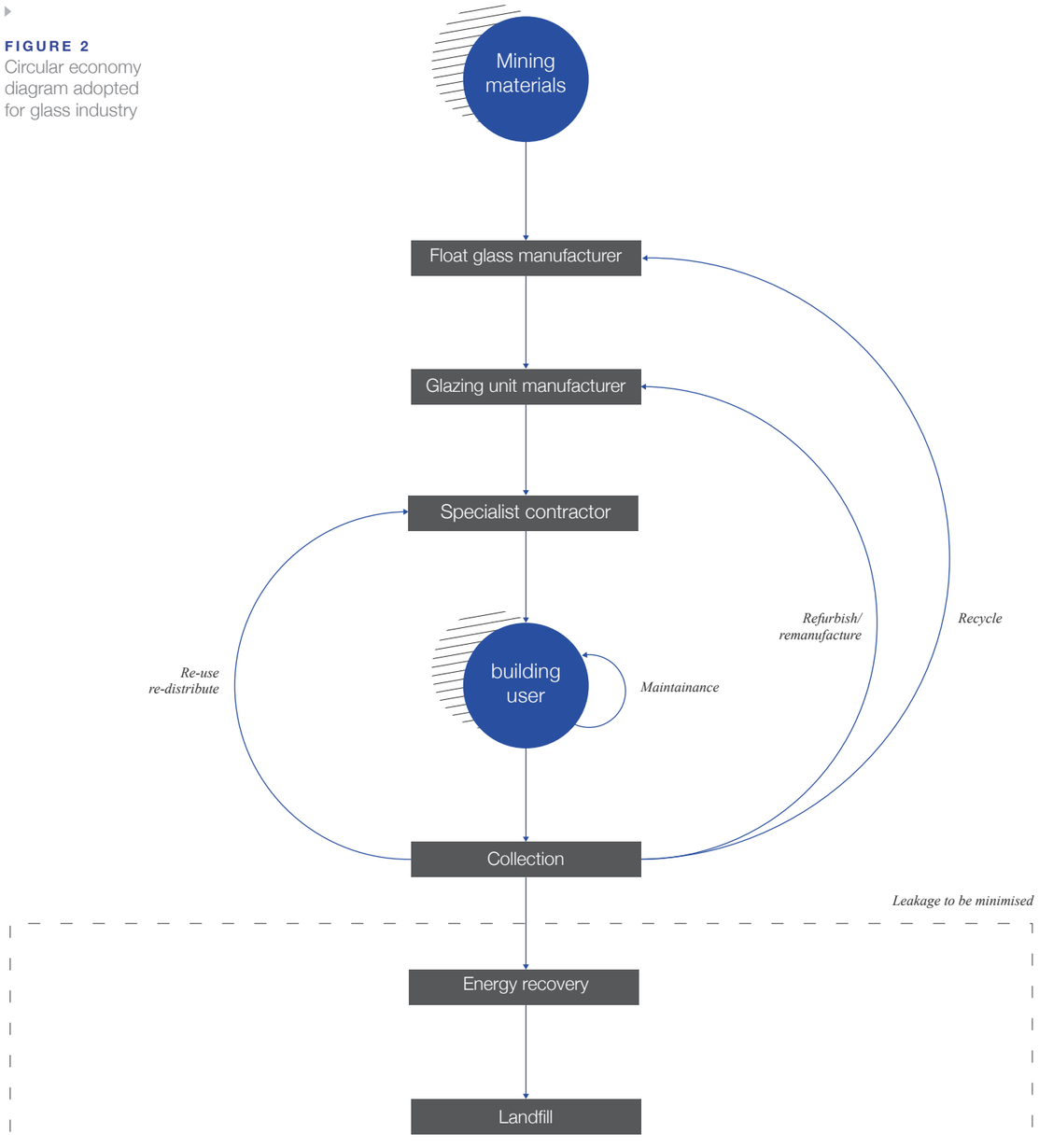


FIGURE 2
Circular economy diagram adopted for glass industry



ENVIRONMENTAL BENEFITS

Raw material use

Per tonne of cullet used in the manufacture of float glass, 1.2 tonnes of raw material is saved[1], reducing requirements for mining quarrying, and associated processing and transportation.

A large proportion of raw materials (35% or more) can be replaced by cullet/recycled materials if they are available at the right quantities, quality and price

Energy use

As cullet melts at a lower temperature than raw materials, for every 10% of cullet added to the furnace, 3% less energy is used. British Glass have described this as 300 kWh of energy saved for every one tonne of cullet used[2].

