D1.4 – Report including mapping and data of laminated glass wastes collection and treatment at European level, including data on other non-EU countries

Project Information

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Dissemination Level

PU	Public	**x**
PP	Restricted to other programme participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for the members of the consortium (incl. Commission Services)	

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Document Log

Version	Date	Author	Organization	Comments
V1.0	30/09/2021	Marine Ronquetti, Baudouin Ska	DENUO	First version submitted
V2.0	15/02/2022	Marine Ronquetti, Baudouin Ska	DENUO	Update with new answers collected
V2.1	25/01/2023	Marine Ronquetti, Baudouin Ska	DENUO	Update with clarifications of estimations of coverage of the survey in Europe recycling market

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1 Executive Summary

The Sunrise project focus on the recycling of PVB from laminated glass. Laminated glass is obtained by bonding two glass layers using a polymeric interlayer. PVB is used as the polymeric interlayer. Nowadays, only 9% of PVB from laminated glass is recycled in secondary uses. The rest is incinerated or landfilled.

The objective of this project aims to demonstrate within the current glass recycling business the application of an innovative optical multi-sensor tool based on industrial inline techniques which allow optimal classification of laminated glass according to composition and degradation.

Therefore, one of the first step, the task 1.4, consists in the construction of a mapping of PVB waste in order to illustrate the laminated glass market and the potential of PVB for recycling in Europe.

Denuo in representation of FERVER (FERVER, the European Federation of Glass Recyclers) is responsible in the leading of the mapping of PVB. By developping an online survey with specific questions on the collection and proccessing of laminated glass from the construction and/or automotive sector, the aim is to give a clear illustration of the PVB waste from laminated glass all over Europe and its potential for recycling.

In addition, mapping situation of other regions is being developed in parallel to FERVER situation. More specifically Greece situation has been assessed as this country is one of the one with lowest rates of glass recycling. Identification of potential recyclers in other European countries as well as non-European (Japan) is already included.

The questionnaire was prepared in the begining of July 2021 with the aim of sending to different actors active in the flat glass recycling sector. In the V1.0 deliverable, 10 respondents participated to the online survey. However, lots of them were not active in the laminated glass sector. A lack of responses was noticed and solved by contacting the respondents again and improving valuable results. In this second version of the deliverable (V1.1), 19 respondents participated to the online survey (18 collecting laminated glass). The respondents are all active in European countries (EU and non-EU Member States). The responses are aggregated in this report.

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2 Survey preparation

FERVER (DENUO) has constructed its survey via the program Dragnsurvey : https://www.dragnsurvey.com/

A draft questionnaire was prepared by FERVER secretariat and validated by its members and the partners of the task 1.4 (mapping of PVB waste).

Then, the questionnaire was sent in the begininig of July to different actors active in the flat glass sector:

- FERVER members active in the collection and recycling of flat glass;
- FERVER mailing list of contacts and potential partners within this survey

In the V1.0 report, 10 respondents participated to the online survey. However, lots of them were not active in the laminated glass sector. A lack of responses was noticed and solved by contacting the respondents again and improving valuable results. In this second report, the V1.1, 19 respondents participated to the online survey. The respondents are all active in European countries. The responses are aggregated in this report.

3 Data collected from the questionnaire

3.1 Countries active in laminated glass participating to the survey

The respondents are active in 11 European countries and 2 non-EU countries (United Kingdom and Turkey). In the 19 respondents, 14 are FERVER members.

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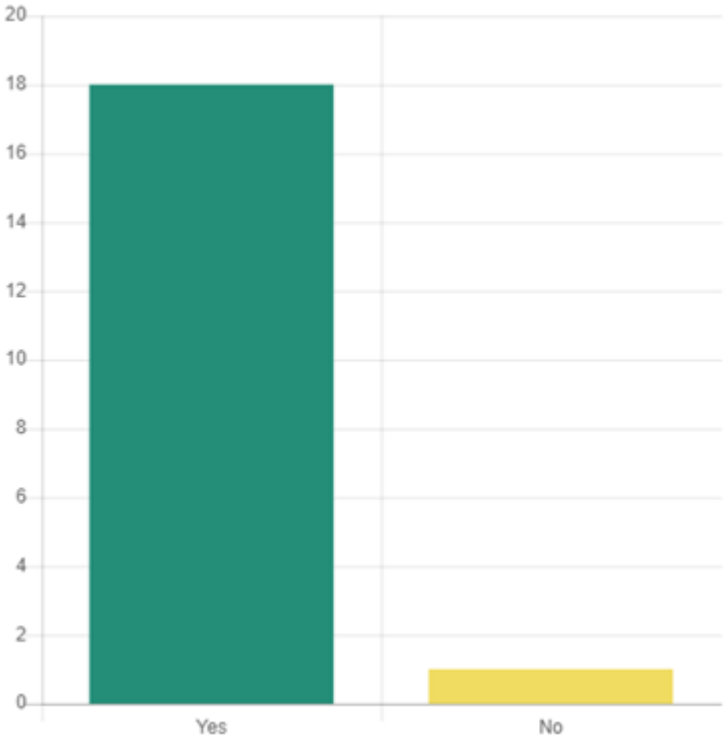
3.2 Do you collect / process laminated glass?



