

Objective
50%
of cullet in the
Saint-Gobain
glass by 2025

A guide
for improved
cullet
recycling



Collecting
and processing
scraps of glass


SAINT-GOBAIN

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editorial

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of primary products
and building glass



Since launching the Glass Forever roadmap in 2017, Saint-Gobain has set out an ambitious goal: increase the proportion of cullet in its glass to 50% by 2025.

As the leader on the glass market, we must come up with tangible solutions to the challenges the industries of construction and mobility are facing today: important use of resources, greenhouse gas emissions, energy consumption, end-of-life of products, etc. Beyond being aligned with the evolution of the national and European regulations, such an objective meets the growing client demand for more sustainable products. Indeed, many buyers now look for low environmental impact materials and make commitments to preserving natural resources.

In an effort to support them, Saint-Gobain must be a pioneer in the industry and shift gears when it comes to recycling cullet. This is a true challenge: collecting, sorting and processing cullet is not a fully organized process yet, our production tools are not always compatible with all types of glass, and mostly, each individual part of glass recycling ecosystem operates independently from all others, making the implementation of such a project all the more complicated. One small mistake during the recycling process would be enough to diminish the cullet's quality and it can also be a major risk for the industrial facilities and products, or have a negative impact on the environment.

Only a commitment from all stakeholders, both at the production and transformation levels can significantly increase the quality and quantity of cullet used on our production sites, thus allowing us to meet our ambitious goal of having 50% of recycled material in our glass by 2025.

The purpose of this document is to lay out key comprehension tools, to allow the stakeholders to:



Be aware
of the stakes of using cullet



Learn the right reactions
and best practices when
it comes to collection
and sorting



Better coordinate
to implement an efficient
flat glass recycling network



Our sustainability journey

Our mission is to create great living places and improve daily life, while preserving the future for all. To achieve this ambitious goal, the Saint-Gobain glass teams are developing the program “Glass Forever”, a complete sustainability approach which includes all our stakeholders: from customers to employees including our suppliers and our local partners.

As small streams make big rivers, our vision for the future should let us grow and differentiate ourselves, while keeping our impact on the environment under control and contributing to people’s well-being.

To learn more, visit our Glass Forever Youtube channel:
<https://youtu.be/NgSkIGJVZMU>

Part I

Why write a booklet on cullet?

Maybe you’re already familiar with what cullet is! Scraps of glass. That’s an easy one. But why is it of interest to us? Well, because cullet is a great way to meet the environmental challenges the glass industry is facing today, and its use could help each of us consolidate our position on the market. We’ll tell you everything you need to know about it!

Developing the circular economy

Our societies are currently going through some important shifts. One of the major trends we can see is the evolution from a linear economic model to a circular one. The “take, make, consume, dispose” model is no longer viable. We must therefore anticipate the end-of-life of our raw materials and think about ways in which we can recycle them.

The good news is: glass is 100% recyclable, with no limits to the number of times it can be recycled!

A good answer to the market's ever-increasing demands

The construction and mobility industries are seeing the development of environmental certification labels (LEED, BREEAM, HQE, etc.) and ever-increasing demand for products with a low carbon footprint. In the wake of these new market imperatives, manufacturers must adapt and offer innovative solutions that will meet their clients' needs. Producing glass from cullet increases the recycled content in the materials (an important requirement in obtaining certification labels) and decreases CO₂ emissions linked to glass production, which is a strong competitive advantage on our respective markets.

1

Seizing a business opportunity

Making our industry last

Manufacturing glass calls for using natural resources in the earth's crust, which are only available in limited quantities. Exploiting these resources leads to increased scarcity and price volatility. The stability of manufacturing line may be threatened. Raw materials reuse already exists, and may become an important aspect in making our industry stand the test of time.

The boom of sustainable construction

According to the World Green Building Council (World GBC), 24% of new constructions worldwide had certification labels (LEED, BREEAM, HQE, etc.) in 2016. This number will keep rising rapidly over in the future, even doubling every three years¹.

¹World Green Building Council, World Green Building Trends 2016 – Developing Markets Accelerate Global Green Growth, 2016.

