Q&A – Understanding flat glass recycling

1) Benefits of flat glass circular economy

1. What makes flat glass particularly suited to a circular economy?

- Flat glass is an indefinitely recyclable material. If not contaminated, flat glass can be processed infinitely without losing its purity or structural integrity.
- Remelting crushed flat glass (cullet) requires lower furnace temperatures than melting virgin raw materials, which reduces manufacturing energy consumption and lowers carbon emissions.
- The European ambition of achieving zero-emission building stock and low-carbon mobility should, in principle, increase the amount of flat glass to be recycled. For instance, coordinating renovation timelines with local cullet collection and processing capacity can help smooth supply to recyclers rather than producing irregular, unpredictable and insufficient volumes.

2. What are the benefits of recycling flat glass?

- Using cullet contributes to reducing both process emissions associated with raw material melting and combustion emissions.
- Every additional 10% of cullet reintroduced into the manufacturing batch leads to a reduction in energy consumption of between 2 and 3%.
- It is estimated that using 1 tonne of cullet saves 1.2 tonnes of raw materials and 310 kg of CO_2 from glass manufacturing, and even around 600 kg of CO_2 when considering the CO_2 savings from the extraction and transportation of raw materials.
- It is particularly relevant considering that while several technologies are evaluated to decrease or suppress CO2 from combustion emissions, substituting cullet to virgin resources is the single alternative solution to decrease or suppress process emissions beside CCS/CCU which is still uncertain approach to abate flat glass CO2 emissions at the required levels to reach the 2040 and 2050 targets.

3. To what extent can the circular economy contribute to the electrification of the flat glass sector?

- The flat glass sector is conducting trials on hybrid furnaces that use a much larger proportion of electricity than the electro-boosting system currently in place[1].
- Cullet (crushed flat glass) melts at a lower temperature and more rapidly than virgin raw materials.

[1] It is currently impossible to produce flat glass using only electricity. A fully electrified furnace would require a considerable amount of electricity and would not currently deliver the necessary level of glass quality.

- Theoretically, electric and hybrid (gas-electric) furnace technologies face higher energy intensity and cost per tonne than conventional gas-fired furnaces, so a higher cullet ratio helps offset that gap and improves the economic case for electric melting.

2) Current state of flat glass recycling

4. Where does recyclable flat glass come from?

- There are essentially three sources of flat glass cullet which can be recycled, each with their own specificities:
    - Furnace process cullet: cullet generated by a glass melting furnace for quality rejects or other reason during production period or during non-production period,
    - Pre-consumer cullet: Any cullet resulting from industrial operations, from the stacking of glass after it leaves the glass melting furnace to the point at which the product is finished. Post-consumer cullet : originated from finished products before, during or after their use at the consumer market.It includes returns or breakages of finished products from the transport and distribution chain as well as all material coming from glass recycling collection schemes such as glass from construction and demolition waste or from end-of-life vehicles.
- Furnace process and pre-consumer cullet are almost fully recovered already by agreements between glass manufacturers and processors, thus making use of their potential. The biggest untapped source of cullet comes from construction and demolition projects, of which only 5% is effectively recycled today.

5. Why isn't all flat glass recycled today?

- Only high-quality secondary raw materials can be reintroduced into the batch without risking damage to the furnace. This level of quality is also necessary to ensure the quality of the new flat glass being produced.
- The challenge is therefore not whether glass is recyclable, but whether it can be collected and treated in sufficient quality for closed-loop recycling.
- Currently much end-of-life flat glass is contaminated or mixed with materials. For building glass, contamination can come from other building materials, window frames, sealants, and ceramics. For end-of-life automotive glazing, the glass fraction collected after shredding and separation from other materials is always contaminated to such an extent that it is unsuitable for closed-loop flat glass recycling. If the glazing is not dismantled properly before shredding, parts that are glued to them, such as connectors, wires and other metallic parts, require specific separate collection and treatment.
- Selective dismantling is not yet common practice across the EU, meaning that recyclers can treat few resources. The situation is further complicated by the fact that collection and sorting infrastructure varies significantly across Europe.

6. What happens to flat glass when it cannot be recycled into flat glass?

- In most cases, flat glass is crushed with other materials and ends up being landfilled or used in low-value applications (downcycled) which means that valuable material is permanently lost from the glass manufacturing loop.
- Flat glass cullet of a lower quality can be used by other glass sectors. These other industries are willing to purchase this cullet that is highly suitable for their needs, but that cannot be used by the flat glass industry.
- When cullet is of a quality suitable for flat glass making, diverting this cullet to other glass sectors is a form of downcycling. Flat cullet should be utilised whenever possible in closed loop recycling in flat glass to maximise benefits in terms of decarbonisation.

3) Market realities about flat glass recycling

7. What role do construction companies and demolition firms, recyclers, manufacturers each play?

- Closed-loop flat glass recycling depends on coordinated action across the entire value chain.
- Construction and demolition companies must preserve the value of flat glass by ensuring it is properly dismantled, recovered separately and with minimal contamination.
- Down the chain, recyclers clean the recovered waste stream and transform it into a secondary raw material suitable for manufacturing.
- At the end of the chain, glass manufacturers purchase the clean cullet.