CO_2

A reduction of CO_2 emissions of 250-300kg is realised for every tonne of cullet added to the furnace[3].

Landfill

By recycling construction glass in a closed loop cycle, materials sent to landfill and associated disposal costs are also reduced.

35%
or more raw material can be replaced by cullet

3%
less energy used for every 10% of cullet

1.2
tonnes of raw material saved with every tonne of cullet used

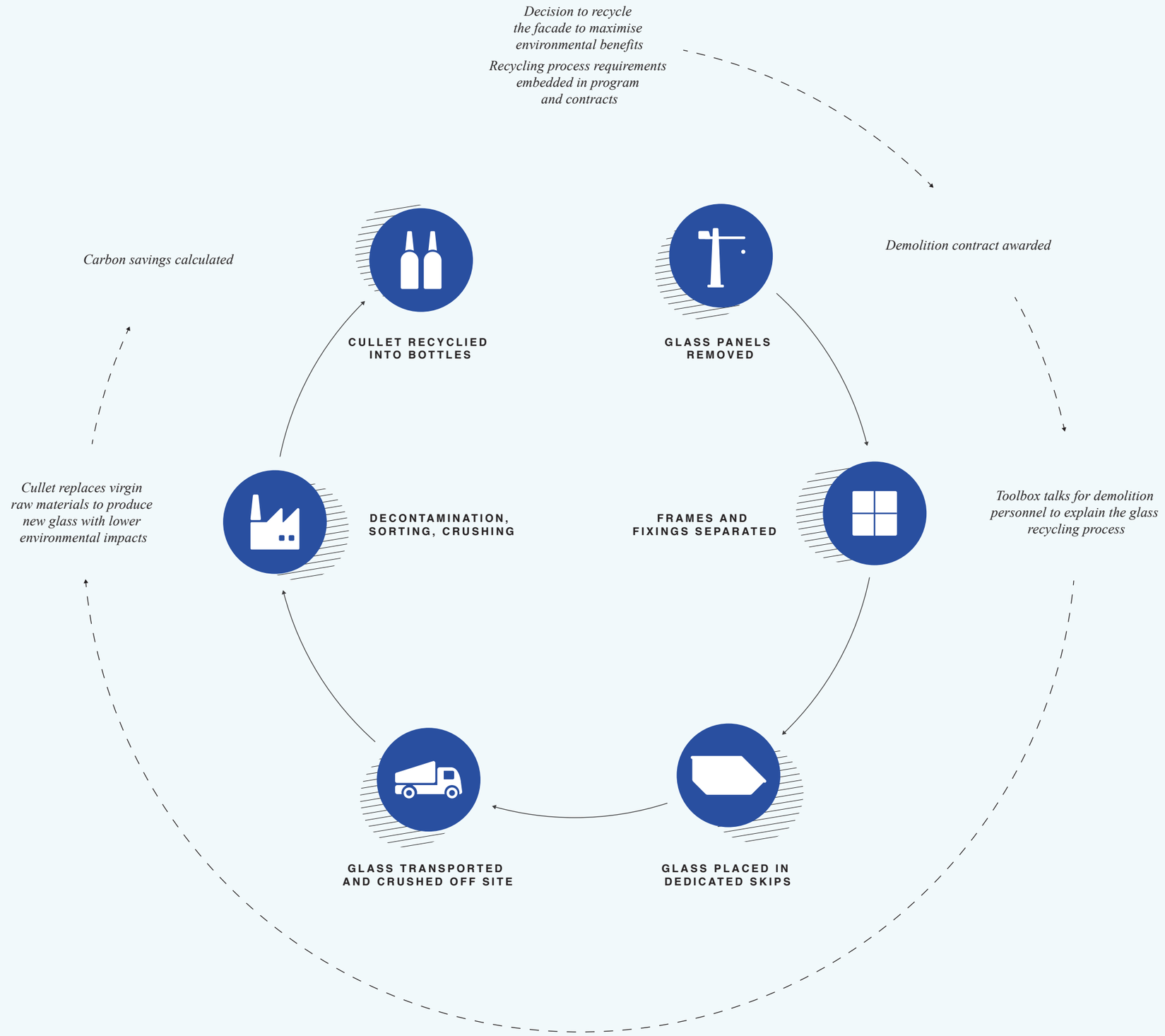
REFERENCES
[1 2 3] Glass Technology Services, 2008. UK Glass Manufacture; A Mass Balance Study.