18 out of the 19 respondents are collecting and processing laminated glass. The respondent who is not active in laminated glass is directly sent to the final page of the questionnaire. According to this respondent, there is no laminated glass recycler in Greece. The rest of the questions counts 18 respondents.

3.3 How much laminated glass do you collect and process yearly? (In thousands of tons)

The total volume of the 18 respondents collecting laminated glass equals **931,26 thousand of tons**.

The responses vary between 4 kt and 350 kt. In Europe, we have laminated glass recyclers working at different scale. Some of them have limited quantities due to other (glass) recycling activities and it is not their core business.

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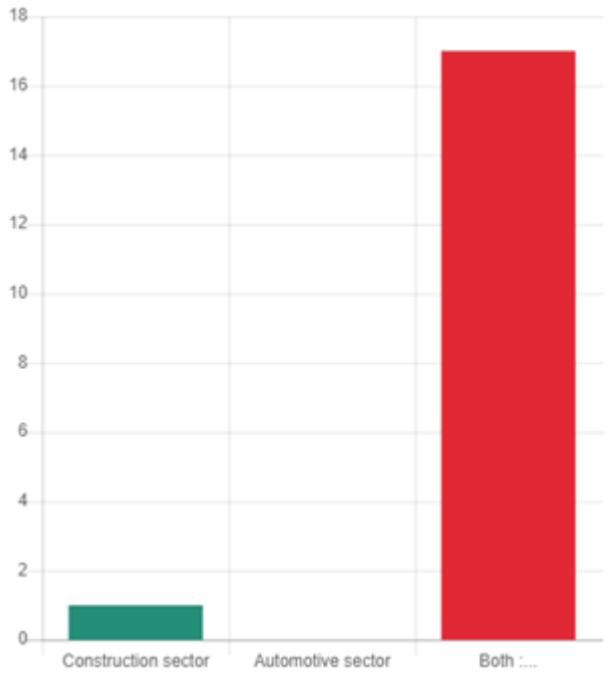
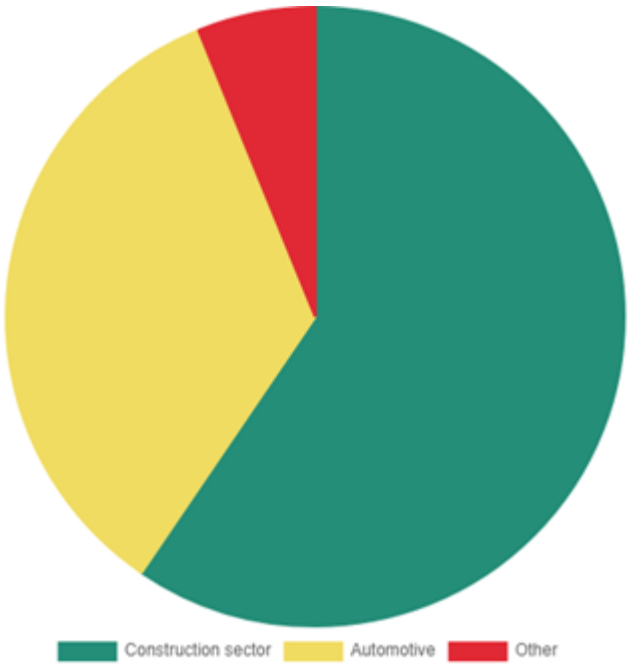
3.4 From which sector are you collecting/ processing laminated glass?



From the 18 respondents, 17 are collecting and processing laminated glass from both construction and automotive sector. 1 is only active in the construction sector. This means that from the 18 respondents, 94,4% are active in both sectors: construction and automotive sectors.

3.5 What is the ratio of each sector providing laminated glass?



The average ratio of the 18 respondents is the following:

- 59,5% for the construction sector
- 34,3% for the automotive sector
- 6,17% for other[1]

