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Sustainable Design in Action

A Case Study on Fused Recycled Glass in the Redruth Buttermarket Restoration

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Abstract

This paper presents a case study that illustrates how discarded glass bottles were transformed into a functional architectural feature. The project aimed to develop a novel product that converts waste glass into a durable material suitable for outdoor cladding in buildings. Prior to the contract, extensive investigation and development were undertaken to ensure that the fused recycled glass met safety and structural requirements. The design—inspired by hanging slates commonly found in architecture across the United Kingdom—incorporates sustainable fused recycled glass, which is innovatively used externally for the first time. Throughout the process, careful assessments were undertaken to evaluate the material's environmental impact. The project establishes a new benchmark for circular economy principles, thus demonstrating how reclaimed materials can drive architectural innovation while reinforcing environmental responsibility.

Introduction

Despite the increasing emphasis on sustainable materials and circular economy (CE) principles, academic research into advanced remanufacturing of waste glass for high-performance architectural applications remains limited. An extensive literature review in Scopus reveals a scarcity of published studies that examine the full potential of recycled fused glass, particularly concerning its structural integrity, durability, and viability for exterior applications (Bristogianni et al., 2018, 2020). While some investigations have explored cast glass and façade integration, this area of study remains underdeveloped compared to conventional materials such as concrete, ceramics, and metals (Oseng-Rees et al., 2025).

Recognising the potential of utilising waste glass, Oseng-Rees et al. (2014) conducted an early investigation into fused recycled glass, exploring its feasibility as an aesthetic architectural material. This research laid the foundation for further developments in recycled fused glass applications, ultimately leading to the establishment of a spin-out company that was commissioned to develop and fabricate tiles for the case study described in this paper. The potential for recycled glass applications is emphasised by its environmental benefits, including a significantly lower carbon footprint compared to traditional glass production methods, which have been investigated during the case study.

The potential of recycled glass for high-value applications

Glass recycling is a widely adopted practice in modern waste management, and it significantly contributes to resource conservation and environmental sustainability. Post-

consumer bottle glass is ideally processed for conventional reuse or reintroduced into container manufacturing. However, a substantial proportion of recovered glass is downcycled into aggregate production or filter beds. According to Harder (2018), surprisingly only 21% of glass is recycled on a global scale; in 2015, the recycling rate for container glass in the EU-28 (including the UK) was 76% (Harder, 2018). In the UK, container glass accounts for 60% of total mass output, with a recycling rate of 76.5% reported in 2019, which is attributed to extended producer responsibility and investments in collection methods. Consequently, the remaining 23.5% is eliminated from the CE. In contrast, flat glass used for architectural and automotive purposes constitutes 30% of total mass output, yet it is infrequently recycled into new flat glass products (Hartwell et al., 2023). This trend limits the potential of glass for high-value applications, particularly in structural and architectural contexts (Bristogianni & Oikonomopoulou, 2022). In the paper titled 'A glass industry in denial', Whettingsteel and Day (2025) argue that this diversion reflects deeper systemic issues, including fragmented sector governance, misaligned legislation, and a lack of unified messaging, which have permitted lower-value reuse to dominate both policy and public perception.

While glass is infinitely recyclable, several critical factors determine its suitability for secondary applications. These include the purity of the glass, the separation of different glass types, and the cost of logistics associated with its collection and processing (Bristogianni, & Oikonomopoulou, 2022). For example, research indicates that mixed glass collections often result in colour contamination, which can significantly degrade the quality of recycled glass cullet and limit its use in high-performance applications (Bristogianni, et al., 2020). Whettingsteel and Day (2025) further highlight that economic and legislative frameworks tend to penalise glass's upfront energy use without crediting its long-term environmental advantages, thereby reinforcing a cycle of downcycling—mostly as aggregate in landfills, filling or in concrete mixes in the best of scenarios (Premathilaka et al., 2024)—and missed opportunities for premium reuse.

This project also involves meticulous monitoring and analysis of the carbon footprint associated with the production of the recycled glass shingles. The data collected was analysed by the University of Salford as part of the Future Homes UKRI Innovation Accelerator Project (University of Salford, 2025), employing established standards to quantify greenhouse gas emissions, energy consumption, and material flows throughout the project. This comprehensive approach emphasises the commitment to sustainability at every stage of the project.

The redruth buttermarket restoration project

The Redruth Buttermarket restoration project represents an outstanding undertaking in heritage conservation and sustainable architectural innovation. Located in Redruth, a town in Cornwall, England, this initiative aims to revitalise a historic marketplace that has long served as a focal point for the local community. The Buttermarket, originally constructed in the early nineteenth century, has undergone a comprehensive transformation to enhance its functionality while preserving its historical significance. The project is characterised by the integration of modern design principles with traditional architectural elements, thus showcasing a commitment to sustainability and environmental responsibility. The restoration was undertaken by Architectural Thread Ltd, an architectural practice specialising in blending contemporary design with historical context. Founded by Claire Fear, Architectural Thread Ltd has acquired recognition for its ability to navigate the complexities of heritage projects while pushing the boundaries of material innovation. The firm's approach to the Buttermarket project involved extensive collaboration with conservation specialists and local stakeholders, thereby ensuring that the revitalisation aligns with both the historical integrity of the site and the evolving needs of the community (Chalk, 2025).