2

Meeting environmental constraints

Protecting natural resources

The worldwide construction and mobility boom of these past few years is leading players to look at the use of natural resources. Each year, 40 billion tons of sand and gravel are extracted from the earth, which represents about three quarters of all resources exploited in the world. Demand for these raw materials has increased 20 folds over the past century, mostly carried by the construction industry. With reserves estimated at about 120 million of billions of tons, these resources may seem endless. However, not all of the world's sand reserves are fit for industrial use, and some of it are inaccessible.

This issue's importance is heightened by the fact that the glass has to be made with extremely pure sand (not contaminated and with low iron oxide content) to meet the demand for increasingly clearer glass. Therefore, today, experts estimate that we have about 50 years' worth of exploitable sand resources for glass making.

Protecting biodiversity

Exploiting natural resources is a danger to the preservation of the environment and to biodiversity. Sand extracted from quarries is the only type of sand fit for making glass. There are numerous negative consequences to the extraction of sand (modification of the soil, noises, dust, etc.). This process also has a direct negative impact on biodiversity, and demands high energy consumption and the use of heavy machinery.

Reducing greenhouse gas emissions

In comparison to traditional glass making, the introduction of cullet in the composition of glass has a two-fold positive impact on the preservation of the earth's atmosphere. Firstly, cullet does not emit CO₂ because it was already decarbonated during the initial raw materials fusion. Secondly, melting down cullet requires less energy. By reducing our need for primary raw materials in the production of glass, we limit CO₂ emissions and sulphur oxide (SO_x) created by combustion.

3 Anticipating regulatory evolutions

Increasingly more demanding waste management regulations

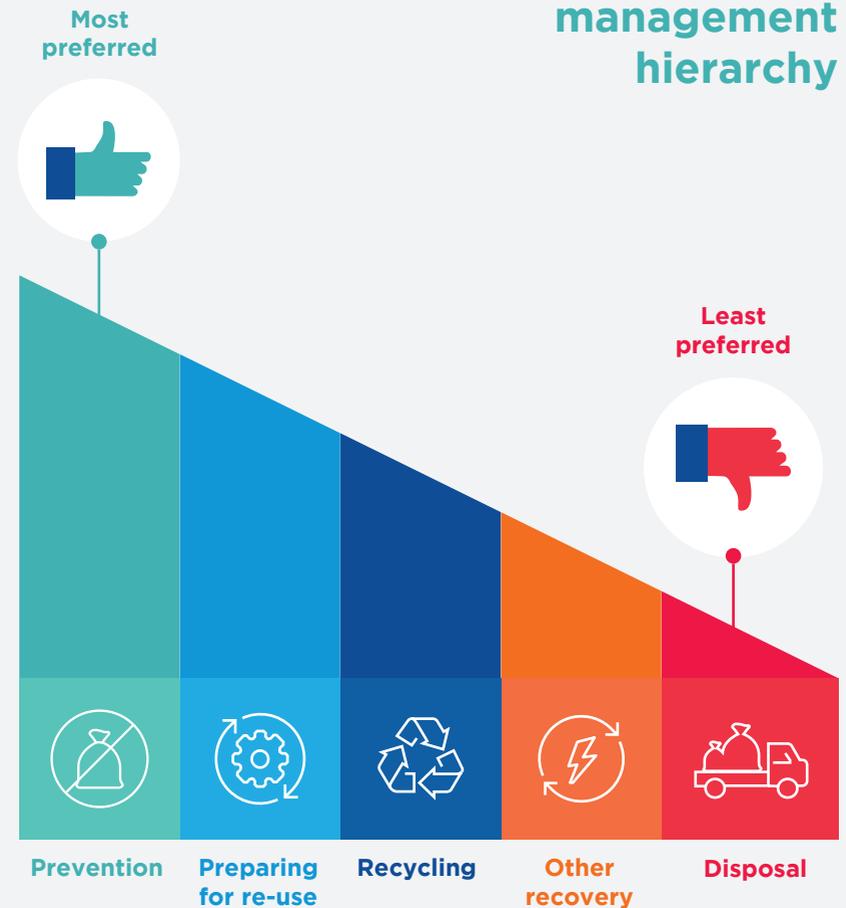
Since 2008, the European directive 2008/98/CE aims at limiting the amount of construction waste going into landfills. The European Union's member states have set the objective of collecting and recovering at least 70% of construction site waste by 2020. In order to meet this objective, the directive ranked waste management methods as shown in the picture opposite.