[1] Contact could be made to know from what another sector

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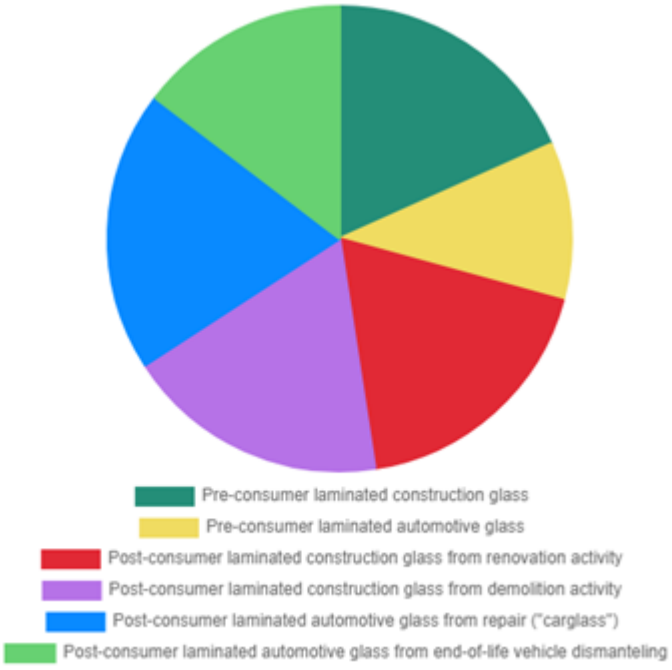
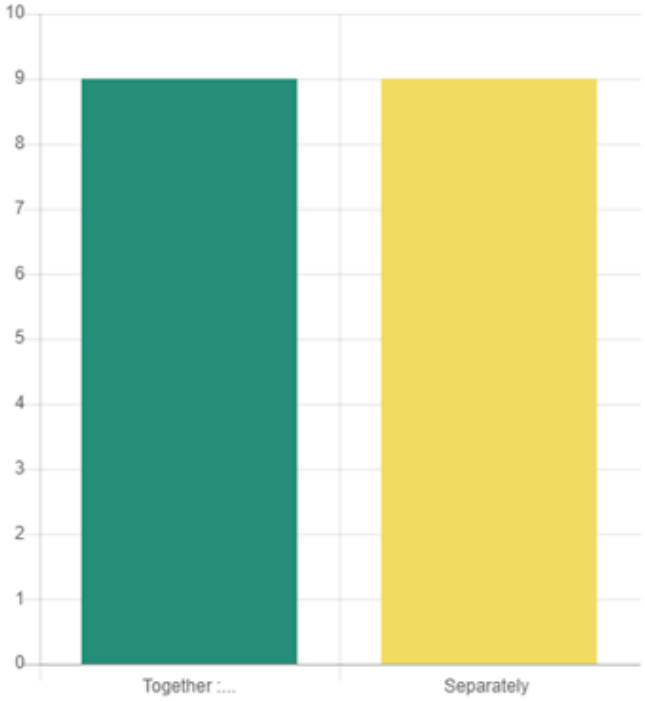
3.6 What kind of laminated glass do you collect?



This question allows multiple responses. From the different options:

- 83,33% of respondents are treating pre-consumer laminated construction glass (dark green)
- 50% of respondents are treating pre-consumer laminated automotive glass (yellow)
- 83,33% of respondents are treating post-consumer laminated construction glass from renovation activity (red)
- 83,33% of respondents are treating post-consumer laminated construction glass from demolition activity (purple)
- 88,89% of respondents are treating post-consumer laminated automotive glass from repair ("carglass") (blue)
- 66,67% of respondents are treating post-consumer laminated automotive glass from End-of-life vehicle dismantling (light green)

3.7 If both, do you store the laminated glass from both sectors together or separately?



Here, there is equality in the response of the respondents: 50% are storing laminated glass from both sectors together, while 50% are keeping the input material stored in function of its origin (Construction/Automotive). Knowing that 1 respondent only collects and treats laminated glass from the construction sector, 8 respondents, collecting from both sectors are storing them separately (47% of the respondents).

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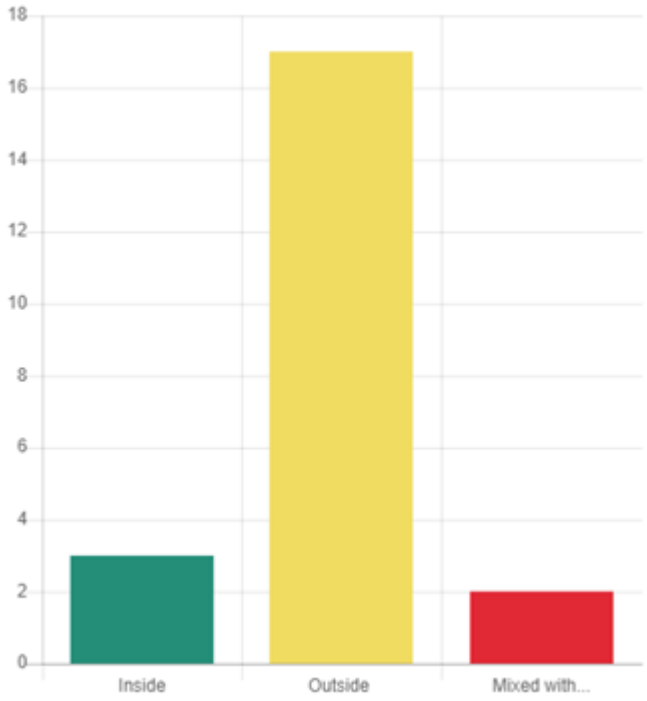
3.8 How do you store your laminated glass in your sorting facility?