The key feature of this restoration project is the glass façade, which is constructed from recycled glass shingles methodically fabricated from post-consumer waste bottle glass. This façade aimed to enhance the aesthetic quality of the structure and serve as a focal point for entering the building. This paper examines the development and fabrication processes of these glass tiles. By utilising upcycled materials, the project exemplifies the principles of a CE—repurposing materials that would otherwise contribute to landfill waste. This approach highlights the engagement of architectural practice in sustainable material sourcing and utilisation, thereby addressing critical environmental challenges, for example by transforming post-consumer bottle glass into a durable façade material that reduces both waste and the demand for virgin resources. The following sections will explore the methodologies employed in the fabrication of the glass tiles, the collaborative efforts involved, and the broader implications of this project for future architectural projects.

The removal of a deteriorating 1970s extension, illustrated in Figure 1, created the space for constructing a new gable that forms a double-height dining space, which serves as a central gathering point. This intervention integrated contemporary design principles focused on environmental sustainability and accessibility while respectfully acknowledging the site's layered history. The recycled glass material became a key element of this transformation and embodied the project's commitment to sustainability and material innovation. These alterations were guided by operational strategies, long-term maintenance projections, and carbon reduction targets, all partially achieved by using recycled and reclaimed materials

(Fear, 2025). The following sections detail the fabrication methodologies behind the glass tiles, the collaborative processes that enabled their development, and the broader architectural implications of this approach.

Figure 1

The 1970s extension prior to revitalisation. Image source: Claire Fear, Thread Ltd, 2023.



The Buttermarket: a fusion of heritage and innovation

With sustainability and heritage sensitivity at the forefront, the design draws inspiration from local shingle profiles traditionally used in roofing and cladding applications. Slate, a stone material regionally abundant and culturally embedded material, has long been favoured for its durability, weather resistance, and understated elegance. Typically, available in sizes ranging between 300 mm and 600 mm, slate is installed using precise overlapping techniques that ensure effective water shedding and long-term structural integrity. Fixings are commonly made with copper or stainless-steel nails to prevent corrosion, thereby reinforcing slate's reputation as a resilient and low-maintenance solution.

In this project, the architect sought a material that could sit alongside slate both visually and conceptually, both honouring the traditional installation and overlapping features while

introducing a contemporary layer of colour and translucency. The ambition was to allow light penetration without compromising the façade's rhythm or integrity. To achieve this, Thread's team custom-built a full-scale 1:1 shingle trial in collaboration with the commissioned specialist recycled glass company. The selected fused recycled glass tiles were engineered to echo the proportions and installation logic of slate while offering a luminous quality that activates the courtyard space throughout the day. The translucent properties of the glass tiles, combined with robust environmental credentials and proven durability, marked a pioneering application in exterior architecture.

Material integrity

In 2022, material testing was conducted in collaboration with a European-funded initiative that involved four Welsh universities: Wrexham Glyndŵr University, Aberystwyth University, Bangor University, and the University of South Wales. This initiative aimed to support Welsh businesses in enhancing their products and processes. Extensive testing and refinement, accredited to this initiative, ensured the material's safety, resilience, and suitability for long-term outdoor use.

- Environmental Testing: The fused recycled glass tiles underwent rigorous environmental exposure testing, including dry heat, damp heat, and freeze–thaw cycles. The samples were subjected to five cycles of these extreme conditions, and close visual inspections revealed no adverse effects on the tiles; they remained in the same state as before testing.

- Impact Resistance Testing: The impact resistance testing produced varied results depending on the type of glass material and its origin. Notably, two tile sets exhibited impact energy resistance comparable to commercially available ceramic and porcelain tiles of similar dimensions. This affirmed the suitability of utilising fused recycled glass material in architectural applications (Oseng-Rees et al., 2025).

During the pre-commission phase, additional tests of the glass material specified by the architects were undertaken to validate the material's suitability for outdoor applications. These tests were conducted by Lucideon Ltd, an international commercial provider of materials testing and accreditations. This comprehensive investigation of optimal performance characteristics was funded by the European project Agor Innovation at Swansea University (Swansea University, 2025).

Thirteen environmental tests were performed at Lucideon's UKAS-accredited facility, assessing factors such as frost resistance, impact durability, bending strength, staining

susceptibility, chemical release, and weathering properties. These tests adhered to industry standards and are listed below.

