





## Short Report

<b>Topic</b>	Recycling of flat glass in the building industry - Analysis of the current situation and derivation of recommendations for action
<b>Short title</b>	Recycling of flat glass
<b>Funded by</b>	Forschungsinitiative Zukunft Bau of the Federal Institute for Building, Urban and Regional Planning (Reference number: SWD-10.08.18.7-16.07)
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Rosenheim, November 2019

The research project on which this report is based was funded by the Forschungsinitiative Zukunft Bau of the Bundesinstitut für Bau-, Stadt- und Raumordnung (Reference number SWD-10.08.18.7-16.07).

The authors are responsible for the contents of this report.





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## 1 Motivation and aim of the project

In Germany, according to the "Kreislaufwirtschaft Bau", 14.6 million tonnes of construction site waste were generated in 2014. In a position paper, "Glass for Europe (GfE)", the interest group representing European float glass manufacturers, estimates that float glass accounts for less than 1 % of construction site waste. Even this apparently small amount is not negligible as glass is predestined for closed-loop recycling. The use of glass cullet not only conserves natural raw material resources but also reduces the melting energy required, and thus, also the CO<sub>2</sub> emissions.

GfE assumes that building glass is hardly ever recycled into new glass products but that it is landfilled or reused together with other mineral waste in inferior applications, e.g. in road construction.

The European study on ecodesign requirements for windows carried out on behalf of the European Commission by VHK from the Netherlands and ift Rosenheim showed that no reliable data is available on the recycling of flat glass from the construction industry, neither at the level of the member states nor at the European level.

According to the Bundesverband Glasindustrie e.V. (Federal Association of the Glass Industry) (BV Glas), the use of glass cullet in the flat glass production is usually limited to pre-consumer glass from their own breakages or from offcuts from local glass processors.

Therefore the aim of the research project was to provide a detailed analysis of the current situation of the recycling of flat glass in Germany. Based on the results, the intention was to suggest means for an enhanced closed-loop recycling of flat glass.





## 2 Course of action

First, a qualitative material flow model for float glass was developed. It shows the material flows from the production in float glass works via the refinement to semi-finished products, the production of multi-pane insulating glass and the application in windows and facades up to the recycling to new float glass or other uses or the final disposal on a landfill site. This model shows the stakeholders involved in the material flow, e.g. float glass works, window/facade manufacturers and recycling companies.

Quantitative and qualitative data on the recycling of flat glass were gathered in questionnaires and interviews with stakeholders. While the group of flat glass recyclers provided extensive quantitative and qualitative information, only a few companies from the other stakeholder groups (float glass works, glass refiners, insulating glass manufacturers and the window/facade industry) were willing and able to provide data.

In parallel to the surveys, an attempt was made to estimate the quantities of flat glass waste generated by pre- and post-consumer sectors in Germany in 2016 by calculation from statistical data. The input variables for the calculations were:

- Statistical data of the Bundesverband Flachglas e.V. (Federal Flat Glass Association) (BF) on the production and sales of flat glass and its applications as multi-pane insulating glass in windows, facades, external doors, etc.
- Information from the German Window+Facade Association (VFF) on the number of window units placed on the market in Germany and their distribution between new construction and modernization
- Data from the Federal Statistical Office (Destatis) on the demolition of residential and non-residential buildings.

The information from the stakeholder surveys and from the mathematical estimates based on the statistical data of the amounts of flat glass waste were summarised and compared with the aim of producing a quantitative material flow model,

In addition, the current status of recycling technology was determined through literature studies and discussions with experts from industry. This task was carried out by the Fraunhofer Institute for Silicate Research ISC, project group for resource cycles and resource strategy IWKS, as a subcontractor.





## 3 Results

### 3.1 Technical and economic aspects of flat glass recycling

In the manufacture of flat glass using the float glass process, the use of cullet is desirable. In addition to savings in primary raw materials, energy savings of around 3 percent and a reduction in CO<sub>2</sub> emissions of around 3.6 percent are expected for every 10 percent of cullet used. Typically, the use of cullet is 20-30 %.

Most of the cullet used is pre-consumer offcut and breakage from the float process itself and from subsequent processing (e.g. coating, heat treatment). However, cullet is also bought from flat glass recyclers.

Float glass works have very high requirements concerning the absence of contaminations in cullet, since even small amounts of impurities, e.g. from ceramics, stones, porcelain or metals such as nickel and iron, can lead to inclusions in the glass, discolouration of the glass or damage to the float tank. The quality requirements of float glass works are considerably higher than those of container glass works or the insulation material industry.

Due to these high quality requirements, besides cullet from the float process, mainly cullet from the pre-consumer sector is used. This is cullet from glass processing (coating, tempering, bonding, insulating glass production, window/facade construction). The risk of contamination is considerably lower with this cullet than with post-consumer cullet, e.g. from the building envelope.