This question allows also multiple answers:

- 3 out of 18 are storing inside (16,67%)
- 17 out of 18 are storing outside (94,44%)
- 2 out of 18 are storing in mix with non-laminated glass (11,11%)

3 respondents out of 18 ticked multiple answers:

- 1 respondent is storing inside, outside and mixed with non-laminated glass.
- 1 respondent is storing inside and outside. This means that some are storing as well outside than inside, in function of their storage capacity
- 1 respondent is storing outside and mixed with non-laminated glass.

3.9 How much PVB do you obtain from laminated glass processing yearly (in thousands of tons)?

From the 931,26 thousands of tons of laminated glass collected, between 92,11 and 97,11 thousands of tons PVB is obtained from laminated glass processing. This means that between 9,8% and 10,4% from laminated glass is PVB fraction. But as explained through the next question, this R-PVB fraction still contains a significant percentage of glass.

3.10 What is the average of glass remaining to the PVB fraction (% weight)?

The average of glass remaining to the PVB fraction reaches 13,2%. The responses vary from 1% to 30% or 50%. Out of the 16 respondents, 10 are below or equal to 10% and 3 are above or equal to 20%.

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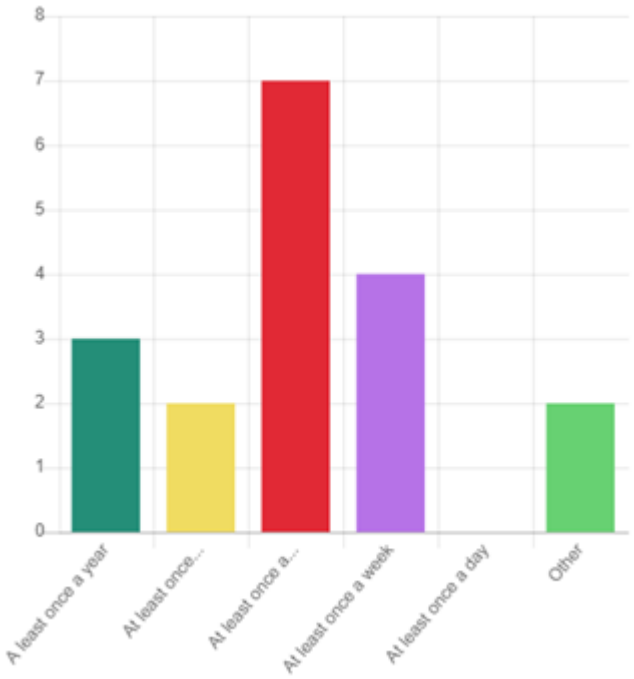
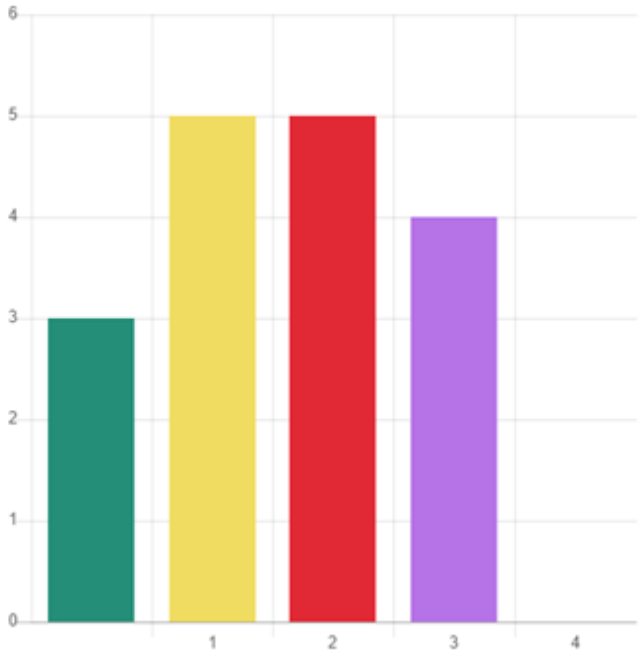
3.11 How often can you provide samples of PVB from laminated glass recycling?



From the 18 respondents:

–3 respondents, 16,67% of the responses, answered at least once a year (dark green)
–2 respondents, 11,11% of the responses, answered at least once every 6 months (yellow)
–7 respondents, 38,89% of the responses, answered at least once a month (red)
–4 respondents, 22,22% of the responses, answered at least once a week (purple)
–2 respondents choose the category other because of a misunderstanding of the question or because they are only active on the collection and not the processing.

3.12 What is the quality of PVB obtained from laminated glass recycling? (From 0 = bad quality to 4 = good quality)



The quality results can vary here:

– 3 respondents gave a result of 0/4 (17,67% of the responses)
– 5 respondents gave a result of 1/4 (29,41% of the responses)
– 5 respondents gave a result of 2/4 (29,41% of the responses
– 4 respondents gave a result of 3/4 (23,53% of the responses)

The average rating (between 0-4) equals 1.59.

– This rating is not weighted by the quantities produced respectively by each respondent
– It shows the importance of the project: for a significant part of the glass recyclers, the PVB-fraction is considered as a waste, reason why it is not treated carefully in order to preserve its quality and its recycling potential. But some other glass recyclers are already focussed on the potential of this waste stream.

