

RECYCLING BOROSILICATE GLASS FOR A FACADE SYSTEM ASSEMBLED OF DRY-INTERLOCKING CAST GLASS COMPONENTS IMPLEMENTED IN CASA DA MÚSICA

Eliza Scholtens - April 8th,
2019 - P5 Presentation

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Tillmann Klein
Telesilla Bristogianni



Crystal houses - Amsterdam



<https://brickarchitecture.com/images/projects/crystal-houses-mvrdv/description-2.jpg>




<https://brickarchitecture.com/images/projects/crystal-houses-mvrdv/description-1.jpg>

What is glass?

- Sand + Soda ash + Limestone

What is glass?

- Sand + Soda ash + Limestone = Glass
- 

What is glass?

• Sand + Soda ash + Limestone = Glass



Soda-lime



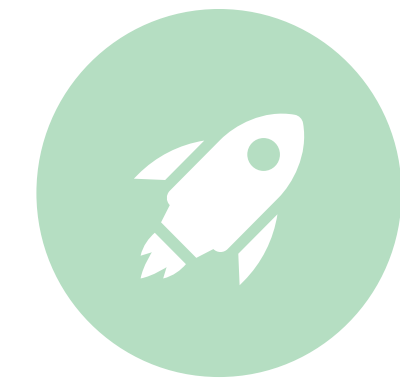
Borosilicate



Lead glass



Alumino silicate



Fused silica
96% silica

What is glass?

• Sand + Soda ash + Limestone = Glass



Soda-lime



Borosilicate



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What is glass?

• Sand + Soda ash + Limestone = Glass



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Borosilicate



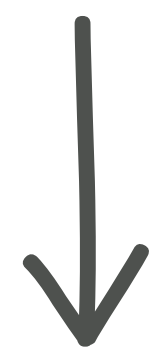
Lead glass



Alumino silicate



Fused silica
96% silica



Focus

What is glass?

• Sand + Soda ash + Limestone = Glass



Soda-lime



For comparison
Mature recycling
industry



Borosilicate



Focus



Lead glass

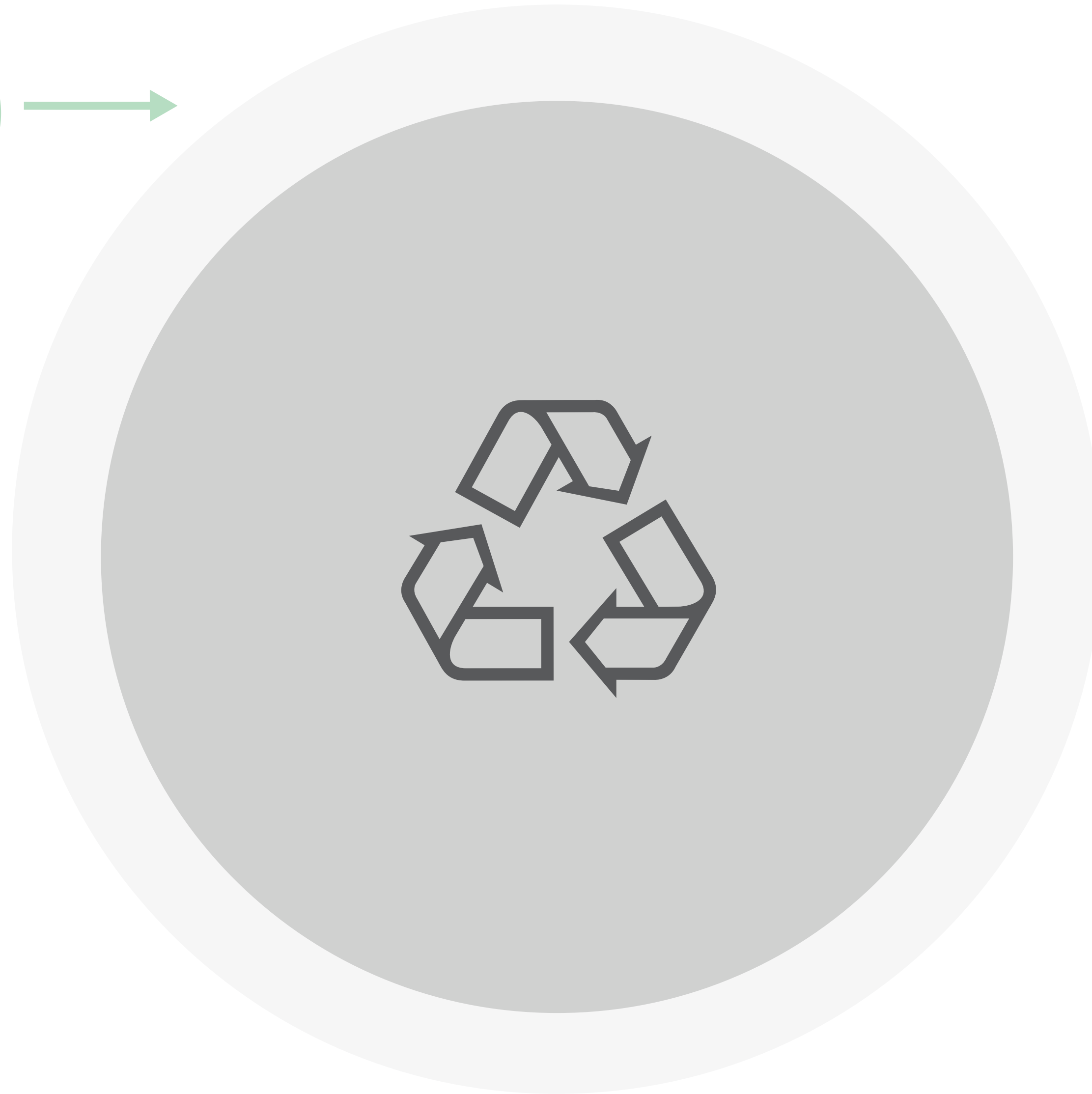


Alumino silicate

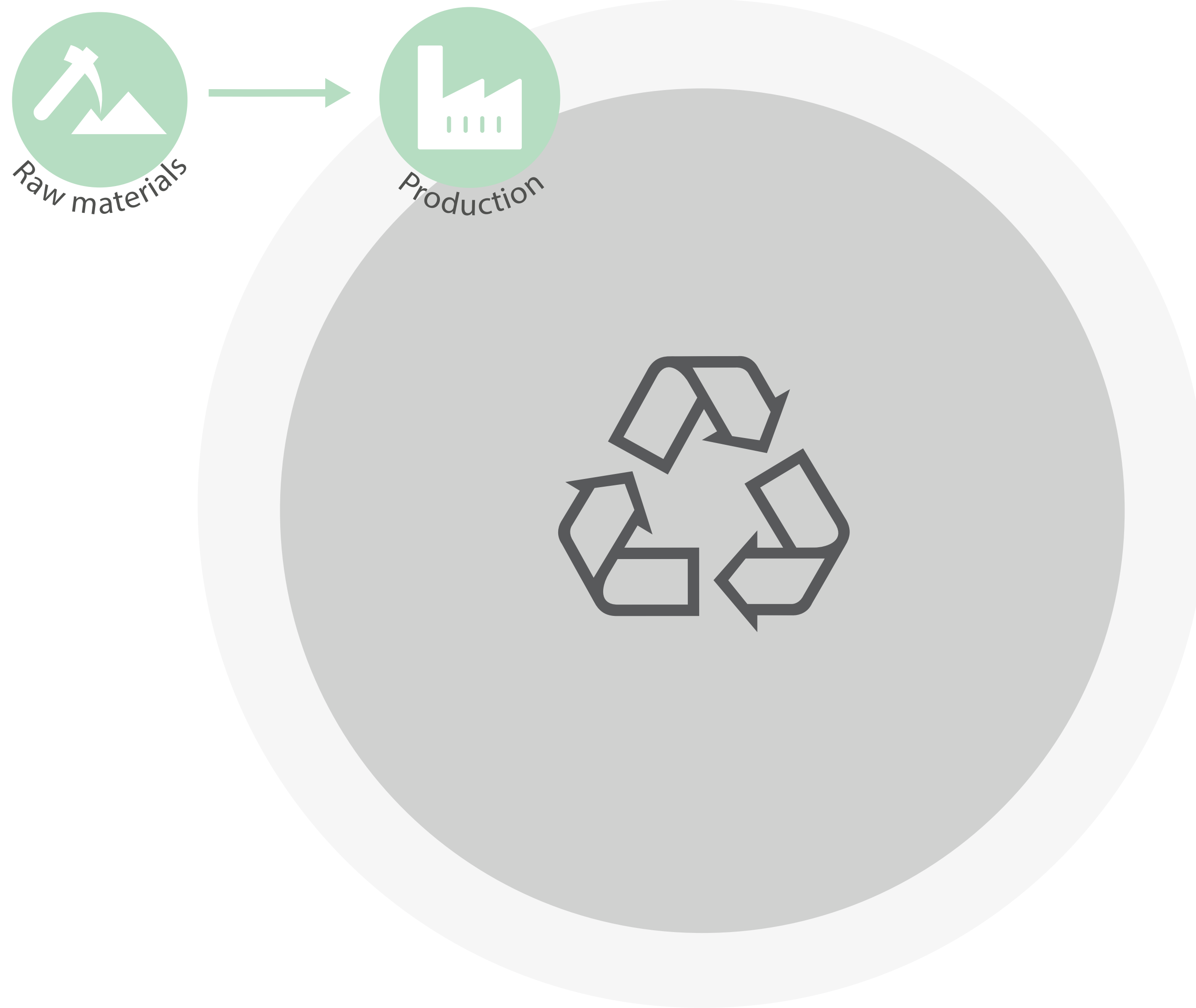


Fused silica
96% silica

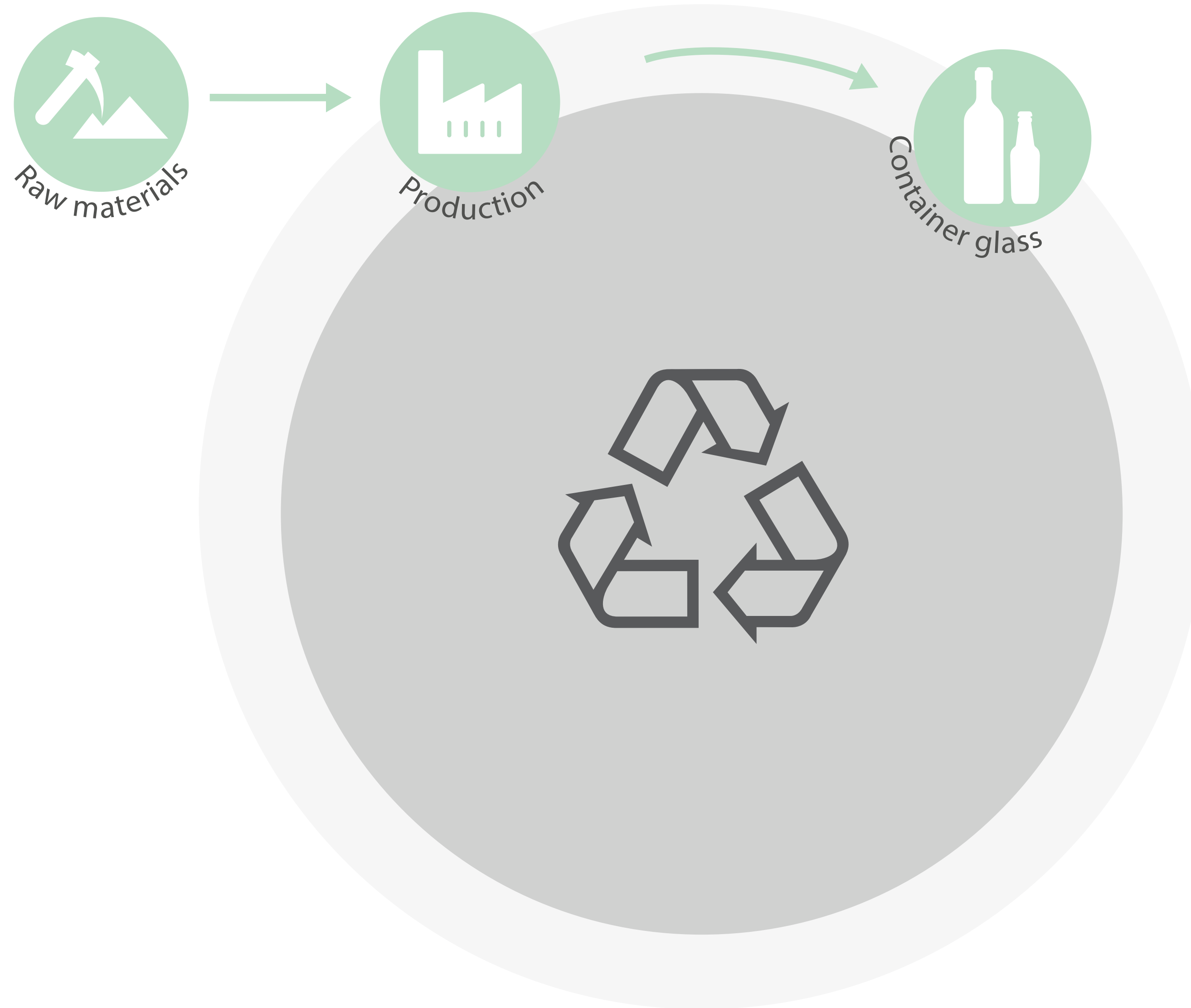
Life-cycle of soda-lime container glass



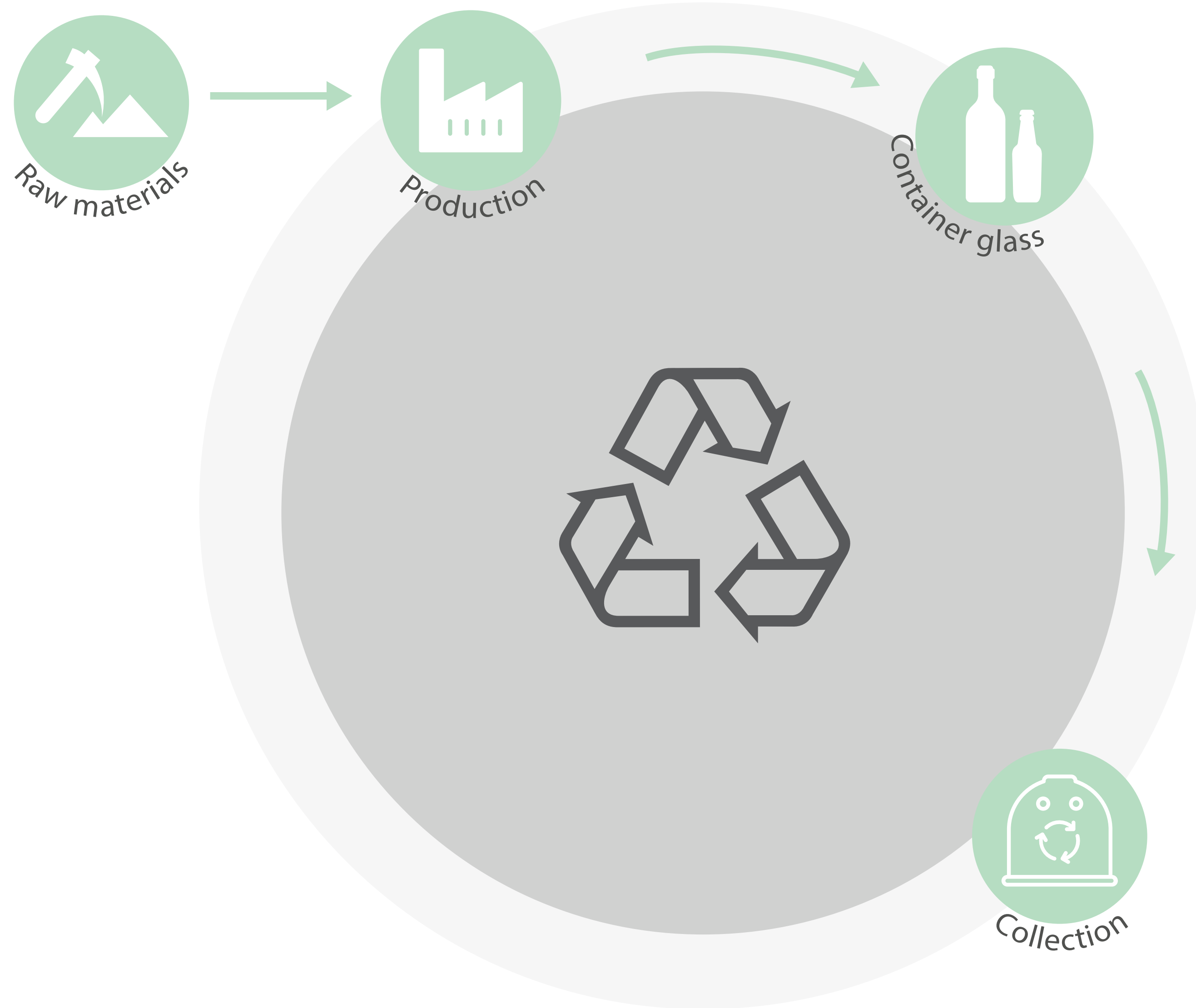
Life-cycle of soda-lime container glass



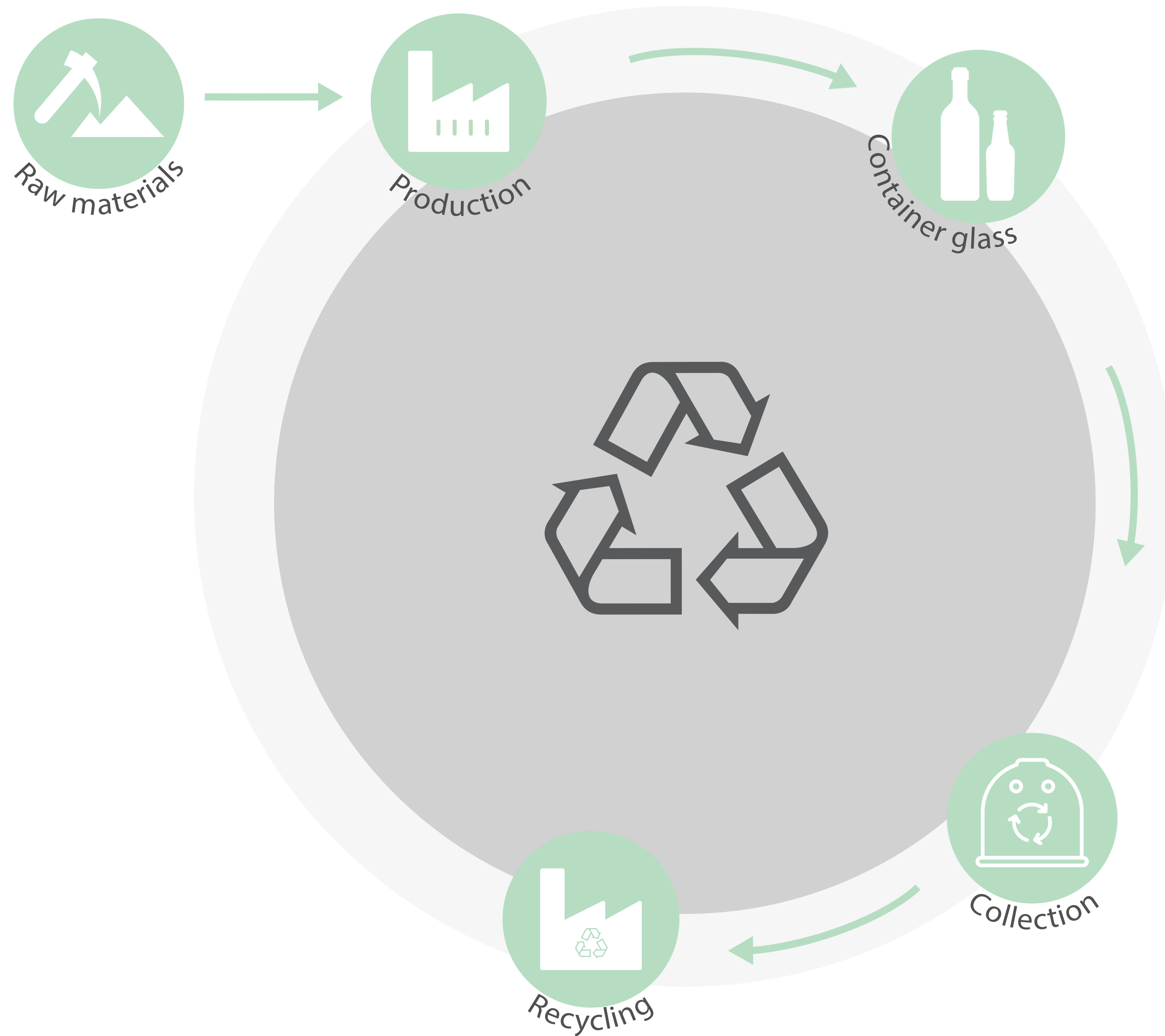
Life-cycle of soda-lime container glass



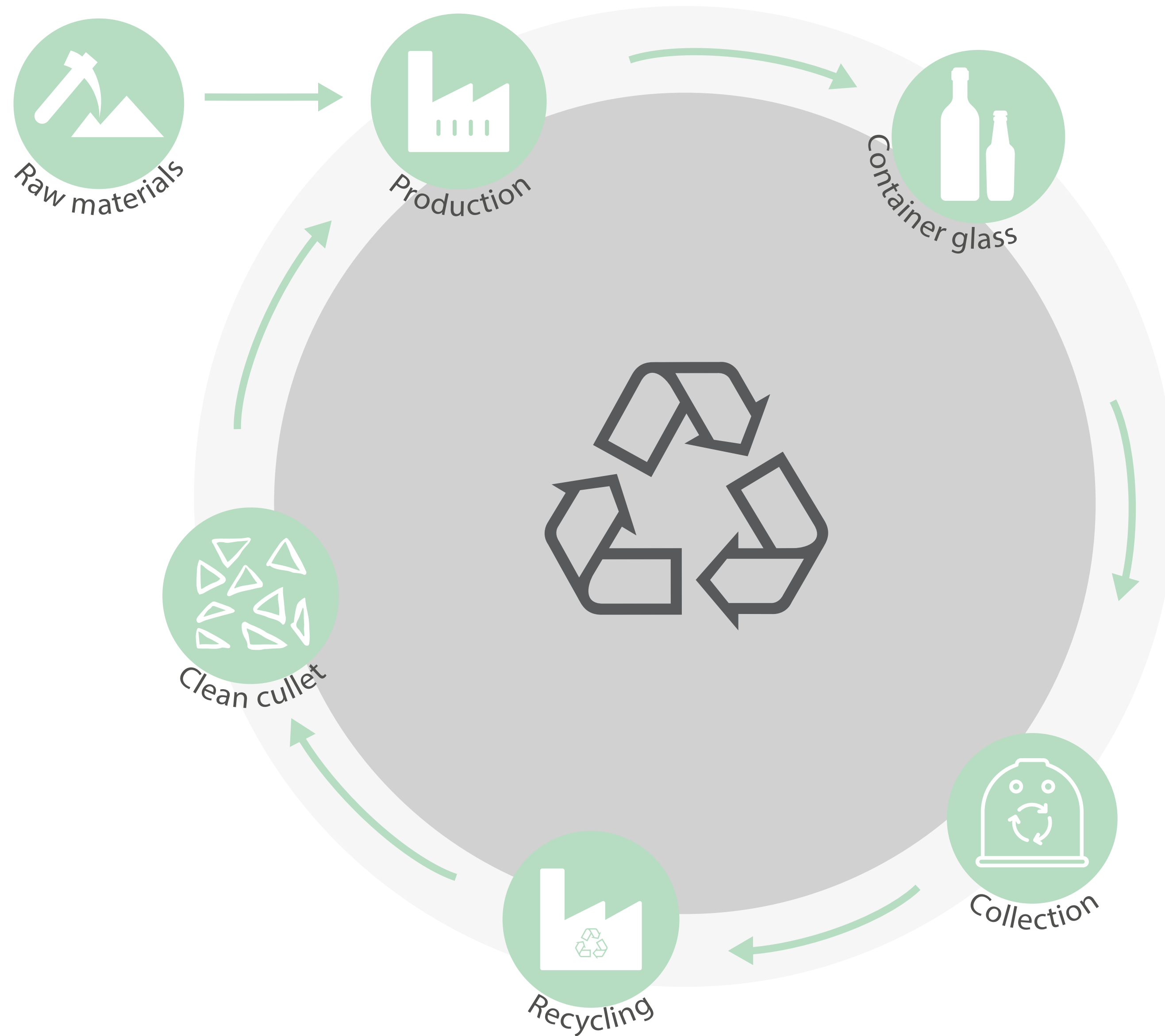
Life-cycle of soda-lime container glass



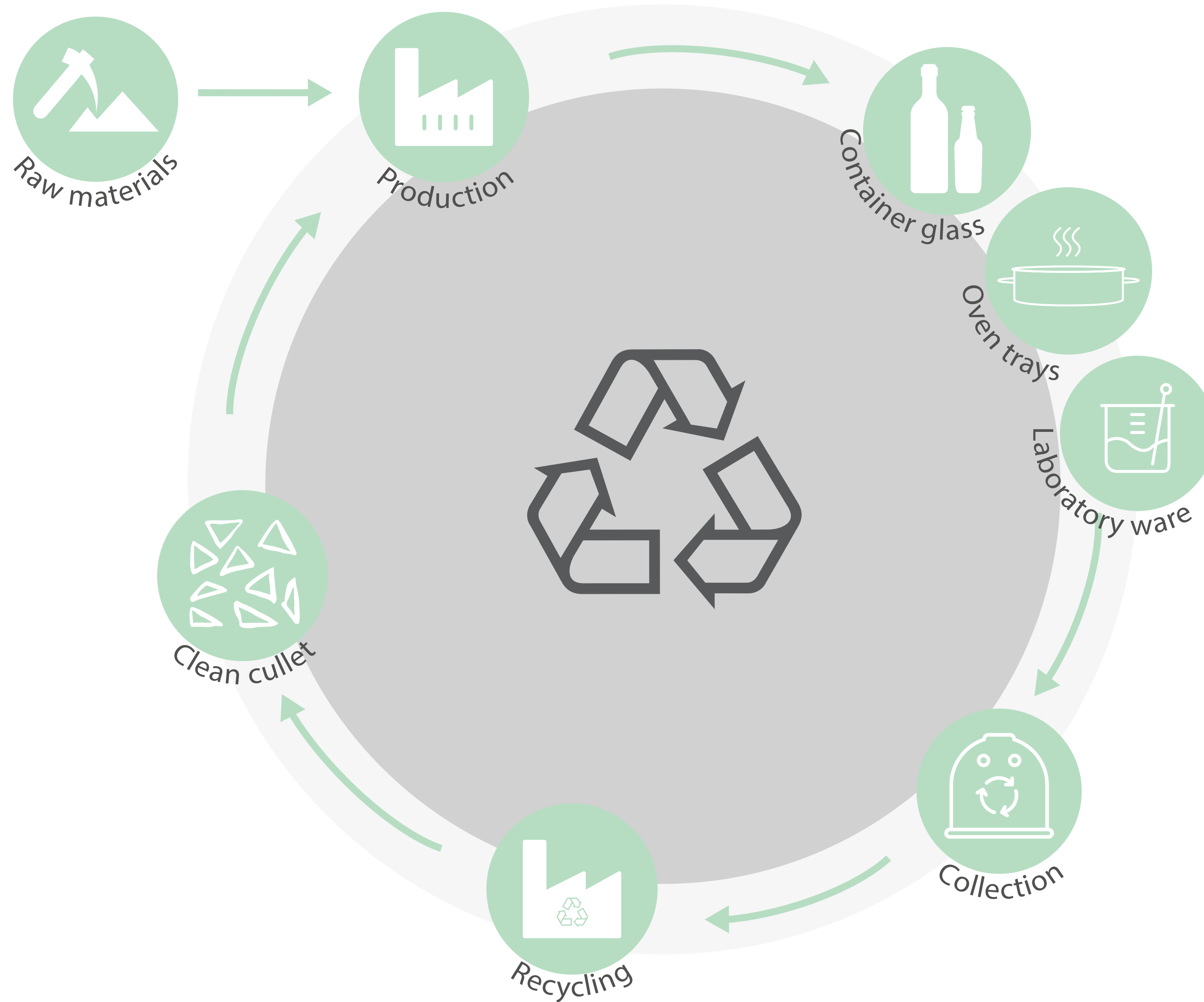
Life-cycle of soda-lime container glass



Life-cycle of soda-lime container glass



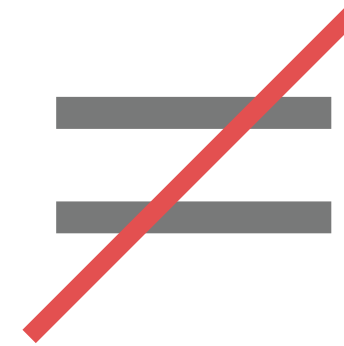
Life-cycle of soda-lime container glass





=







Borosilicate glass

Soda-lime glass



Borosilicate glass

- Higher melting temperature
- Expensive production
- Low thermal expansion coefficient
 - Heat resistant
 - Reduced annealing time

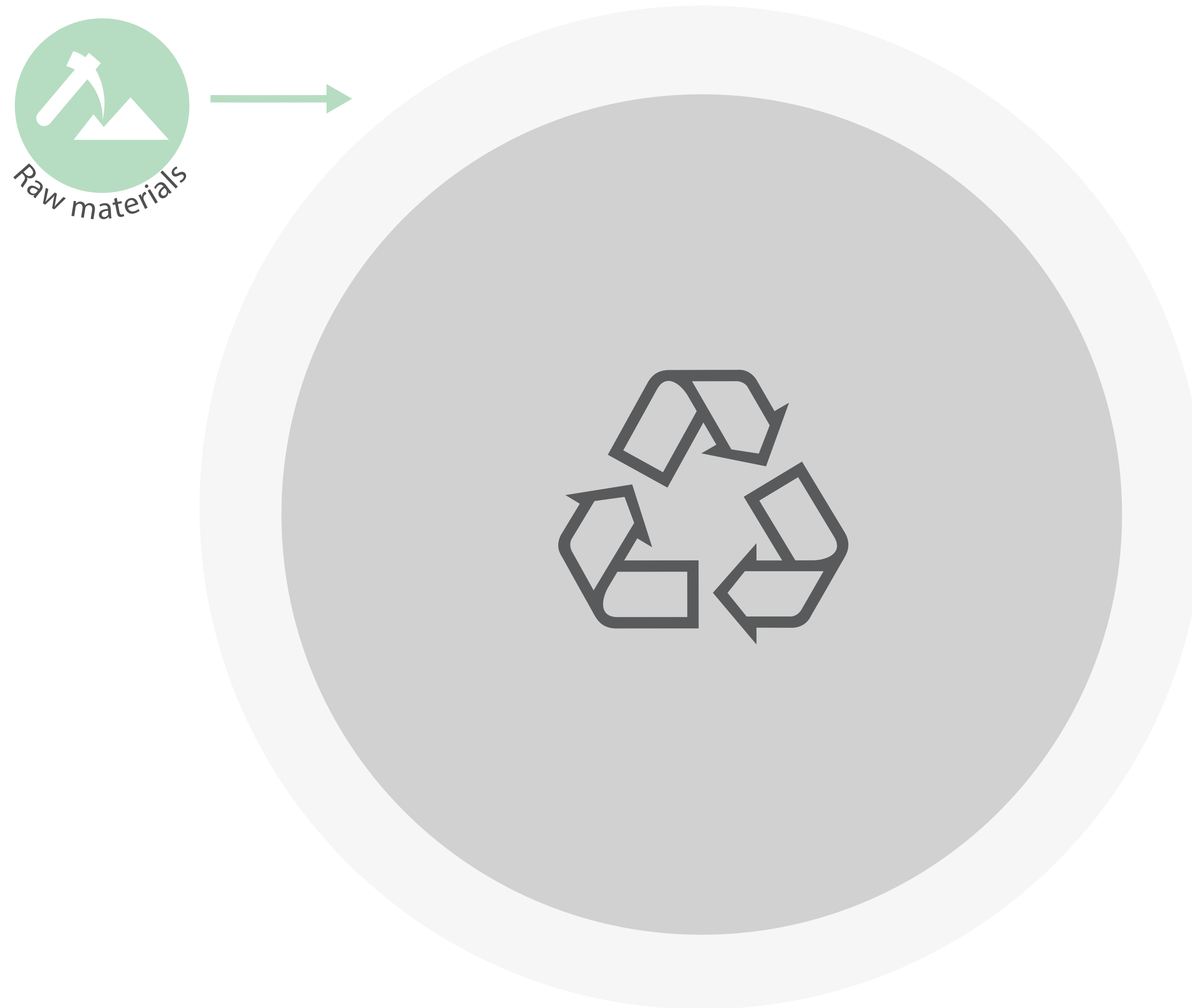
Soda-lime glass

- Lower melting temperature
- Relatively low cost production
- High thermal expansion coefficient
 - Not heat resistant
 - Longer annealing time