The recycling of flat glass waste requires a collection infrastructure through which the cullet reaches a flat glass recycler without additional contaminations being introduced. The recycler removes foreign matter in technically complex processes and breaks the cullet to a size that is suitable for further use. Recyclates of different quality are produced. Depending on the market situation of a recycling company, these are recyclates for the production of float glass, of containers glass and/or of insulating materials. The market situation depends on which input qualities of flat glass waste are available at the respective location, which potential customers there are for the recyclate (float glass works, container glass works, insulating material industry), and the price structure for the various recycled products. The transport of the glass waste to the recycler and the recyclate to the customer plays an important role. For a recyclate for float glass production, the transport costs can be up to one third of the total costs of the recyclate.

### 3.2 Quantitative material flow model

Figure 1 shows the quantitative material flow model developed as part of this research project. The model contains both the mass flows of production and sales in Germany as well as the amounts of flat glass waste from the pre- and post-consumer sector.

The main insights and conclusions of this project can be summarised as follows:

- In 2016, a total of approx. 900,000 tons of flat glass were installed in the building envelope. It can be assumed that the volume could increase in the coming years. This is due to the generally unbroken trend towards transparent construction and the further increase in the use of triple glazing. A general reduction in construction activities, both in new constructions and in the area of building modernisation, could be counteracting. However, due to the current situation (lack of living space, necessary energetic building modernisation to achieve the CO<sub>2</sub> targets), this is not very likely.
- In 2016, a total of approx. 500,000 tons of flat glass waste were generated. The pre-consumer sector accounted for slightly more than 1/3, the post-consumer sector for almost 2/3.
- Of the recyclates produced by the flat glass recyclers, only approx. 11 % were returned to flat glass production. Almost half of the cullet was used in container glass production. The remainder of approx. 30 % went to other fields, such as the production of mineral wool, glass beads and glass flour.
- The reasons for the low proportion of foreign cullet in the production of float glass are essentially economic. The high quality requirements of the float glass works play a crucial role as well.
- The transport costs of the cullet to the recycler and from the recycler to the float glass works can amount to one third of the total costs of the recyclate.
- Most of the pre-consumer cullet from flat glass processing/finishing and insulating glass production is currently sent to flat glass recyclers. In principle, it would be possible to feed most of this pre-consumer cullet directly into the production of new float glass. It would be easy to collect the cullet by type, and transportation could be done with the vehicles that deliver float glass and semi-finished products to the processors. Some flat glass refiners and insulating glass manufacturers have confirmed that this path is being taken. In the majority of cases, however, the cullet is first sent to a flat glass recycler in order to remove any contaminants and meet the strict quality requirements of float glass works.
- The separation of glass and frame represents a great effort for the interviewed window manufacturers and replacement companies. It is usually carried out manually by de-glazing of the window or smashing of the glass. This is largely done because the majority of recycling companies for PVC or aluminium window frames only accept windows without a significant proportion of glass. It would be a major advantage if recycling companies were to accept whole windows, including the glass. However, glass can account for a large proportion of the total weight of a



window. With a weight per length of the frame profile of 3 kg/m, the proportion of glass for a double-glazed unit with a total glass thickness of 10 mm (e.g. 2 x 5 mm) and dimension 1.23 m x 1.48 m is approx. 2/3. Long transport routes would therefore not be sensible.

- According to the data collected within the framework of this project, almost 90% of the flat glass waste generated in Germany is already being recycled. This applies in particular to cullet from the pre-consumer sector. Most of the recyclate goes to the container glass industry and the insulating material industry. Only slightly more than one tenth of the recyclate is reused for the production of flat glass, i.e. forms a closed-loop. The distribution of the recyclate to the three main customers, and thus also the closed-loop recycling rate, seems to be the result of a complex interaction of the high quality requirements of the float glass works, the market prices which the main customers are prepared to pay for the recyclate, and the total transport costs.
- From the data obtained and discussions with various stakeholders within the framework of this project, it was not possible to identify control variables or mechanisms that could easily increase the closed-loop recycling rate. Float glass works will in all probability not be able to reduce their quality requirements for foreign cullet, as the effects of contaminations in the melt are very costly for them. As long as container glass works have a high demand for cullet material, they will also want to buy flat glass cullet. And as long as the container glass works pay a cullet price that is only marginally below the price that the float glass works are willing to pay, flat glass recyclers will supply cullet to the container glass industry, especially as the quality requirements of the container glass industry for cullet are lower than those of the flat glass industry, so the processing of the cullet is simplified.