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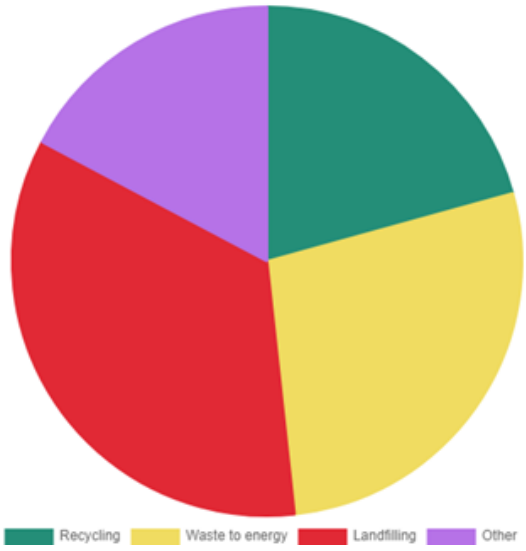
3.13 If you have different levels of quality of PVB, please describe them.

Out of the 18 respondents:

- 12 respondents answered negatively
- 2 respondents consider 2 quality levels in function of the origin: pre- and post-consumer
- 1 respondent manages 3 different qualities, being (1) from pure (pre-consumer) laminated flint glass, (2) from automotive and (3) from mixed origins
- 3 respondents confirm the existence of a gradient or quality, function of the quality of the entering laminated glass fraction

3.14 What are the end-use(s) of your PVB obtained from laminated glass recycling?



For this question, multiple answers are allowed:

- 6 respondents are doing recycling of PVB, 33,33% of the responses (green)
- 8 respondents are doing waste to energy, 44,44% of the responses (yellow)
- 10 respondents are doing landfilling, 55,56% of the responses (red)
- 5 respondents choose the category other, 27,78% of the responses (purple)

NB

That means that several respondents are applying more than on treatment routes for their PVB production, un function of (1) its quality, (2) the available routes and (3) the economic conditions of each route.

The category other is chosen for ongoing project or when PVB is stored on-site.

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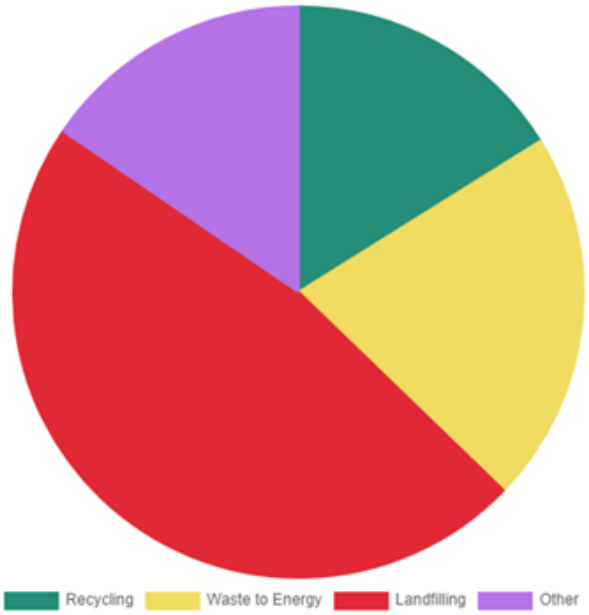
3.15 What is the average ratio per end-use of your PVB?



The average rating between the different end-uses of PVB are the following:

– 16,11% of the responses for recycling (green)
– 21,11% of the responses for waste to energy (yellow)
– 47,33% of the responses for landfilling (red)
– 15,44% of the responses for other end-uses (purple)

4 Mapping of actors outside FERVER network

4.1 Greece

To the best of our knowledge there is no company in Greece associated with laminated glass recycling. According to the contacts we made with 18 companies so far, e.g., car recycling companies and windscreen replacing companies, all post-consumed automotive laminated glass wastes are currently landfilled, due to high costs of reprocessing or even higher costs of exporting them in recycling companies along Europe. However, there are some companies occupied with glass recycling (mostly wastes from blue bells, urban glass wastes and packaging glass) shown in the table below. The questionnaire prepared by FERVER was recently forwarded to all of these companies.

Companies	Website
Hellenic Recovery Recycling Corporation (HERRCO)	https://www.herrco.gr/
Siakandaris Group	https://www.siakandaris.gr/
ASA RECYCLE S.A. / ELLAKTOR	https://ellaktor.com/en/activity/asa-recycle-s-a/
THALIS ENVIROMENTAL SERVICES S.A.	https://www.thalis-es.gr/index.php/en/
Hellenic Waste Management S.A. (ELDIA)	https://eldia.gr/?lang=en

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NEILOS S.A.	https://www.neilos.gr/default.asp
Creta Eco Phoenix S.A.	http://cretaeco.gr/
DEDISA S.A.	https://www.dedisa.gr/
TEHAN S.A.	https://recycling-center.gr/en
THALIS ENVIROMENTAL SERVICES S.A.	https://www.thalis-es.gr/index.php/en/
Neonakis S.A.	https://neonakiscars.gr/
Karastefanou S.A.	https://www.karastefanou.gr/

In addition, there are some companies in Greece being active in the field of laminated glass production or import. The questionnaire prepared by FERVER was forwarded also to these companies.