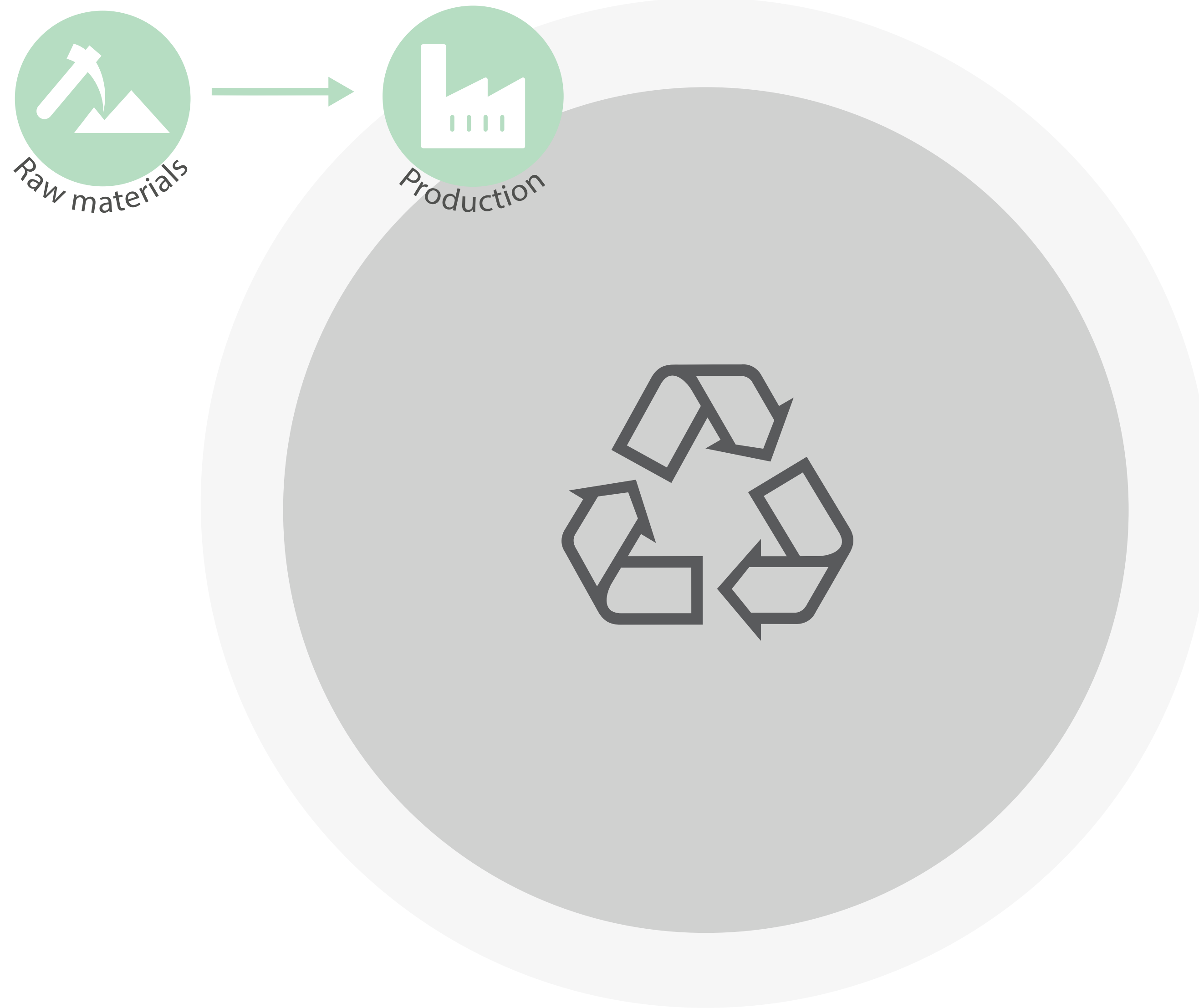
Examples of borosilicate glass



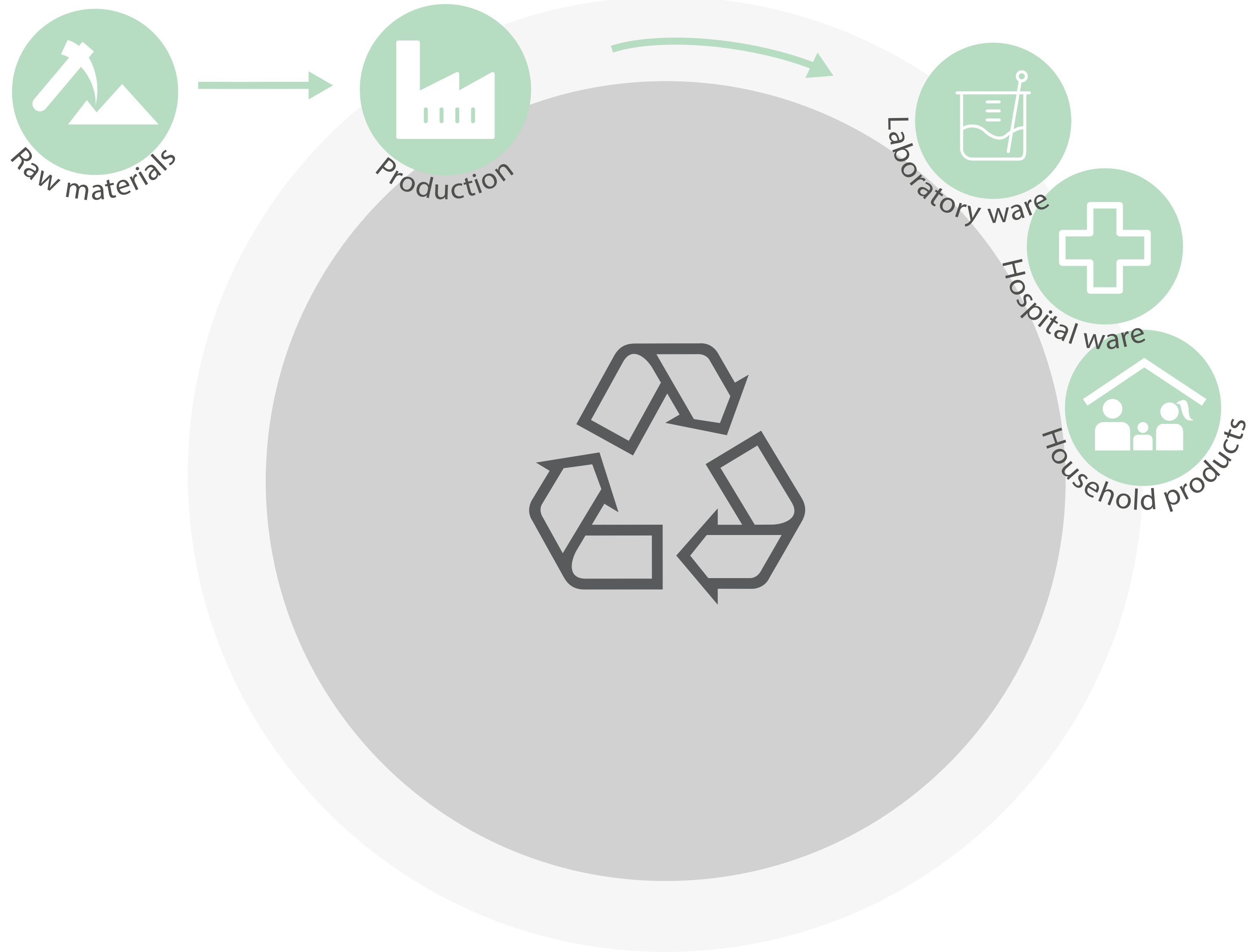
Life-cycle of borosilicate glass



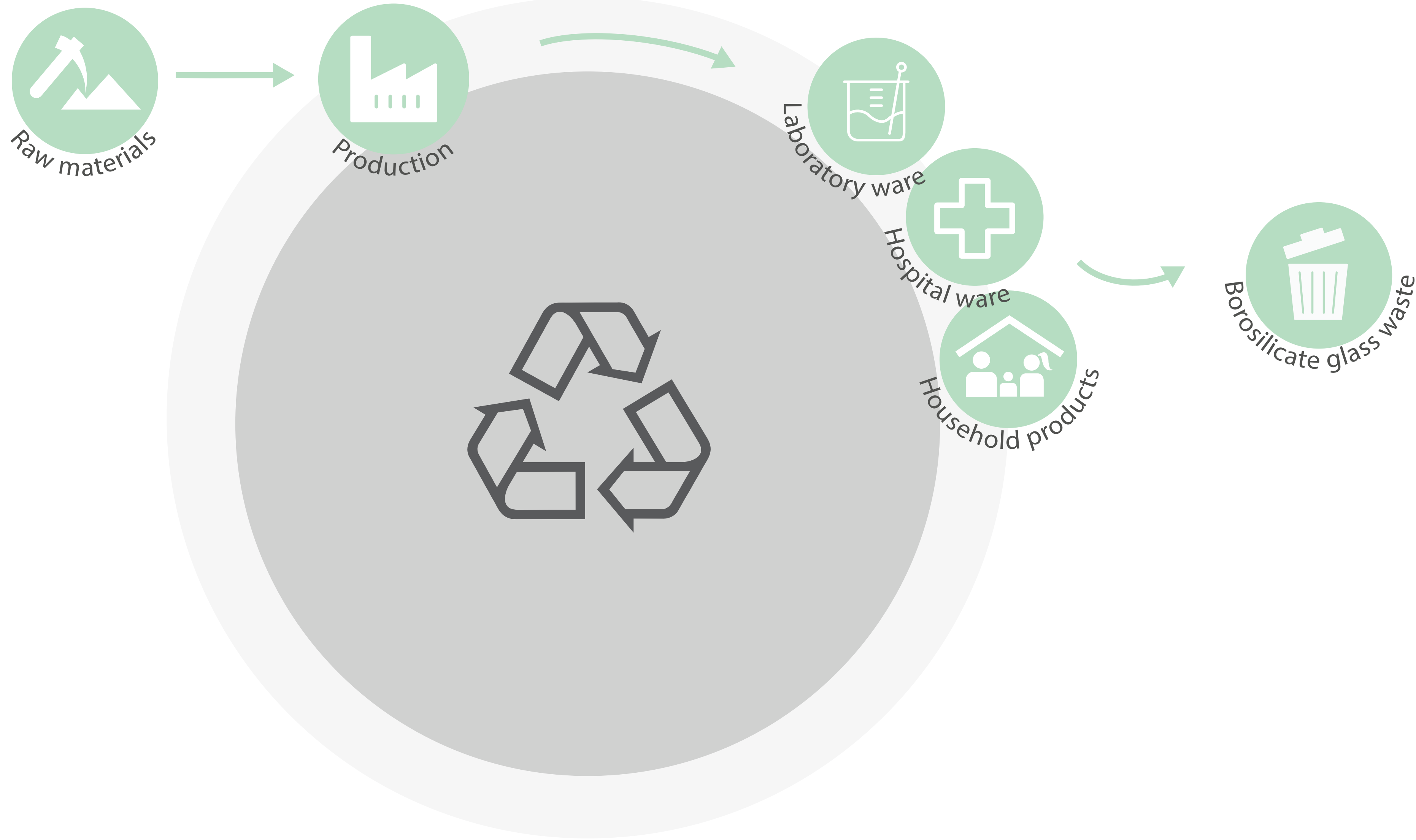
Life-cycle of borosilicate glass



Life-cycle of borosilicate glass



Life-cycle of borosilicate glass



Life-cycle of borosilicate glass



Life-cycle of borosilicate glass





Borosilicate glass

Borosilicate glass

Downgrading to aggregate



Loss of high quality glass

Borosilicate glass

Downgrading to aggregate



Loss of high quality glass

Waste



Takes up valuable land

Borosilicate glass

Downgrading to aggregate



Loss of high quality glass

Waste



Takes up valuable land

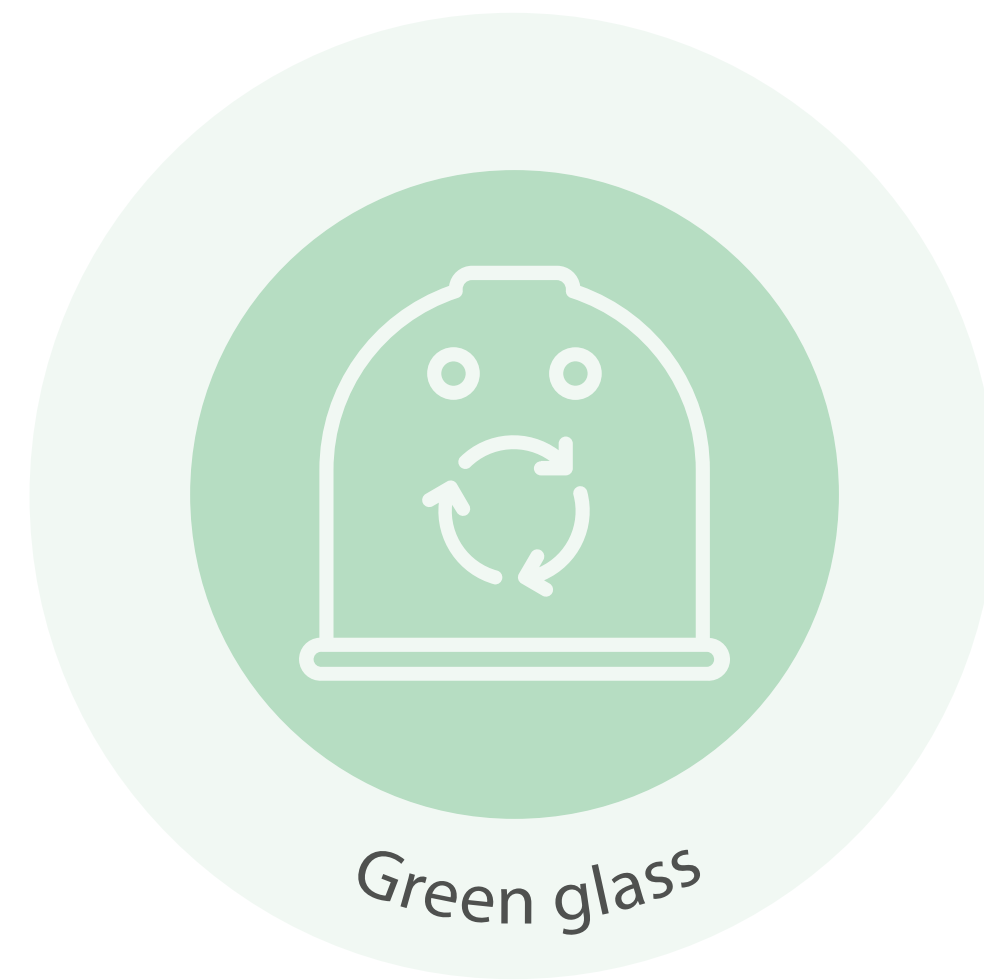
Ends up in soda-lime
glass recycling



Ruins batches of soda-
lime glass recycling

→ More waste

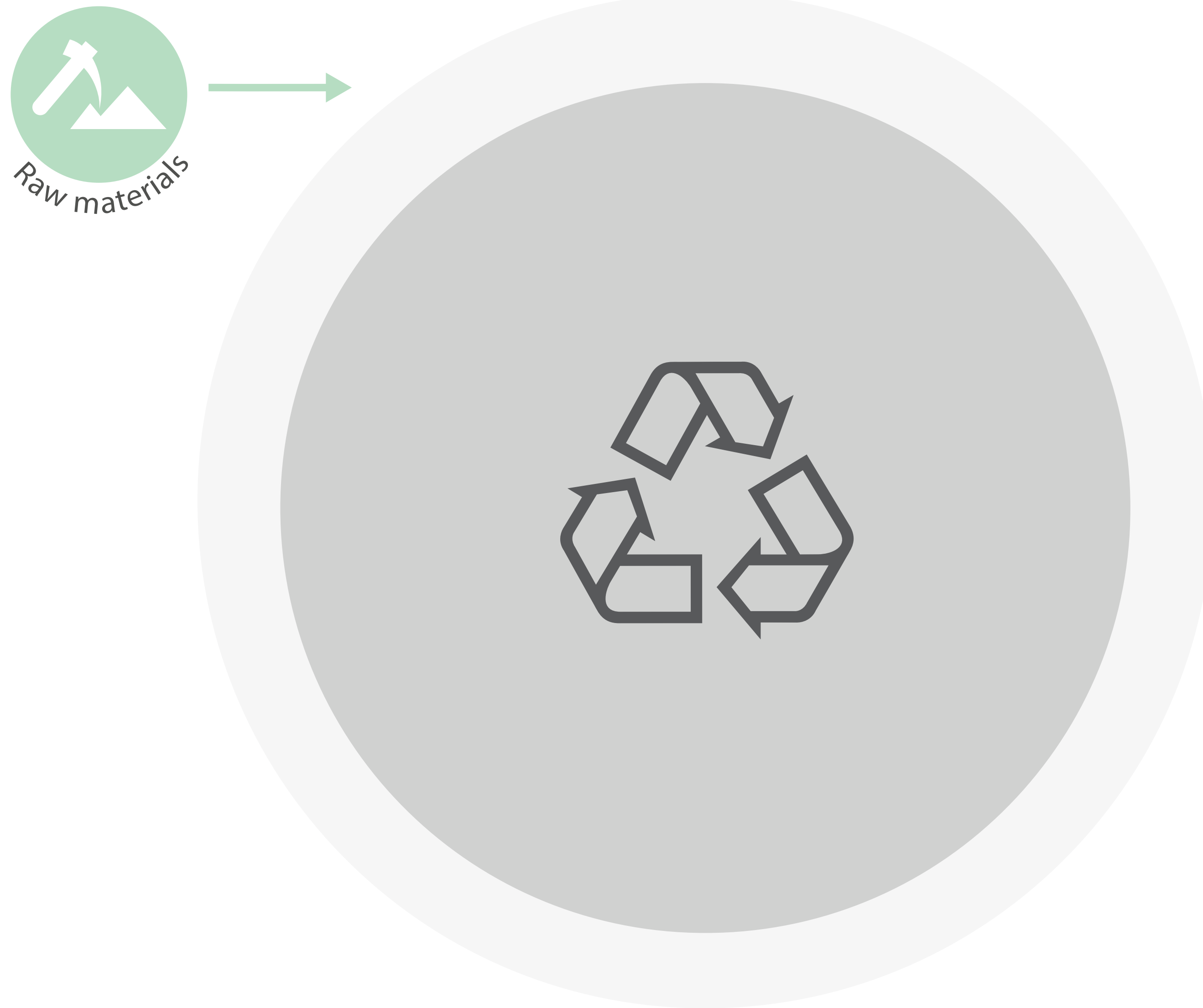
Current collection containers



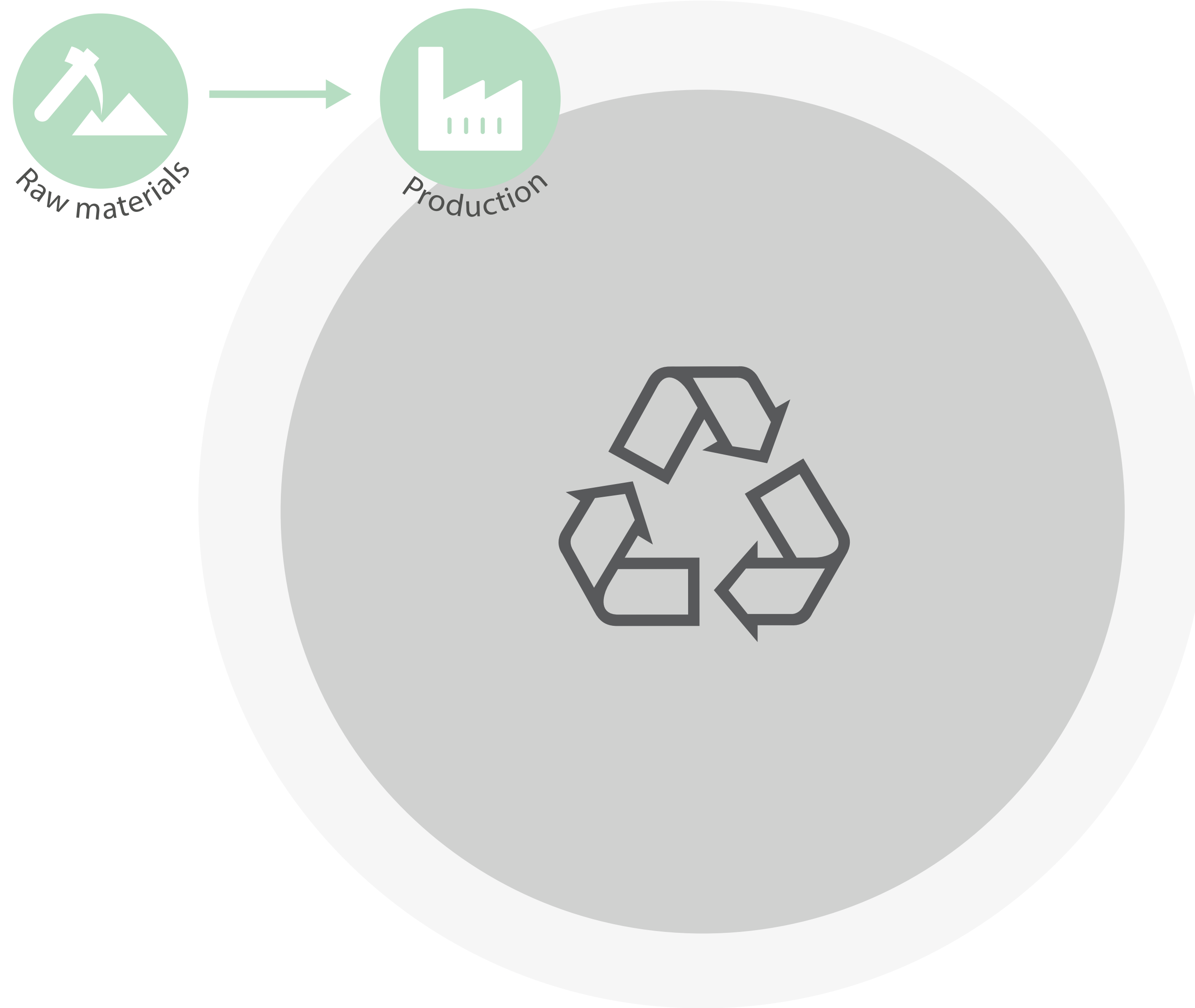
Proposed collection containers



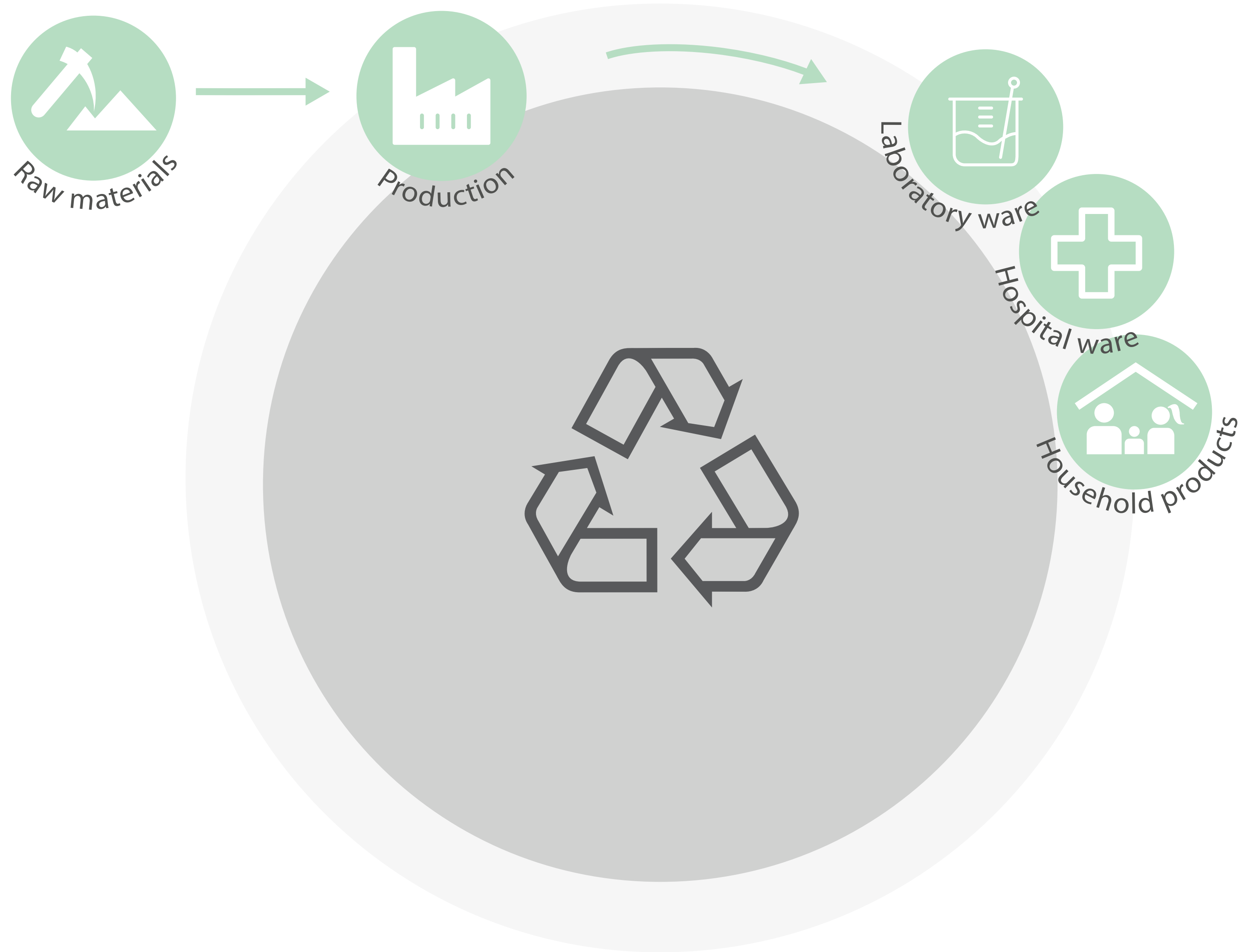
Desired life-cycle of borosilicate glass



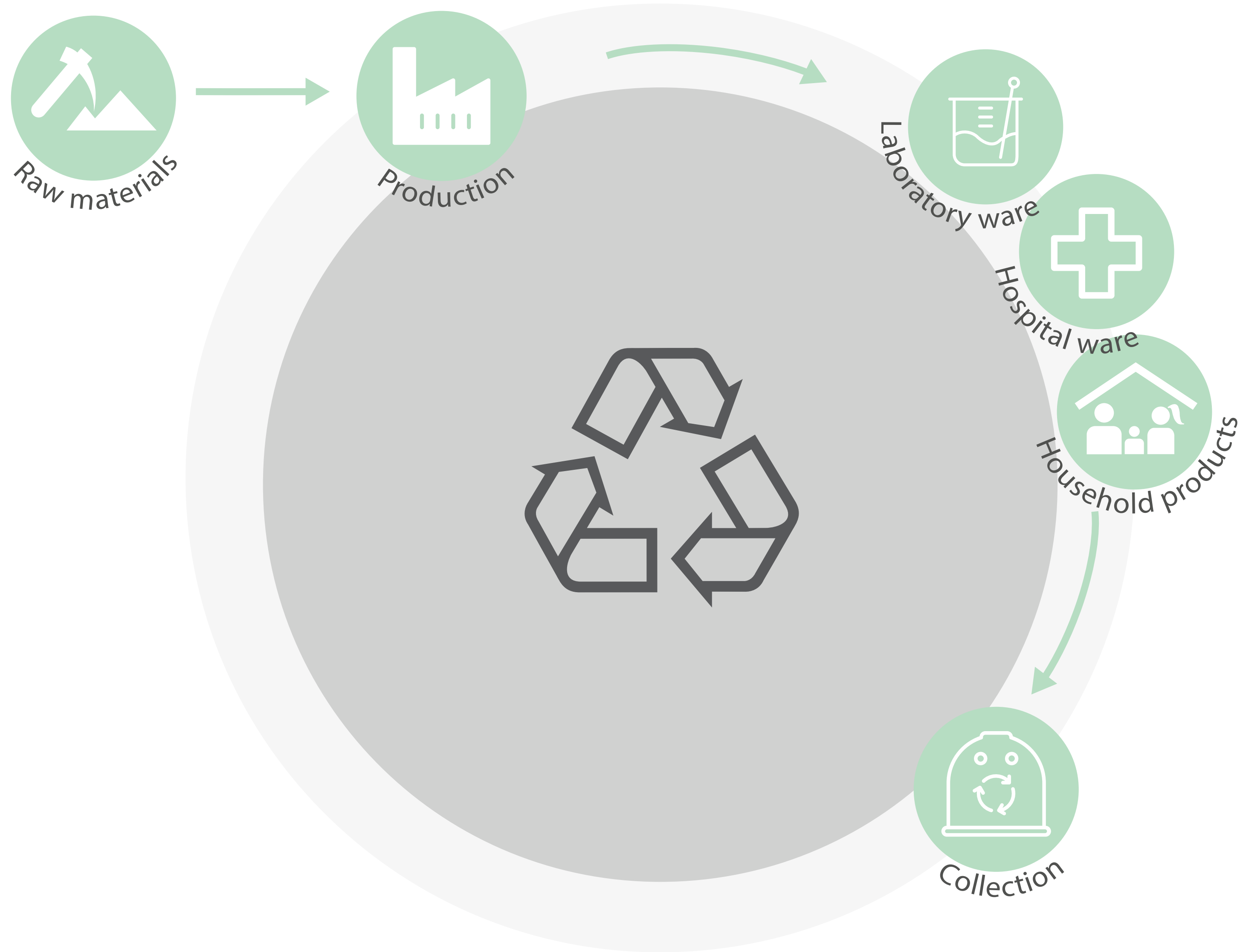
Desired life-cycle of borosilicate glass



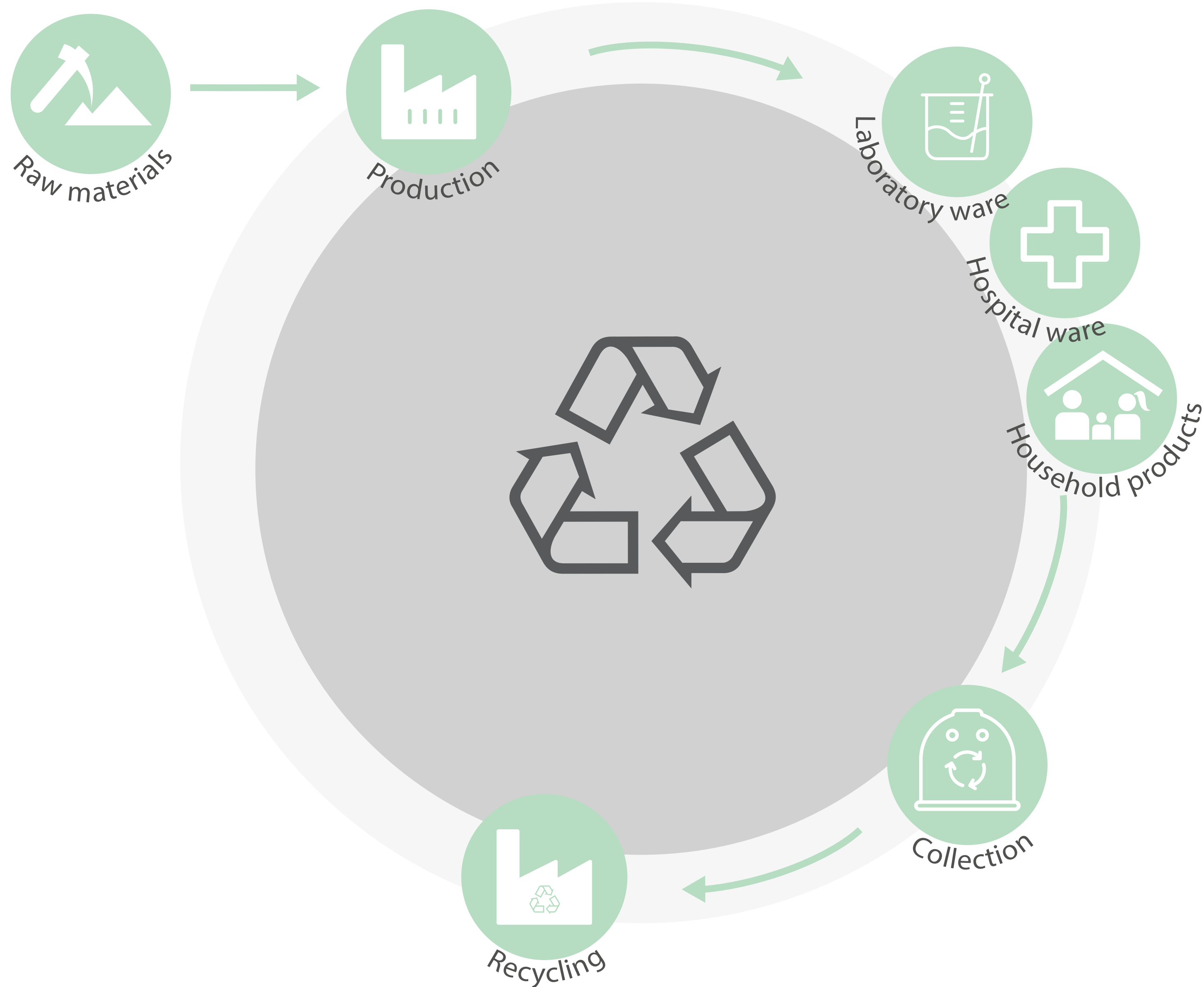
Desired life-cycle of borosilicate glass



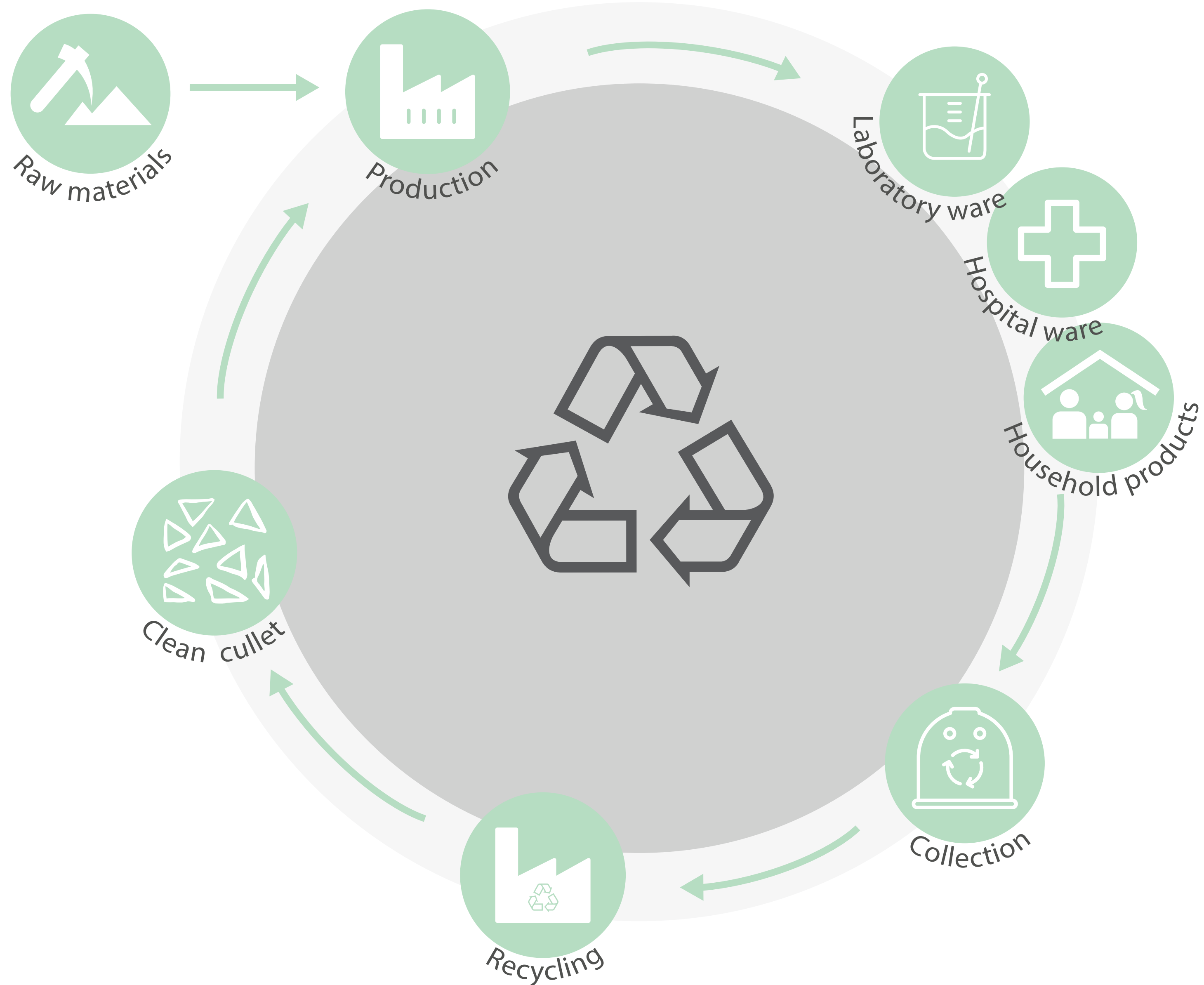
Desired life-cycle of borosilicate glass