1. BS EN ISO 10545-13: Ceramic tiles – Part 13: Determination of chemical resistance. London: BSI. (British Standards Institution, 2016)

2. BS EN ISO 10545-5: Ceramic tiles – Part 5: Determination of impact resistance by measurement of coefficient of restitution. London: BSI. (British Standards Institution, 1998)

3. BS EN ISO 10545-6: Ceramic tiles – Part 6: Determination of deep abrasion resistance for unglazed tiles. London: BSI. (British Standards Institution, 2012)

4. BS EN ISO 10545-2: Ceramic tiles – Part 2: Determination of dimensions and surface quality. London: BSI. (British Standards Institution, 2018)

5. BS EN ISO 10545-12: Ceramic tiles – Part 12: Determination of frost resistance. London: BSI. (British Standards Institution, 1997)

6. BS EN ISO 10545-15: Ceramic tiles – Part 15: Determination of lead and cadmium given off by glazed surfaces. London: BSI. (British Standards Institution, 1997)

7. BS EN ISO 10545-10: Ceramic tiles – Part 10: Determination of moisture expansion. London: BSI. (British Standards Institution, 1997)

8. BS EN ISO 10545-4: Ceramic tiles – Part 4: Determination of the modulus of rupture and breaking strength. London: BSI. (British Standards Institution, 2019)

9. BS EN ISO 10545-14: Ceramic tiles – Part 14: Determination of resistance to stains. London: BSI. (British Standards Institution, 2015)

10. BS EN ISO 10545-8: Ceramic tiles – Part 8: Determination of linear thermal expansion. London: BSI. (British Standards Institution, 2014)

11. BS 1902-5.3: Methods of testing refractory materials – Part 5.3: Determination of linear change on heating (thermal expansion). London: BSI. (British Standards Institution, 1990)

12. BS EN ISO 10545-9: Ceramic tiles – Part 9: Determination of resistance to thermal shock. London: BSI. (British Standards Institution, 2013)

13. BS EN ISO 10545-3: Ceramic tiles – Part 3: Determination of water absorption, apparent porosity, apparent relative density, and bulk density. London: BSI. (British Standards Institution, 2018)

The report containing the material test results was submitted to the structural engineer, where it underwent thorough review and scrutiny. After careful evaluation, the structural engineer accepted the findings and confirmed the material's suitability for use. It is important to note that these material test results have not been published, as they are proprietary to the glass studio.

The integrity of the material's weathering properties was a significant focus during the assessment, particularly due to its novel application. The findings of the report validated previous research, confirming that the fused recycled glass exhibited properties similar to those of ceramics, thereby ensuring that, in the event of tile fracture, the edges would not present sharp hazards. This conclusion aligns with earlier studies on material integrity conducted by Oseng-Rees et al. (2014) and Oseng-Rees and Donne (2015), which investigated the mechanical properties of fused recycled glass materials. In addition, Halley et al. (2017) explored the impact behaviour of recycled materials, further reinforcing quality assurance in sustainable material development.

Product development trial and testing

During the production of test samples, it was observed that when using 4 mm clear float glass laminated to the fused recycled glass material, the float glass often cracked during the drilling of the pre-fix holes for the shingles. Through the trial of a custom-built full-scale 1:1 shingle mock-up and the development of the glass shingle product, testing revealed that fused recycled glass exhibited greater strength than the float glass laminated onto it. During hole drilling, the laminated float glass—which was intended to reinforce the fused material—frequently cracked and failed, whereas the fused recycled glass remained intact. This outcome demonstrated that the addition of float glass compromised durability rather than enhancing it, thus confirming the structural integrity of the fused recycled glass alone. This finding eliminated the need for additional lamination, thereby simplifying the fabrication process.

The addition of the float glass laminated onto the recycled glass material would not only have complicated the manufacturing process but also raised concerns regarding the added weight transferred to the structural frame of the glass wall. If an additional sheet of 4 mm float glass had been added to the recycled glass shingle, it would have increased the overall weight, thereby posing a concern regarding the structural system designed to support the shingles.

Encouraging observations from Oseng-Rees et al. (2025) indicated that when glass does crack, the resulting edges are not sharp, as typically associated with conventional glass shards. Instead, the fractured edges of the fused recycled glass resembled those of ceramics, thus significantly reducing the risk of injury.

These observations made by the building structural engineers and the architect during the full-scale mock-up with material samples purchased from the glass studio were crucial in approving the material for use without lamination, thereby ensuring safety while maintaining aesthetic and functional performance. The elimination of lamination not only simplified the fabrication process but also contributed to the overall sustainability of the project by reducing material waste and energy consumption associated with additional lamination processes.

Design and planning

The extensive range of textures and colours achievable through various fabrication methods and waste glass sources created an inspiring platform for collaborative discussions. With the expertise of the recycled glass specialists, a large amount of surface finishes, translucency levels, and tonal variations were presented, thereby enabling the architects to explore the opportunity of customising the aesthetics and functional solutions. A specific emphasis was placed on achieving a small-grained texture in white glass, which was designed to create a striking contrast against the grey slate tiles. This interplay between materials highlighted the subtle beauty of recycled glass and reinforced the project's commitment to balancing tradition with innovation. The large number of options available encouraged a dialogue-driven approach, where material characteristics were fine-tuned based on architectural and environmental considerations before final implementation decisions were made.