Companies	Website
KYRIAKIDIS VAS S.A	https://www.kiriakidisglass.gr/
Manios Glass	https://www.maniosglass.gr/
MAXIMIADIS S.A.	https://maximiadis.gr/
DIMGLASS	https://www.dimglass.gr/
S-PLASTICON	https://s-plasticon.gr/
ERGOFIL S.A.	https://www.ergofil.gr/welcometoergofil.php

4.2 Other European actors

Other European actors has been identified within the mapping study. While in the case of Greece, it has not been found laminated glass recyclers, neither there are Greek glass recyclers in FERVER association, for other countries (Spain, France, Italy, Ireland and Slovenia), small companies and also industrial groups outside of FERVER has been identified.

Companies	Country	Website

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Recuperadora de Vidrio de Barcelona SA	Spain	https://revibasa.com/
Recuperación de Vidrio Aguado e Hijos SL	Spain	http://www.rvaguado.com/
Camacho Recycling	Spain	https://www.camachorecycling.es/
Recuperación de vidrio Policart SL	Spain	https://www.policart.info/
TMA Recicla	Spain	https://tmarecicla.com/
SRPV Industriels (Potters Group)	France	https://www.pottersindustries.com/
Metal fer Recycage	France	https://www.metal-fer-recyclage-86.fr/
Ekonsult	Slovenia	http://www.ekonsult.si/
Gannon Eco	Ireland	www.gannoneco.ie
Gruppo Beta	Italy	https://www.gruppobeta.it/
Glass Recycling	Italy	https://www.glassrecycling.it/it/

4.3 Non-European actors

The mapping of other non-European actors has been focused in Japan. Japan is a model country in terms of recycling. In addition, similarly to FERVER, The Glass Recycling Committee of Japan (GRCJ), was established in 1999 to coordinate and promote waste glass recycling polices, technology, to support market expansion and to advocate and offer guidance on the use of eco-friendly glass material in compliance with the international standards of LCA.

In this way, a mapping of potential glass recyclers has been done mainly focused in members of GRCJ, but also others have been identified. The following table includes the first findings:

Companies	Website
Donico Inter Co. Ltd	http://donico.co.jp/
HAMADA Co. Ltd	https://www.kkhamada.com/
Honjo Co. Ltd	http://www.hon-jo.com/
Kaiho Sangyo co. LTD	https://kaihosangyo.jp/
Keiaisha Co. Ltd.	https://www.keiaisha.co.jp/
Recycle Tech Japan Co. Ltd	http://www.r-t-j.co.jp/

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Glass Resourcing Co., Ltd.	https://www.glass-r.com/?hl=es
Ohara Glass Co., Ltd.	http://www.ohara-glass.com/
Sano Store	http://cullet.jp/
Toyo Caret Shokai Co., Ltd.	https://www.toyo-cullet.co.jp/glass/
West Japan Glass Recycle Center Co., Ltd.	http://www.wjgrc.jp/

5 Market analysis of the laminated glass

In order to evaluate the mid/long term recycling potential of PVB, Denuo ordered an international market study on the laminated glass. Hereafter the most significant data of this report:

The construction sector is the major user of laminated glass, followed by the automotive sector.

The global construction sector is projected to grow at a rate of 6,02% from 2020 to 2024.

FIGURE 5 THE CONSTRUCTION INDUSTRY ACCOUNTED FOR A LARGER SHARE OF THE LAMINATED GLASS MARKET IN 2020

Polyvinyl Butyral is the major polymer used in the production of laminated glass, as shown in the following figures.

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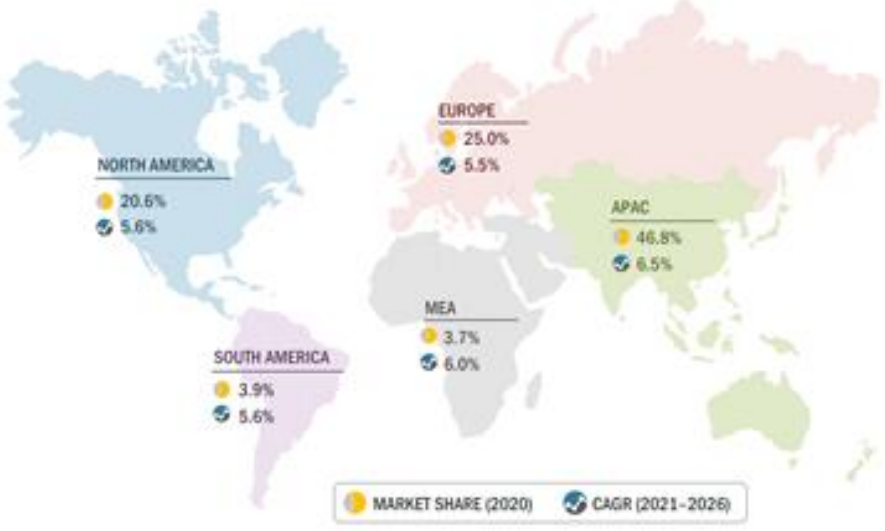
FIGURE 6 POLYVINYL BUTYRAL INTERLAYER DOMINATED THE LAMINATED GLASS MARKET IN 2020