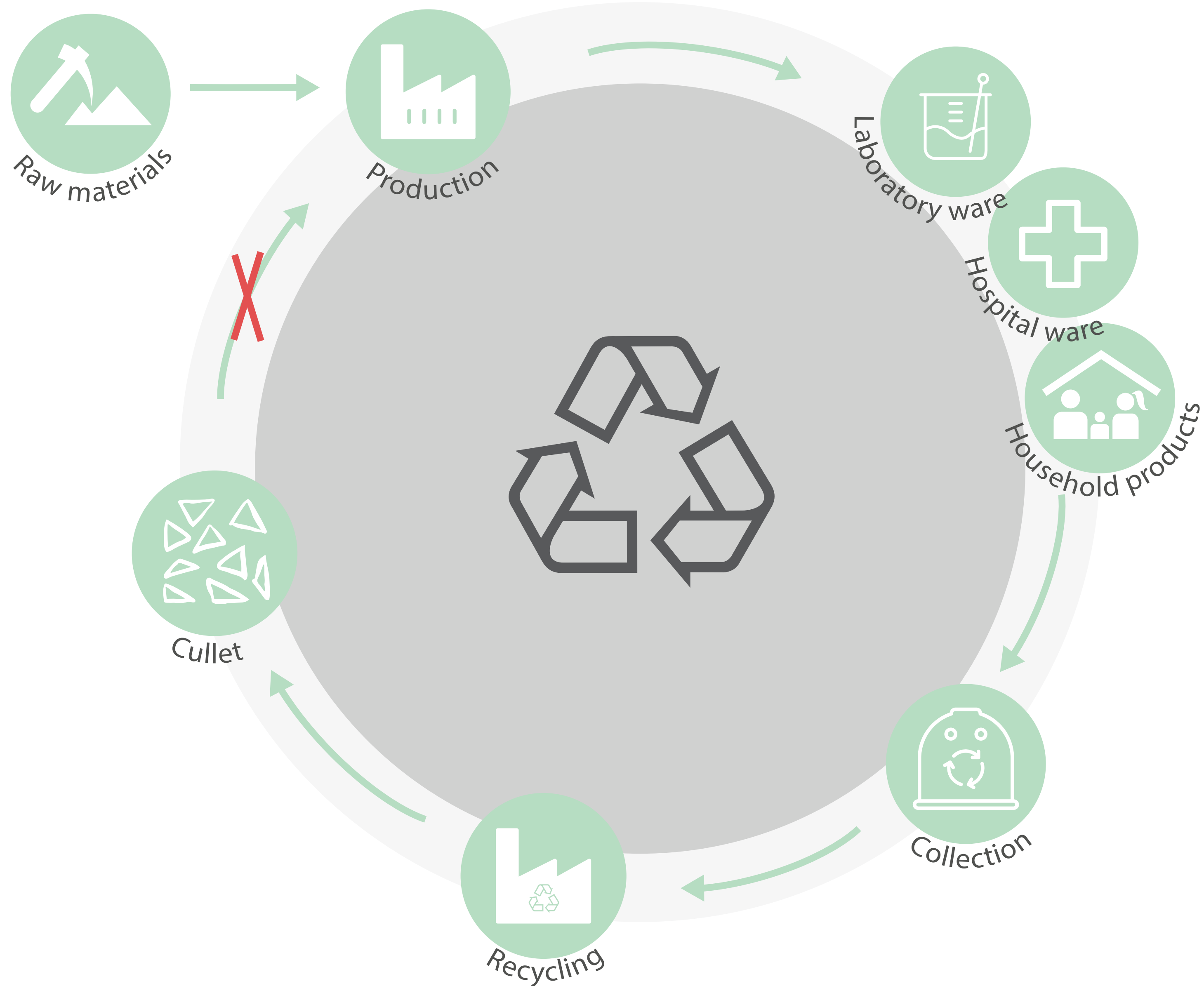
Desired life-cycle of borosilicate glass



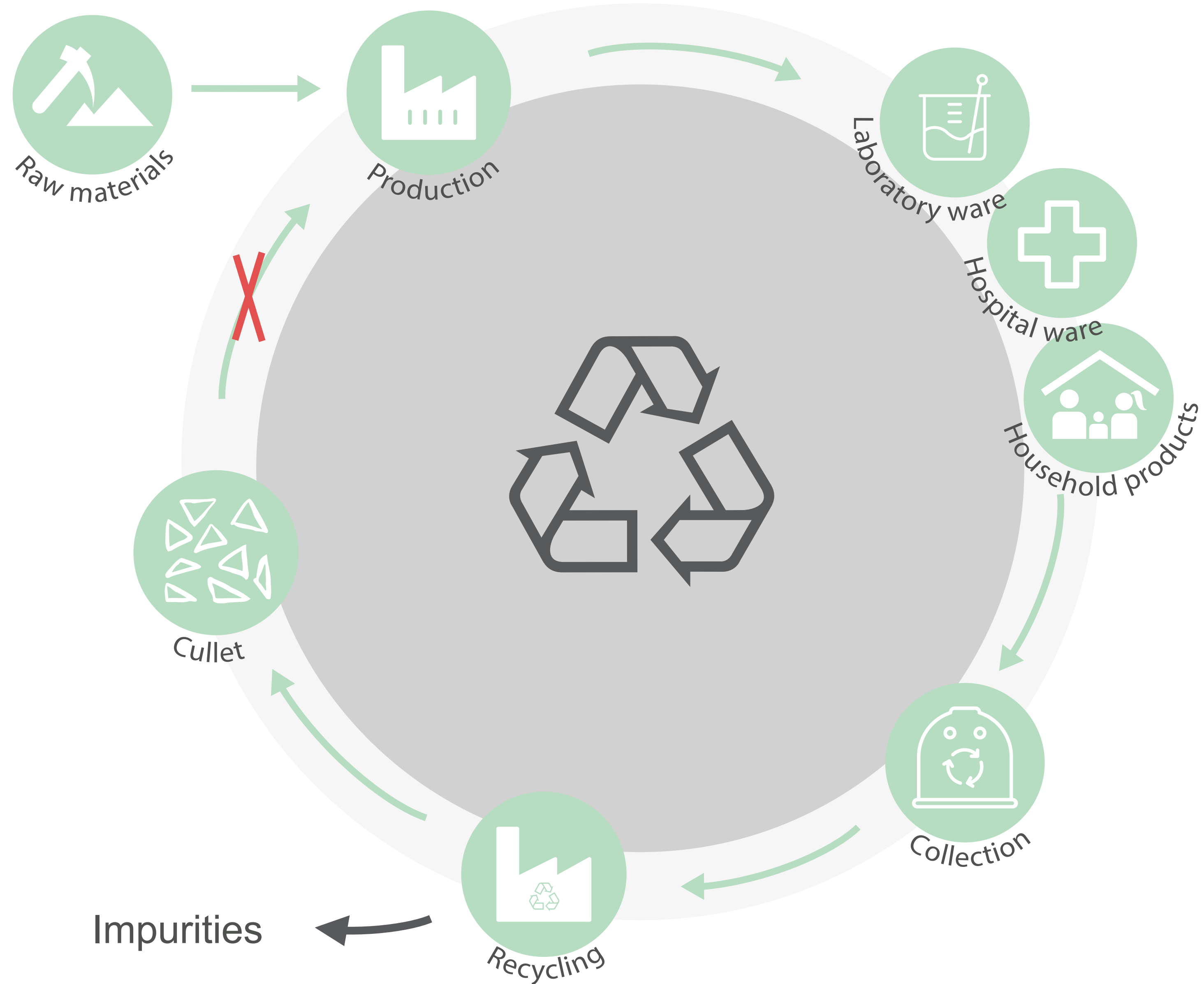
Desired life-cycle of borosilicate glass



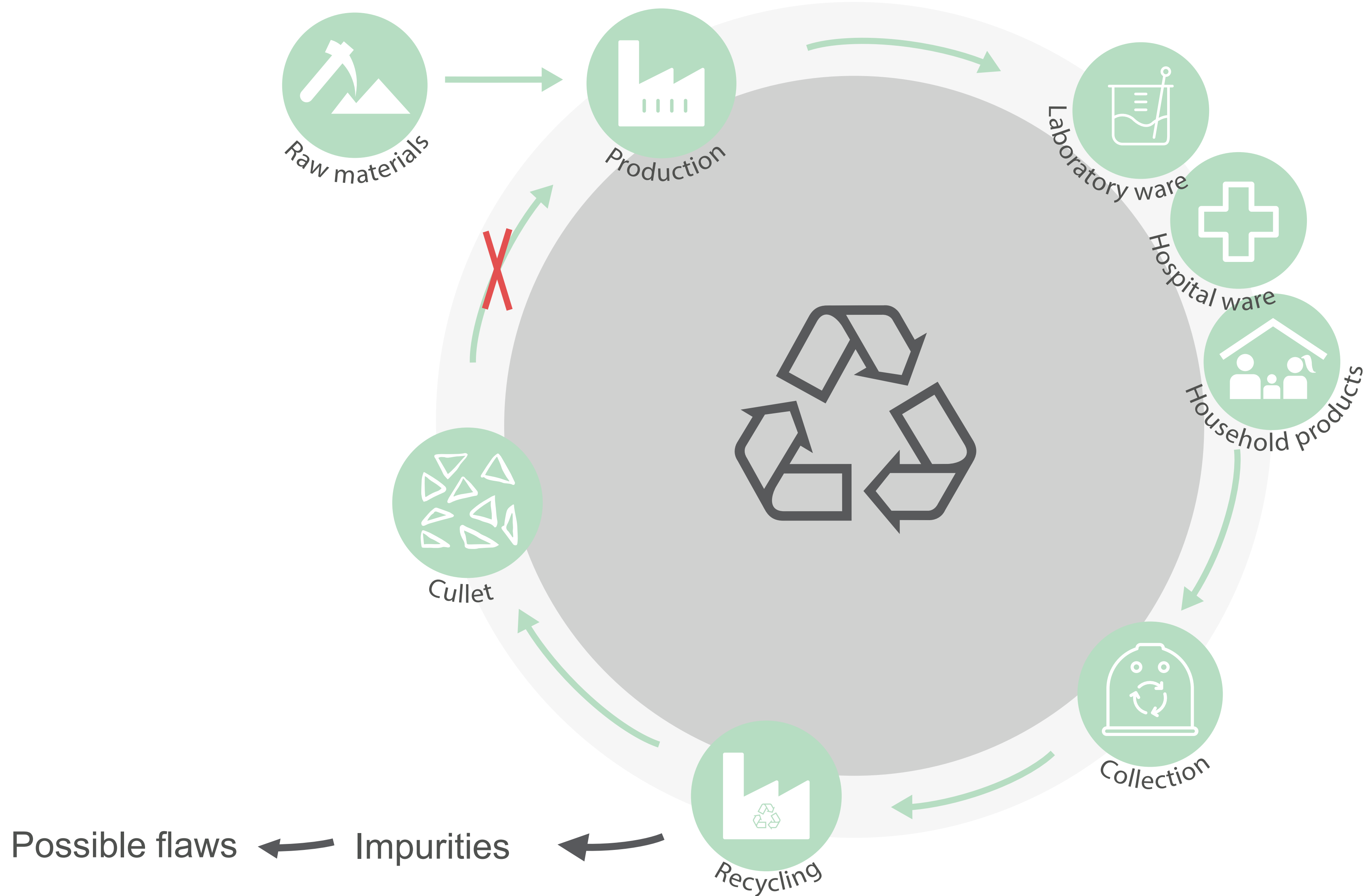
Desired life-cycle of borosilicate glass



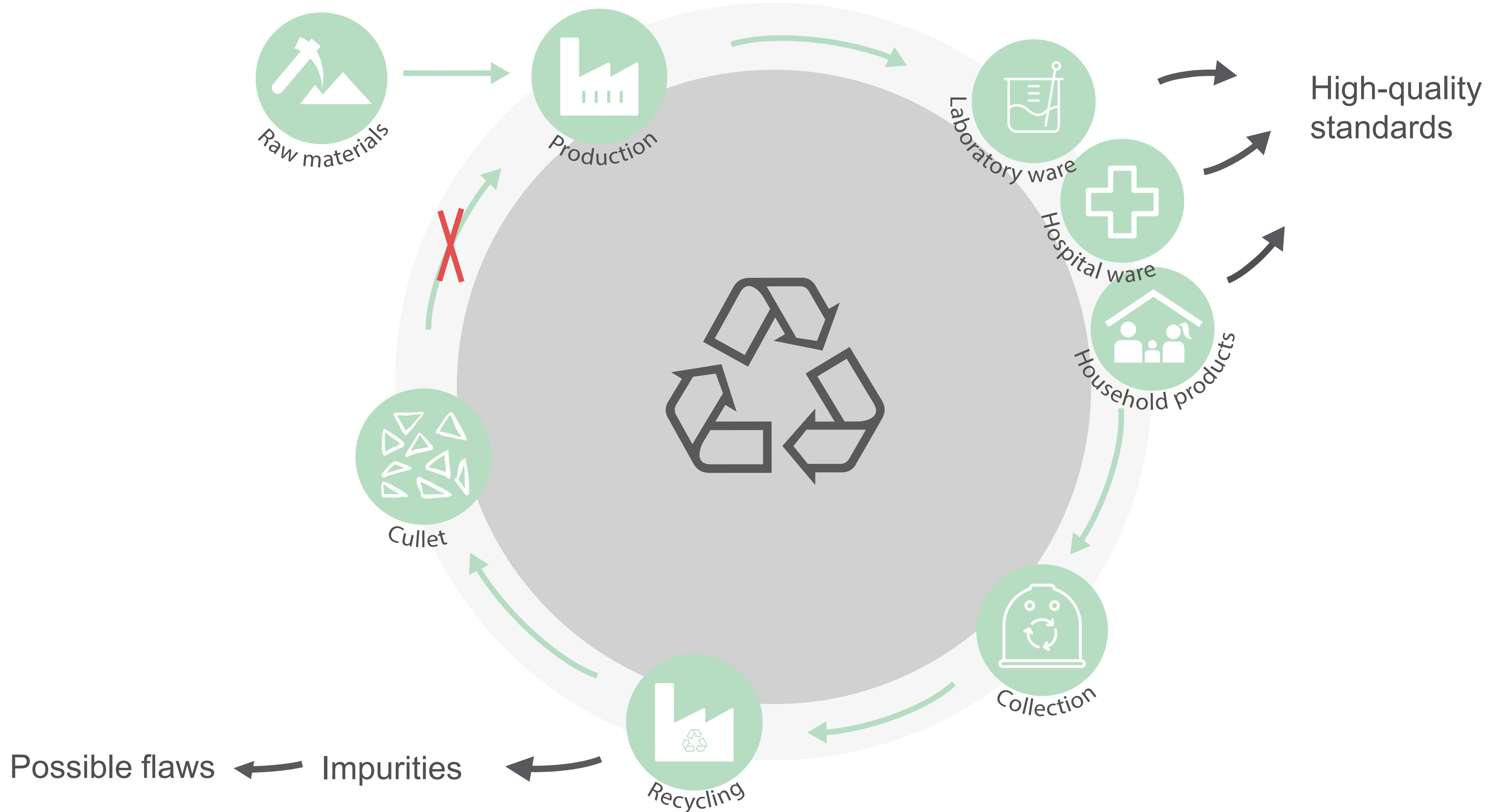
Desired life-cycle of borosilicate glass



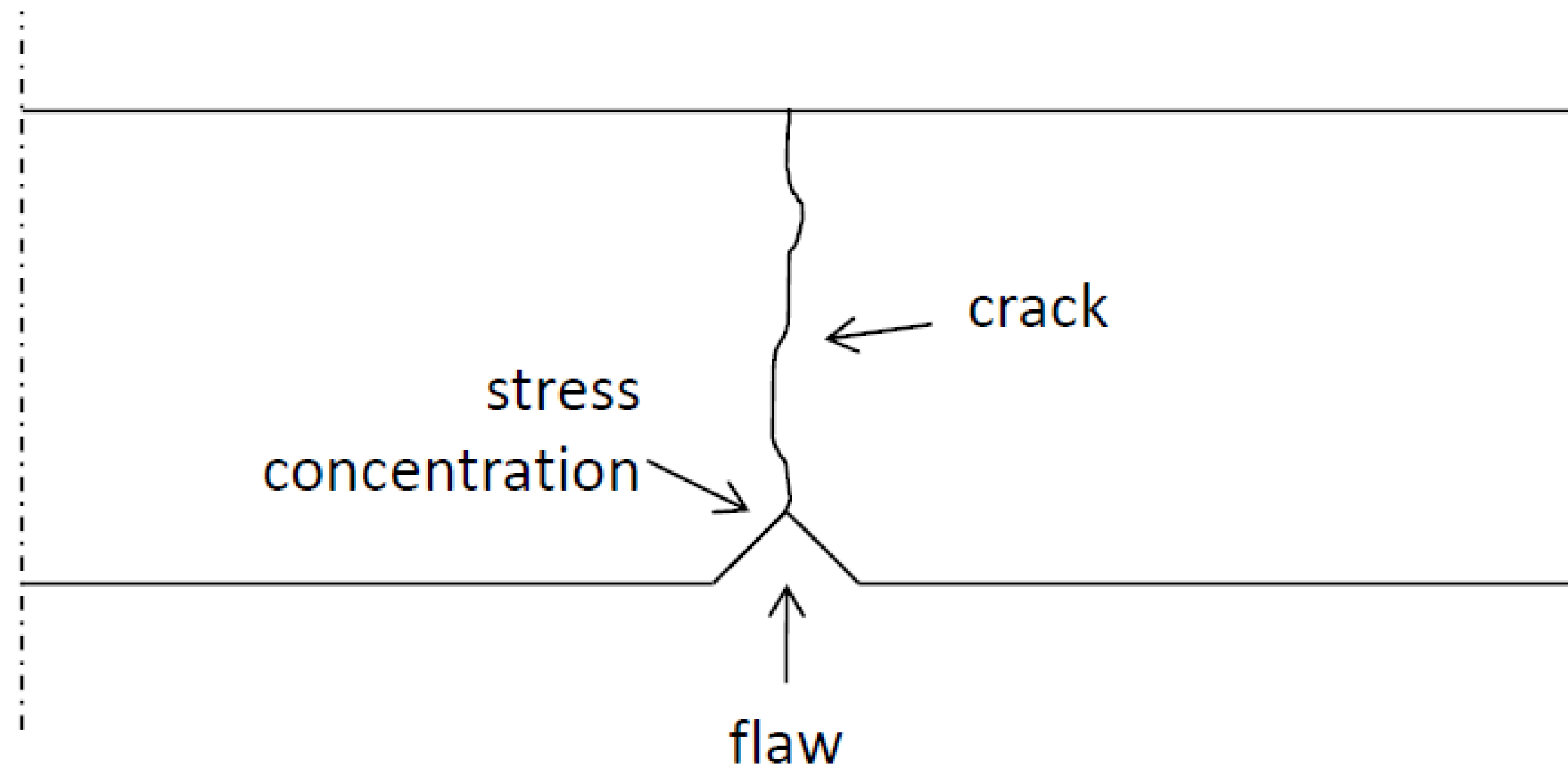
Desired life-cycle of borosilicate glass



Desired life-cycle of borosilicate glass



Development of flaw to crack



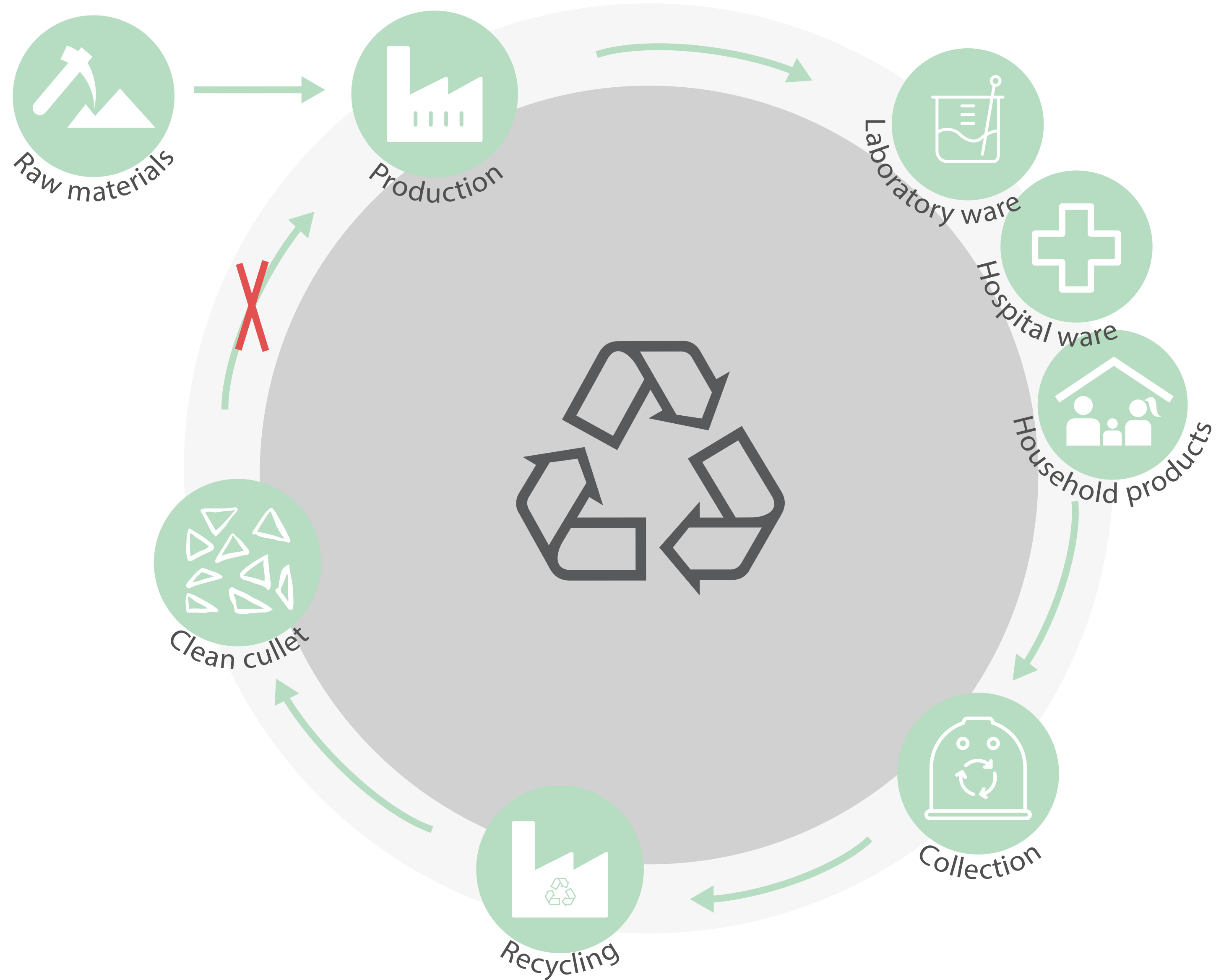
Source: (Haldimann, Luible, & Overend, 2008)

Cast glass

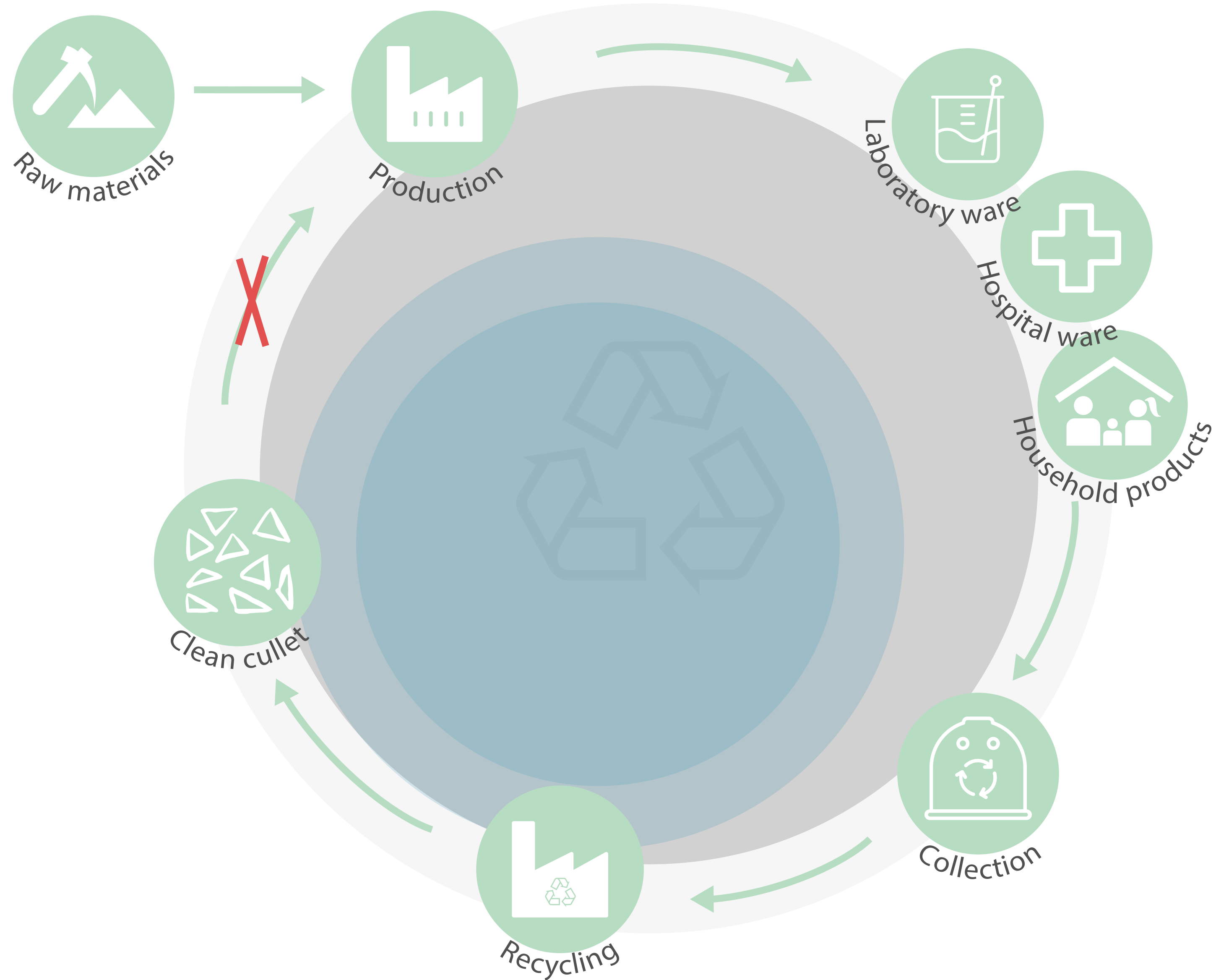


(Oikonomopoulou et al., 2018)

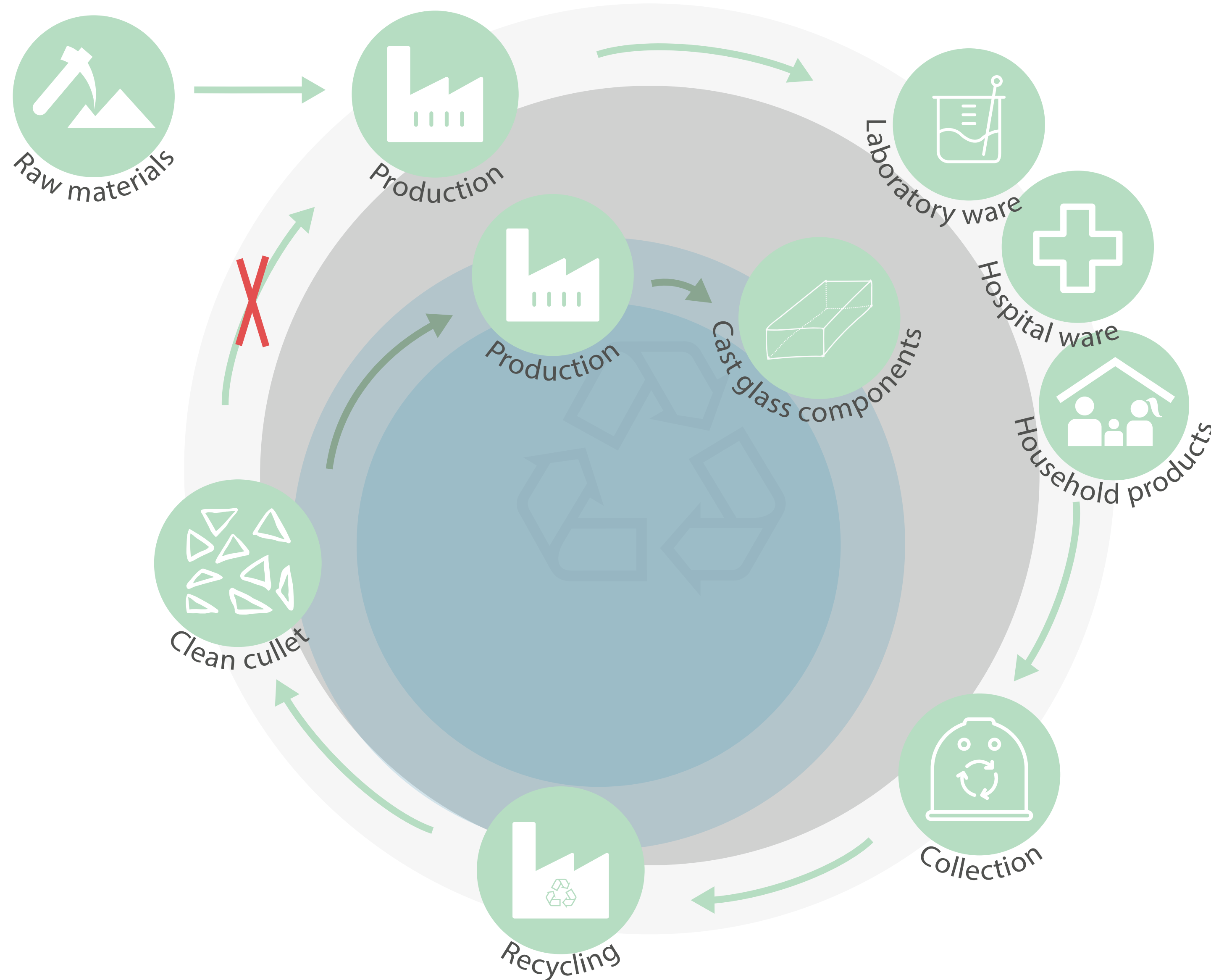
Proposed life-cycle of borosilicate glass



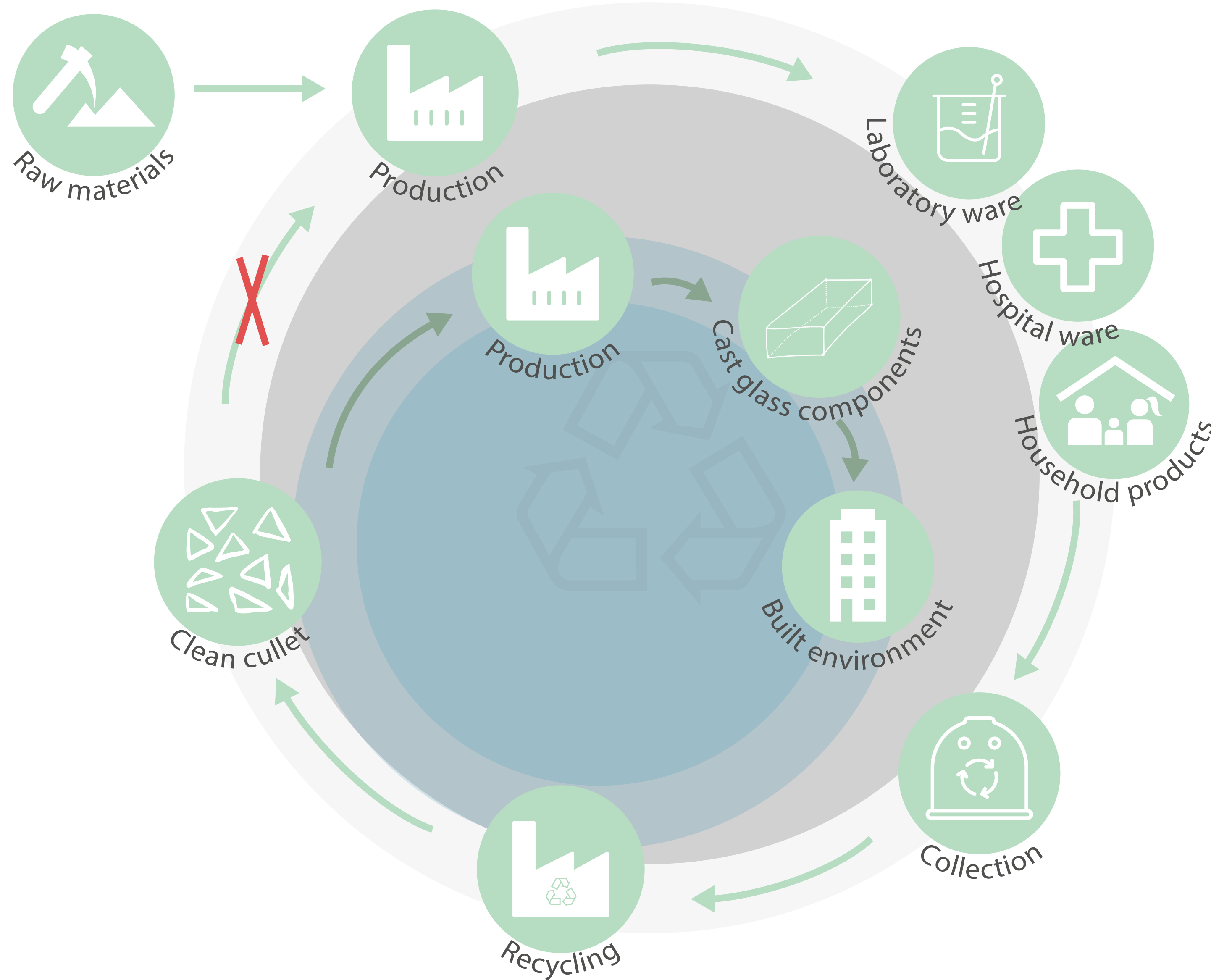
Proposed life-cycle of borosilicate glass