On 30 May 2018, the European Union published the 2018/851 Directive urging Member States to ensure that by 2030, no waste that can be recycled or recovered is allowed in a landfill. To best anticipate this new regulation, we must work together to develop a flat glass recycling chain.

Coordinating local initiatives

Several country wide initiatives have emerged to support the implementation of a true circular economy. In France, the Ministry of Sustainable Development, key players in the sector (glass, construction, demolition, recycling) and the Ministry of Finance created a "Commitment to Green Growth" (CGG) focusing on the collection and recycling of flat glass from building dismantling and renovation. This commitment aims at supporting the development of the glass recycling chain to reach the objective of collecting and processing 40,000 tons of glass per year by the end of the commitment and 80,000 tons collected and processed per year by the year 2025. Additionally, this commitment's final objective is for 50% of this collected and processed glass to go into flat glass' furnaces. Other European countries are implementing similar initiatives. For example, the "Green Deal" launched in 2011 in the Netherlands. Considering this trend, Saint-Gobain encourages its federations to implement similar initiatives.

Waste management hierarchy

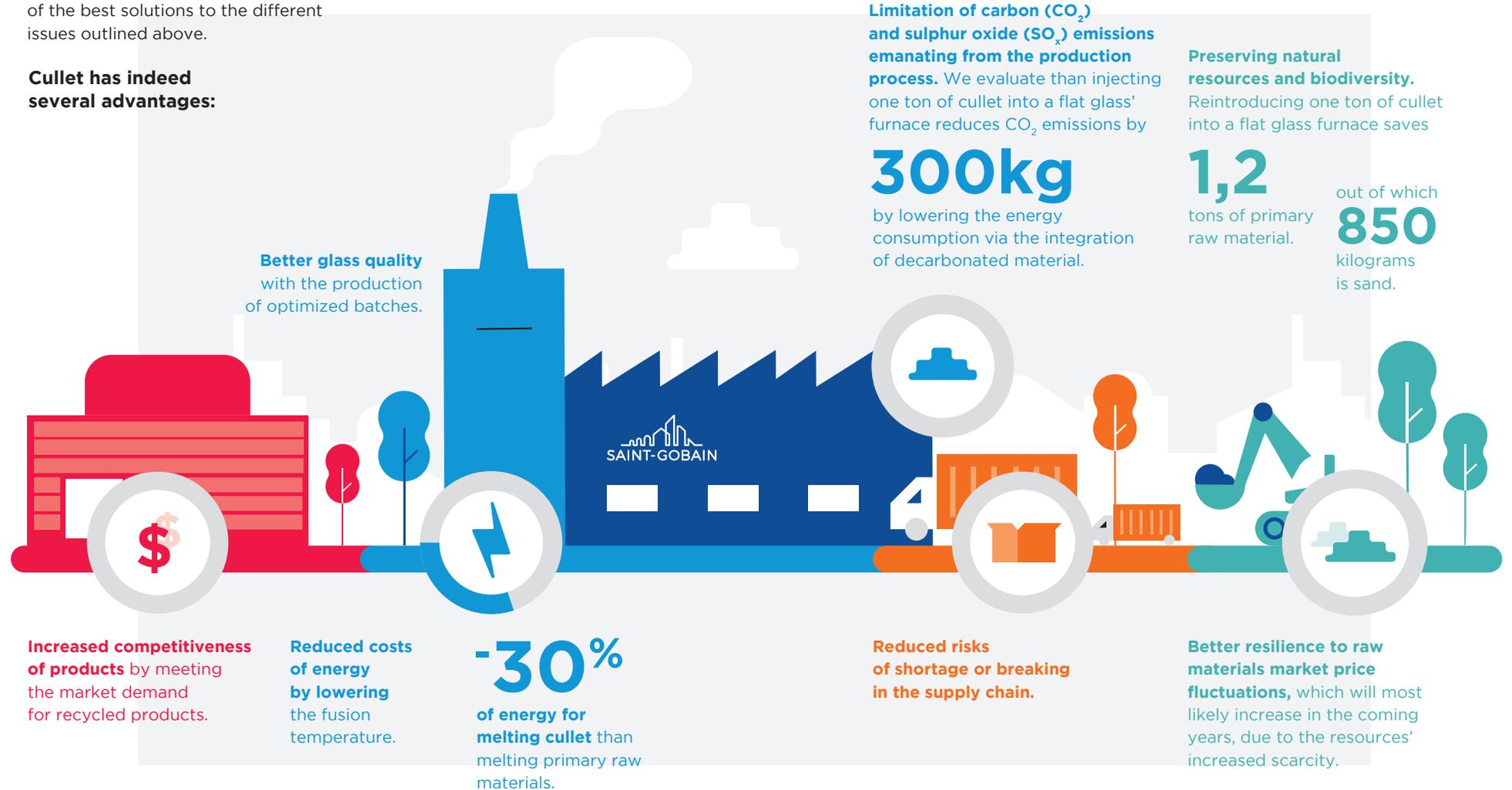


« The best waste is the one that we do not produce! »

Is cullet the magic bullet?

Without being the magic bullet, using cullet to make glass is one of the best solutions to the different issues outlined above.

Cullet has indeed several advantages:



Part II

Everything you need to know about cullet

Cullet are scraps of glass created during the production and transformation (cutting) of glass sheets, or simply when glass is broken. Today, the Saint-Gobain glass is made of 30% cullet, but our objective is to increase this proportion to 50% by 2025.

Flat glass cullet, an important resource for our floats

Due to its demanding nature, flat glass can only be made from flat glass, even though it can be used to produce any other type of glass objects.

The drawing on the right illustrates the recycling possibilities of cullet. As an example, it is possible to make hollow glass or glass-wool from hollow glass cullet. However, such a type of cullet cannot be reintegrated in the flat glass industry because it doesn't meet the colour, purity and quality standards of this type of glass.

Flat glass industry (construction)