The design of the recycled glass shingles carefully balanced tradition and innovation, drawing inspiration from historic slate-hanging techniques while incorporating modern sustainable materials. In addition, the combination of glass and slate was carefully governed by two key factors: the production capacity of the glass studio and the need to honour the heritage of slate-clad structures. By aligning the design with the material output capabilities, the project maintained both its sustainability goals and its commitment to craftsmanship, thus ensuring that the final installation harmoniously reflected both historical preservation and contemporary material innovation.

Transition to production

With the successful commissioning and approval of the design of the recycled glass shingles, the project moved forward into the critical phase of production. A key component of this process was the collection of waste glass bottles, which was facilitated through a

collaboration with local pubs and restaurants. Dedicated bins were provided for clear glass bottles, which were collected weekly from each establishment, as presented in Figure 2. Over a six-month period, these venues voluntarily contributed 1.5 tonnes of glass bottles, an estimated 4,000 bottles, to Oseng-Rees Studio. This initiative introduced an additional step into their recycling processes, thus requiring adjustments from both staff and management to accommodate the collection system.

Figure 2

Dedicated bins were provided for the collection of clear glass bottles. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



This initiative emphasised community engagement in sustainability, thereby ensuring that the shingles were made from locally discarded glass bottles while demonstrating a commitment to short-distance material sourcing. By directly collecting waste glass from nearby pubs and restaurants, the project minimised transport emissions and reinforced the importance of repurposing materials that would otherwise go to waste. This approach fostered a shared sense of environmental responsibility among local businesses, thus proving that architectural innovation can thrive using genuinely reclaimed resources.

Processing and production

The selection of bottles was intentional, with only clear glass bottles being collected, while green and brown bottles were excluded to ensure colour uniformity and achieve the desired aesthetic quality in the final product. Clear glass contributes a white-toned appearance to the fused recycled glass material and enables optimal light transmission, thus enhancing the visual impact of the shingles. The origin of the bottles is unknown, as they were sourced from general recycling streams and not traced to specific factories. Compatibility issues were addressed during the development of the fused glass material as part of doctoral research conducted in Oseng (2009). These findings fall beyond the scope of this paper and it suffices to mention that they confirmed the structural integrity of the material. This earlier research helps mitigate potential risks associated with using glass from unknown sources.

Once the bottles were collected, they underwent a cleaning process to remove labels and adhesive residues, leaving only the clean glass bottles for further processing. Figure 3 shows the clear glass bottles ready for crushing. The cleaned glass was then crushed using a specialised imploder purchased from Krysteline Technologies, which fragmented the material into uniform particles suitable for fabrication, also known as cullet or frits, as seen in Figure 4. This process ensured that the glass fragments were of a consistent size, which is essential for achieving a uniform texture and appearance in the final panels.

As seen in Figure 5, the processed glass fragments were transformed into large-format panels through fusion techniques in a flat-bed glass kiln operating at temperatures below 900°C. A carefully controlled kiln cycle, developed by Oseng-Rees Reflection Ltd, enabled the glass to undergo a specialised sintering and annealing process, thereby yielding the unique fused glass material that resembles stone or ceramics in both visual and material properties. These fabrication methods produced durable and visually refined glass material that aligned with the project's sustainability objectives by utilising lower temperature fabrication techniques compared to cast or blown remelted glass. Each firing cycle was also monitored for energy consumption, and the data collected contributed to the overall carbon footprint analysis of the fabrication process. This approach supported the project's sustainability goals by enabling a more accurate assessment of environmental impact.

Figure 3

Clear glass bottles cleaned and ready for crushing. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



Figure 4

Clear glass bottles processed using a specialised imploder purchased from Krysteline Technologies. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



Figure 5

Glass fragments fused into large-format panels in a flat-bed glass kiln. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



This controlled environment ensured that the production process remained energy-efficient, thus reducing excessive heat consumption while maintaining the structural integrity of the fused glass. A total of 90 panels were produced, each measuring 8 mm in thickness, designed for both durability and aesthetic impact, as presented in Figure 6. These panels underwent precision cutting using advanced water-jet technology, as depicted in Figure 7, thus guaranteeing uniformity in size and shape for their seamless integration into the façade's architectural framework. A total of 800 recycled glass tiles were needed for the project, each precisely cut to a length of 305 mm and a breadth of 178 mm, as seen in Figure 8 below.