Proposed life-cycle of borosilicate glass



Proposed life-cycle of borosilicate glass



Example of cast glass application



© Daria Scagliola+Stijn Brakkee

Example of cast glass application



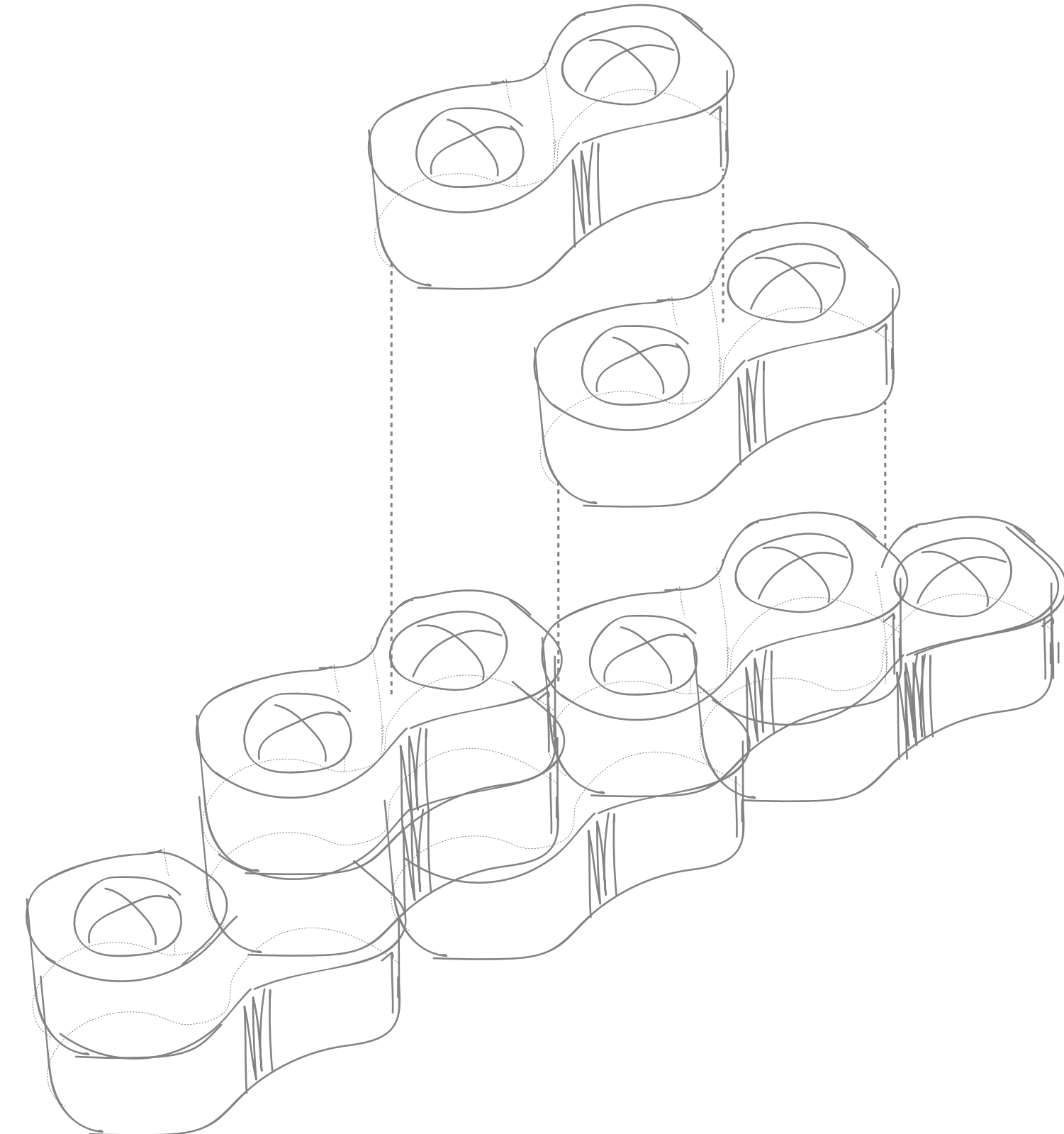
- Components are glued
- Disassembly not possible
- Glue is non-recyclable

© Daria Scagliola+Stijn Brakkee

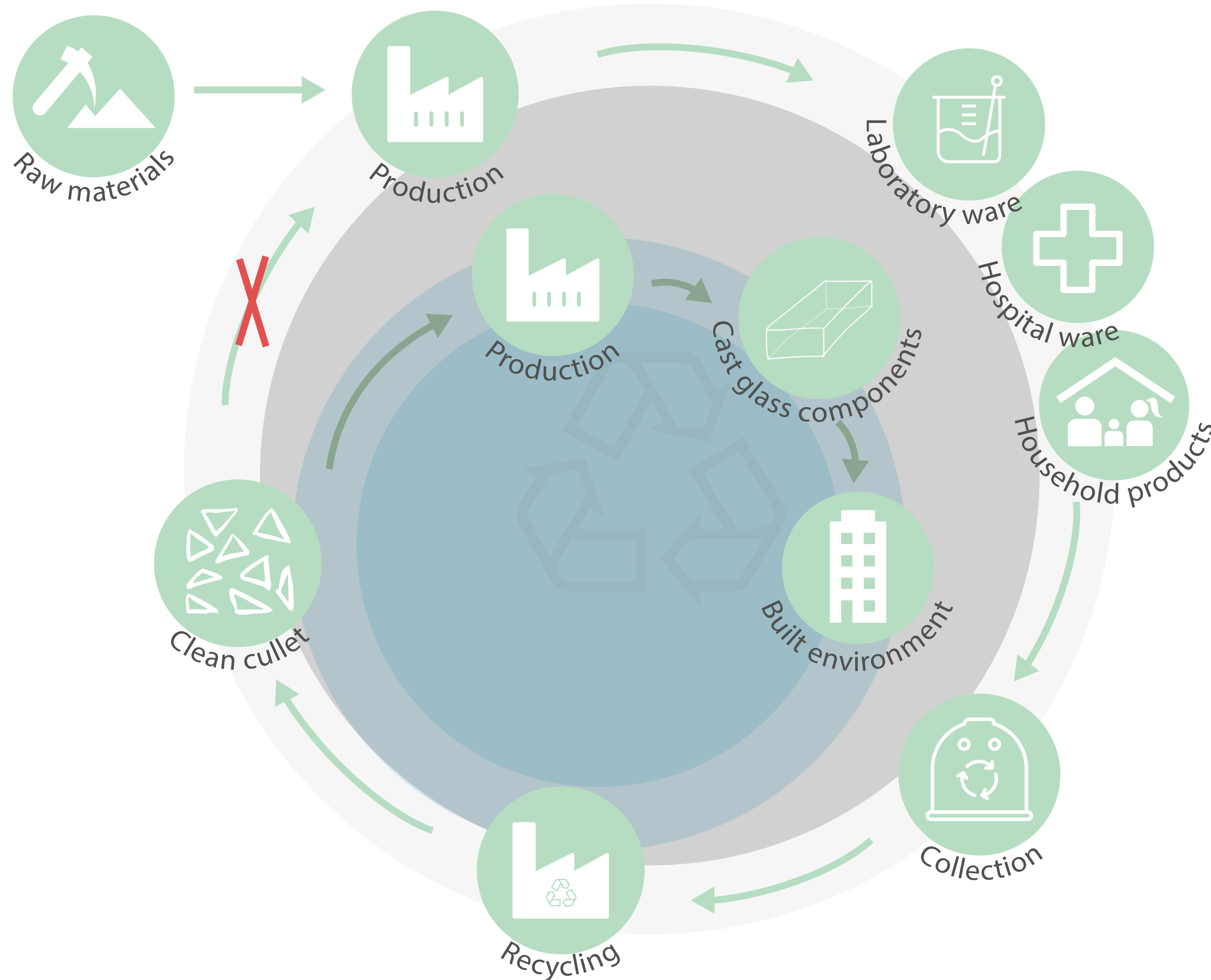
Dry-interlocking cast glass



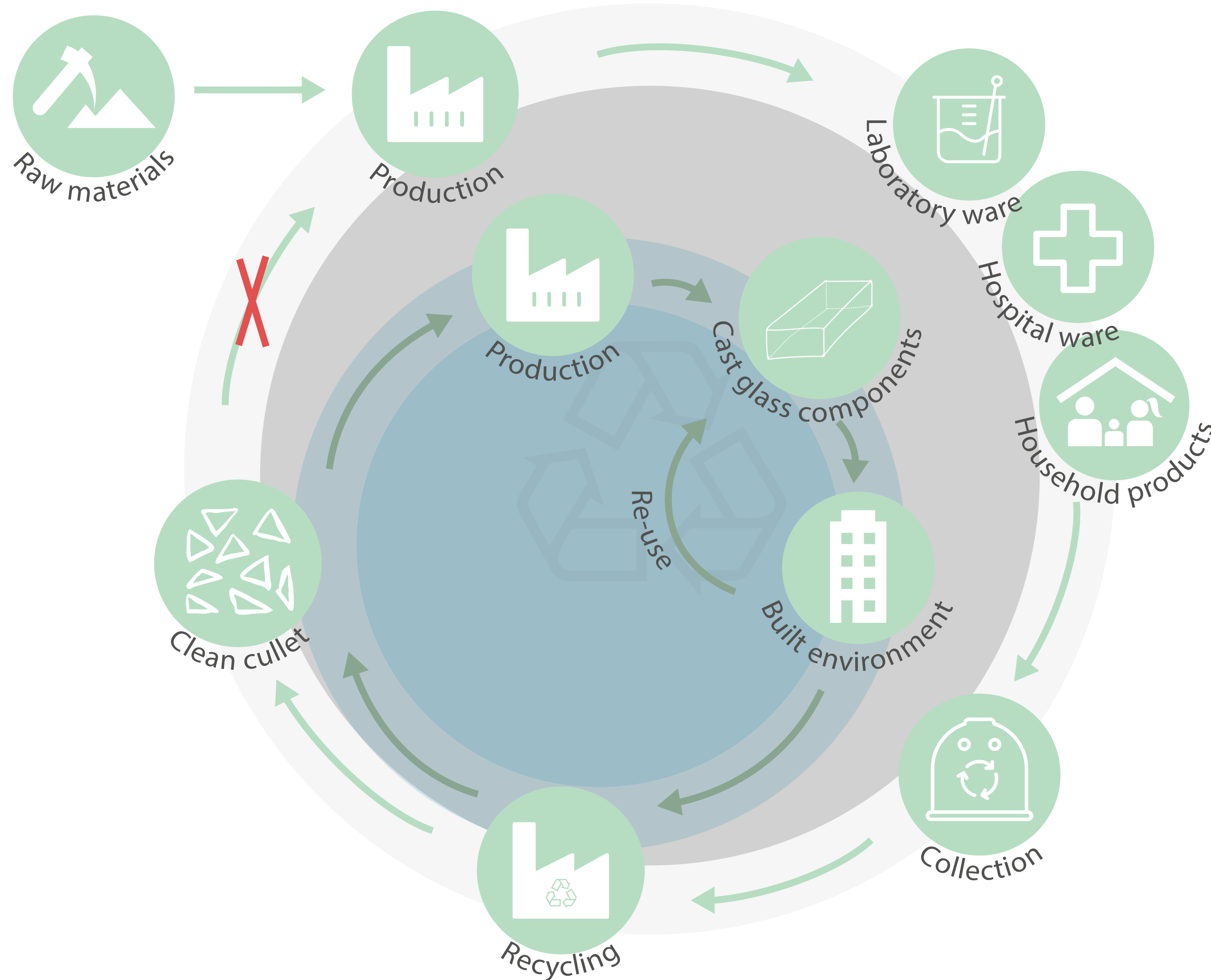
(Oikonomopoulou et al., 2018)



Proposed life-cycle of borosilicate glass



Proposed life-cycle of borosilicate glass



Research objectives

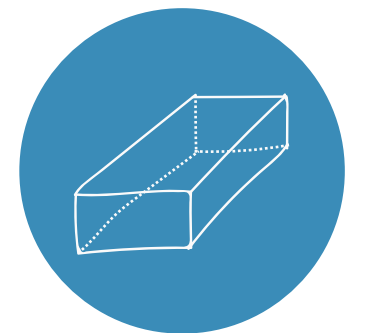
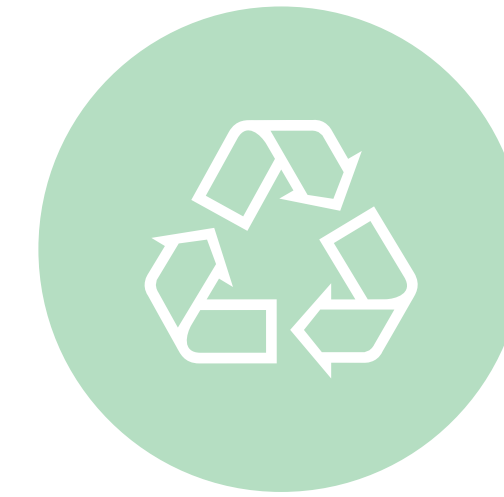
- Introducing new closed life-cycle of borosilicate glass using cast glass components
- Applying reversible cast glass components in the built environment

Main question

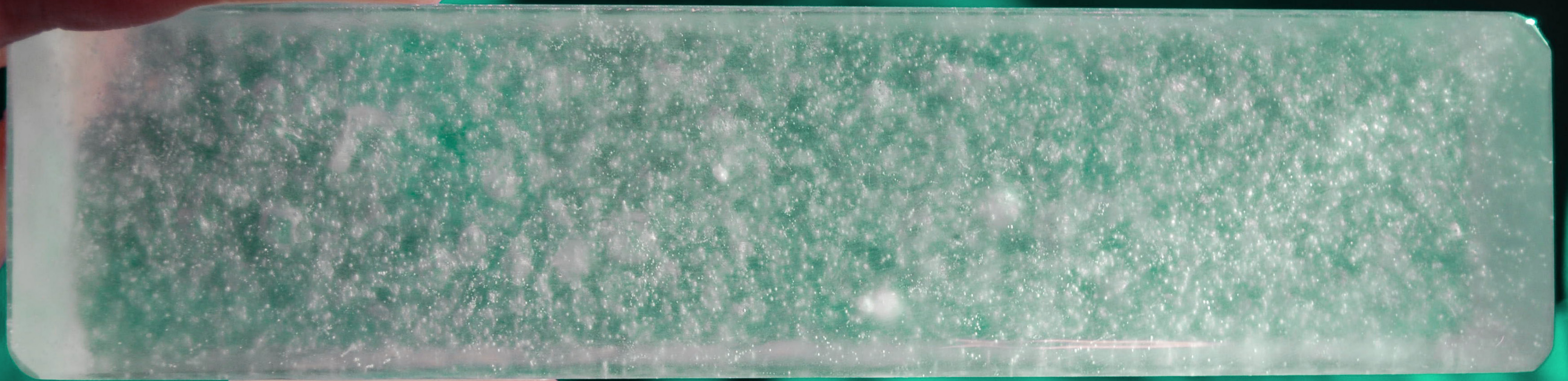
*How to use **recycled** borosilicate glass in **dry-interlocking cast glass** components implemented in a **reversible** facade system?*

Content

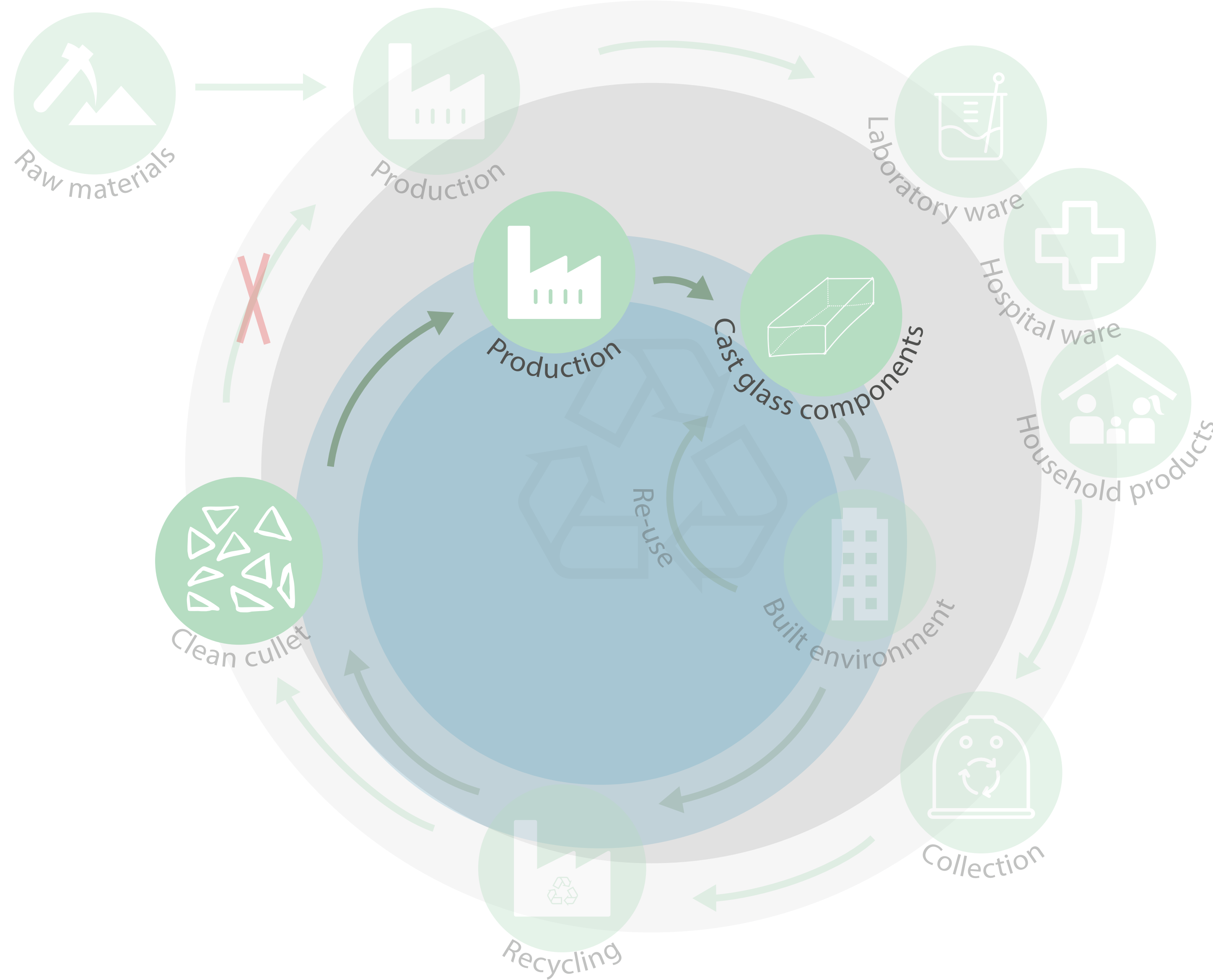
- Recyclability of borosilicate glass
 - Experiments
- Design
 - Component design
 - Application in a case study
- General conclusions & recommendations



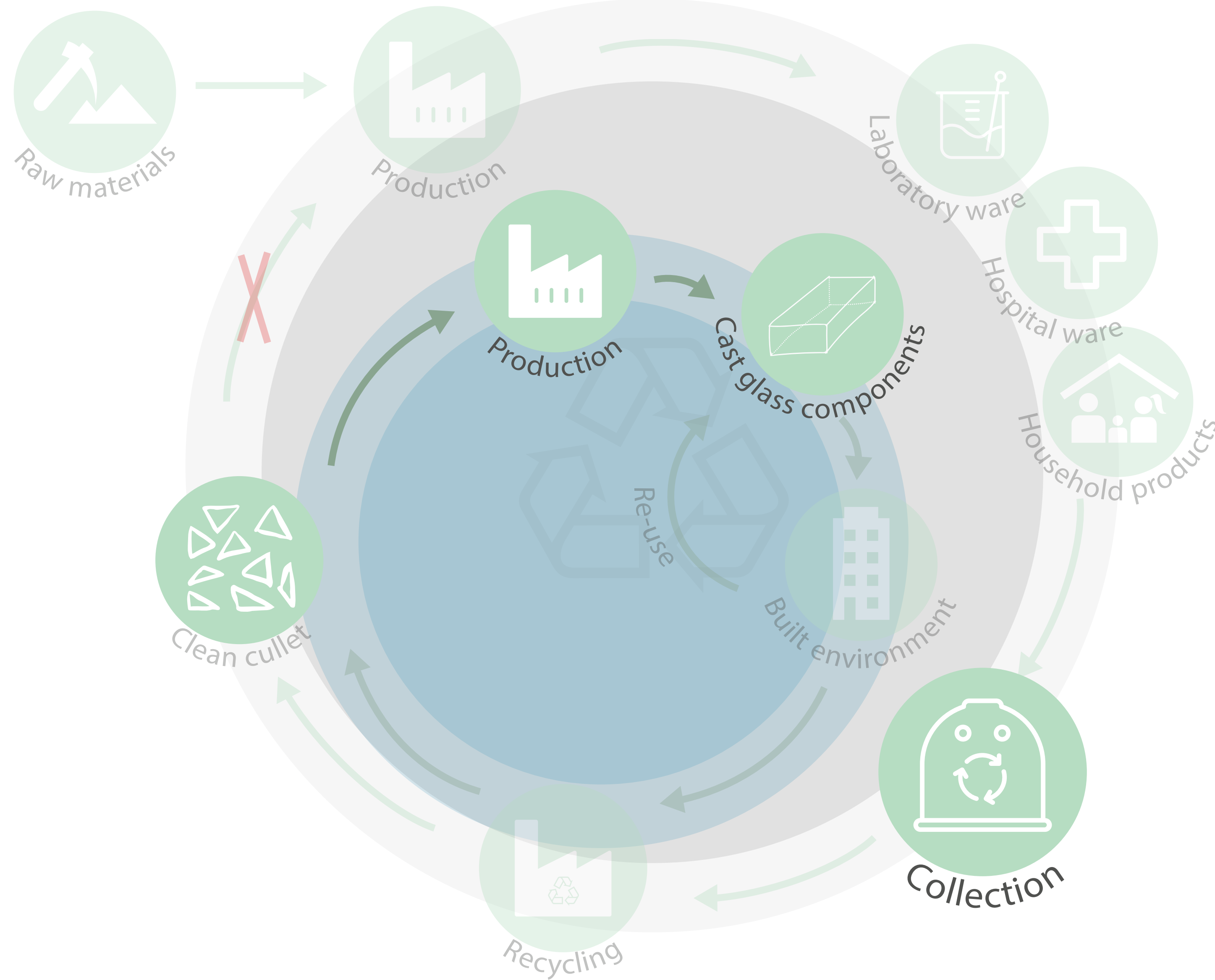
RECYCLABILITY OF BOROSILICATE GLASS



Recyclability of borosilicate glass



Recyclability of borosilicate glass



Challenges mixed collection



- Mixed chemical compositions
 - Slightly different types of borosilicate glass
- Effect on mechanical properties

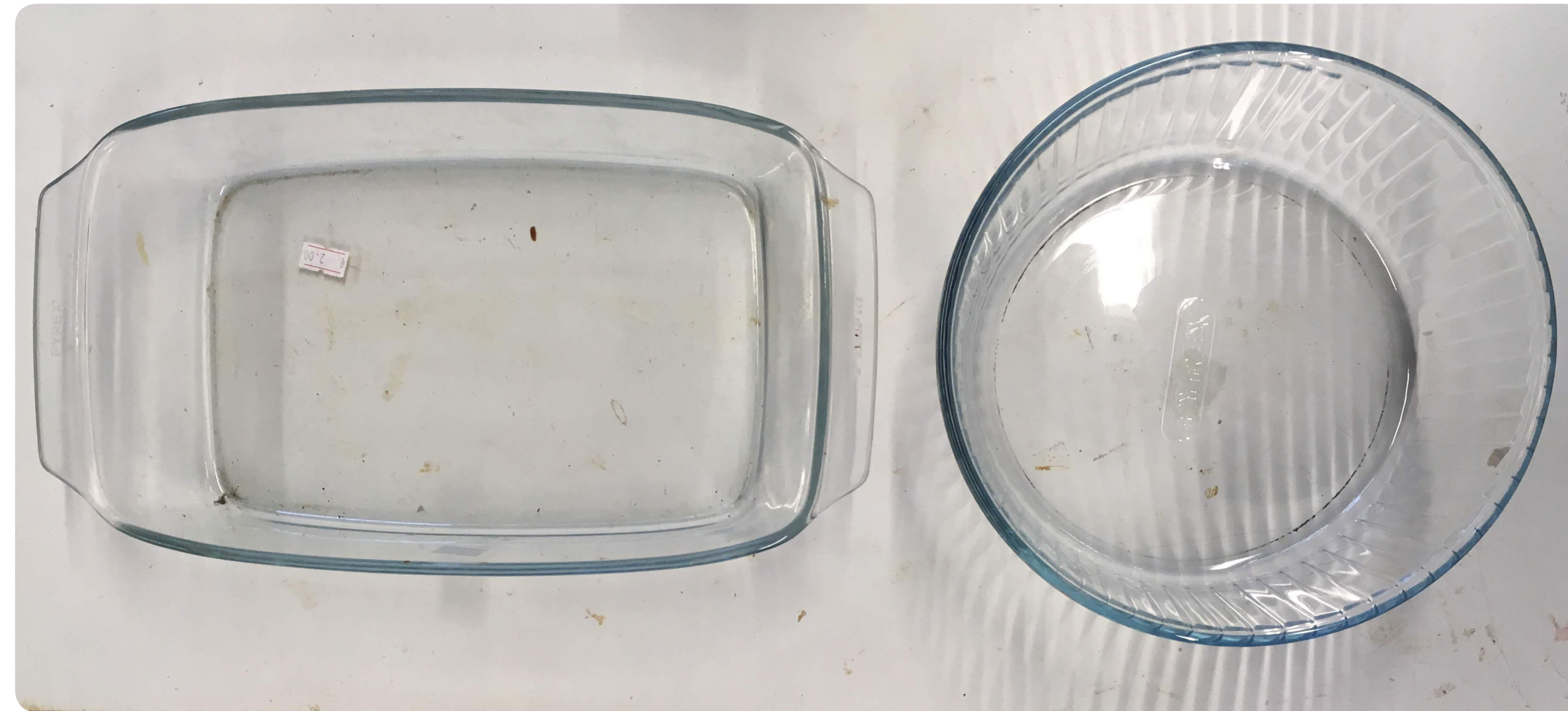
EXPERIMENTS

- **Mixability** of recycled borosilicate glass
- **Mechanical properties** of recycled borosilicate glass

Four different borosilicate glass objects



Laboratory ware



Two different oven trays



Rods

Smashing and crushing the glass



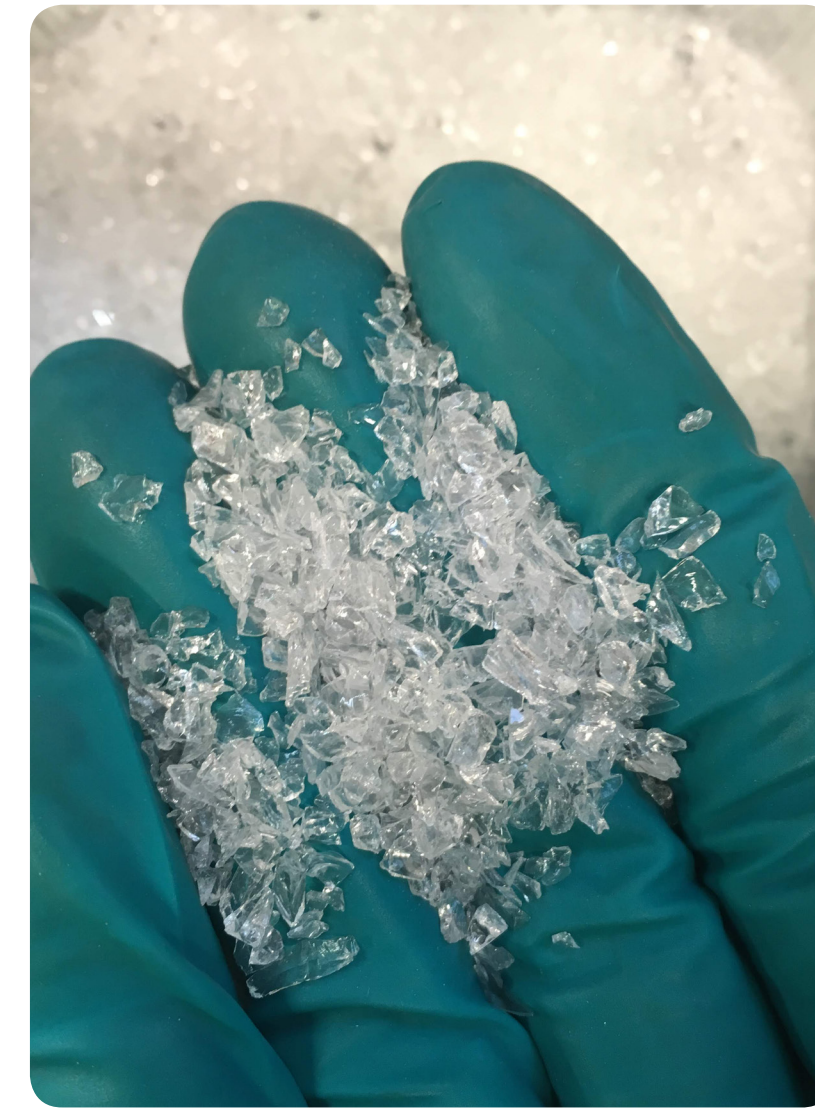
Smashing glass



Big shards



Big shards



Fine cullet



Powder

Glass cullet in the mould



Big pieces



Big pieces



Fine cullet

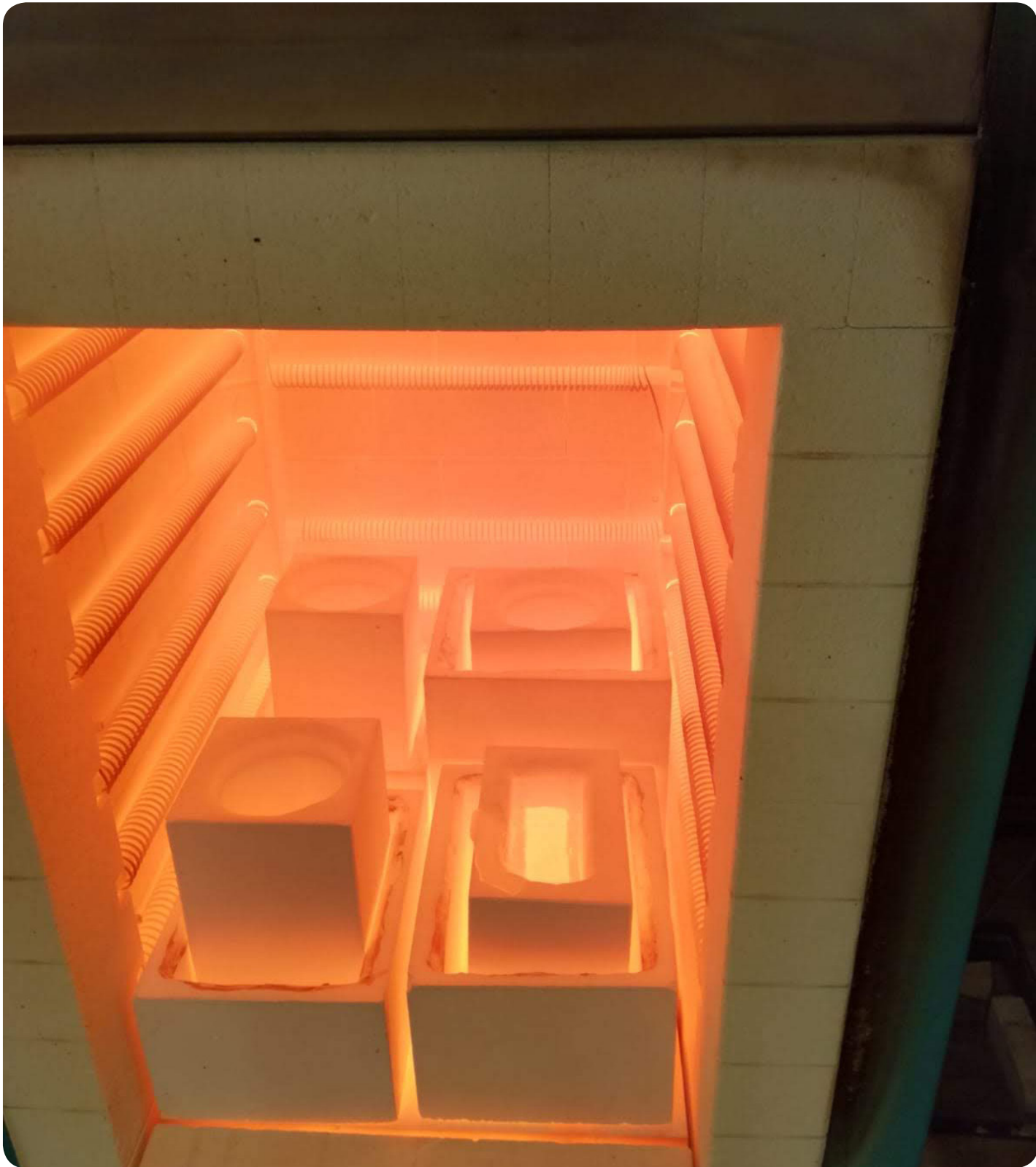


Powder

Moulds in the oven



Before



During



After

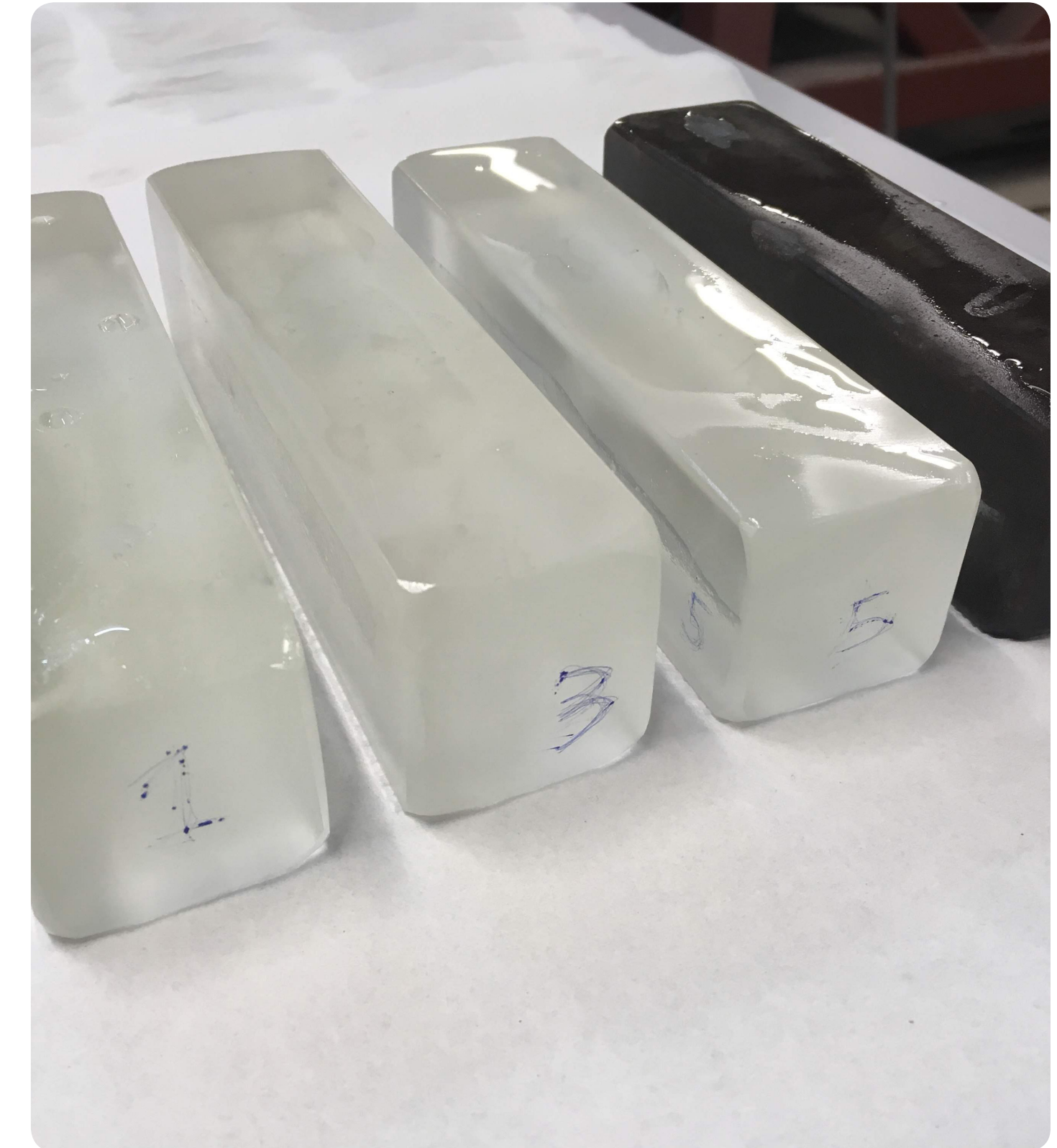
Grinding and polishing the glass beams



Before

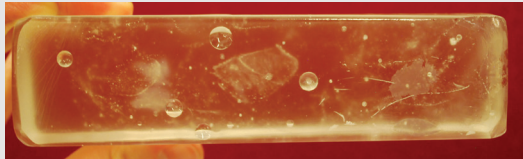
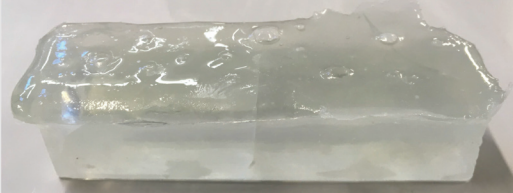
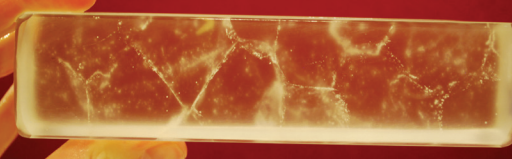