Flat glass can only receive flat glass, it is very demanding!



Hollow glass industry (bottles)
Hollow glass can include flat glass or hollow glass in its composition.

Glass-wool industry (insulating material)
Glass-wool can include flat or hollow glass and glass-wool in its composition.



Embankment
As a last resort, cullet that cannot be recycled into any type of glass can be used as embankment. We call this material recovery rather than recycling.

Is cullet waste?

According to the European directive 2008/98/EC, cullet that meets the quality standards for recycling is not legally considered as waste, which makes its handling, transportation and use as a resource within the European Union easier. However, the legislation around cullet is not the same around the world, and one should keep in mind that this "non-waste" status isn't necessarily applicable outside the European Union. For more information on this, please reach out to the Saint-Gobain lawyers outside the European Union.

Cullet types

There are 3 types of cullet, depending on its origin, as defined by the ISO 14021 standard



19%*

Internal cullet

Cullet that comes directly from glass production. This type of cullet does not leave the flat glass making facility, and it is directly recycled on the production lines.



11%*

Pre-consumer cullet

Glass waste coming from glass sheet transformation and from products that have not yet been delivered to the final client. This type of cullet can be found on coating lines and transformation sites.



<1%*

Post-consumer cullet

Cullet generated after the delivery to the final client. In the construction industry, post-consumer cullet mainly comes from renovation and, building dismantling. In the auto industry, it mainly comes from the replacement of windshields and the dismantling of cars at the end of their useful life.

*Percentage of material used in Saint-Gobain's flat glass furnaces in 2018

Part III

The steps for a perfect cullet!

Cullet is a precious resource for producing flat glass, but its use entails the implementation of a rigorous collection and sorting process. Cullet's recycling cycle can be compared to a chain constituted of several different interdependent links. And, for the chain to remain intact, one must respect a certain set of rules.

The risks of using cullet

Indeed, if there is even just one contaminant (metal, infusible, etc.) in the cullet reinjected in the float furnace, the glass production can be exposed to the following risks.