8. What are specific realities of automotive glass recycling?

- While a low percentage of automotive glass was recycled (less than 10% in 2021), the End-of-Life of Vehicles Regulation (ELVR), which entered into force in 2026, foresees several glass recycling measures.
- The ELVR mandates that automotive glass to be designed in such a way that dismantling is not hindered.
- The ELVR also mandates that 70% of the glass parts be dismantled and recycled into glass.
- Finally, the ELVR mandates the introduction of Extended Producer Responsibility (EPR) schemes for vehicles to finance these circularity measures.
- ELVR also requires that the removed glass from the end-of-life, as a minimum shall be recycled into container glass, fibre glass or equivalent quality. The challenge will be to raise the quality level of the cullet, so that it can be used to produce new automotive glazing, i.e. ‘close-loop recycling’.

9. Can glass used in solar panels be recycled?

- A typical crystalline silicon solar photovoltaic (PV) panel consists of glass (about 76% to 80%), plastic polymers, aluminium, silicon, and metals like copper and silver
- The glass used in solar panels (PV glass) can be recycled into new flat glass products if the following conditions are met.

- The glass used by the solar panel manufacturers often contains antimony and arsenic. These elements should be limited as they can have an impact on production lines and the quality of the glass producedFumes generated during the process could also be hazardous.
- When the glass is dismantled by the recyclers, it is necessary that all the different elements constituting the panels are well separated. The possible recycling of glass will depend on the recycler's ability to separate all polluting elements (plastic polymers, silicon, metals...) from the glass. Dismantling the glass from the rest of the PV module in a non-destructive way must therefore be considered.

10. How is the price of cullet determined?

- The exact price of cullet varies significantly based on glass quality, purity, and trade dynamics.
- The break-even point for flat glass manufacturers depends on several factors, including the availability and proximity of raw materials, energy cost and the value of the saved CO2.
- Total cost of collection, logistics, recycling, storage, handling and other operational activities among market dynamics can often today bring the total delivered price above this break-even point in absence of suitable infrastructure for collect and massification of these diffuse cullet sources

11. Are there enough collection and processing facilities across Europe today?

- Coverage is uneven: some regions have well-established collection and massification structure with adequate sorting for flat glass, while others lack dedicated capacity and post-consumer flat glass is more likely to be downcycled or landfilled by default.
- Flat glass treatment is generally made on specific lines, its requirement being different from the treatment of container glass, which limits the number of facilities able to process it to float-furnace quality.
- However, developing local collection, sorting, and processing capacity for flat glass cullet creates regional jobs in logistics, sorting, and quality control, complementing manufacturing and processing employment.

12. Is there a distance limit for transporting cullet?

- Because glass is heavy and its intrinsic material value is relatively low, moving cullet is expensive.
- The inland distance at which transport emissions start to erode the net environmental benefit depends on the transport mode (road versus rail or barge), the melting energy savings achieved, and the carbon intensity of the transport fuel used.
- For this reason, industry practice favour sourcing cullet regionally, close to collection points, processing and sorting facilities and manufacturing plants.

13. What role does the legal classification of glass under waste legislation play?

- Post-consumer flat glass removed from a building is classified as waste until it meets applicable end-of-waste criteria[2], which triggers administrative and permitting requirements for handling, storage and transport.
- Cross-border movement of glass cullet classified as waste falls under the EU Waste Shipment Regulation, which can add administrative steps to what would otherwise be a straightforward raw material trade between neighbouring countries.
- An important fraction of pre-consumer glass cullet meets all legislative requirements to be considered as a 'by-product'. In this case, transportation is made easier, however not all countries grant the status of 'by-products' to pre-consumer glass cullet.
- Clearer or harmonised end-of-waste and "by-product" criteria for glass cullet across Member States would reduce friction in an EU-wide cullet market.

4) Increase quality and quantity of cullet

14. What is the issue with the transportation of pre-consumer cullet?

- While most pre-consumer flat glass cullet which can be used without much processing (off cuts generated on glass processors' transformation sites) meets the conditions to be considered a *'by-product'*, many Member States do not directly recognise this status[3].
- Although the EU definition allows by-product status to be determined through self-assessment, many Member States require a specific review and approval process. This creates restrictions on cross-border movements.
    - For example, self-assessment declarations are fully recognised in Belgium, while Germany requires a state assessment and does not recognise self-assessments. As a result, additional handling costs are incurred.
    - Spain also requires additional permits or authorisations for materials to be recognised as by-products, despite EU rules already defining when by-product status applies. Furthermore, Spain does not recognise assessments or self-assessments conducted in other jurisdictions as sufficient.
    - A similar situation exists in Poland, where by-product status granted in another jurisdiction is not systematically recognised. Instead, a separate Polish approval is required.
- It means that trucks of flat glass pre-consumer cullet get controlled, questioned, and stopped, sometimes within a Member State itself or at borders within the EU.
- This situation could be rather easily solved with an EU-wide recognition[4] of the 'by-product' status for pre-consumer cullet. If needed, this recognition can be linked to specific harmonised technical specifications.