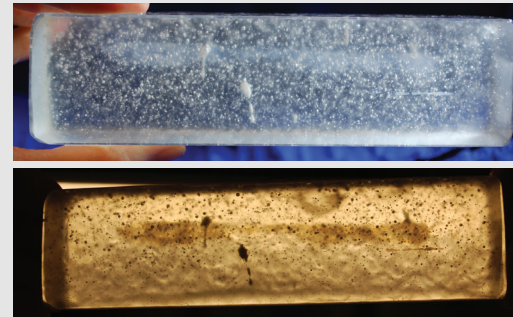
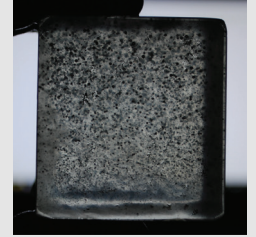


During

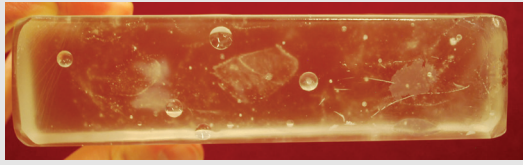
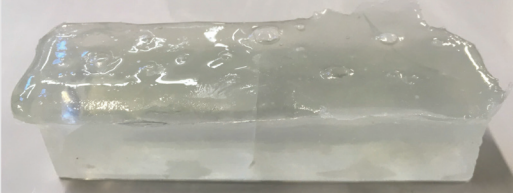
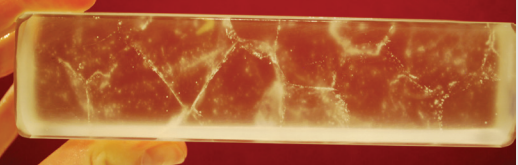


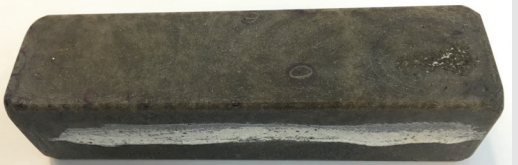
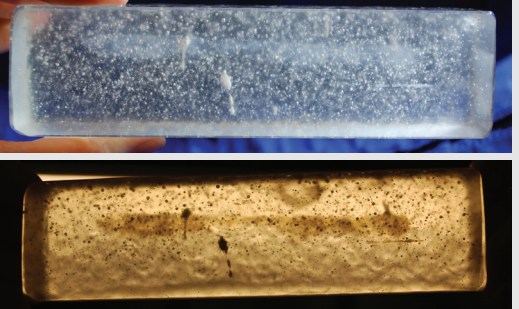
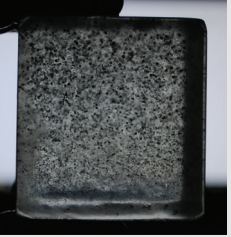


After

Overview of created 8 specimens

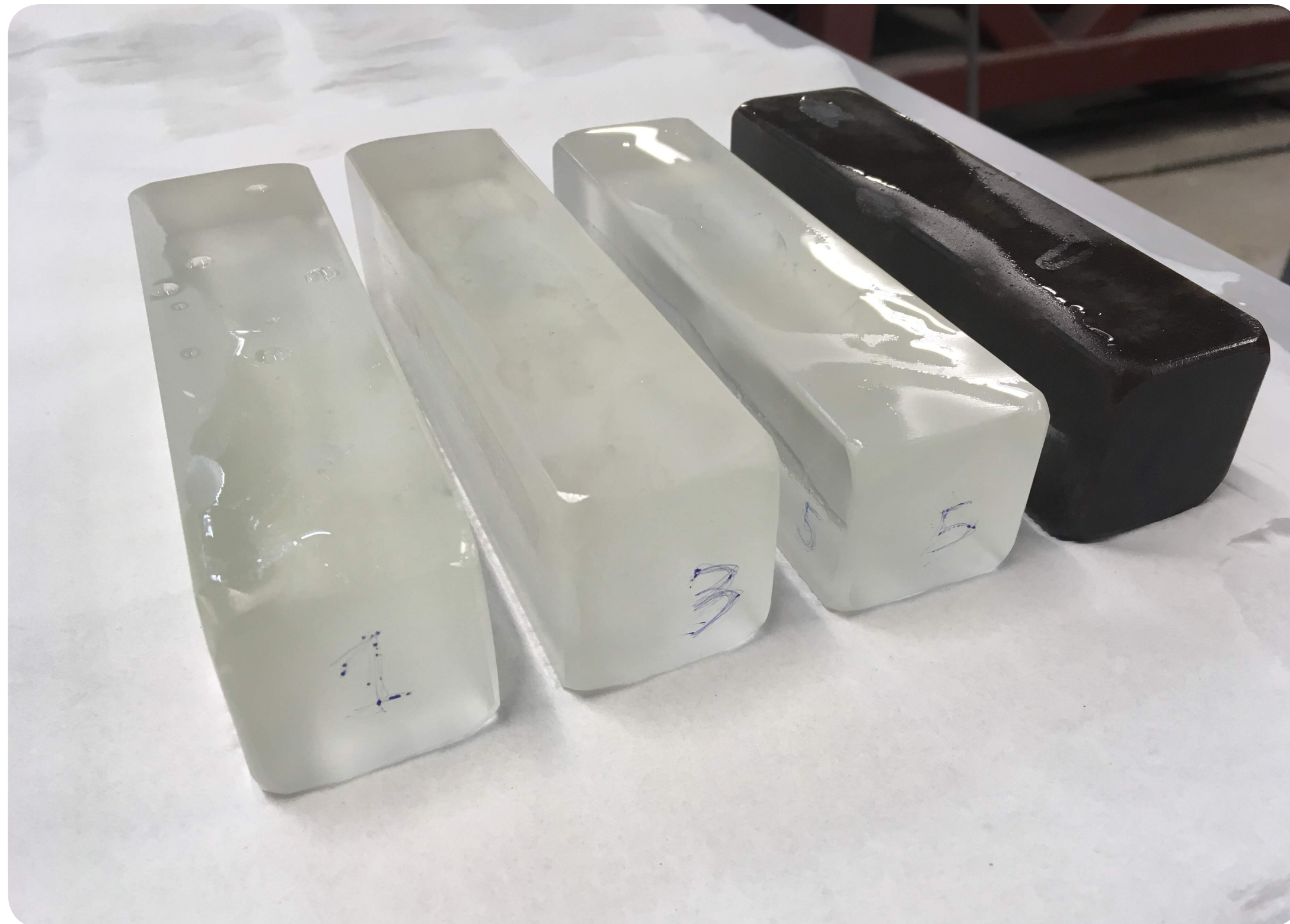
	BEAM 1	BEAM 2	BEAM 3	BEAM 4	BEAM 5	BEAM 6	BEAM 7	CUBE
GLASS TYPE <small>(All types are borosilicate)</small>	Rods* laboratory ware*	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Rods*	Rods*	Rods*	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round
COMPOSITION	<i>Aim:</i> 50% Rods 50% Laboratory ware	<i>Aim:</i> 25% Tube 25% Laboratory ware 25% Oven tray round 25% Oven tray rectangular	<i>Aim:</i> 100% Rods	<i>Aim:</i> 100% Rods	<i>Aim:</i> 100% Rods	<i>Aim:</i> 25% Tube 25% Laboratory ware 25% Oven tray round 25% Oven tray rectangular	<i>Aim:</i> 25% Tube 25% Laboratory ware 25% Oven tray round 25% Oven tray rectangular	<i>Aim:</i> 25% Tube 25% Laboratory ware 25% Oven tray round 25% Oven tray rectangular
CULLET SIZE \varnothing	Pieces > 50 mm	Pieces > 50 mm	Pieces between 10 and 30 mm	Pieces between 10 and 30 mm	Pieces between 10 and 30 mm	Powder	Pieces between 2.3 and 5 mm	Pieces between powder and 2.3 mm
PICTURE								

Overview of created 8 specimens

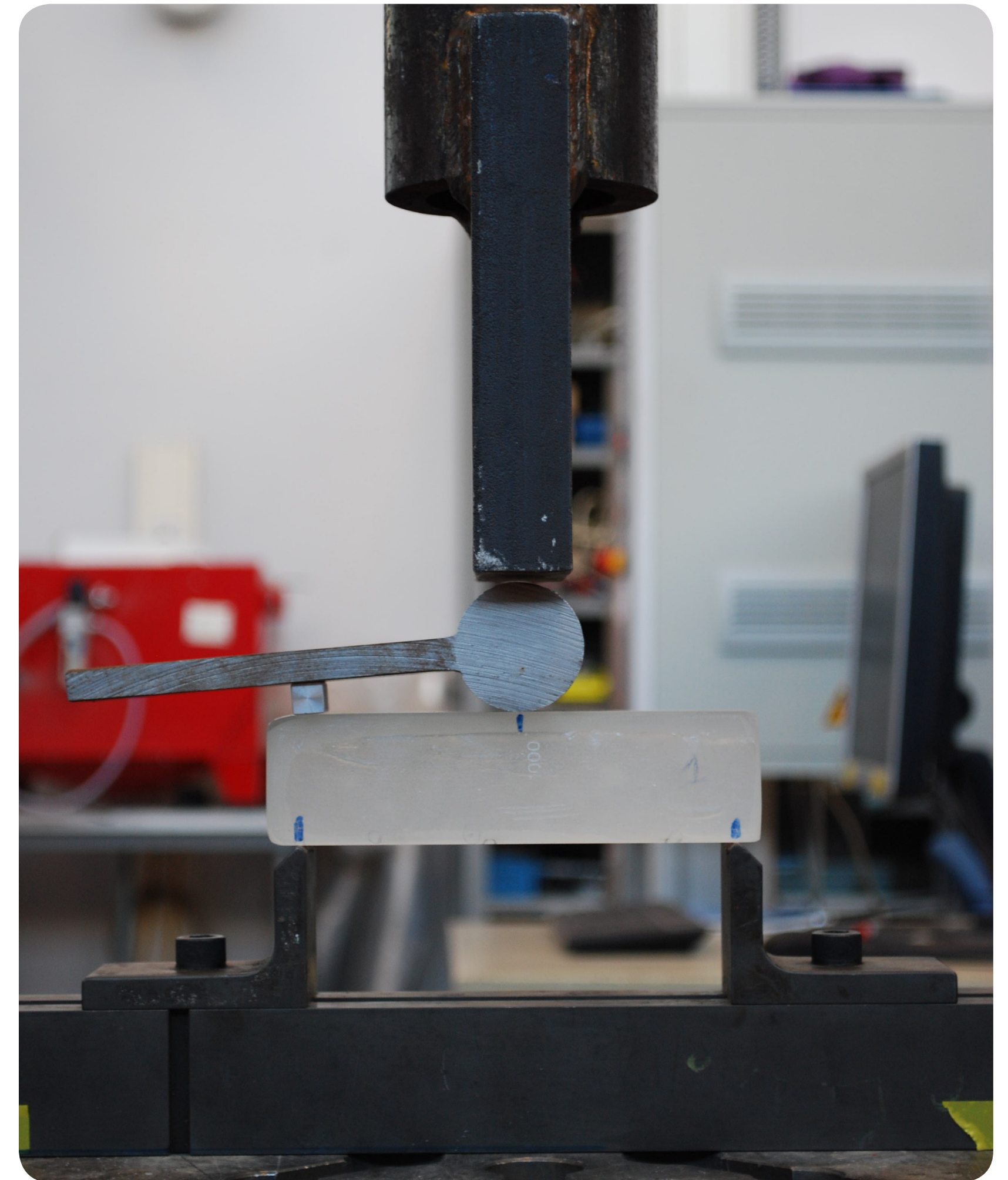
	BEAM 1	BEAM 2	BEAM 3	BEAM 4	BEAM 5	BEAM 6	BEAM 7	CUBE
GLASS TYPE <small>(All types are borosilicate)</small>	Rods* laboratory ware*	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Rods*	Rods*	Rods*	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round	Tube* Lab. ware* PYREX oven tray rect. PYREX oven tray round
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PICTURE								



Experiment setup



Mixability



Mechanical properties

Mixability experiments

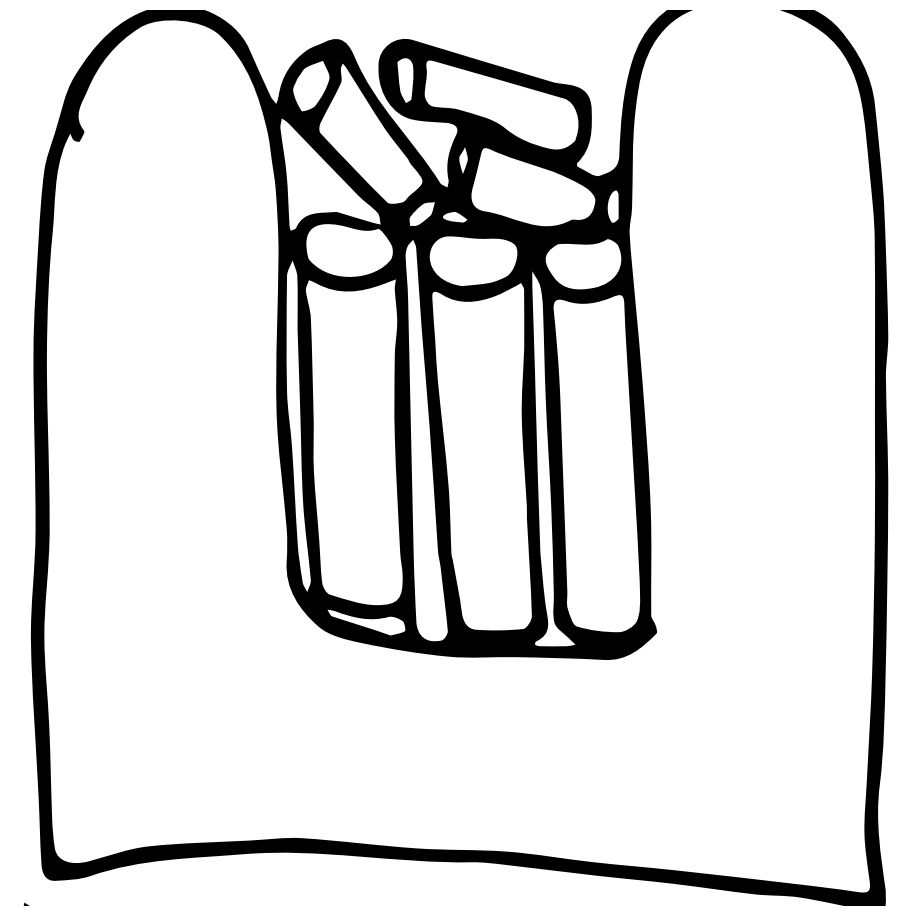
Beam 5 - big pieces



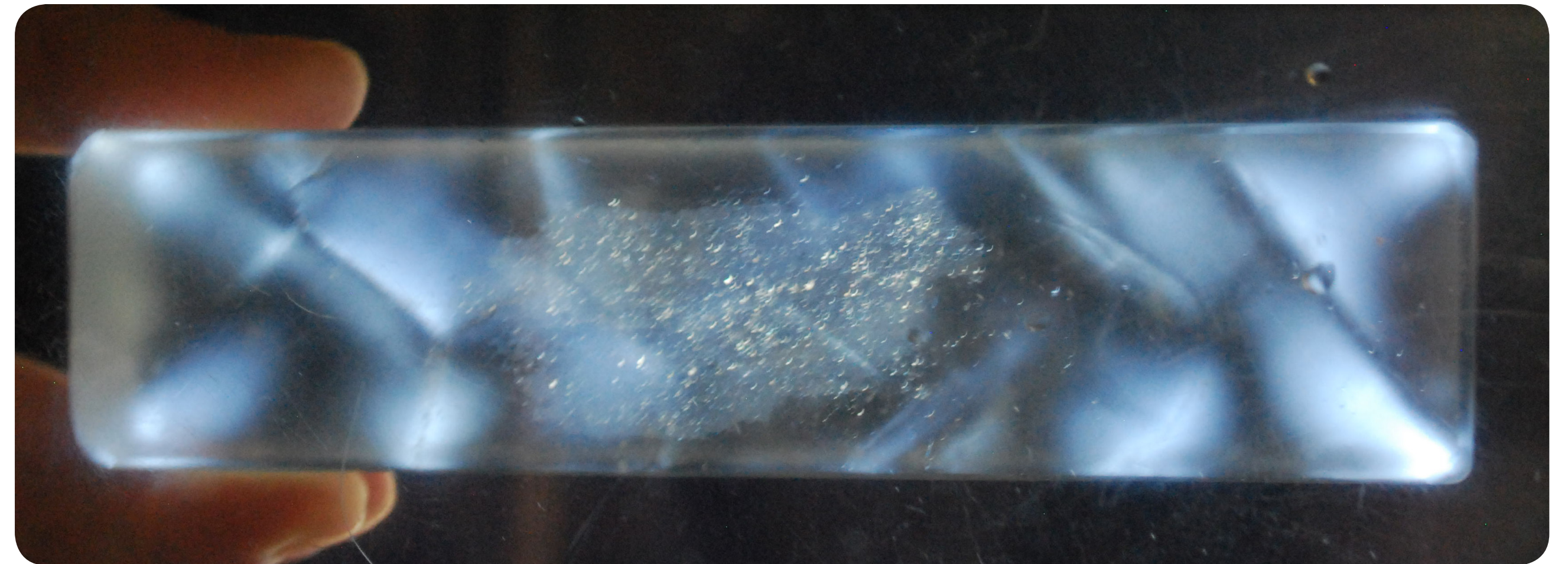
Beam 5 - big pieces



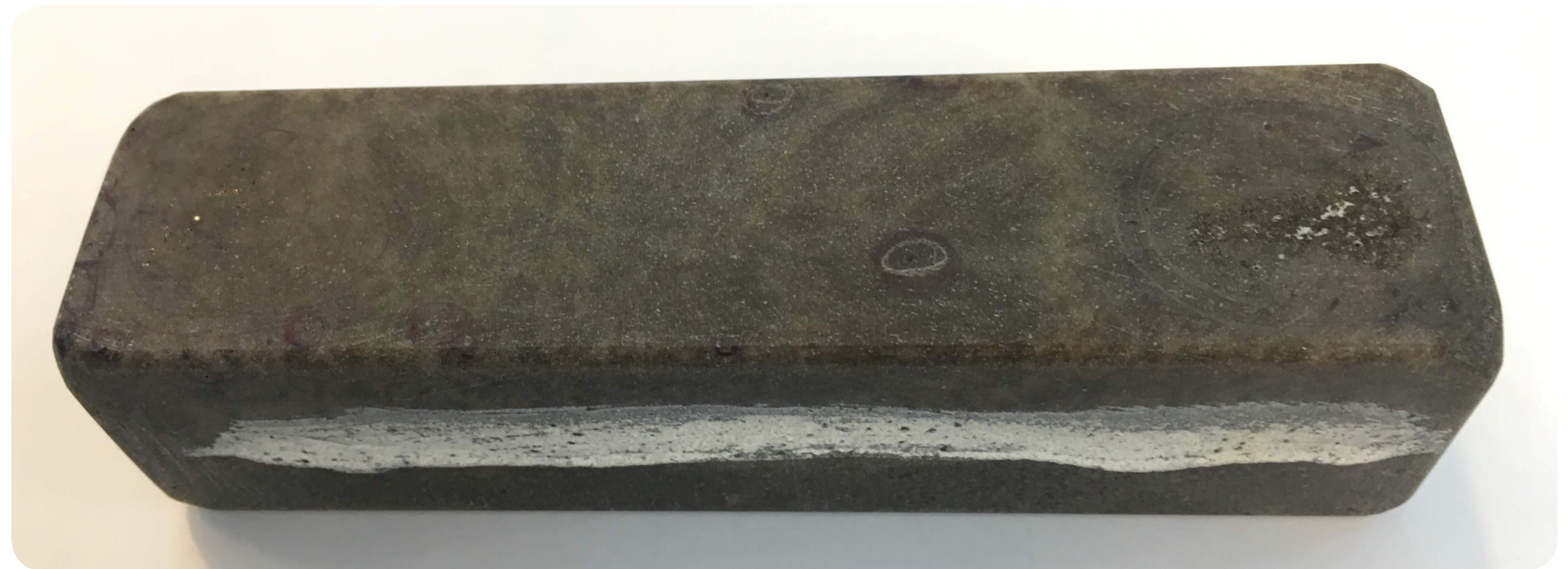
TOP



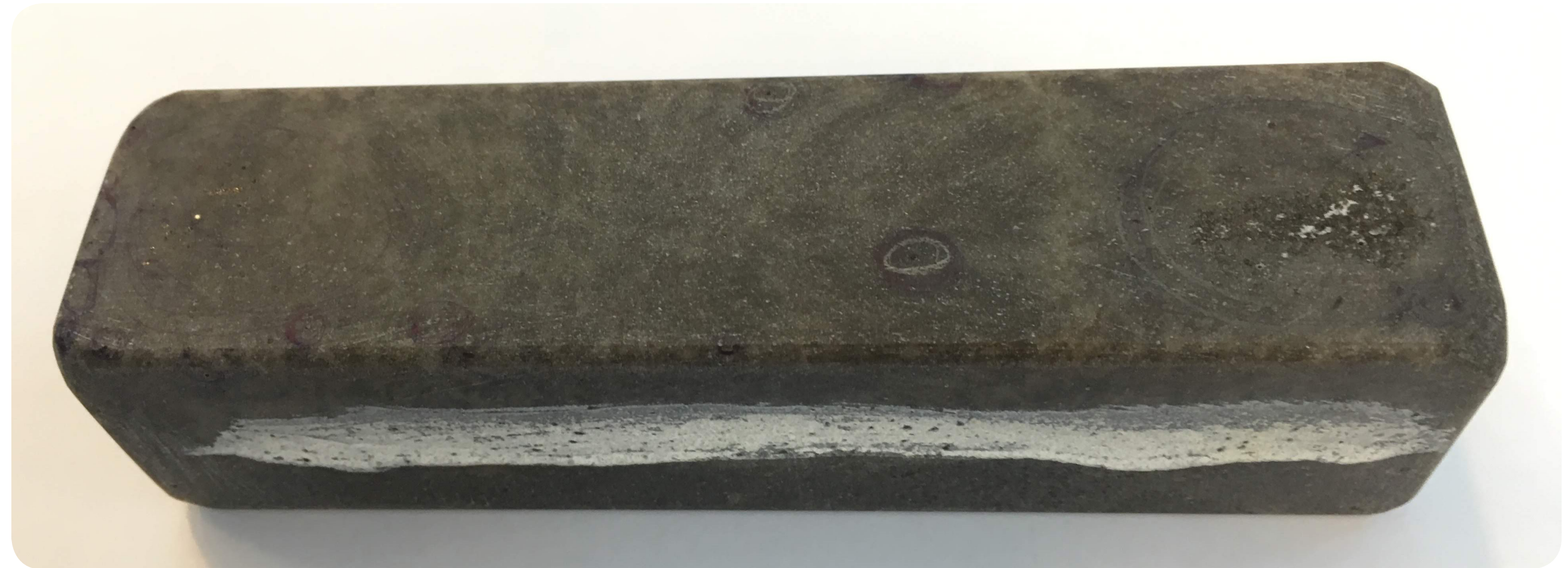
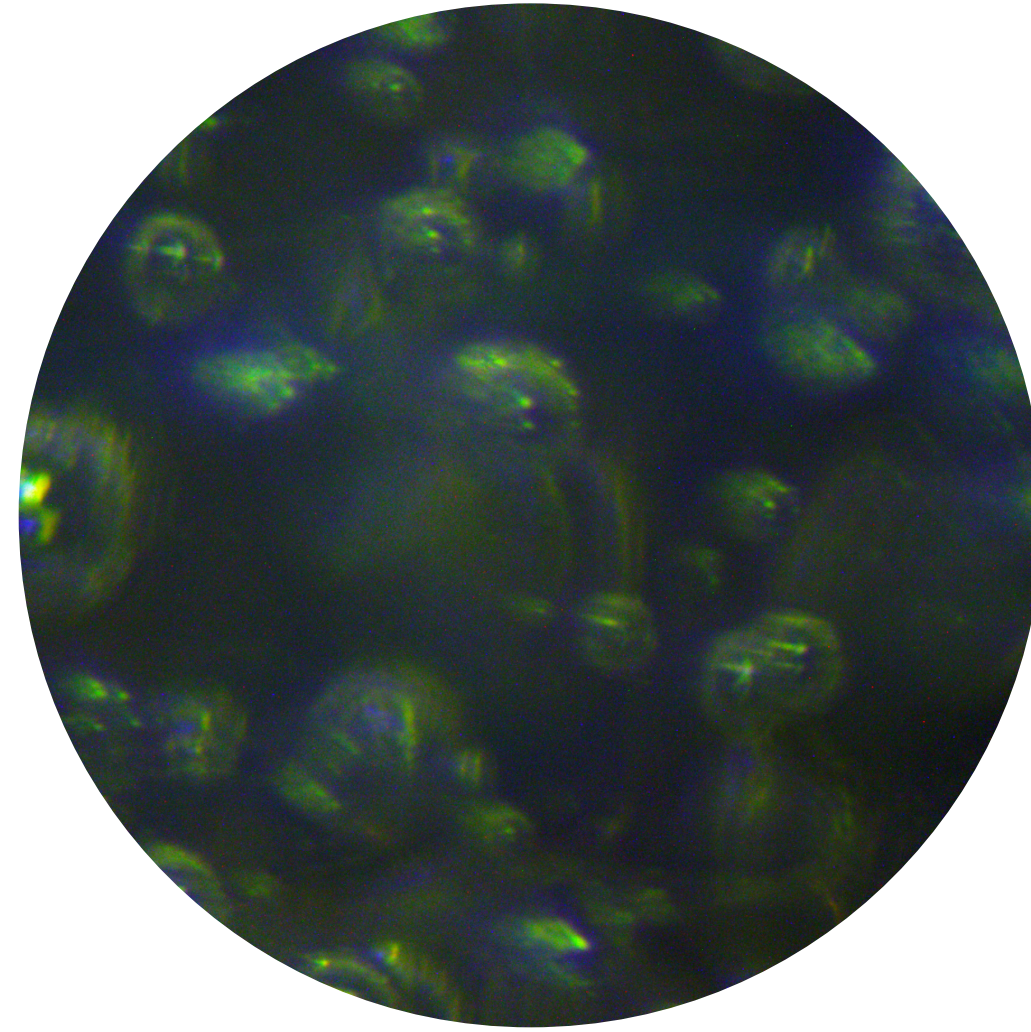
Beam 5 - big pieces