Asia Pacific (APAC) represents the biggest market, followed by Europe and North America, with comparable expected annual growth in the coming 5 years (CAGR = Compound Annual Growth Rate). Europe is in second place because it counts some major producers in the laminated glass industry, knowing there are limited producers in the world. Besides, the automotive industry is highly developed in Europe.

FIGURE 7 ASIA PACIFIC LED THE LAMINATED GLASS MARKET IN 2020



As shown above, the construction sector is the main user of laminated glass. In the global laminated glass market, Polyvinyl Butyral (PVB) is the major interlayer used in the production of laminated glass. The automotive sector is quasi exclusively using PVB as interlayer.

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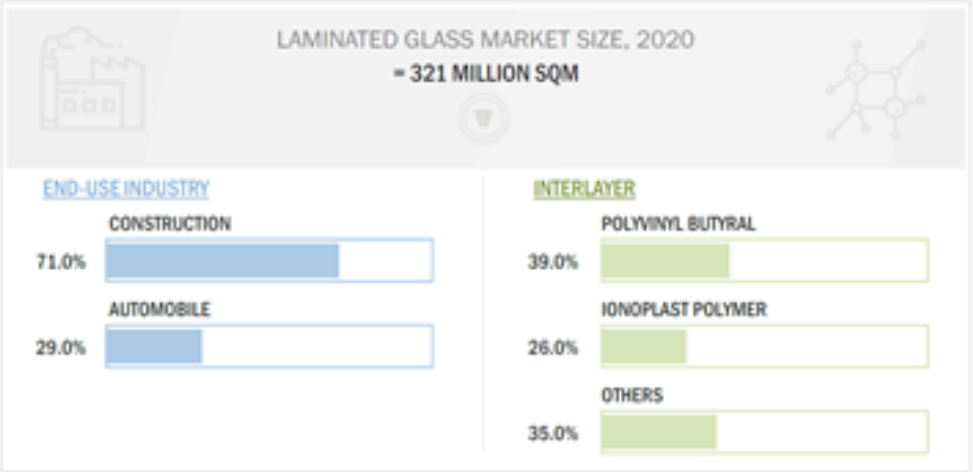
FIGURE 9 THE CONSTRUCTION INDUSTRY LED THE LAMINATED GLASS MARKET WITH POLYVINYL BUTYRAL AS THE MAJOR INTERLAYER

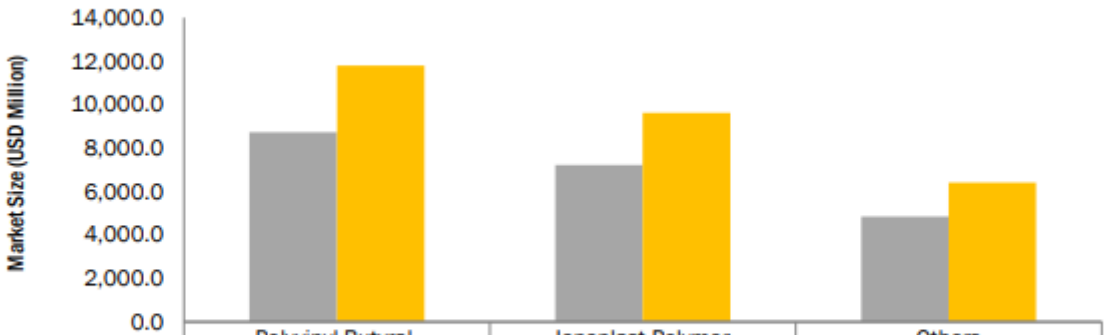


Hereafter some key findings on the market share of the different interlayer's figures Nd tables illustrating the market share of the different interlayers and their expected evolution:

- PVB as an interlayer accounted for 42% of the total laminated glass market in 2020;
- The Ionoplast polymer interlayer is projected to register CAGR of 5,9% between 2021 and 2026 by value;
- Other polymeric interlayers used are EVA but this is used for special laminates such as glasses with electrochromic layers or photovoltaics. Other polymers found are polyurethanes and polycarbonates for special cases like in bulletproof glass and/or polyolefins for photovoltaics.

The following figure shows the ratio between the different polymers used as interlayer in laminated glass. Each type of interlayer affects the overall strength of laminated glass.