Each recycled glass shingle underwent a meticulous finishing process designed to enhance durability, reinforce structural integrity, and ensure long-term performance in exterior applications. All edges and drill holes were carefully arrised and countersunk to eliminate sharpness and improve material resilience. Thereafter, each shingle was individually inspected for chips, cracks, uneven surfaces or other defects. To further extend the lifespan of the shingles, a water-resistant and dirt-repellent coating was applied—BriteGuard Pro as seen in Figure 9 below, sourced from Bhole and commonly used on architectural glazing. This layer inhibits moss growth and reduces dirt accumulation, thereby preserving the clarity and aesthetic quality of the façade over time. The treatment was manually applied using a damp cloth to ensure thorough coverage of all edges and surfaces.

Figure 6

Produced panels, each with a thickness of 8 mm. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection, Ltd, 2024.



Figure 7

Precision cutting using advanced water-jet technology. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



To achieve seamless integration with traditional slate arrangements, each tile featured two precision-cut 10-mm holes, thus allowing them to be hung in a manner consistent with conventional slate roofing methods. This approach preserved the historical aesthetic while introducing a pioneering use of recycled glass in architectural cladding.

After the production in the studio, the shingles were packed and transported to the site, where the contractor installed them alongside the slate. This marked the conclusion of the contract for the glass studio.

Figure 8

Finished recycled glass tile. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection, Ltd, 2024.

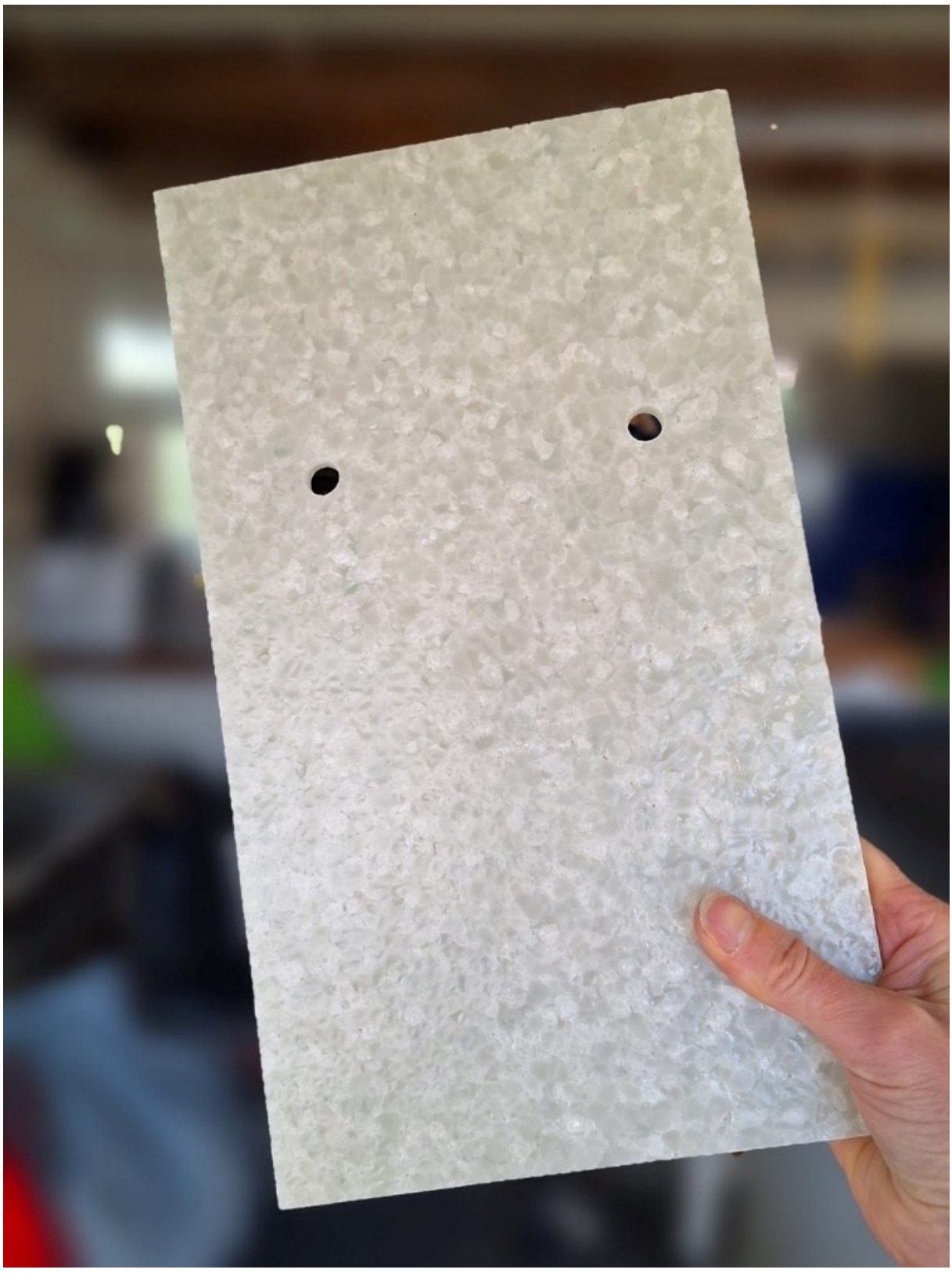


Figure 9

Application of a water-resistant and dirt-repellent coating, BriteGuard Pro. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2024.