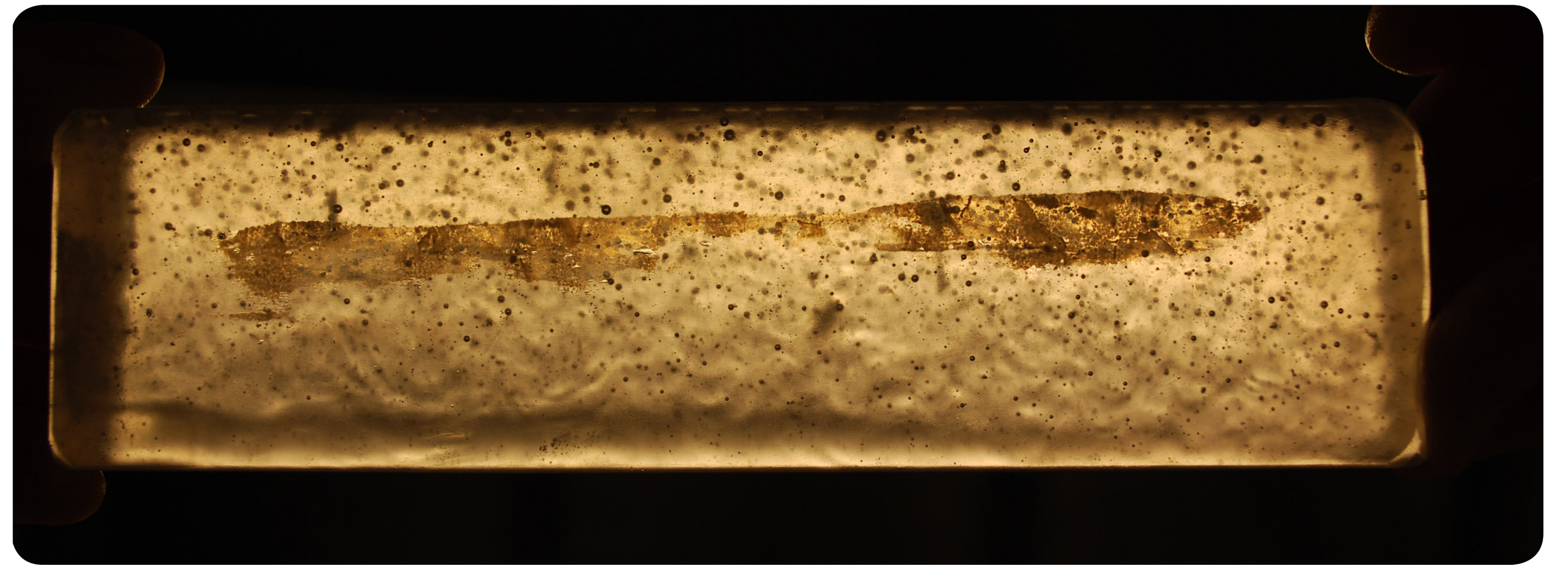
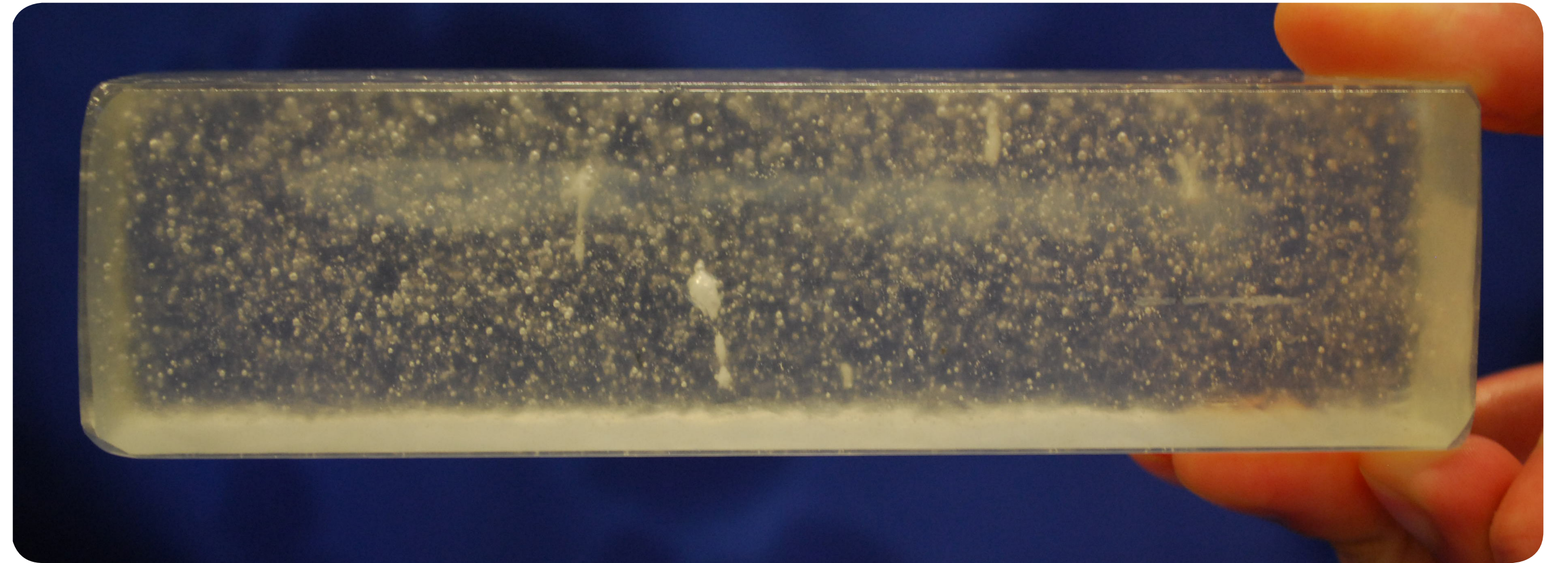
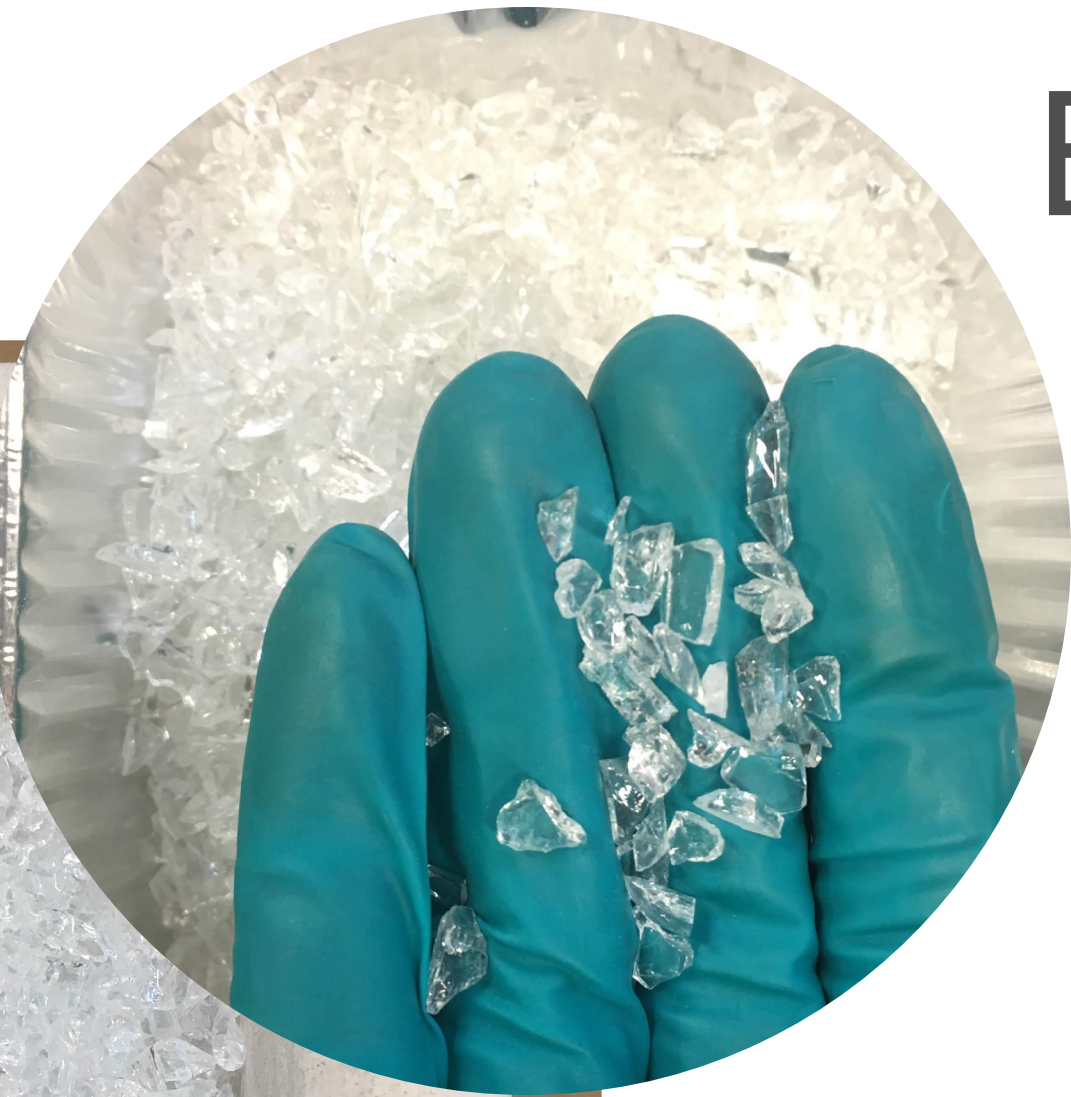
Beam 6 - powder



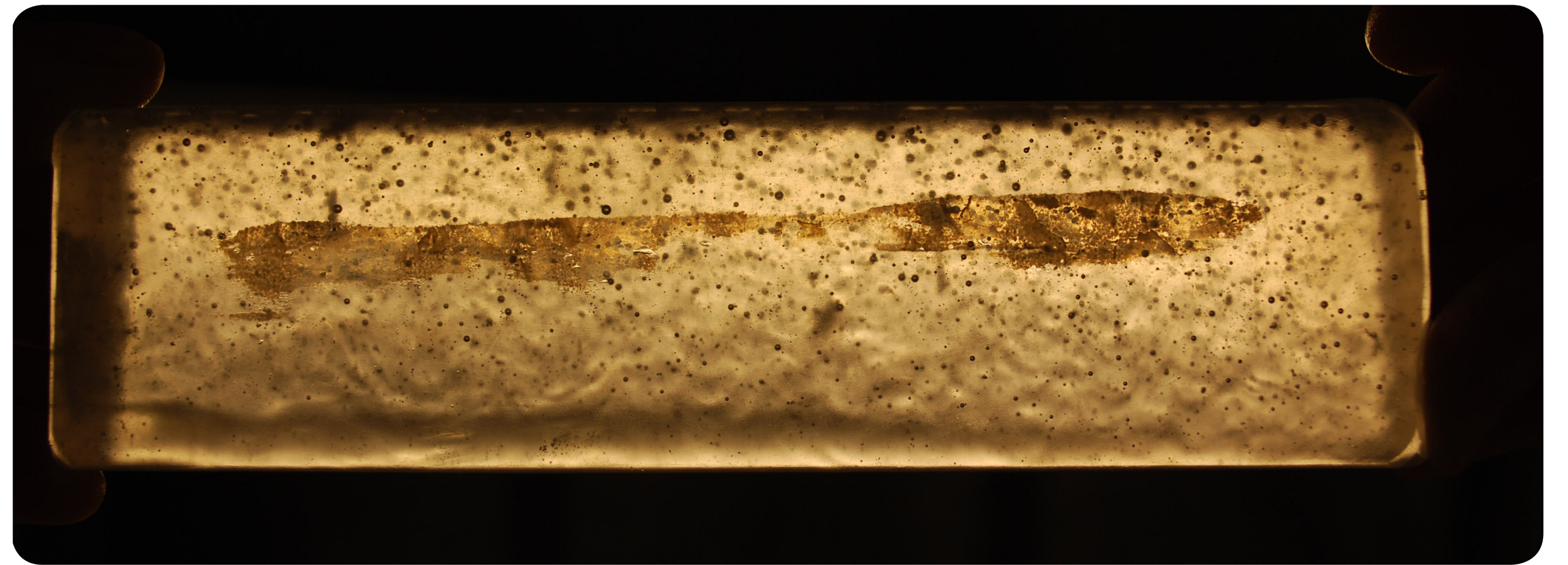
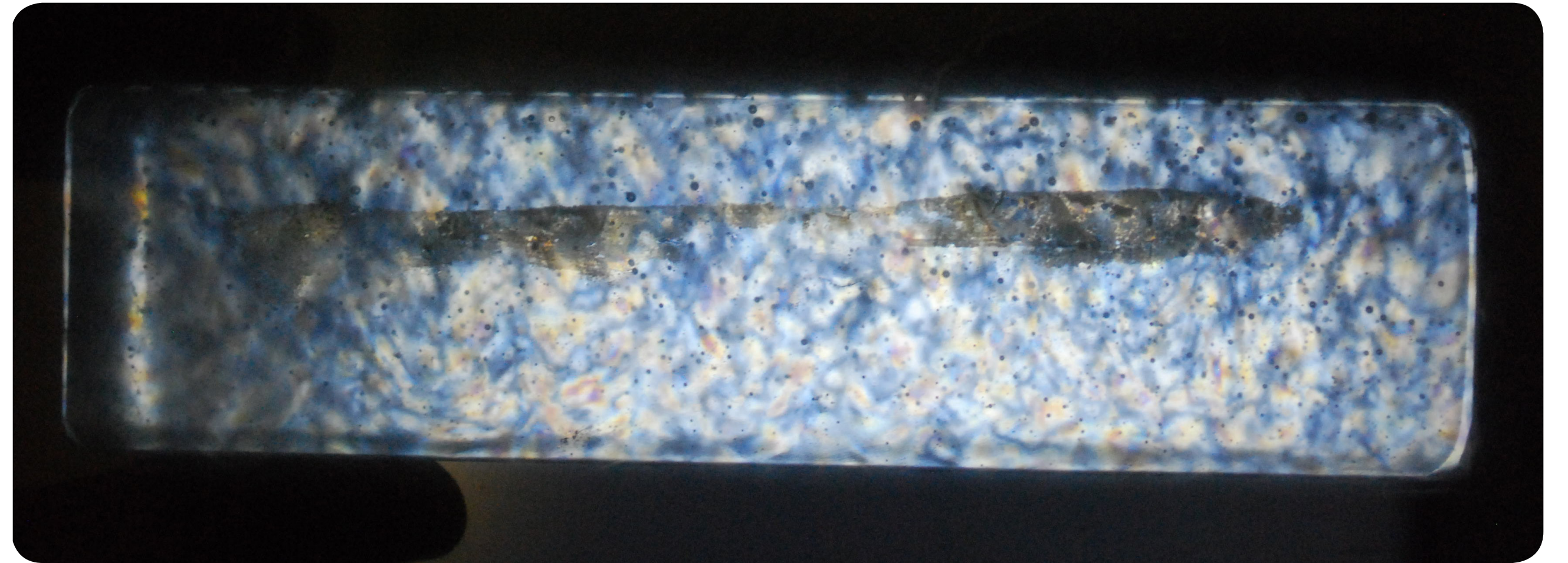
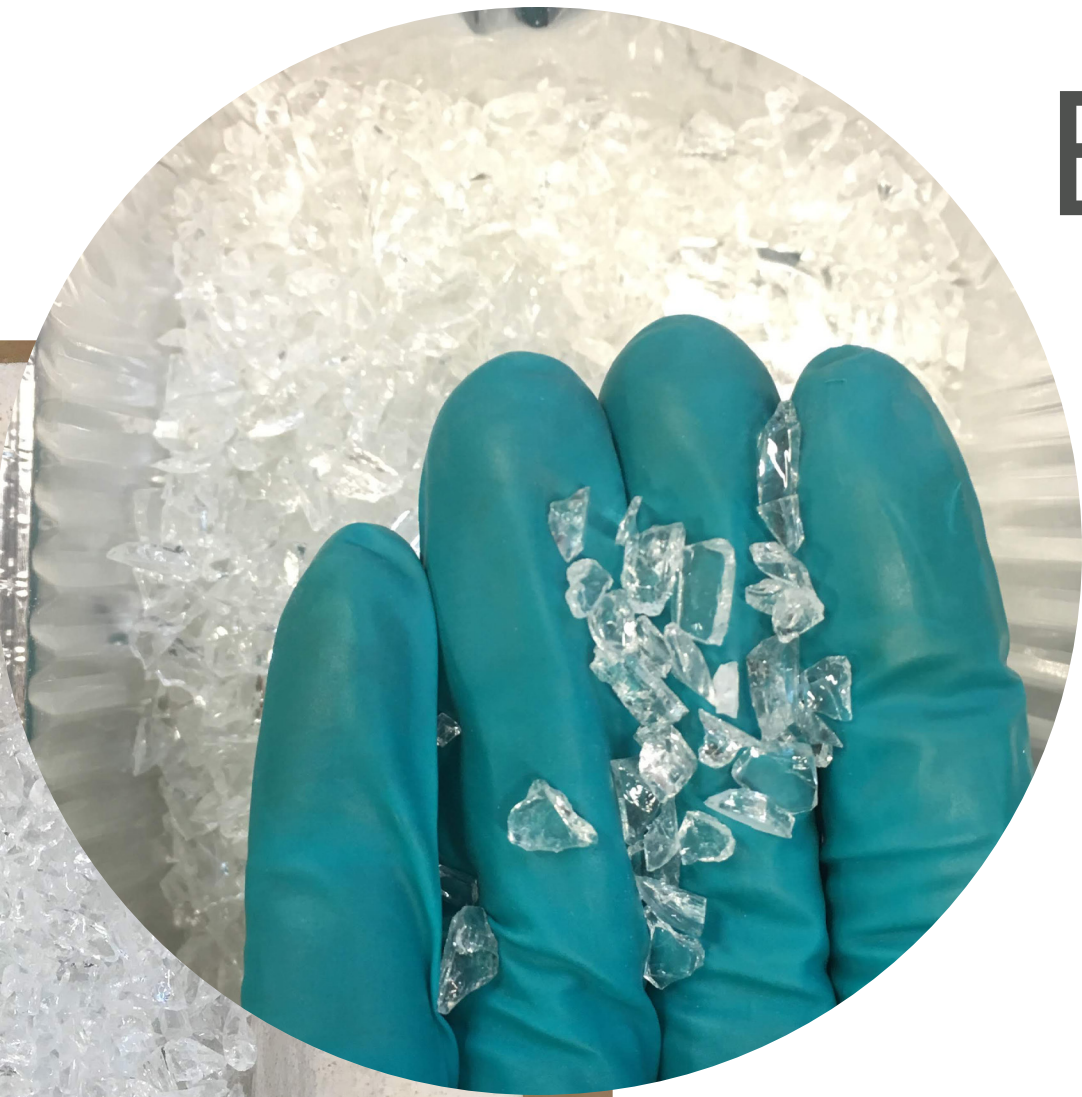
Beam 6 - powder



Beam 7 - fine cullet



Beam 7 - fine cullet

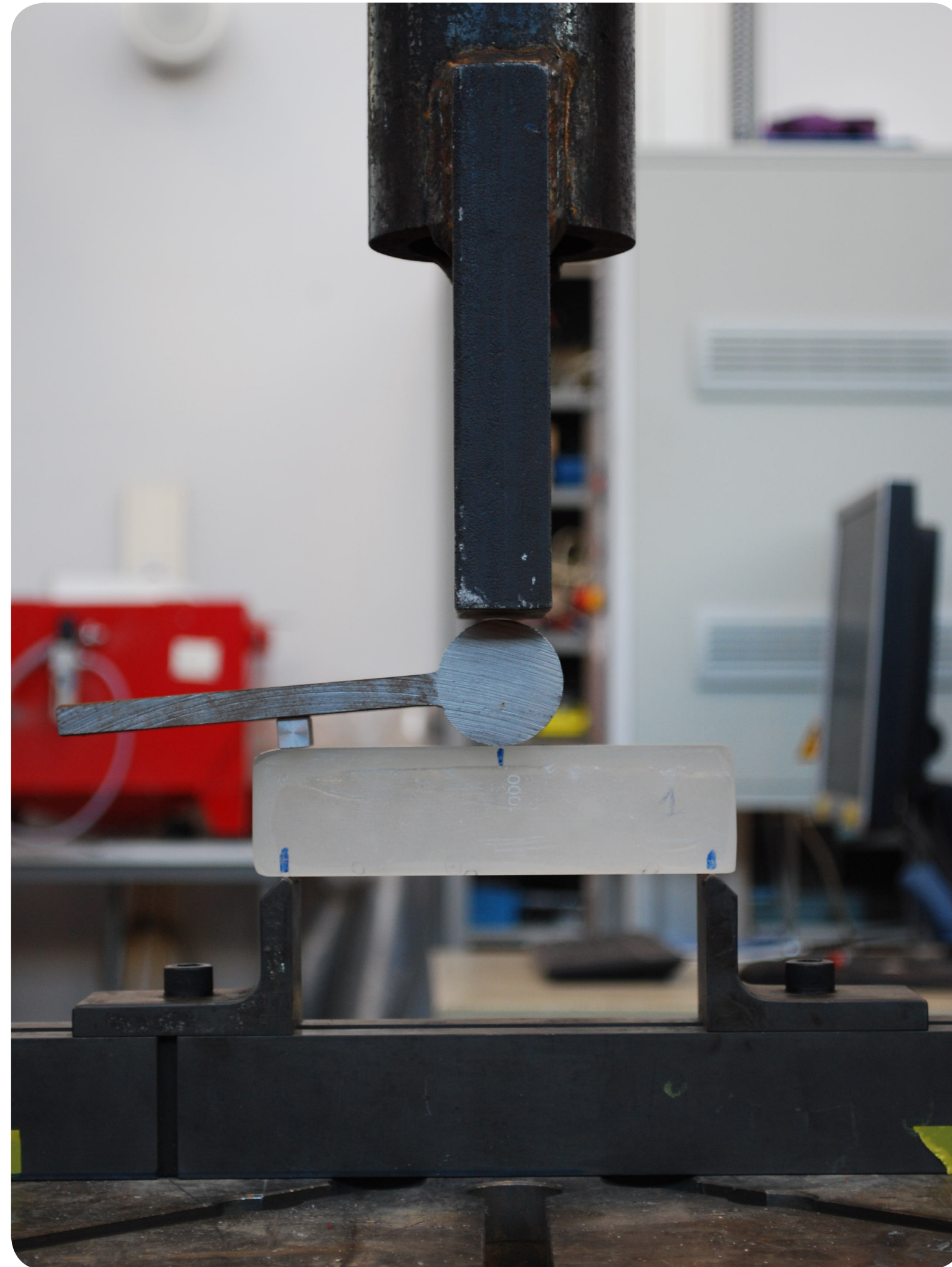


Comparing results: mixability

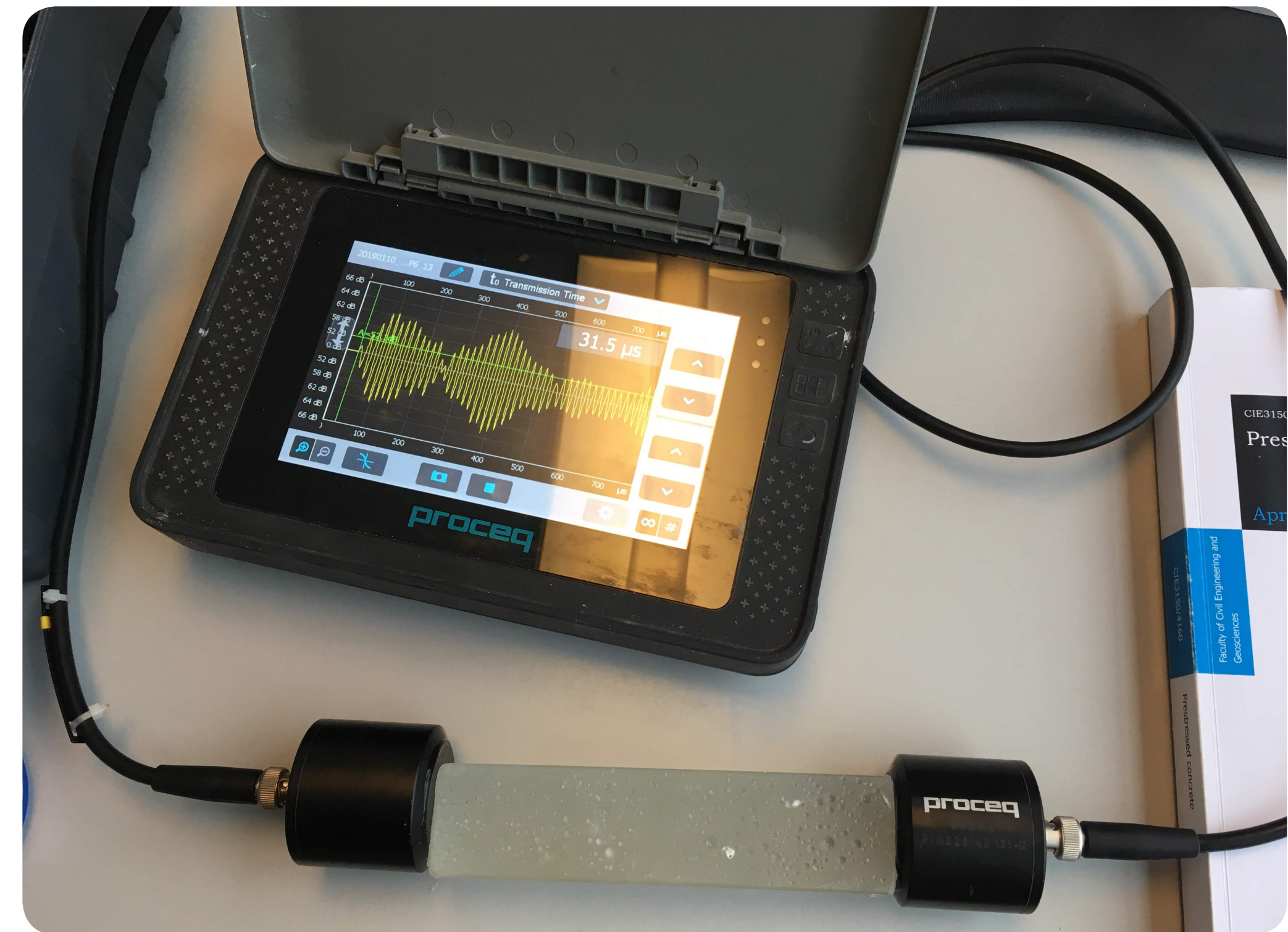
	SAME CHEMICAL COMPOSITION	DIFFERENT CHEMICAL COMPOSITION
BIG PIECES	✓	✗
FINE CULLET	✓	~
POWDER	✓	✓

Mechanical properties experiments

Mechanical properties of beams 1, 3, 5, 6 & 7 (Beams 2 & 4 cracked)



Flexural strength



Young's Modulus

Comparing results: mechanical properties

	BEAM 1	BEAM 2*	BEAM 3	BEAM 4*	BEAM 5	BEAM 6	BEAM 7	STANDARD NON-RECYCLED BOROSILICATE GLASS
YOUNG'S MODULUS Measurement 1 (GPa)	59	–	60	–	55	62	–	64
YOUNG'S MODULUS Measurement 2 (GPa)	52	–	Not available	–	52	50	53	64
FLEXURAL STRENGTH (MPa)	52	–	56	–	54	28	27	69
AMOUNT OF AIR BUBBLES	Moderate	–	High	–	High	Extreme	Extreme	–
GLASS TYPE (Borosilicate)	Rods & lab beaker	Rods Lab beaker Oven tray rect. Oven tray round	Rods	Rods	Rods	Rods Lab beaker Oven tray rect. Oven tray round	Rods Lab beaker Oven tray rect. Oven tray round	–

* Beam 2 and beam 4 cracked upon firing. Mechanical properties could not be defined.

Comparing results: mechanical properties

	BEAM 1	BEAM 2*	BEAM 3	BEAM 4*	BEAM 5	BEAM 6	BEAM 7	STANDARD NON-RECYCLED BOROSILICATE GLASS
YOUNG'S MODULUS Measurement 1 (GPa)	59	—	60	—	55	62	—	64
YOUNG'S MODULUS Measurement 2 (GPa)	52	—	Not available	—	52	50	53	64
FLEXURAL STRENGTH (MPa)	52	—	56	—	54	28	27	69
AMOUNT OF AIR BUBBLES	Moderate	—	High	—	High	Extreme	Extreme	—
GLASS TYPE (Borosilicate)	Rods & lab beaker	Rods Lab beaker Oven tray rect. Oven tray round	Rods	Rods	Rods	Rods Lab beaker Oven tray rect. Oven tray round	Rods Lab beaker Oven tray rect. Oven tray round	—

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AMOUNT OF AIR BUBBLES	Moderate	—	High	—	High	Extreme	Extreme	—
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AMOUNT OF AIR BUBBLES	Moderate	–	High	–	High	Extreme	Extreme	–
GLASS TYPE (Borosilicate)	Rods & lab beaker	Rods Lab beaker Oven tray rect. Oven tray round	Rods	Rods	Rods	Rods Lab beaker Oven tray rect. Oven tray round	Rods Lab beaker Oven tray rect. Oven tray round	–

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Comparing results: mechanical properties

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AMOUNT OF AIR BUBBLES	Moderate	—	High	—	High	Extreme	Extreme	—
GLASS TYPE (Borosilicate)	Rods & lab beaker	Rods Lab beaker Oven tray rect. Oven tray round	Rods	Rods	Rods	Rods Lab beaker Oven tray rect. Oven tray round	Rods Lab beaker Oven tray rect. Oven tray round	—

* Beam 2 and beam 4 cracked upon firing. Mechanical properties could not be defined.

Comparing results: mechanical properties

- Beams **1, 3 & 5** similar **Young's Modulus** to non-recycled borosilicate glass
- Beams **1, 3 & 5** similar **flexural strength** to non-recycled borosilicate glass
- Beam **6** was **contaminated**. Drastic change in molecular structure. No cracking, but not suitable for comparison
- Beam **7** has a **lower** Young's Modulus and flexural strength due to **internal stresses**

Conclusions experiments

Mixability

- Mixed chemical composition → fine cullet size or powder desirable

Conclusions experiments

Mixability

- Mixed chemical composition → fine cullet size or powder desirable
- Homogeneous composition → cullet size small influence
- mixes at lower firing temperature, from 1550°C to 1120°C

Conclusions experiments

Mixability

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- mixes at lower firing temperature, from 1550°C to 1120°C

Mechanical properties

- Fine cullet + mixed chemical composition → Negative effect on flexural strength

Conclusions experiments

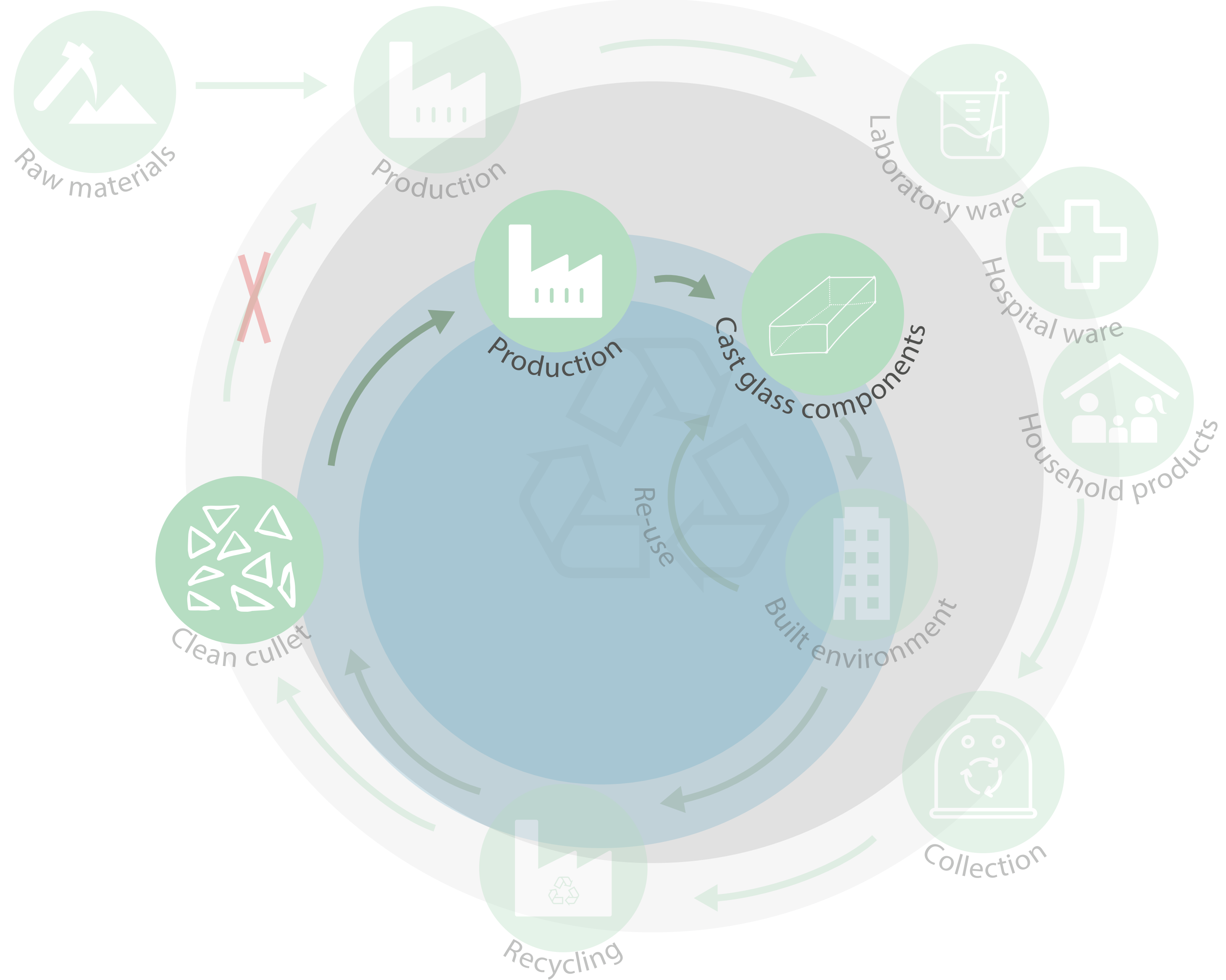
Mixability

- Mixed chemical composition → fine cullet size or powder desirable
- Homogeneous composition → cullet size small influence
- mixes at lower firing temperature, from 1550°C to 1120°C

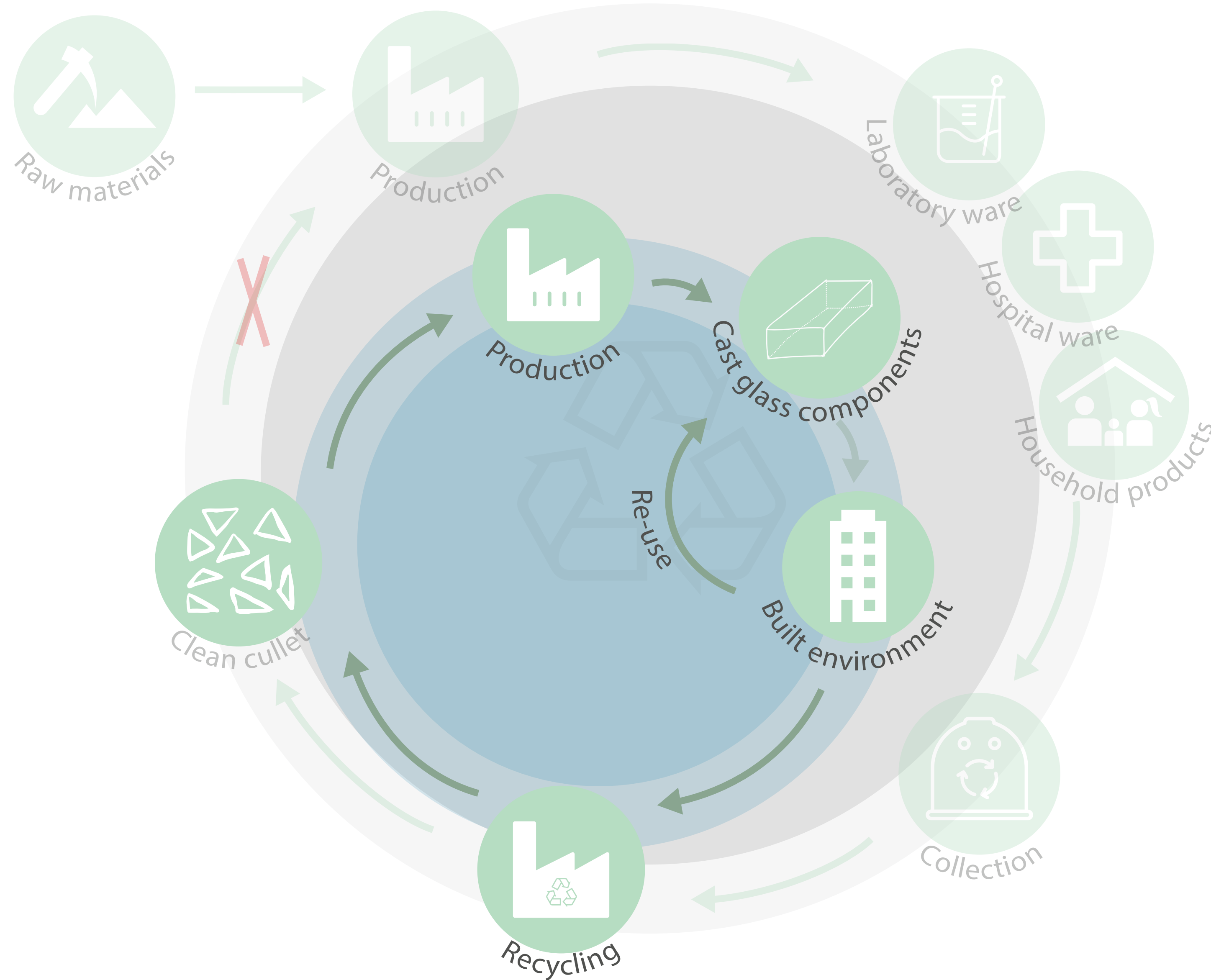
Mechanical properties

- Fine cullet + mixed chemical composition → Negative effect on flexural strength
- Recycling low influence on mechanical properties (except beam 7)
- Beams 1,3 & 5 show great potential for application in built environment

Next step:



Next step: application in built environment



DESIGN



Case study - Casa da Música



Location of Porto

Source: ("Wikivoyage-Iberia," n.d.)



