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Oikonomopoulou, Faidra; DeBrincat, Graeme; Fuhrmann, Sindy

DOI
10.1007/s40940-023-00230-3

Publication date
2023

Document Version
Final published version

Published in
Glass Structures and Engineering

Glass Struct. Eng.
https://doi.org/10.1007/s40940-023-00230-3

EDITORIAL

Glass and circularity

Faidra Oikonomopoulou · **Graeme DeBrincat** · **Sindy Fuhrmann**

/ Accepted: 8 July 2023

Glass is a 100% recyclable. That is, at least in theory. In reality, only a small percentage of glass is being recycled; an even smaller portion does so in a closed-loop manner. With the exception of the glass container industry, most other glass products, including automotive and architectural glass are either downcycled or, even worse, landfilled. The small percentage of such products that gets recycled in a closed-loop manner is almost exclusively internal and pre-consumer cullet (offcuts and rejects during production and processing) which has never exited the factories. Once glass enters the consumer market, the prospects to recycle it back to glass become gloomy.

Multiple causes can hinder glass recycling, from contamination, recipe incompatibility and optical requirements, to the difficult demountability of integrated glass products (e.g. IGUs, smartphones), the lack of proper collection and treatment schemes, and costly transportation of the cullet. Wish-cycling, which stems from the best intentions but further hinders glass (and other materials') recyclability, highlights another of the principal problems: the lack of public awareness on which products can be and which cannot be recycled. All in all, glass waste remains in essence an unresolved problem.

Yet, there is a wind of change. New international guidelines, such as EU's climate neutrality 2050 target and the European Green Deal urge a shift in materialization: passing materials in closed loops will be essential for our future society, stable economies and a sustainable living on our Earth. This represents an opportunity to change the current practices.

Glass is an essential material in our modern life: in architecture, mobility, telecommunication and digitalization. It is required from high-tech applications to cheap mass products. Developments in glass are now stirred towards a sustainable future, as recognized by the United Nations with the "International Year of Glass" in 2022. In this context, circularity in glass production and for glass products is an essential strategy for achieving sustainability and for resolving the glass waste problem in particular.

The benefits of adopting a circular approach in the glass industry that reduces virgin raw material use and the carbondioxide emissions of new glass manufacture is widely accepted for all glass products. It is time now to start the conversation to how this can be achieved for all glass products. In this issue, the papers address a wide range of solutions and opportunities across the circularity hierarchy and the glass sectors; from extending

F. Oikonomopoulou (✉)
Department of Architectural Engineering and Technology, Faculty of Architecture and the Built Environment, TU Delft, Delft, The Netherlands
e-mail: F.Oikonomopoulou@tudelft.nl

G. DeBrincat
Arup, Glasgow, Scotland, UK

S. Fuhrmann
Institute of Glass Science and Technology, TU Bergakademie Freiberg, Freiberg, Germany
e-mail: sindy.fuhrmann@igt.tu-freiberg.de

Published online: 13 September 2023

service life, through material reuse, component remanufacture and recycling.

The opening paper analyses the material flows within glass material fabrication and processing, identifying the existing routes of pre-consumer recycling and environmental opportunities to enhance and extend these systems to include post-consumer glass recycling, indicating the importance of inclusion of this type of recycled content. The following two papers take this mapping of materials towards solutions and actions required to find value of materials and business opportunities for new players in the glazing industry, showing potential in recycling materials, but also reuse and remanufacture.

Papers are then presented that respond to extending service life and reuse opportunities, identifying the need for methodologies to assess existing materials, system condition and performance to determine remaining service life or upgrading potential. Barriers, such as collaboration, logistics, time and cost are identified, promoting further research and pilot projects to drive these initiatives forward. Technical testing procedures and validation methods are presented with promising methods of reconditioning outlined for further development.

Finally, the issue closes with two papers researching glass casting as a novel upcycling approach for hard-to-recycle glass waste streams. Specifically, the second from last paper gives an overview of the current barriers hindering the closed-loop recycling of such streams, and presents multiple casting experiments with various glass chemical compositions and contaminants, towards the engineering of novel glass products for the architectural realm. The final paper investigates in depth the recycling of fluorescent light tube glass using kiln-casting techniques to manufacture high value products.

This wide collection of papers identifies the multiple challenges around the logistics for collection of post-consumer glass for secondary uses and around material separation and contamination, but with great hope, it also indicates new solutions and methods towards adapting a circular economy approach that can greatly reduce the carbondioxide emissions and environmental impact of the glass manufacturing industry of the future.