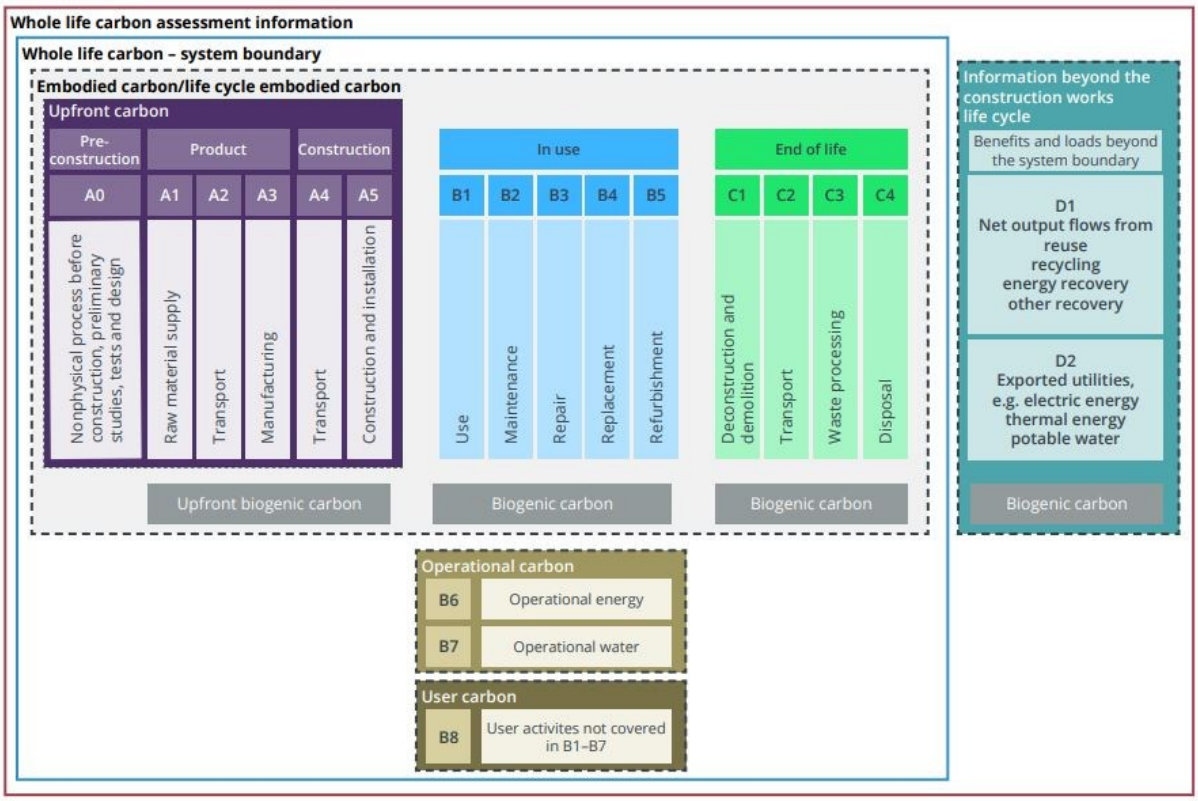
Analysis of the carbon footprint

As part of the Buttermarket restoration project, a comprehensive life cycle analysis (LCA) was conducted to quantify the carbon emissions, energy consumption, water consumption, and material flows associated with the production of the recycled glass shingles. This analysis was pivotal in understanding the environmental impact of the project and ensuring that sustainability remained at the forefront of the initiative.

The LCA was performed under the Future Homes UKRI Innovation Accelerator Project, led by the University of Salford. The methodology adhered to EN 15804+2 (CEN, 2019) and ISO 14025 (2006) /ISO 21930 (2017), utilising OneClick LCA software (One Click LCA, 2025; Ecoinvent, 2025). Data was conveniently recorded by monitoring the entire process from bottle collection to manufacturing and delivery to site, adapting Oneclick templates to the required needs. These data were utilised to estimate the life cycle inventory, supported by the Ecoinvent Database (Ecoinvent, 2025).

Figure 10

Building life cycle and carbon assessment: Adapted from EN 15978, EN 17472, EN 15643, with biogenic carbon considerations (RICS, 2023).



The analysis included several key stages (A1 to A4) of the product life cycle, as depicted in purple in Figure 10 (RICS, 2023):

- A1 – Raw Material Supply: This stage accounted for the collection and processing of the recycled glass, including the energy consumed during collection and transportation from local pubs and restaurants to the processing facility.