To avoid such risks, the collected and used cullet must be of the highest quality possible. A perfect cullet means:

An easier process when it comes to direct insertion of cullet in the flat glass furnaces

An improved ability to reach the final colour

Limiting contamination risks

Having the best possible reaction time in the event of a contamination

Eventually reaching higher glass recycling rates



Risks to the industrial process and facility

Some metals can directly attack the materials making up the flat glass furnace, therefore shortening its lifespan. Over time, this damage can have an extremely high negative financial impact on the production sites.



Risks to the quality of the final product

The glass can leave the factory with aesthetic defects or fragilities, which can lead to breakage during the manufacturing process and up to several years after the product is put on the market (example: nickel sulphide - NiS).



Risks of atmospheric emissions

Contamination can affect the composition of the entering materials and create unexpected chemical reactions during the production and transformation of the glass sheet. This may lead to the increase of Volatile Organic Compounds (VOC) emissions. Emission rates of these compounds are strictly regulated and manufacturers must abide by these regulations.

To get to perfect cullet, one must abide by a set of rules at each step of the cullet's recycling cycle:

Step 1
Choosing the right type of glass and collecting the cullet
Page 20



Step 2
Sorting the cullet and managing the site's cullet stock
Page 22



Step 3
Transporting and storing the cullet
Page 24



Step 4
Controlling cullet quality and reprocessing it on site if necessary
Page 25



Step 1 Choosing the right type of glass and collecting the cullet

Glass is unique in that it is 100% recyclable. However, Saint-Gobain's flat glass furnaces cannot welcome all the different systems in which glass is used. Considering the difficulty of ensuring received cullet quality (sampling), choosing the right type of glass upstream is absolutely necessary to having a properly running recycling process.

Golden rule #1 Ensuring the cullet is in conformity with Saint-Gobain's eligibility criteria

As of today, Saint-Gobain admits the following types of cullet:

<p>Only cullet from flat glass (used in the construction and the automotive industry)</p> <p>Laminated glass, only if it is made up of one or two standard Polyvinyl Butyral sheets (after special reprocessing see page 27).</p> <p>Decorative glass such mirrors and lacquered glass*</p> <p><small>*these types of glass are eligible, however then can only be used in limited amounts in the production mix (see page 26).</small></p>	<p>Magnetron and pyrolytic coated glass</p> <p>Black enamelled glass, only from Saint-Gobain Sekurit factories</p> <p>Coloured in the mass glass, including mixed colour glass if the mix is known and homogeneous</p>
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By definition, anything that isn't on this list cannot be considered eligible cullet today and may not be integrated to Saint-Gobain's furnaces to remake flat glass

This list is constantly evolving because the recycling techniques, along with the products available on the market are evolving as well.

This means that Saint-Gobain excludes all other materials, as they are considered ineligible today:

<p>Metals, and more specifically aluminum, nickel (can be found in stainless steel), tungsten, lead (see page 23)</p> <p>Ceramic glass, a high temperature resistant composite material used for oven doors, ceramic or induction power hobs, fireplace inserts, etc.</p>	<p>Infusibles, which can come from glass making tools, abrasives, or construction site waste like stone or concrete.</p> <p>The other types of glass than flat glass, especially quartz glass, which can be used for lamps, laboratory glassware, optics, or certain types of wine glasses or borosilicate glass, which makes up wine glasses or oven resistant dishes (like Pyrex®)</p>
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Warning!
Some systems which contain flat glass are ineligible:

<p>  </p> <p>Enamelled glass that isn't Saint-Gobain Sekurit's black enamelled glass</p>	<p>  </p> <p>Digital printing glass</p>	<p>  </p> <p>Smart glass</p>	<p>  </p> <p>Electronic mirrors</p>
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Golden rule #2 When recovering end-of-life windows, ensure that they remain in one piece as long as possible

Considering the difficulties of ensuring optimal cullet quality when the cullet is already mixed, the most efficient strategy when recovering end-of-life windows is to keep them in one piece for as long as possible, until they reach the glass reprocessor!

Step 2 Sorting the cullet and managing the site's cullet stock

After looking closely at the eligible cullet, it is critical to sort it properly upstream to avoid contamination risks, and to optimize cullet use.