Casa da Música

© Philippe Ruault

Case study - Casa da Música

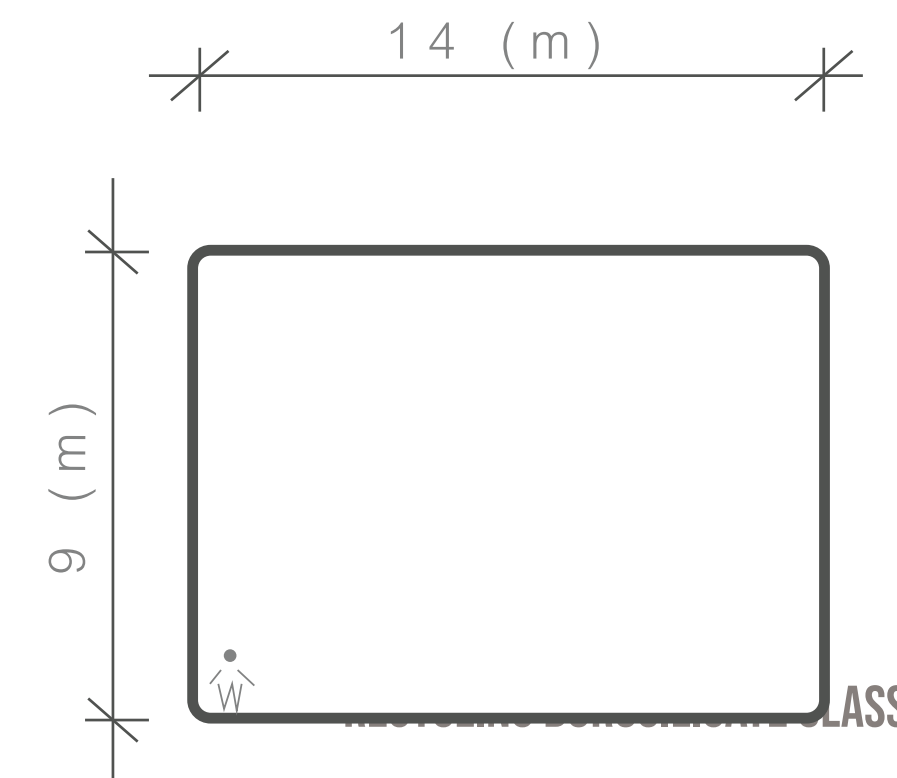
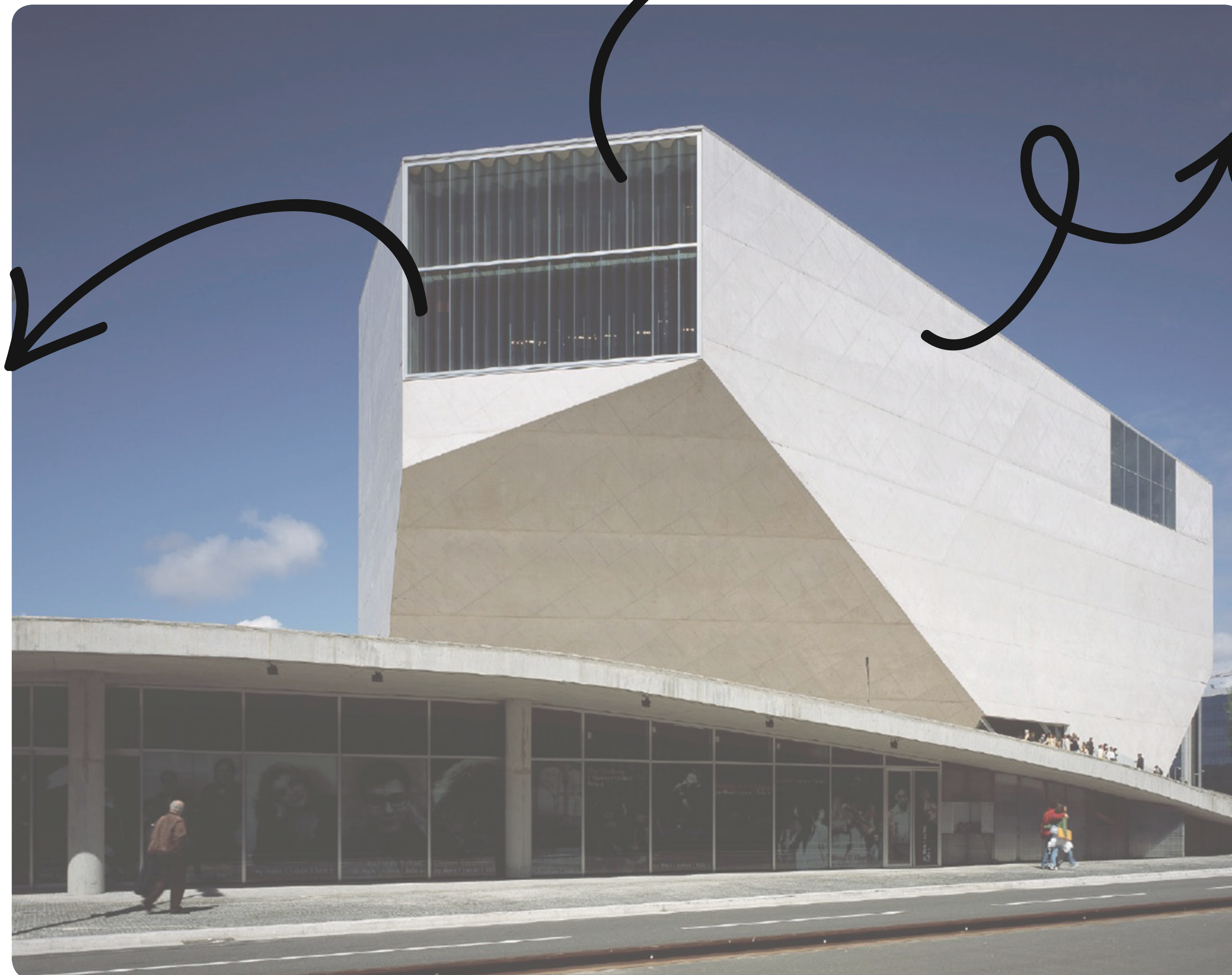


Casa da Música - design concept

CORRUGATED,
SHINING AND
BRILLIANT GLASS
FACADE

FLAT, WHITE AND
SMOOTH CONCRETE
FACADE

GLASS FACADE
WITH AS LESS
STEEL AS
POSSIBLE



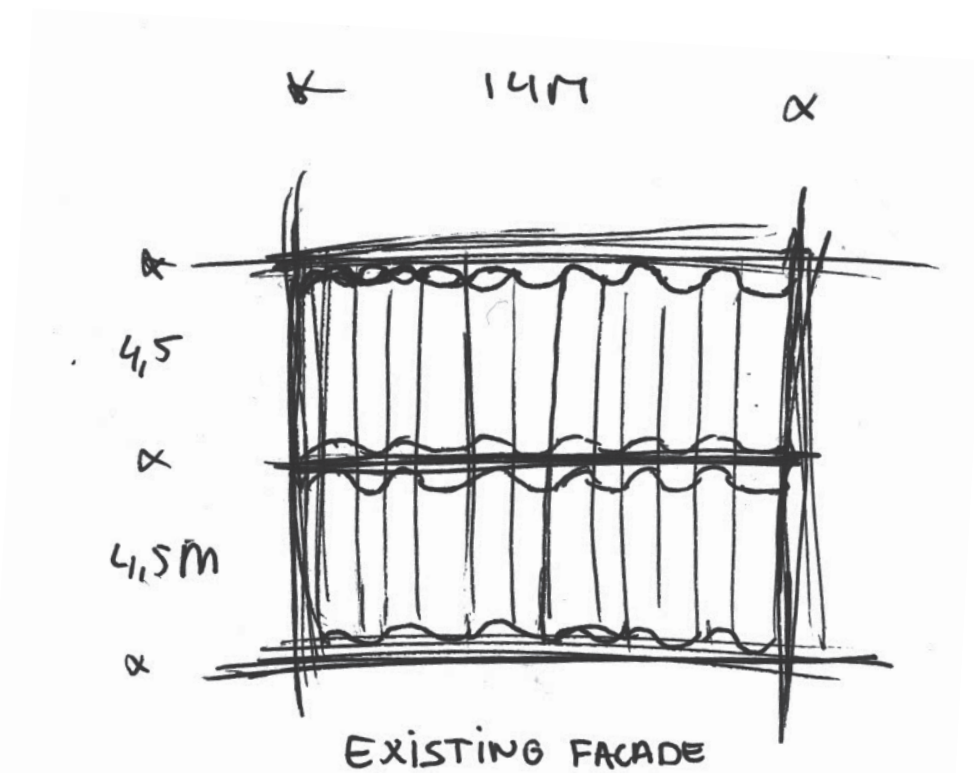
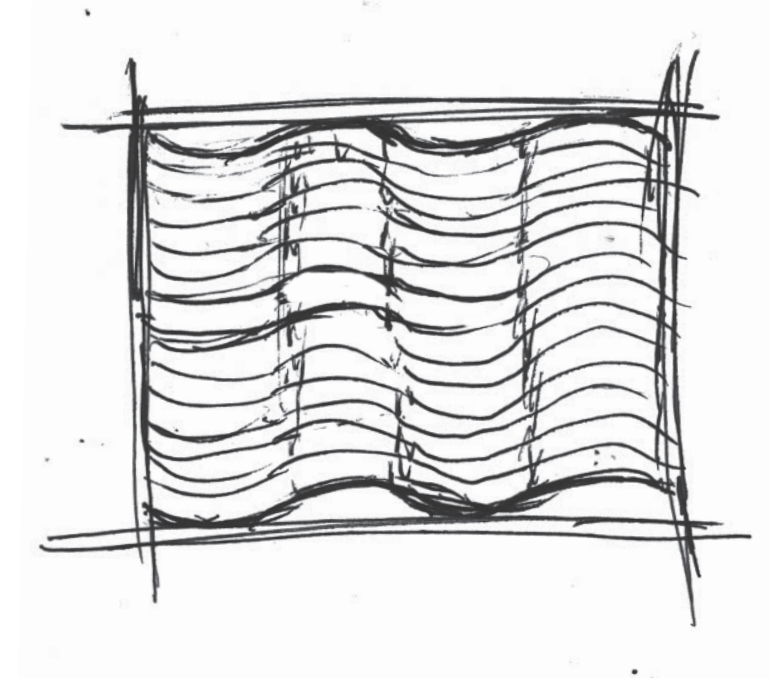
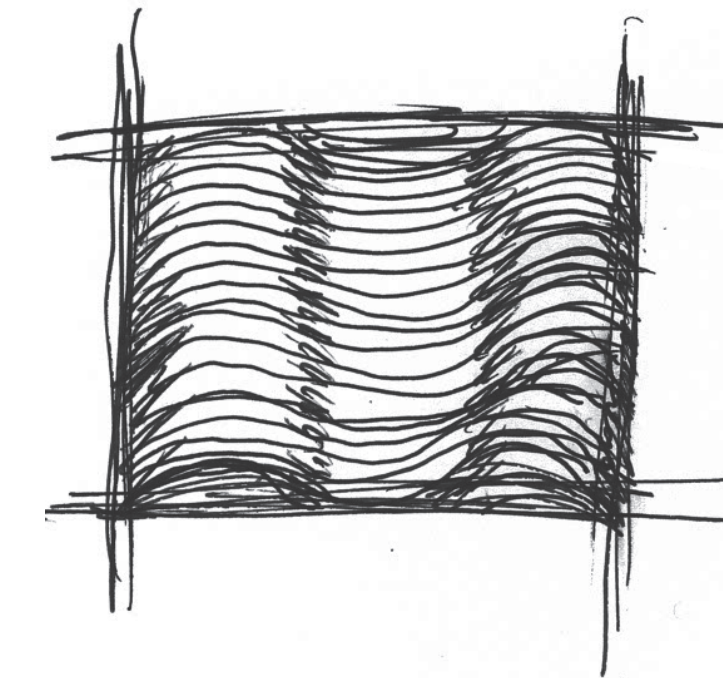
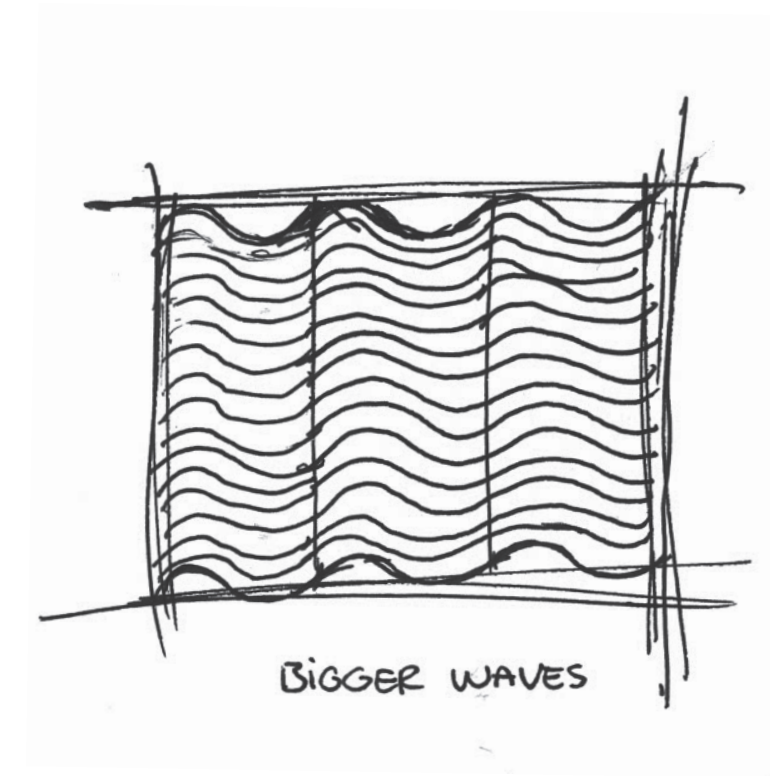
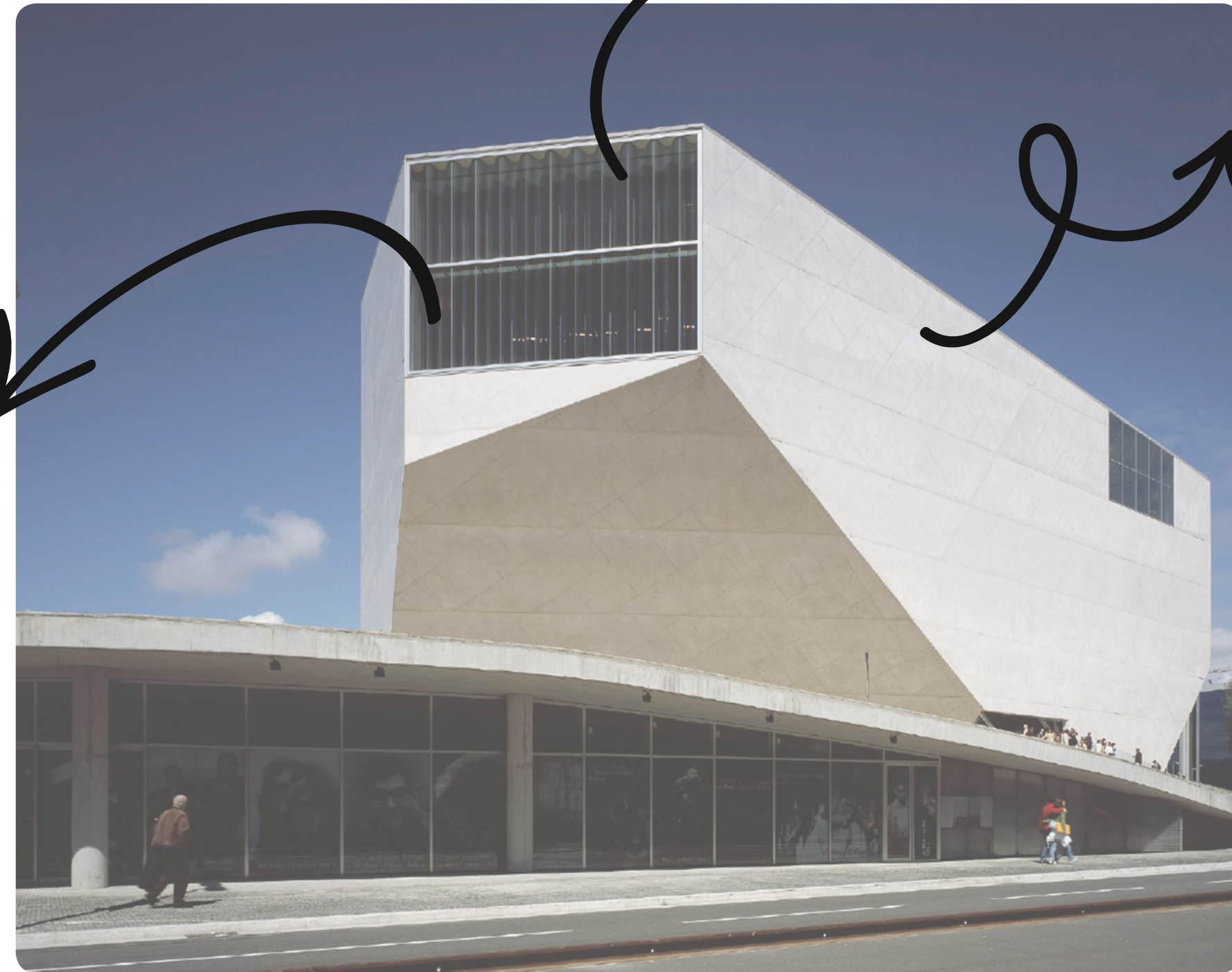
CORRUGATED,
SHINING AND
BRILLIANT GLASS
FACADE



APPEALING
CONTRAST

FLAT, WHITE AND
SMOOTH CONCRETE
FACADE

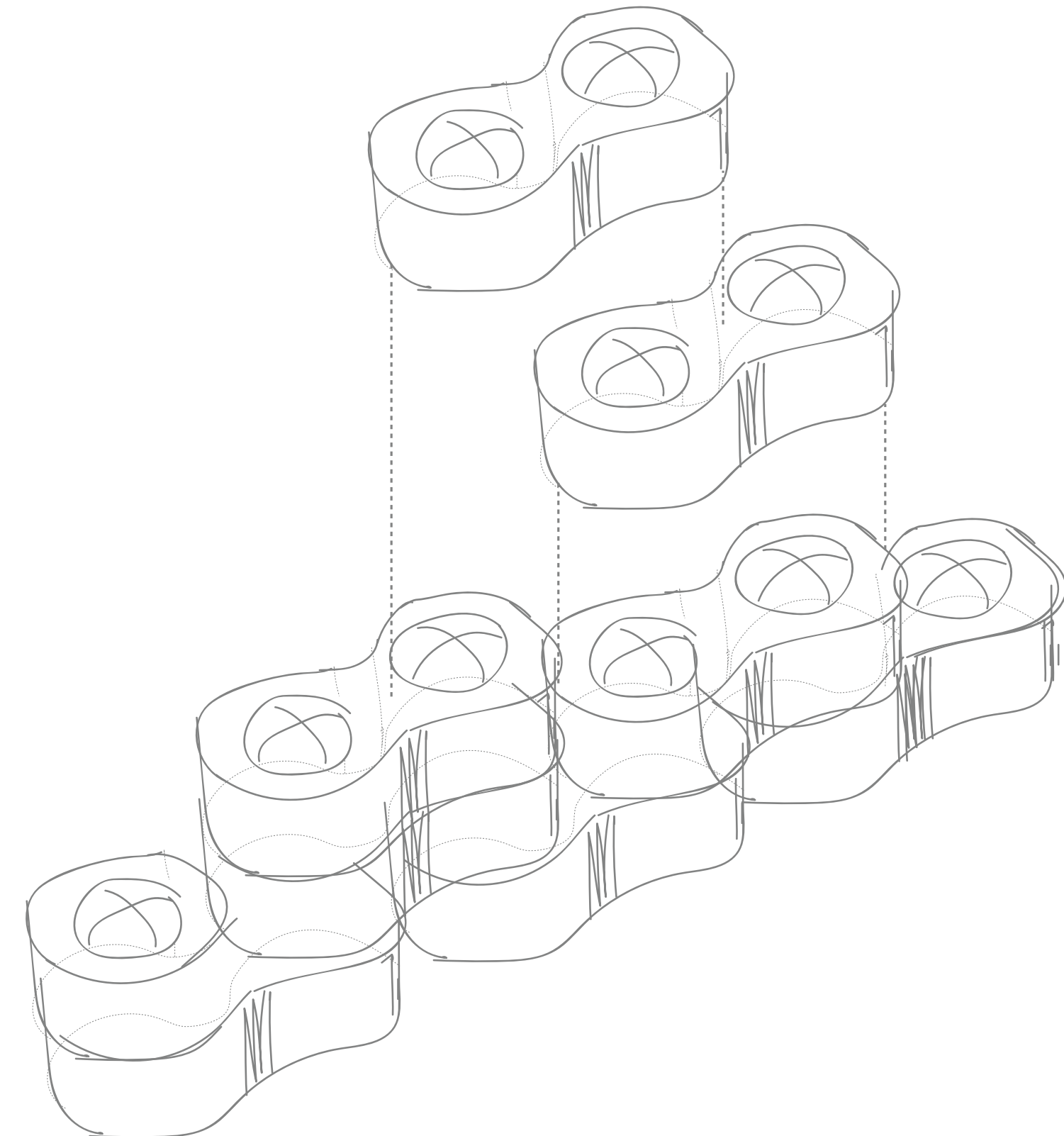
GLASS
FACADE WITH
AS LESS
STEEL AS
POSSIBLE



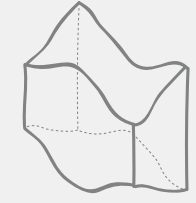
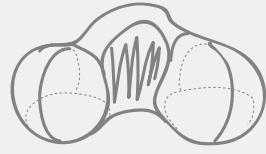
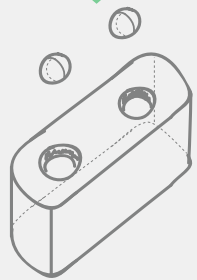
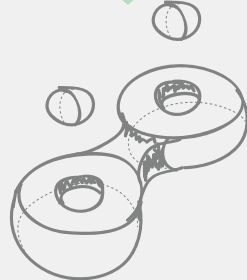

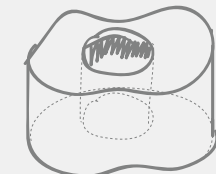
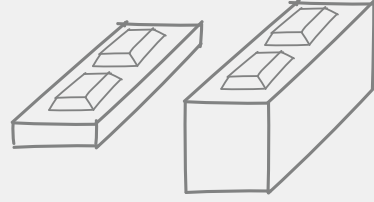
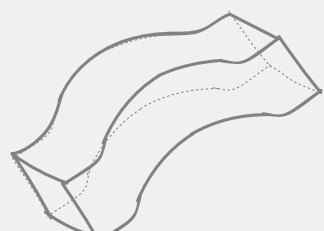
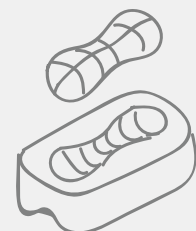
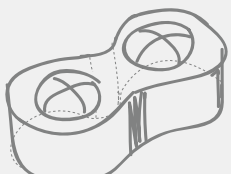
Dry-interlocking cast glass



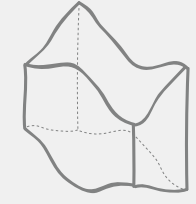

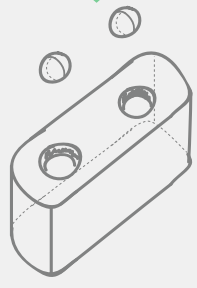
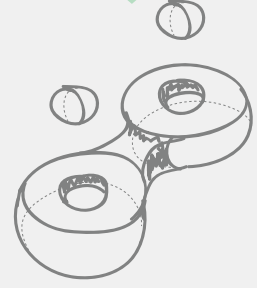

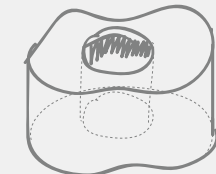
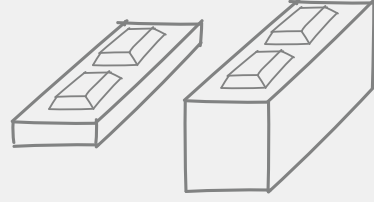
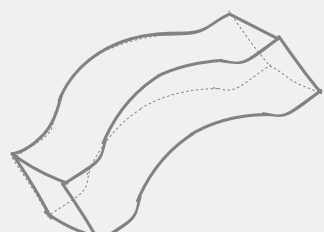
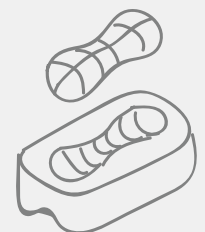
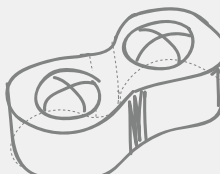
(Oikonomopoulou et al., 2018)



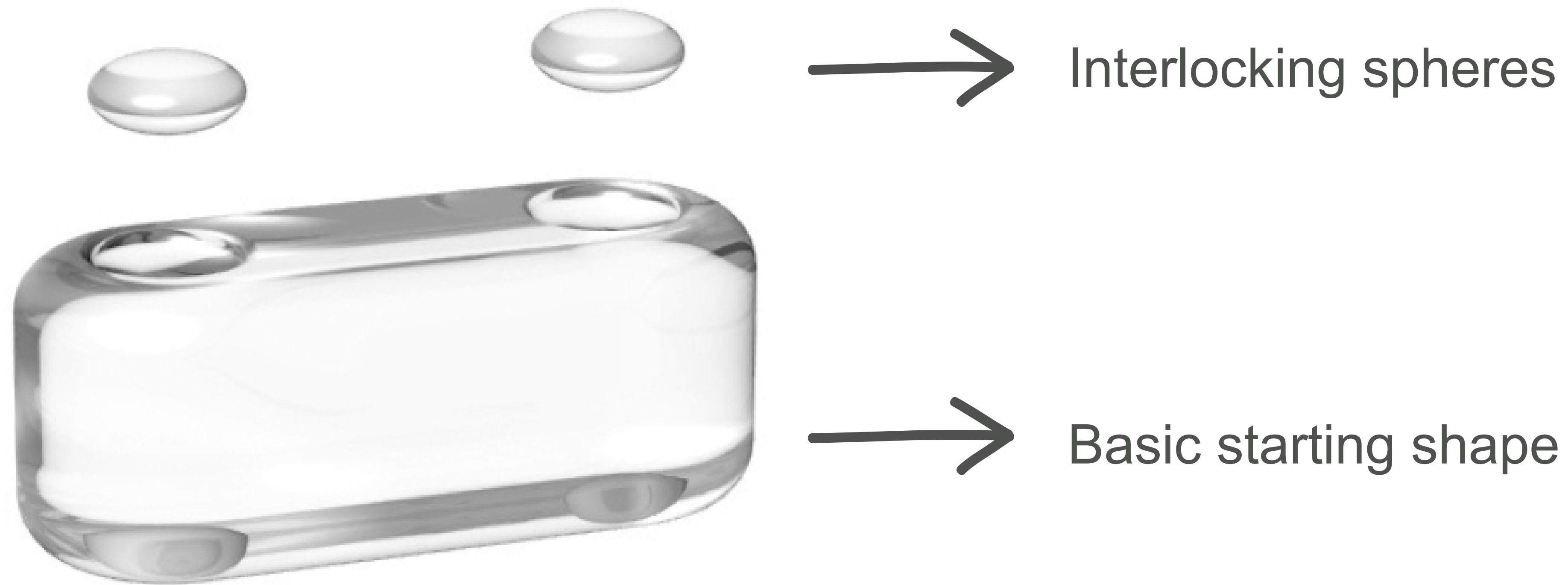
Existing interlocking cast glass systems

	OIKONOMOPOULOU & BRISTOGIANNI 1	JANSSENS	DE VRIES 1	DE VRIES 2	JACOBS	AKERBOOM	BAROU	SOMBROEK/AURIK	OIKONOMOPOULOU & BRISTOGIANNI 2	OIKONOMOPOULOU & BRISTOGIANNI 3
SHAPE										
SUITABLE IN EXTERNAL WALL CONFIGURATION	Yes	No	Yes	No	Yes	No	Yes	No	Maybe	Maybe
SHEAR FORCE CAPACITY	High	High	Sufficient/ high	Sufficient/ high	High	Sufficient	Sufficient	-	Moderate	Moderate/ high
HOMOGENEOUS COOLING IN CASTING	Effective	Effective	Risk of internal residual stresses	Effective	Effective	Effective	Risk of internal residual stresses	Risk of internal residual stresses	Risk of internal residual stresses	Effective
REDUNDANCY	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
EASE OF (DIS)-ASSEMBLY	High	Low	Medium	Medium	High	High	High	Low	Medium	High

Existing interlocking cast glass systems

	OIKONOMOPOULOU & BRISTOGIANNI 1	JANSSENS	DE VRIES 1	DE VRIES 2	JACOBS	AKERBOOM	BAROU	SOMBROEK/AURIK	OIKONOMOPOULOU & BRISTOGIANNI 2	OIKONOMOPOULOU & BRISTOGIANNI 3
SHAPE										
SUITABLE IN EXTERNAL WALL CONFIGURATION	Yes	No	Yes	No	Yes	No	Yes	No	Maybe	Maybe
SHEAR FORCE CAPACITY	High	High	Sufficient/ high	Sufficient/ high	High	Sufficient	Sufficient	-	Moderate	Moderate/ high
HOMOGENEOUS COOLING IN CASTING	Effective	Effective	Risk of internal residual stresses	Effective	Effective	Effective	Risk of internal residual stresses	Risk of internal residual stresses	Risk of internal residual stresses	Effective
REDUNDANCY	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
EASE OF (DIS)-ASSEMBLY	High	Low	Medium	Medium	High	High	High	Low	Medium	High

Starting point - concept by de Vries (2018)



Initial concept of component by (de Vries, 2018)

Starting point - concept by de Vries (2018)



Interlocking spheres

Under shear force:

- Increased freedom of movement
- Desirable failure mode



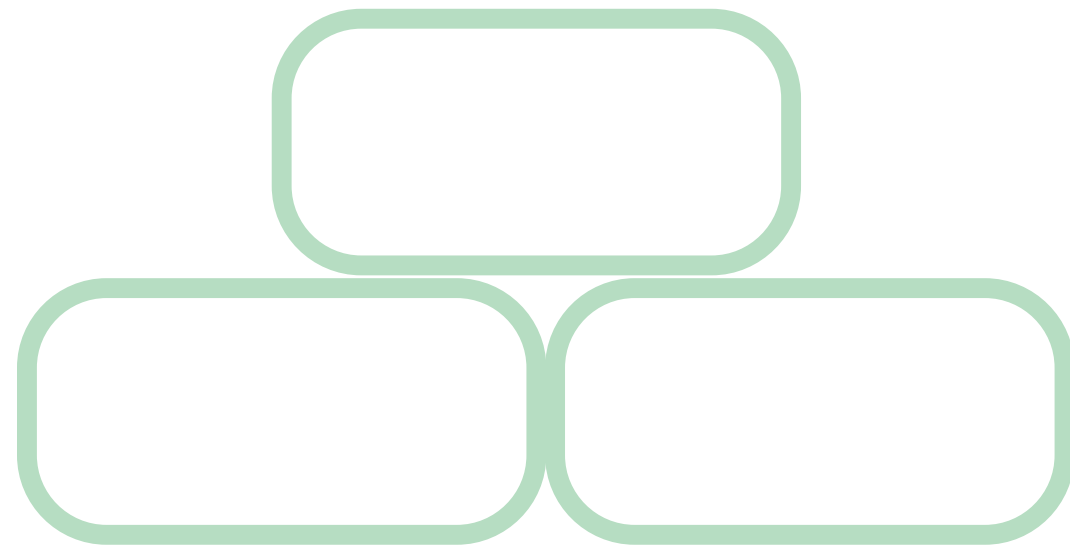
Basic starting shape

Initial concept of component by (de Vries, 2018)