[2] Commission Regulation (EU) No 1179/2012, available here

[3] The legal concept of a by-product under Article 5 of the Waste Framework Directive (WFD) is interpreted differently across Member States, creating barriers to circularity, increasing costs, and adding administrative burdens.

[4] As it is the case for the End-of-Waste recognition according to Commission Regulation (EU) No 1179/2012

15. How can pre-demolitions audits support the collection of more secondary high-quality cullet?

- Pre-demolition audits should help identify both the quantity and quality of recoverable flat glass, whilst also enabling its effective recovery through clear, actionable outputs.
- The audits must contain information relative to the:
    - Location of all flat glass elements: windows, curtain walls, doors, partitions, skylights, facades as well as the estimated surface area, weight, and number of panes.
    - Glass type and composition: pane thicknesses and whether the glazing is even partially composed of coloured glass, monolithic, laminated, insulated, coated, or wired glass.
    - Risk factors affecting dismantling and recycling: contamination, breakage risk and the presence of hazardous substances (e.g. asbestos, lead paint), attached components (e.g. glued glazed façade).
    - Installation and removal methods: accessibility for safe removal, potential for whole-pane recovery versus breakage. The ease of deglazing can vary significantly depending on whether the glass is mechanically retained, structurally bonded, captured within gasket systems or affected by materials such as putties, mastics or sealants that may hinder recovery or introduce contamination. Where possible, audits should also indicate the likely ease of removal (e.g. simple, moderate, complex) and highlight any specific factors that may significantly affect breakage risk or recovery rates.
    - Photographic records and marked-up survey drawings where appropriate.
    - An estimate of potential CO_2 savings associated with recycling.

16. Why does the sector call for more stringent landfilling measures?

- Where landfilling remains cheap or unrestricted, it competes directly with recycling as the lowest-effort option for demolition and construction waste, weakening the economic case for sorting and collecting glass separately.
- Higher landfill costs, or targeted incentives to avoid landfilling, would encourage diversion of recyclable glass only when viable recycling routes exist, in line with the EU waste hierarchy, which prioritises recycling over disposal.
- Consistent enforcement matters as much as the existence of the measure: uneven application across Member States creates an uneven playing field and can encourage waste to move toward jurisdictions with weaker restrictions.
- Such measures would need to be paired with adequate sorting and processing capacity; restricting landfill access without a viable alternative destination for the glass would simply shift the bottleneck rather than resolve it.

17. What role can Extended Producer Responsibility (EPR) schemes play in scaling up flat glass collection?

- EPR schemes can create a structured, funded route for collecting end-of-life flat glass, rather than leaving collection to ad hoc market arrangements but their effectiveness depends on

several factors including price, the product scope, the geographic coverage, the type of recycling route and the contribution from importers.

- There are two successful schemes at Member States level in France and the Netherlands. The schemes however differ in several ways:
    - In France, the EPR scheme for construction products and materials[5] has demonstrated that integrated collection of window frames is achievable, and that building a dedicated network of dismantlers is workable in practice. Under these conditions, the scheme has shown it is possible to collect, dismantle and recycle window-derived cullet in a closed loop back into flat glass. In 2024, 18.000 tonnes of flat glass have been recycled through the EPR scheme. However, even if glass fraction is important in volumes, the rather low value of glass compared for instance to aluminium or PVB can complexify its effective separation and recycling.
    - In the Netherlands, the Building Decree (*Bouwbesluit*) requires that flat glass be kept separated from other waste streams during renovation or demolition. In practice, however, a significant lack of enforcement means much post-demolition flat glass is still lost to mixed waste streams rather than captured for recycling. Alongside this, the Dutch glass and façade industry has entered into voluntary agreements with government to build a circular economy for end-of-life flat glass[6].
- Taken together, the French and Dutch experiences suggest EPR schemes work best when paired with a dedicated dismantling network (not just opportunistic collection), genuine enforcement of separation requirements, and streamlined administrative processes for moving cullet across the supply chain.

18. What role can digital tools such as material or building passports play?

- Material passports recording the type, coating and composition of glazing installed in a building can help future demolition or renovation teams identify what is present before removal begins.
- This supports better sorting decisions at the point of deconstruction and can reduce reliance on post-hoc identification of glass type.
- Their usefulness depends on consistent data being recorded at installation and remaining accessible over the building's decades-long lifespan.

19. What should policymakers avoid as part of the next Circular Economy Act?

- Focusing on recycling volumes instead of recycling quality. In the case of flat glass, sufficient quality is the highest priority to ensure that higher volumes can be recycled.
- Setting targets that are disconnected from available collection and recycling infrastructures.
- Setting minimum recycled content obligations while the infrastructure is not in place to provide high-quality cullet in sufficient quality to meet requirements.

[5] More information on the French scheme can be found on this website: https://filieres-rep.ademe.fr/en/filieres-REP/filiere-PMCB
[6] More information on the Dutch scheme can be found on these websites: Bouwmaterialenakkoord | Home | Volkshuisvesting Nederland & Circulaire Geveleconomie | Op naar een duurzame gevelsector