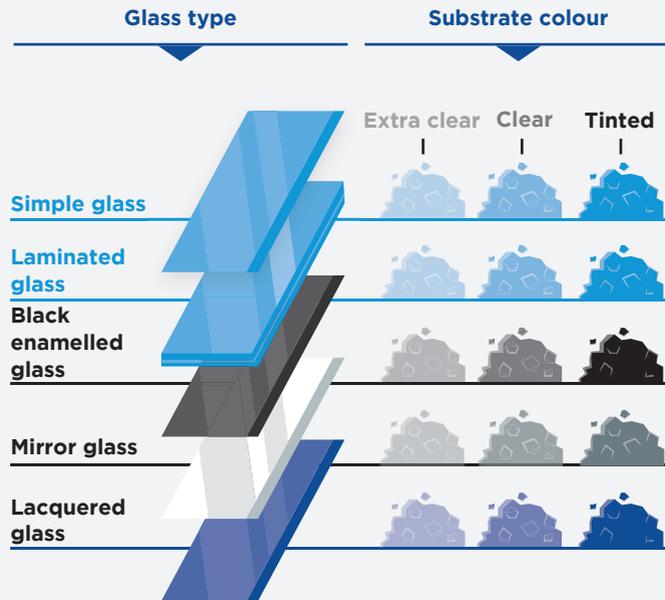
Warning

Once the cullet is contaminated, Saint-Gobain's factories cannot sort it again, because their infrastructure and equipment are not adapted for this operation.

Golden rule #3

Sort cullet by type and by substrate colour

At the Saint-Gobain location, as well as at processors and recycling location, it is necessary to sort the cullet by substrate colour, and by glass type². This operation is designed to make the process of reinserting the cullet in the furnaces easier, and to obtain the appropriate final colour for the glass produced.



²This classification may evolve in correlation with market characteristics and the entry on the market of new products.

Golden rule #4 Create a storing area for each type/color combination

It is highly recommended to create a storing area for each cullet type/color combination. Sites can therefore have up to twenty different storing areas, depending on the cullet they receive. These recommendations are applicable to the different cullet storage sites:



Production sites

Saint-Gobain's factories/floats

Processing sites

Saint-Gobain Glassolutions, Saint-Gobain Sekurit and other processors

Recycling sites

Windows dismantlers, cullet preparation, reproprocessors.

To ensure steady cullet quality, Saint-Gobain's specialists can visit and audit the sites to check, advise on, and if necessary, change the way sorting

Trick for a better sorting process

Sort as far upstream as possible, especially scraps coming from the manufacturing process, because it can be difficult to see the difference between lightly coloured thick glass and highly coloured thin glass (green glass) with a naked eye.

is done on the sites. All of these precautions and best practices are necessary to limit the risk of the cullet getting contaminated, which can have dire consequences on the manufacturing process, the industrial equipment, the final product's quality, but also atmospheric emissions.

Some contamination examples

Aluminium



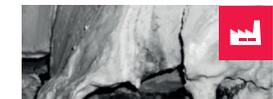
Can lead to the creation of infusible particles on the glass ribbon making it unfit for sale and unrecyclable in flat glass furnaces.

Nickel



Can cause the glass to crack during the manufacturing process and up to several years after it is put on the market.

Tungsten and lead



Can lead to deposits of these metals in the flat glass furnace and directly attack the materials that constitute it.

Step 3 Transporting and storing cullet

Transporting and storing are key steps in the cullet's recycling process because contamination risks are particularly high.

Golden rule #5 Make sure the type/color combination sorting rules are respected during transportation

If the cullet has to be transported to a location outside the production and processing site, it is critical that it is not mixed during this step. The type/color combination sorting rules must be respected (see previous page).

Golden rule #6 Check that the cullet stock is in good condition at the departure site and at the destination site

It is especially critical to pay attention to the stone fragments that can be mixed in with the cullet.

Golden rule #7 Make sure the cullet storage area is far enough from the general waste storage area

The objective here is to avoid any external contamination (cigarette butts, aluminum cans, paper, etc.) that could negatively impact cullet quality.