- A2 – Transportation: The emissions associated with transporting the processed glass to the manufacturing site were evaluated, considering the distances travelled and the modes of transport used.

- A3 – Manufacturing: This stage included the processes that occurred during the manufacturing of the glass shingles, such as cleaning, fusion (which eliminates the need for additives and resins), coldworking, and packaging.

- A4 – Transportation to onsite installation: The emissions related to the transportation from studio to site were also considered, thus ensuring a holistic view of the carbon footprint.

Results

The revitalisation of the iconic courtyard of the Redruth Buttermarket Restoration exemplifies a pioneering approach to sustainable architecture through the integration of the recycled glass tiles on to its exterior cladding, as depicted in Figure 11. The white tiles, crafted from waste glass bottles, exhibit light transmission properties that enable natural light penetration into the dining room during the daytime (Figure 12) and illuminate the space with specialised light fixtures at night (Figure 13). Designed with a thickness of 8 mm, these tiles create dynamic visual effects in the double-height dining space throughout the day. As evening falls, a specialised lighting design highlights the material's translucency, projecting its glow back into the courtyard and enhancing the nighttime atmosphere, as depicted in Figure 14. These white tiles have been positioned as a horizontal band, thus creating a visual contrast with the grey slate shingles above and a subtle line at the bottom. This single skin cladding not only enhances the aesthetic appeal but also facilitates a dynamic interplay of light and shadow within the space, thereby producing ever-changing patterns that blend functionality with artistic expression.

Figure 11

The courtyard of the Redruth Buttermarket that integrates recycled glass tiles into its exterior cladding. Image source: Claire Fear, Thread Ltd, 2025.



Figure 12

The white tiles made from recycled glass let natural light into the double height dining space. Image source: Claire Fear, Thread Ltd, 2025.



Figure 13

Specialised light fixtures at night. Image source: Huw Briscoe, Unfold Studio, 2025.



Figure 14

Specialised lighting accentuates the material's translucency at night. Image source: Huw Briscoe, Unfold Studio, 2025.



The grey slate shingles provide a traditional architectural element that informed the design and installation of the white glass tiles, thereby enabling a sleek transition between the two materials and facilitating their connection. The fusion process employed in the fabrication of the glass tiles preserves the integrity of each glass fragment, thus resulting in a distinctive visual texture that emphasises the material's origin as broken glass bottles. Upon close examination, as illustrated in Figures 8 and 15, the origins of each glass piece remain visible and impart an added layer of depth and character to the tiles. This installation, positioned alongside traditional slate shingles, creates a weather-screening wall that harmoniously balances contemporary design with architectural heritage. The integration of these recycled glass tiles not only showcases the potential of repurposed materials in modern construction but also reinforces the project's commitment to sustainability and environmental stewardship.

Figure 15

Details of glass and traditional slate. Image source: Clarie Fear, Thread Ltd, 2025.



This project stands as a testament to the power of repurposed materials, showcasing how recycled glass can be effectively utilised in architectural applications. The Buttermarket opened in January 2025, as depicted in Figure 16, and it is set to become an example of sustainable innovation, demonstrating how historic sites can evolve with modern, eco-friendly solutions while remaining true to their cultural roots. Architect Jen Boddington of

Thread Ltd. emphasised the seamless blend of recycled glass and slate, noting how the façade supports sustainable practices and local craftsmanship while permitting the client to express their ethos through the building fabric:

> We specified recycled Oseng-Rees glass for a distinctive shingle façade, supporting sustainable practices and local craftspeople while allowing the client to showcase their ethos through the building fabric. We are particularly happy with the outcome of how naturally the recycled glass sits next to the slate shingles, and that this innovative material integrates with the aesthetic of the historic buildings. (Jen Boddington)

Reflecting on the project's success, Tamsin Spargo, Director of Redruth Revival CIC, shared the following thoughts:

> We have worked with our design team at Thread to commission striking new features that align with our principles of reuse and environmental and architectural sensitivity but add a bold modern element to our site. The design featuring Oseng-Rees Reflection Ltd glass tiles is one of the outstanding design additions that we believe contribute to making the Buttermarket a fine example of sensitive but creative restoration of a historic building using the best of innovative modern technology. (Tamsin Spargo)

The carbon footprint analysis of the project revealed that the Global Warming Potential (GWP) of the repurposed glass (A1–A4 stages) is approximately 1.41 kg CO_{2e} per kilogram of product. This figure is strikingly lower than that of traditional float glass (used, for example, as flat glass in windowpanes), which can reach up to approximately 7.00 kg CO_{2e} per kilogram. This substantial reduction highlights the environmental benefits of utilising recycled materials in construction, thus demonstrating how innovative approaches can significantly reduce carbon emissions.

Figure 16

Opening day of the Buttermarket at the iconic courtyard. Image source: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2025.