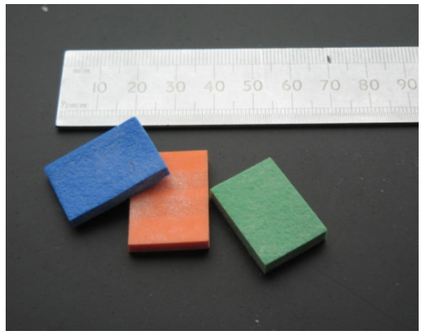
"As a society, we must move away from this 'take, use, dispose' mentality, and as members of the construction industry, it is our duty to take on this challenge."

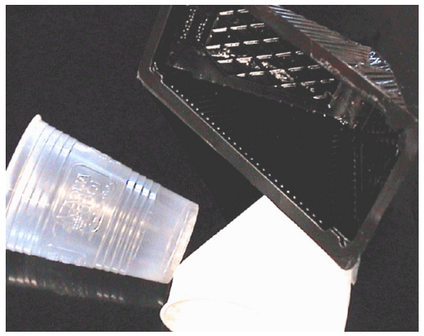
RECYCLING OF FLAT GLASS IN CONSTRUCTION PROJECTS

Figure 3 illustrates how value would be created in a circular glass recycling approach. Designs and specifications for new façades should follow guidance to maximise the potential of glass to be recycled. This can drive the increase of waste construction flat glass recycling, therefore reducing virgin raw material use and reducing the carbon intensity of flat glass manufacturing.

FIGURE 3
Glass recycling process for Verde SW1







CONTAMINATION
From top: foam spacers, food packaging & Silicon carbide.

MINIMISING CONTAMINATION DURING OPERATION

Contamination is the biggest technical challenge to overcome to increase the availability of quality cullet for the remelt process. Currently the collection method requires that contamination is very carefully controlled. Removal of the glazing units from the building site to a factory environment for disassembly appears to the best way to provide the quality control required.

Any contamination of the recycled glass used to manufacture glass will cause rejectable defects. Once introduced into a furnace contamination can take several days to pass through the system. Thus low levels of contamination can result in several days of lost production which will cancel out the environmental and cost benefits of recycling.

The best way to control contamination is at source. When a batch of cullet becomes contaminated it is very difficult and costly to remove the contaminant. The most common contaminants found in cullet are listed below.

- Metal drinks cans
- Floor Sweepings
- Cutting blades
- Silicon carbide discs
- Spacer bars from sealed units (clear cullet only)
- Paper and cigarette packets
- Foam spacers

These contaminants are usually introduced into the cullet by items thrown into skips by passing staff and visitors To prevent this it is essential that all glass skips and bins are clearly labelled, additional bins are available for other types of waste and staff are fully trained in their use.

Special glass types can cause significant problems as they are very difficult to identify and separate at the cullet processor, trade names of the most commonly used heat resistant and fire glasses are detailed in the table below. Nickel containing stainless steel and alloys such as those found on machine wear plates can also cause problems for glass manufacture. Common types of heat and fire resistant glasses that must not be included in flat glass cullet.

CONTAMINATION
Contaminated glass cullet

Product	Glass type	Applications	Supplier
Borofloat	Borosilicate Float	Oven doors, chemical industry, lighting.	Schott
Pyran	Toughened Borosilicate Float	Fire doors, windows, partitions etc.	Schott
Robax	Glass ceramic	Gas fires and cooker tops.	Schott
Ceran	Glass ceramic panel	Cooker tops	Schott
Pyrostop	Laminated fire glass	Fire doors and partitioning	Pilkington
Pyrodur	Laminated fire glass	Fire doors and partitioning	Pilkington
Pyroguard	Laminated fire glass	Fire doors and partitioning	CGI International

CLEAR CULLET

Off-cuts of clear flat glass only. The following are not permitted :

Heat resistant glass	Laminated fire glass	Other glass	Metals	Other waste
Borofloat	Pyrostop	Sealed units	Drinks cans	Foam spacers
Pyran	Pyrodur	Mirrored	Spacer bars	Paper
Robax	Pyroguard	Laminated	Cutting blades	plastics
Ceran		Windscreen		Cutting disks
		Wired		Stones

MIXED CULLET

All clean off-cuts of standard flat glass should be placed in a clear cullet bin/skip.