Golden rule #8 Make sure the skips and big bags are clean and in good conditions

The most important part is to check that there is no rust.

Golden rule #9 Inspect the trucks before and after the cullet transportation

To prevent the trucks from contaminating the cullet, it is necessary to ensure they are clean before and after they are used to transport cullet. If you have any doubt on their cleanliness, don't hesitate to reach out to the site manager.

Golden rule #10 Use reverse logistics as much as possible

When a processing site transports cullet to the factories, it is preferable to fill the returning trucks with cullet. By optimizing transportation streams, we can reduce shipment costs, as well as the CO₂ emissions coming from the trucks.

Warning!
As soon as the cullet is dropped off at the factory's sorting area, it is deemed to have been accepted³. However, it is hard to check cullet quality when the trucks arrive.

Step 4 Controlling cullet quality and reprocess it on site if necessary

Golden rule #11 Control cullet quality at each step of the chain

Each time cullet arrives on site, it must go through a visual check in Saint-Gobain's factories. This step lets us make sure the cullet is of the appropriate quality, and to decide whether to accept it or not. If there is any doubt, the cullet can be refused by the Saint-Gobain teams, therefore cancelling all the previous efforts.

What is the main objective of this control?

Identify any major irregularities which would call for a reprocessing of the cullet. Cullet quality must be controlled to ensure that an additional reprocessing step is not necessary. Such an additional step would impact the financial balance of the operation and the environmental impact of the recycling operation.

Steps for receiving and controlling cullet on a Saint-Gobain site

When the cullet arrives at a Saint-Gobain site, it goes through several steps before being reintroduced in the furnace:

1 Checking

Verification of the cullet's appearance and identification of the large elements (spacers, aluminum brackets for double paned windows, pieces of wooden pallet, etc.).

2 Unloading

The carrier unloads the cullet in the cullet storage area, while respecting the sorting rules outlined above (see page 22)

3 Silaging

During this step, magnets and metal detectors will remove any potential magnetic and non-magnetic metallic elements found in the cullet (screws, steel dust, etc.). However, contamination by other materials (plastic, wood, stone, concrete, ceramic glass, etc.) cannot be detected.

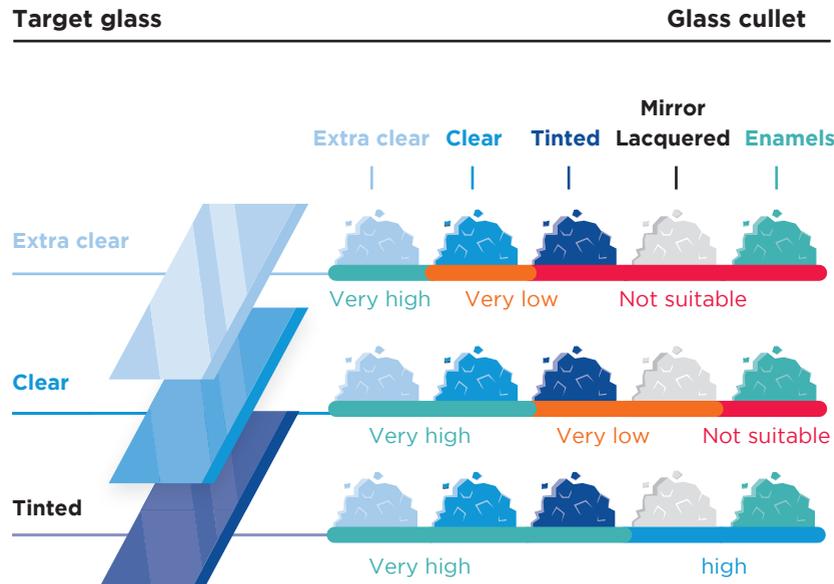
³Unless specified otherwise in the agreement with the service provider.

Therefore, it is critical for Saint-Gobain to only receive high quality cullet, because the production sites do not currently have the appropriate infrastructure and equipment to sort, sample and test the cullet they receive. If one link in the chain does not respect the recommendations presented in this document, the whole cullet recycling chain is at risk.