Furthermore, the project reported that the production of fused recycled glass consumes less than 0.008 m^3 of fresh water per kilogram, which is approximately three to four times less than the 0.028 m^3/kg required for traditional float glass. This aspect of the analysis emphasises the water conservation benefits associated with the use of recycled materials.

Discussion

The LCA of the Buttermarket restoration not only validated its sustainability credentials but also established an important benchmark for future projects that seek to integrate recycled materials into architectural design. The carbon analysis conducted provides a valuable reference point for environmentally responsible construction, thereby illustrating how material choices directly impact greenhouse gas emissions and overall resource efficiency.

A key takeaway from the analysis is the substantial reduction in environmental impact achieved by using recycled glass. Added to the optimum resource efficiency achieved, with practically null use of raw materials, the use of low-embodied carbon materials can contribute to the reduction of the building carbon footprint. Additionally, it supports the

value chain of materials and strengthens supply chain resilience with local provision of resources and local manufacturing. This difference highlights the critical role of material innovation in reducing carbon emissions, thus reinforcing the broader movement towards low-impact, resource-efficient architecture.

Beyond carbon savings, the project exemplifies how aesthetics and sustainability can coexist, challenging existing perceptions of waste materials. The recycled glass shingle façade is not just an environmentally responsible choice but serves as a visual statement, sparking discussions on how waste can be reinterpreted through creativity, innovation, and environmental responsibility. The inclusion of a small-grained white glass texture, contrasting against the grey slate tiles, further demonstrates how material selection influences architectural expression, thus proving that recycled materials can enhance both beauty and function.

Equally important is the collaborative approach underlying the project's material sourcing. The collection of waste glass bottles relied on engagement with local pubs and restaurants, both of which voluntarily contributed 1.5 tonnes (approximately 4,000 bottles) to the Oseng-Rees Studio. This initiative introduced an additional step into their existing recycling processes—requiring coordination between staff and management. While this model successfully diverted glass from conventional waste streams, it also emphasises the challenges of scaling material collection processes for future projects. Further exploration is required about scaling up and standardisation of this procedure across industries to ensure wider adoption and optimisation.

Similarly, the manufacturing process substantially relied on handcrafting. This enhanced environmental performance in several aspects, such as local sourcing of materials and local production; however, other inefficiencies were identified in the LCA study, including the transport of small material loads between collection and production sites and the continued dependence on manual labour, which prolongs fabrication time. This confirms the opportunity for wider carbon emission and water reductions with a few improvements. For example, the implementation of greener technologies, such as water recirculation, can provide further optimisation and reduction of environmental impacts.

Looking beyond the Buttermarket, this project raises questions regarding the future of sustainable architecture. How can the findings from this restoration influence policy frameworks, construction standards, and urban planning? The success of integrating recycled glass into historic architecture suggests exciting possibilities for material reuse in heritage preservation, thus providing an inspiring precedent for designers and developers worldwide. However, broader industry adoption will require further research, policy

support, and supply chain coordination to make these solutions more scalable and accessible.

A video has been included in this paper that showcases the production of the recycled glass wall at the Redruth Buttermarket (Video 1). Titled 'The Award-Winning Glass Wall at The Buttermarket in Redruth', the film is produced by Oseng-Rees (2025). The video features the process from bottle collection to the final installation of the fused recycled glass shingles, thereby highlighting a novel approach to sustainability in architectural design. The video can be viewed on Video 1.

Video 1

Production of the recycled glass wall at the Redruth Buttermarket. Click on the image to watch the video. Producer: Tyra Oseng-Rees, Oseng-Rees Reflection Ltd, 2025. (Click on the image to watch the video)



In summary, the Buttermarket restoration does more than showcase material innovation—it invites critical reflection on the intersection of heritage, sustainability, and architectural aesthetics. By proving that recycled materials can be both visually striking and functionally viable, it challenges industry norms and encourages a rethinking of traditional construction approaches. As the unveiling of the new façade marks an important milestone, the

conversation on waste reuse, carbon reduction, and sustainable design must continue, pushing boundaries for future projects.

Conclusion

The Buttermarket project stands as a testament to how heritage, innovation, and sustainability can seamlessly coexist, thus proving that traditional spaces can be revitalised through eco-conscious solutions. By prioritising recycled materials, particularly recycled glass, the project demonstrated significant environmental benefits, notably reduced greenhouse gas emissions, and reinforced global efforts to combat climate change.

Beyond its environmental impact, this restoration serves as a valuable model for future architectural projects, illustrating how historical preservation can integrate modern sustainability principles without compromising aesthetics or cultural integrity. The project's artistic use of repurposed glass has further challenged conventional perceptions of waste, turning discarded materials into visually compelling architectural elements.

More than a restoration, the Buttermarket project is a commitment to environmental responsibility, showcasing the potential of merging traditional craftsmanship with contemporary innovation. As its new façade is unveiled, it stands as a symbol of progress, encouraging architects and developers to embrace sustainable practices that honour both cultural legacy and ecological balance.

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