Only:

- Sealed units,
- *Mirrored glass,*
- *Tinted glass,*
- *Laminated glass,*
- *Wired glass,*
- *Printed glass*

The following are not permitted :

Heat resistant glass	Laminated fire glass	Metals	Other waste
Borofloat	Pyrostop	Drinks cans	Foam spacers
Pyran	Pyrodur	Cutting blades	Paper
Robax	Pyroguard		plastics
Ceran			Cutting disks
			Stones

PROCEDURE
uncontaminated cullet

RECOMMENDED PROCEDURES

Collection

Contamination of flat glass cullet will usually occur at the point of collection. The following good practice should be used to avoid contamination at this point.

- Full training should be given to all staff handling cullet. (See appendix two for a set of example training slides)
- All waste on site should be segregated using clearly labelled, colour coded bins.
- There should be a sufficient number of bins on each site to cover all types of waste, these should be placed in all relevant areas.
- Labels on all glass collection bins and skips shall clearly state what can and cannot be placed in the bin.

Transportation, handling and storage

For good practice in transportation, handling and storage:

- The handling of recovered glass should be minimized to reduce the potential for breakage and contamination.
- Dedicated transport should be used where possible, where it is not possible transport skips must be thoroughly cleaned and inspected to ensure no contamination is present.
- Everyone involved in the cullet collection process should receive training in order to understand the implications of contamination
- Cullet should be stored in bays that are of sufficient size to avoid spillage and mixing of loads.
- When picking up cullet the loader must avoid touching the floor or sides of the bays to reduce the risk of chipping the bays adding contamination into the load.
- Keep records of the source of glass in each bay to allow the sources of problems to be traced.
- Arrange drainage to minimise the flow of rainwater into the bays.
- Night time deliveries should be avoided so that any contamination can be more easily spotted when loads are tipped.

FLOAT LINE
The float glass process is widely used for construction and automotive glass manufacture

"In the UK there are currently three operating glass float lines; operated by Pilkington in Merseyside, Saint Gobain and Guardian both inYorkshire...

Around 700,000 tonnes of glass is produced in the UK each year from the three lines."

USEFUL REFERENCES

Re-thinking the life-cycle of architectural glass. Arup, 2018.

First steps towards a circular built environment. Arup, 2018.

Circular Economy: UKGBC Sustainability 360 survey findings 2017. UKGBC, 2018.

Glass from Glass: leading by example - setting a precedent in the construction industry. Tishman Speyer, 2016.

UK Glass Manufacture - A Mass Balance Study. Glass Technology Services, 2008.

DESIGNING FOR SUCCESS

Key project requirements

- Close collaboration with partners from the outset ensures that sustainability principles are embedded in all processes: contractor, demolition contractor, recycler, Life Cycle Assessment (LCA) analyst; and ensures all parties' buy-in to a project.
- Early and ongoing engagement with a glass reprocessing company is critical
- Embedding requirements in the process pre-tender ensures inclusion in the demolition contract.
- Appointing a recycling champion to oversee the process is important during the glass removal stage. This helps prevent contamination of the glass from the old façade.

Overcoming barriers

Networking, education and awareness of environmentally sustainable products will raise the profile of specialist window supply companies offering recycling services. Project examples and case studies are needed to prove to the industry that glass recycling is a viable and achievable alternative. The growth of a network of sustainable glass industry specialists will also help to disseminate learning and develop practices around the UK.

Legislation is also required to ensure contracts for window replacement include recycling of all removed materials in closed-loop schemes. Government Buying Standards (GBS) could be more ambitious to encourage further uptake of recycled content entering the supply to glass manufacturers.

Standards such as BREEAM could be updated to emphasise reuse and recycling of building materials from existing building stock and capture the potential materials available from their refurbishment and demolition. It should include points for the off-site recycling of glass from building projects, and clarity of eligibility of recycling in a closed-loop system in a network that may or may not include the original manufacturer is also required. BREEAM RFO regulations could also be updated to allocate points for the retrieval of high quality glass cullet from refurbishment projects.

Costs related to demolition and glass removal may increase, creating an additional burden (and disincentive) for certain parties. Current industry practices need to be examined to understand how to incentivise contractors to change their approaches without incurring significant costs. Benefits - such as lower landfill taxes - should also be highlighted.

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