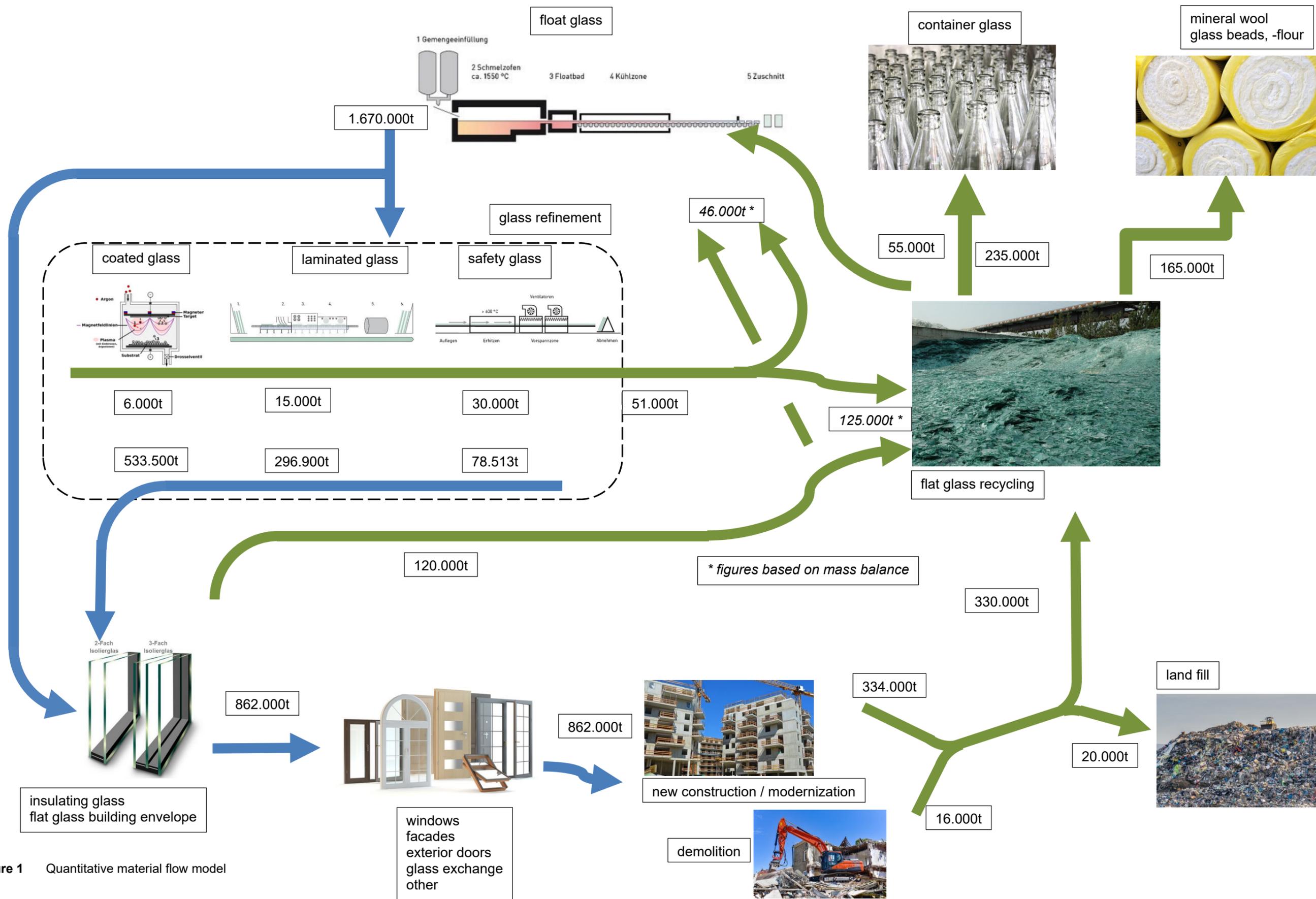


Figure 1 Quantitative material flow model





## 4 Acknowledgements

The research project on which this report is based was funded by the Forschungsinitiative Zukunft Bau of the Bundesinstitut für Bau-, Stadt- und Raumordnung (Reference number SWD-10.08.18.7-16.07). Responsibility for the content of the report lies with the authors.

Special thanks are due to the Bundesverband Flachglas e.V. (Federal Flat Glass Association) and its members, who supported the entire project both ideally and financially.



Bundesverband Flachglas e.V.

In addition, we would like to thank the bvse (Federal Association for Secondary Raw Materials and Disposal) and Reiling GmbH & Co. KG for their idealistic support of this research project and the supply of much information on the topic. Particularly the gentlemen Heitmann and Hohage of the company Reiling are to be mentioned here.

We would also like to thank all the participants in the surveys who helped us by filling in the questionnaires and by answering our questions in subsequent telephone conversations.



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