FIGURE 4 POLYVINYL BUTYRAL TO DOMINATE LAMINATED GLASS MARKET DURING FORECAST PERIOD



	Polyvinyl Butyral	Ionoplast Polymer	Others
2021	8,728.4	7,217.6	4,835.5
2026	11,786.8	9,613.3	6,410.2
CAGR (2021–2026)	6.2%	5.9%	5.8%

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The following table shows the evolution of the laminated glass market by component between year 2017 and 2020. We notice a decrease in year 2020 due to the COVID-19 pandemic. However, the expectations for the next coming years are upwards.

TABLE 16 LAMINATED GLASS MARKET SIZE, BY COMPONENT, 2017–2020 (MILLION SQM)

Component	2017	2018	2019	2020	CAGR (2017–2020)
Polyvinyl Butyral	133.0	138.8	145.0	125.2	-2.0%
Ionoplast Polymer	90.1	94.0	98.2	83.5	-2.5%
Others	120.0	124.8	130.0	112.4	-2.2%
Total	**343.1**	**357.5**	**373.3**	**321.0**	**-2.2%**

We can summarise the market share of PVB in laminated glass as follows:

The PVB interlayer dominates the laminated glass market. PVB is majorly used in automobile applications and is also used in the construction industry. Due to its higher price, it is majorly used for specialized applications in construction like facades of high-rise buildings. Ionoplast interlayer is used majorly as security glass in offices, shops, and homes. It is also primarily used to make bulletproof glass.

6 Conclusions

The answers obtained until now are providing crucial information for the project. After detailed checking of the actual answers received, it can be considered that the 18 answers coming from FERVER and other flat glass recyclers represent together around 50% of the flat glass post-consumer recycling sector in the European Union and UK. By recycling, we understand a high level recycling, re-introducing the recycled glass material in the production of new glass products, including flat glass, packaging glass, fibre glass and foam glass. A real potential exists, even if there is presently no legal support (no mandatory selective collection nor recycling targets) in the European legislation.

FERVER members recycle 70% of all glass waste in Europe. In the answers of our survey, the quantities collected by the FERVER members represent more than 90% of the total. A few number of representative members of FERVER did NOT answer the questionnaire. The recyclers of glass being not member of FERVER are (1) owned for more than 50% by glass producers (avoiding conflict of interest and client/supplier relations within a same federation) or (1) not active in the majority of their business in high recycling activities). But on the recycling market, only some packaging glass producers are also active in the recycling of post-consumer packaging glass waste. The producers of flat glass are generally NOT active on the recycling market, or for some of them, only on the segment of PRE-consumer flat glass waste.

The focus of the glass recyclers is logically set on the recycling of glass. Consequently, the quality of the PVB-fraction is not optimal, even if some recyclers are already paying sufficient attention to the PVB in order to allow its recycling. The figures confirm the limited percentage of PVB actually sent for recycling, being less than 20% (16.11%).

It is important to notice that recyclers received wide variety of origins: pre- and post-consumer, from renovation and demolition for the construction sector and from repair or dismantling (End of Life Vehicle) for the automotive sector. This wide variety of origin has a direct influence on the quality of the interlayer collected and automatically on its potential for recycling.

As some respondents refer to ‘other options’ for the treatment of PVB, we can assume that the material is stored in the hope of the development of alternative (more economically acceptable) routes. But the risk is a further degradation of the material in case of outside storage.

Answers of other glass recyclers in and outside Europe are ongoing.

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Outside of FERVER members, identification of additional laminated glass recyclers has been done including the following companies for survey realisation. REVIVASA, Recuperación de Vidrio Aguado e Hijos SL, Camacho Recycling, Policart SL and TMA Reciclatges in Spain. SRPV Industriels (Potters Group) or Metal fer Recycage in France. EKONSULT in Slovenia. Gannon Eco in Ireland and Gruppo Beta and Glass Recycling in Italy.

In addition, a review of potential glass recyclers has been done focusing in Japan market. The following ones has been identified and selected for potential contact and mapping of the situation including Donico Inter Co. Ltd, HAMADA Co. Ltd., Honjo Co. Ltd, Kaiho Sangyo co. LTD., Keiaisha Co. Ltd. and Recycle Tech Japan Co. Ltd.

The global market analysis confirms the major role of PVB as interlayer in the production of laminated glass. This major role is as good as exclusive in the automotive sector. In the construction sector, alternative polymers are significant and it will be required to consider the effect of these other polymers in the recycling chain:

- Identification during the mechanical processing of laminated glass
- Sorting per polymer after glass-polymer separation
- Effect of mixtures during the recycling process of R-PVB

The market survey demonstrates the APAC dominating market, followed by the European one, confirming the high potential on mid-/ long term of PVB recycling in Europe. The actual situation of the laminated glass marked as well of the dominant position of PVB as interlayer is expected to grow in the coming years, justifying our efforts to develop new recycling routes for this polymer.

Finally, the actual energy transition will have an impact on the renovation sector to improve energy efficiency (growth rate of 6,02% from 2020 to 2024) and on the automotive sector to switch to electric vehicles

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