Good to know: the importance of sorting cullet according to its colour

Using extra-clear cullet to make extra-clear glass, and prioritizing tinted cullet to make tinted glass. Why? Because tinted glass impacts the glass mix and makes it harder to get clear glass.

What colour of cullet do target glasses accept?



Reprocessing operations for certain types of cullet

For certain types of cullet, a reprocessing operation at the Saint-Gobain factory may be necessary before it is stored.

For mirror, planilaque, and screen-printed glass

Dilution of the mirror glass with the cullet in the furnace

Selection of the appropriate grain size

Homogenization of the cullet size to get a better melting fusion behaviour and an improved effectiveness for the magnets and metal detectors.

For laminated glass

Aging of the glass sheets outside for 3 months, before grinding the glass to separate it from the Poly-vinyl Butyral sheets

Recovery of the cullet, and integration in the furnace with a maximum grain size of 20x20 square millimetres. If this criterion isn't respected, the size of the cullet pieces may disrupt the material's transporting and its fusion.

The process to ensure cullet quality and its recyclability in the flat glass furnaces is long and arduous. The only way to create an efficient and viable flat glass recycling process is by making sure the different players are extremely well coordinated.

If you would like to ask questions or share comments, please feel free to write to cullet@saint-gobain.com

Indeed, recycling cullet is a great way to meet the market's needs, to make our production tools last, to anticipate legal changes, while maintaining a focus on preserving the environment. We hope that, by providing our advice and guidance in this guide, we contribute to the implementation of a circular economy based on resources reuse, which will bring value to all the stakeholders. Here at Saint-Gobain, we are convinced that this is a win-win situation!

Glossary

Borosilicate glass

High-temperature resistant glass. Chemically undetectable, this type of glass is generally used to make wine glasses and Pyrex® oven safe dishes.

Ceramic glass

Mixed material made from glass and nanometric crystals, which are invisible to the naked eye. Ceramic glass and glass have very different mechanical properties. This material is used for oven doors, ceramic glass or induction hotplates, and fireplace inserts to name a few.

Enamelled glass

Glass that is coated with one or several coloured, opaque, or glazed enamels, on one or both sides. This type of glass is used for car windshields.

Grain size

Size of powders and grains, and study of their distribution in different size intervals.

Inloaders

Trailer trucks used to transport flat glass.

Laminated glass

Glass made up of two glass sheets glued together with a Polyvinyl Butyral sheet, making it practically unbreakable. This is a safety glass used for car windshields and store fronts.

Magnetron and pyrolytic coated glass

Glass with improved acoustic, visual, and thermal performances thanks to its specific coating.

PVB (Polyvinyl Butyral)

Synthetic thermoplastic polymer used to assemble glass and make laminated glass.

Quartz glass

Glass that is entirely made of silica, making it highly resistant to high temperatures and thermal shocks. This type of glass also has a broader transparency spectrum than traditional glass (for ultraviolet, visible rays, and rays close to infra-red). Thanks to these specific properties, it is often used for light fixtures (halogen, fluorescent light, etc.).

Saint-Gobain Glassolutions

Factories processing flat glass for the construction industry.

Saint-Gobain Sekurit

Factories processing flat glass for the auto industry.

SO_x

Sulphur oxide

Soda-lime glass

Glass used to make flat glass for the construction and mobility industries (cars, trucks, planes, trains...).

Steps to achieving perfect cullet

Golden rule #1

Ensuring the cullet is in conformity with Saint-Gobain's eligibility criteria

Golden rule #2

When recovering end-of-life windows, ensure that they remain in one piece for as long as possible

Golden rule #3

Sort cullet by type and by substrate colour

Golden rule #4

Create a storing area for each type/color combination

Golden rule #5

Make sure the type/color combination sorting rules are respected during transportation

Golden rule #6

Check that the cullet stock is in good condition at the departure site and at the destination site

Golden rule #7

Make sure the cullet storage area is far enough from the general waste storage area

Golden rule #8

Make sure the storage skips and big bags are clean and in good conditions

Golden rule #9

Inspect the trucks before and after the cullet transportation

Golden rule #10

Use reverse logistics as much as possible

Golden rule #11

Control cullet quality at each step of the chain