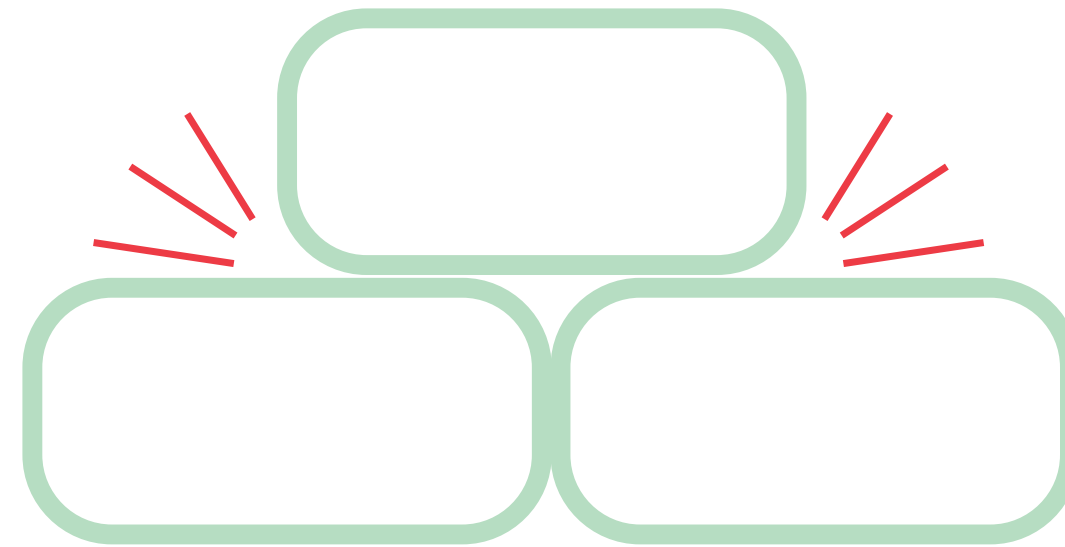
Glass to glass contact



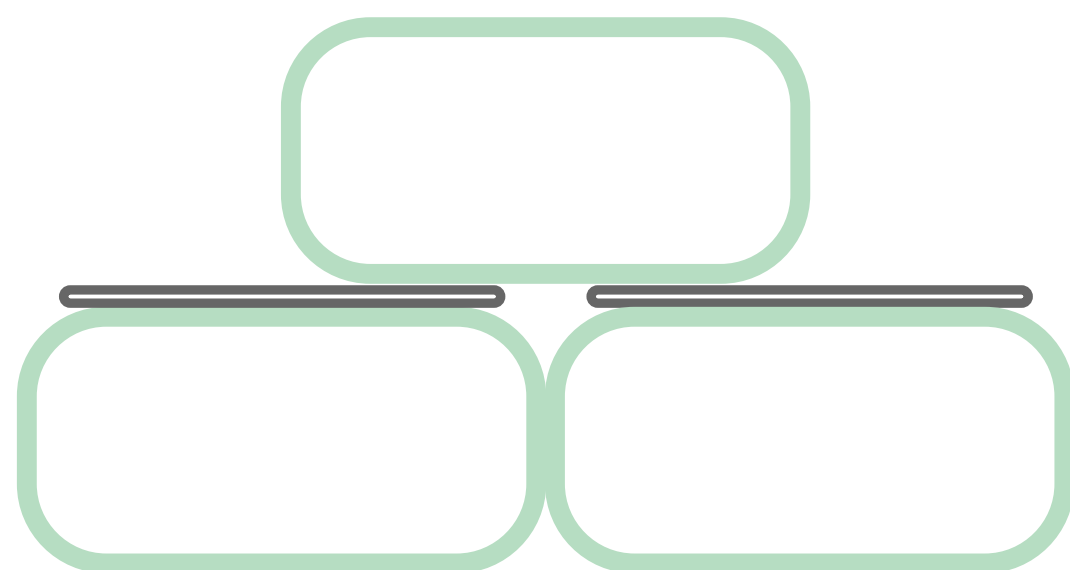
Glass to glass contact



Glass to glass contact

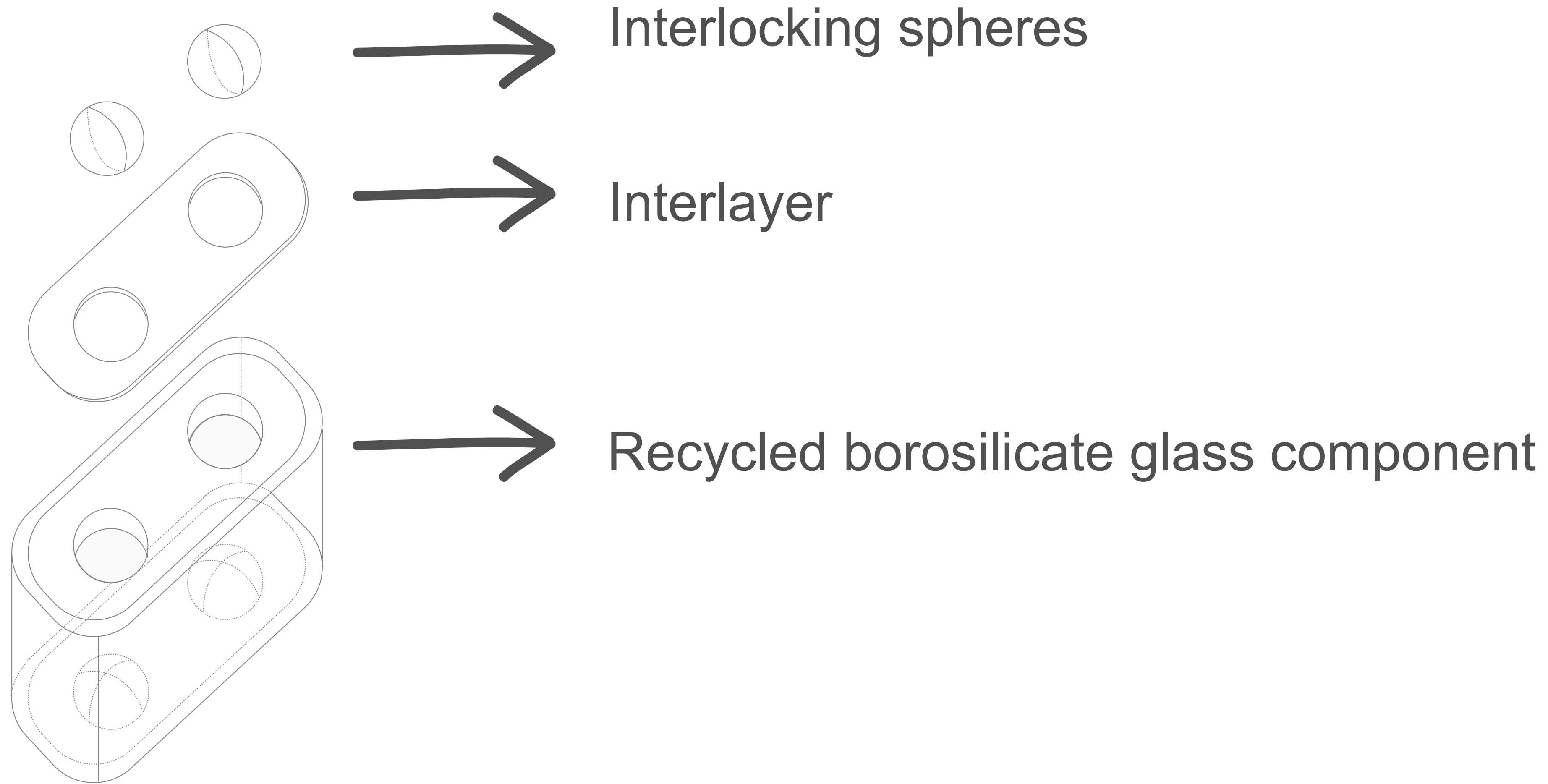


Glass to glass contact



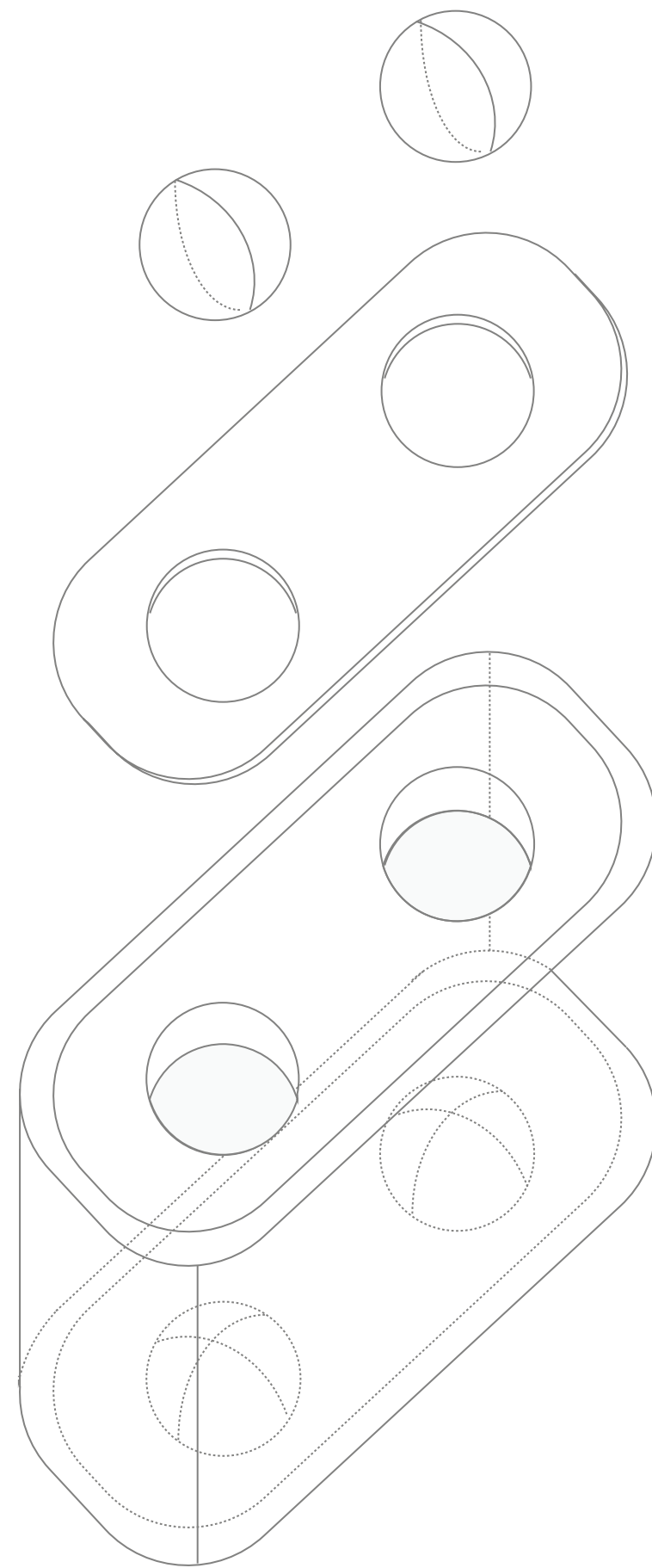
Interlayer required

Initial component design



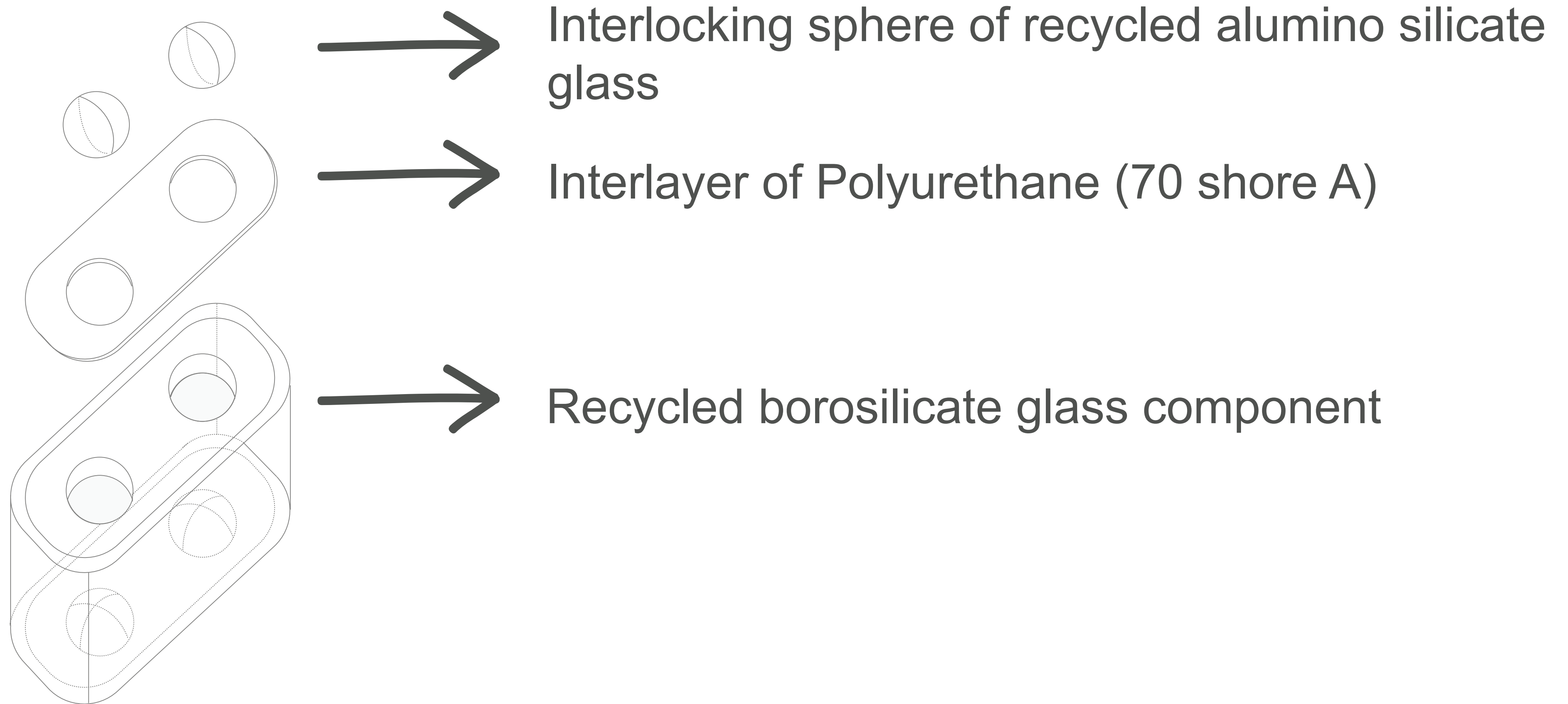
Initial component concept based on (de Vries, 2018)

Initial shape from design criteria



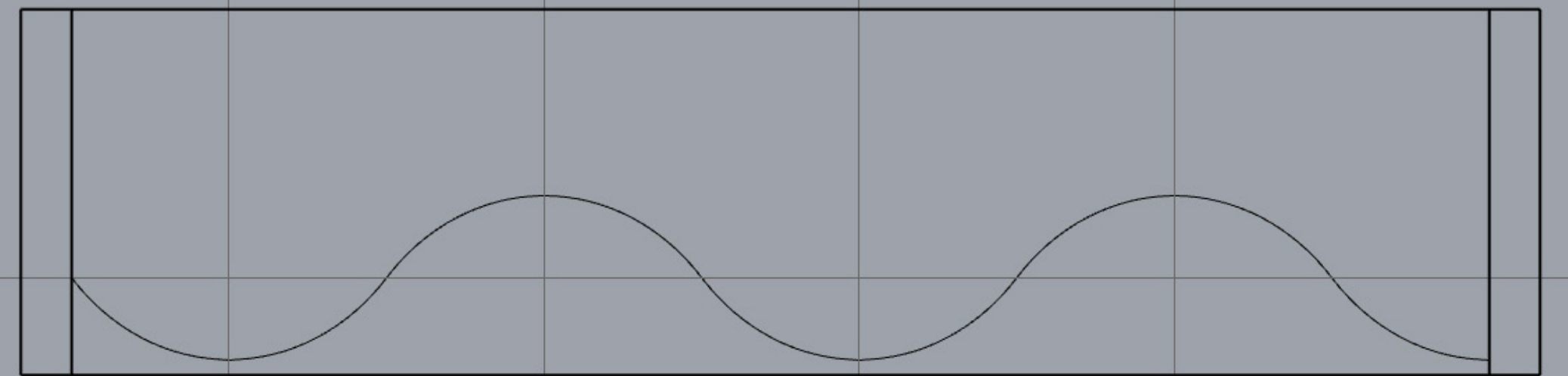
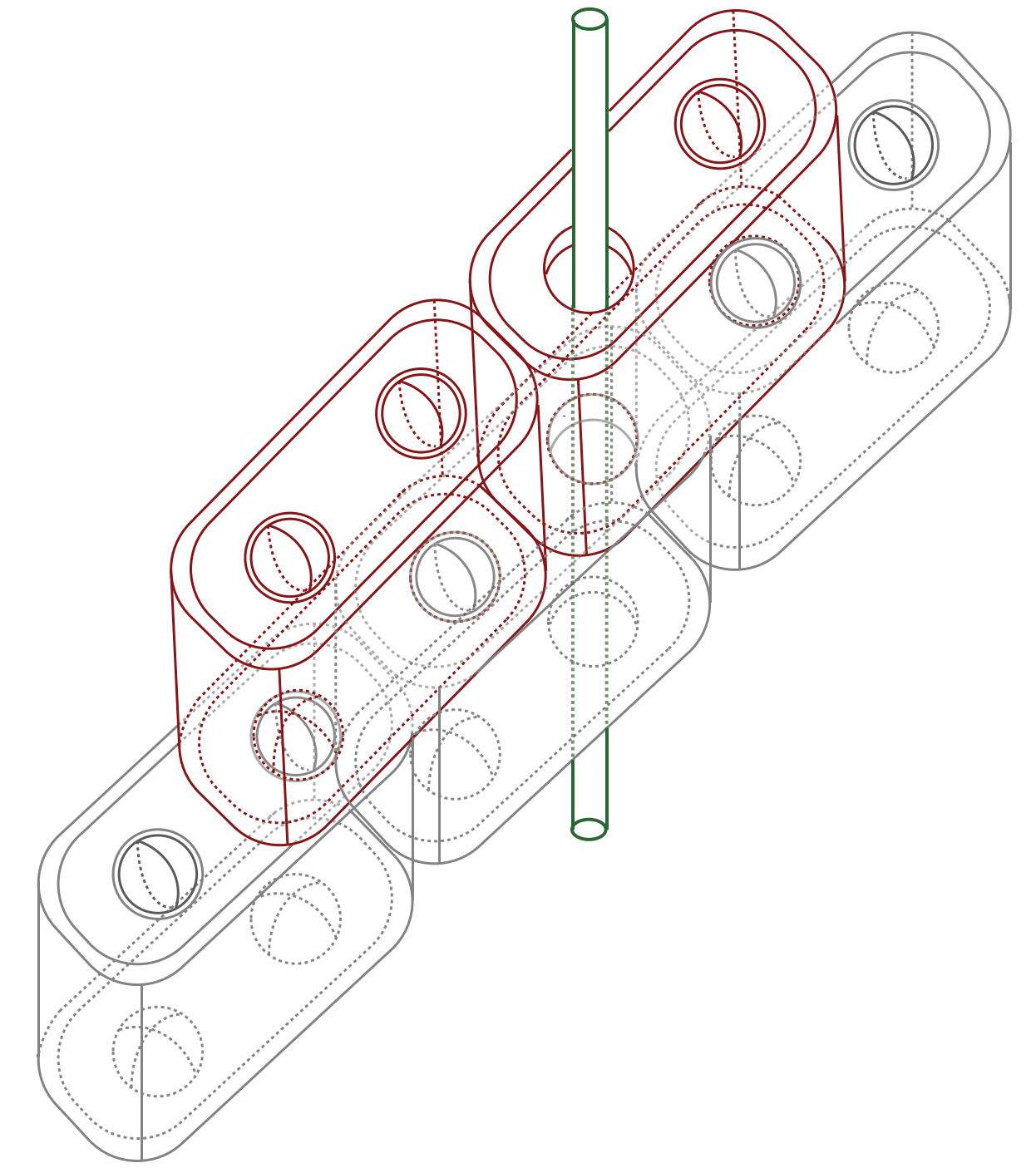
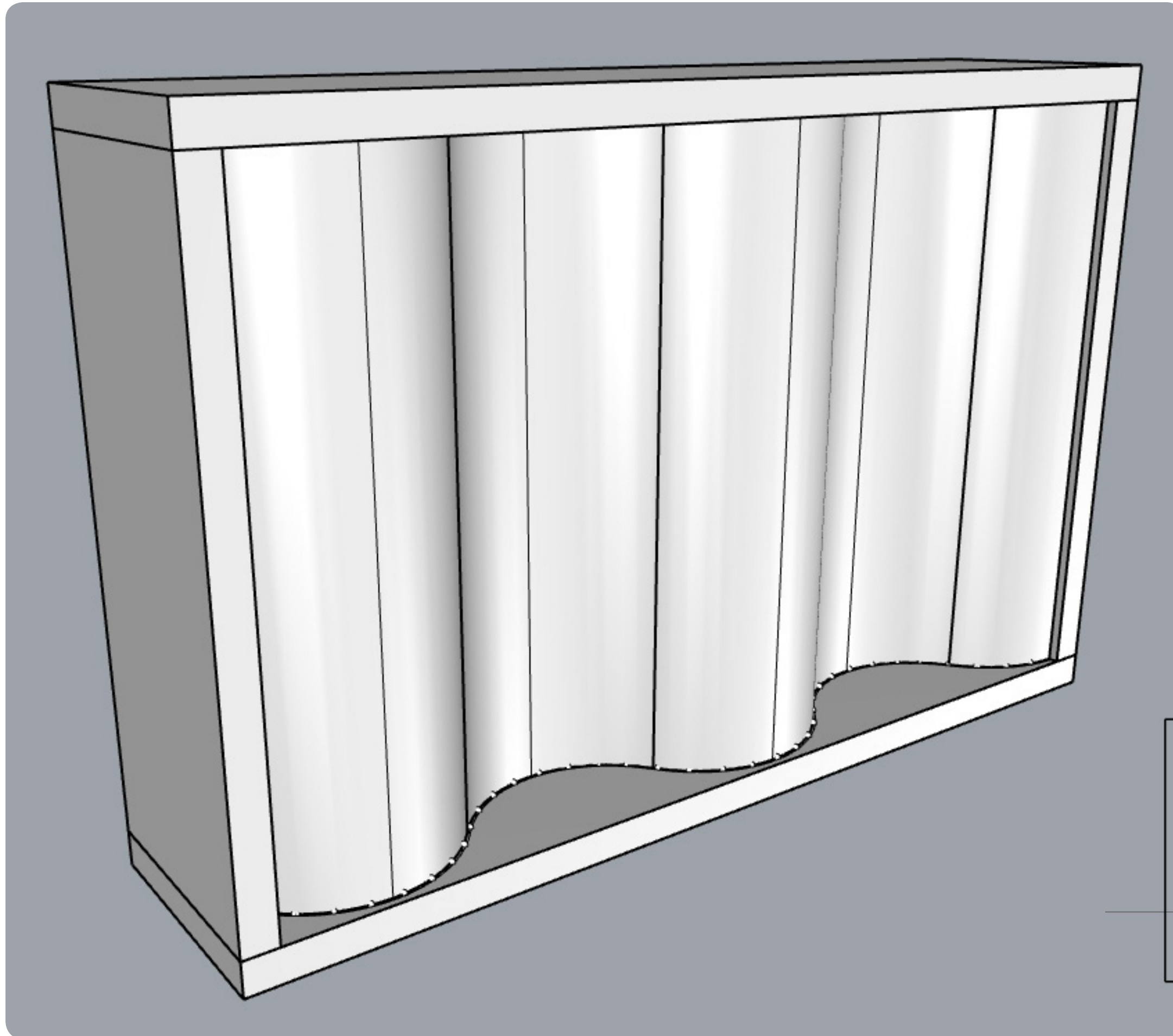
- Showcase of recyclability
- Showcase of optical quality borosilicate glass
- As slender as possible

Material choice



Initial component concept based on (de Vries, 2018)

Initial facade design



Further component development

Handwritten notes and diagrams illustrating component development for recycling borosilicate glass. The notes include calculations for weight (X) based on density (2230) and dimensions, along with sketches of various glass components.

Calculations:

- $2230 \cdot 0,3 \cdot 0,08 \cdot X = 10$ (density)
- $53,52X = 10$
- $X = \frac{10}{53,52}$
- $X = 0,19$

Diagrams and Dimensions:

- A cylindrical component with a height of 19 cm and a diameter of 30 cm. A 10 kg block is shown on top.
- A rectangular component with a height of 8 cm and a width of 45 cm. A 10 kg weight is shown on top.
- A cylindrical component with a height of 12,5 cm and a diameter of 45 cm. A 10 kg weight is shown on top.
- A cylindrical component with a height of 17 cm and a diameter of 45 cm. A 10 kg weight is shown on top.
- A rectangular component with a height of 7 cm and a width of 45 cm. A 10 kg weight is shown on top.

Additional Calculations:

- $2230 \cdot 0,45 \cdot 0,06 \cdot X = 10$
- $60,21X = 10$
- $X = 0,17$

- $2230 \cdot 0,45 \cdot 0,07 \cdot X = 10$
- $70,25X = 10$
- $X = 0,14$

- $2230 \cdot 0,45 \cdot 0,08 \cdot X = 10$
- $80,28X = 10$
- $X = 0,125$

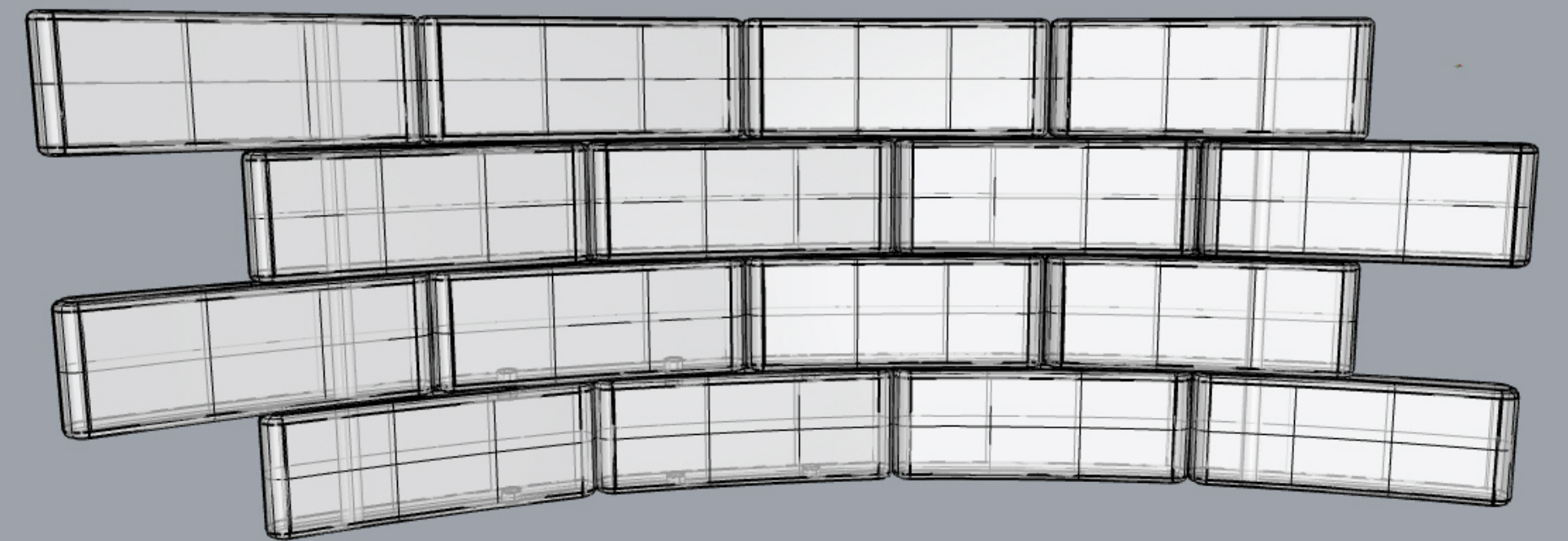
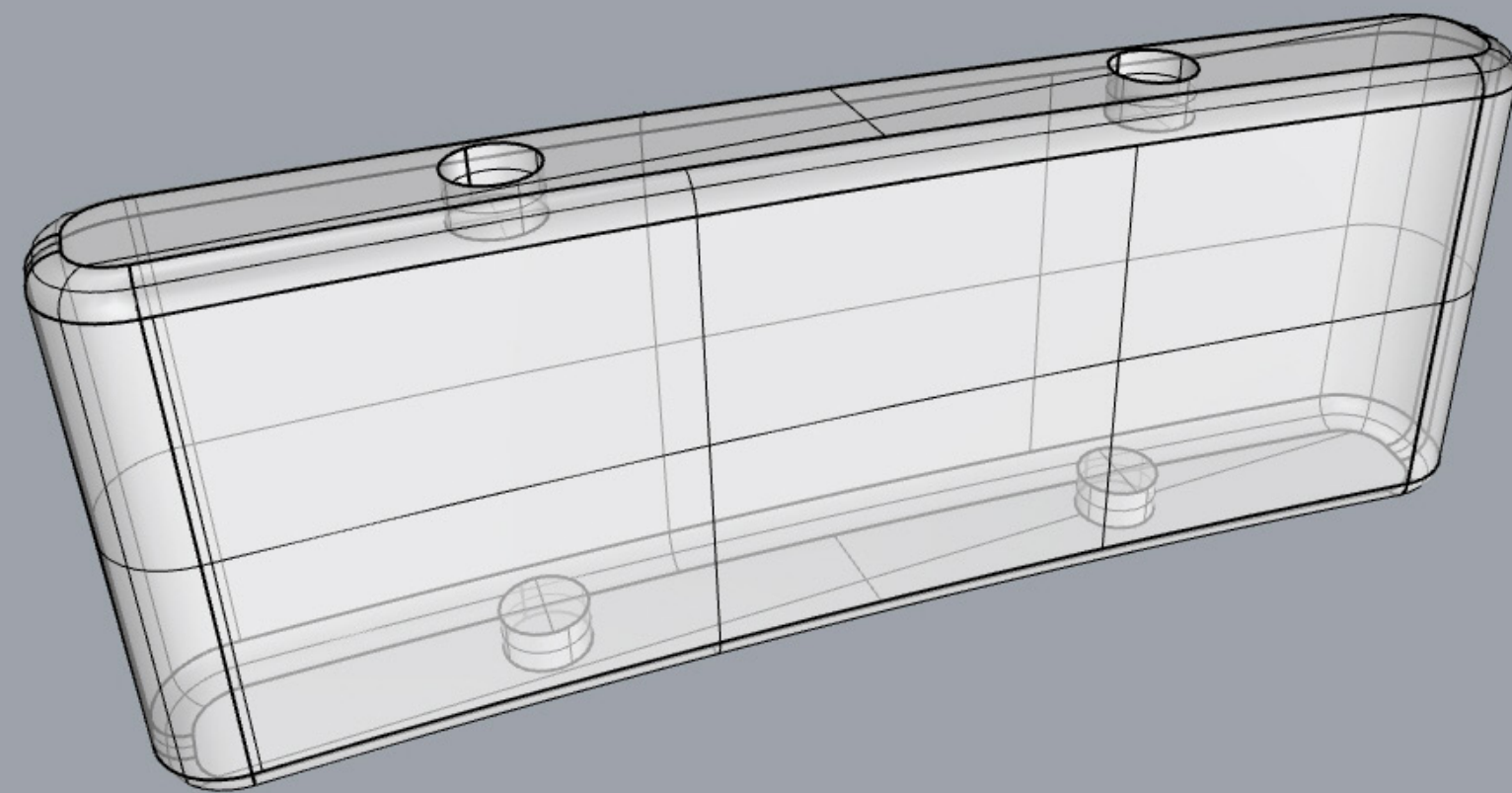
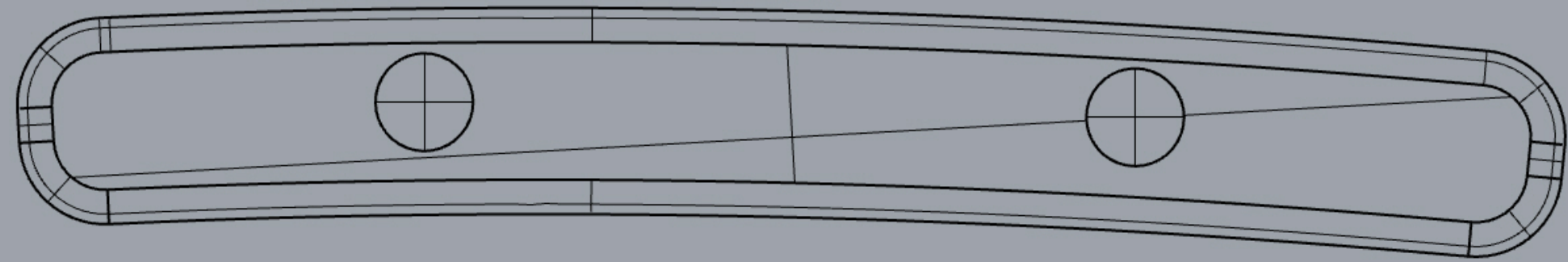
- $2230 \cdot 0,45 \cdot 0,07 \cdot X = 12$
- $70,25X = 12$
- $X = 0,17$

- $2230 \cdot 0,45 \cdot 0,08 \cdot X = 12$
- $80,28X = 12$
- $X = 0,15$

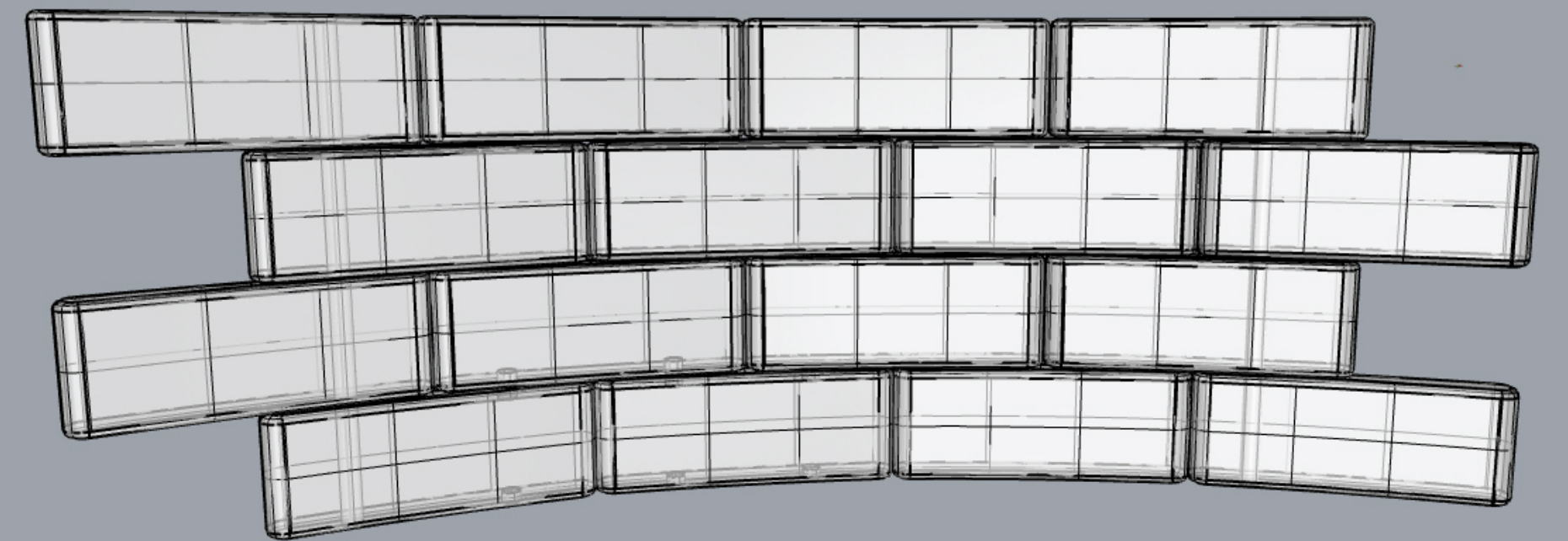
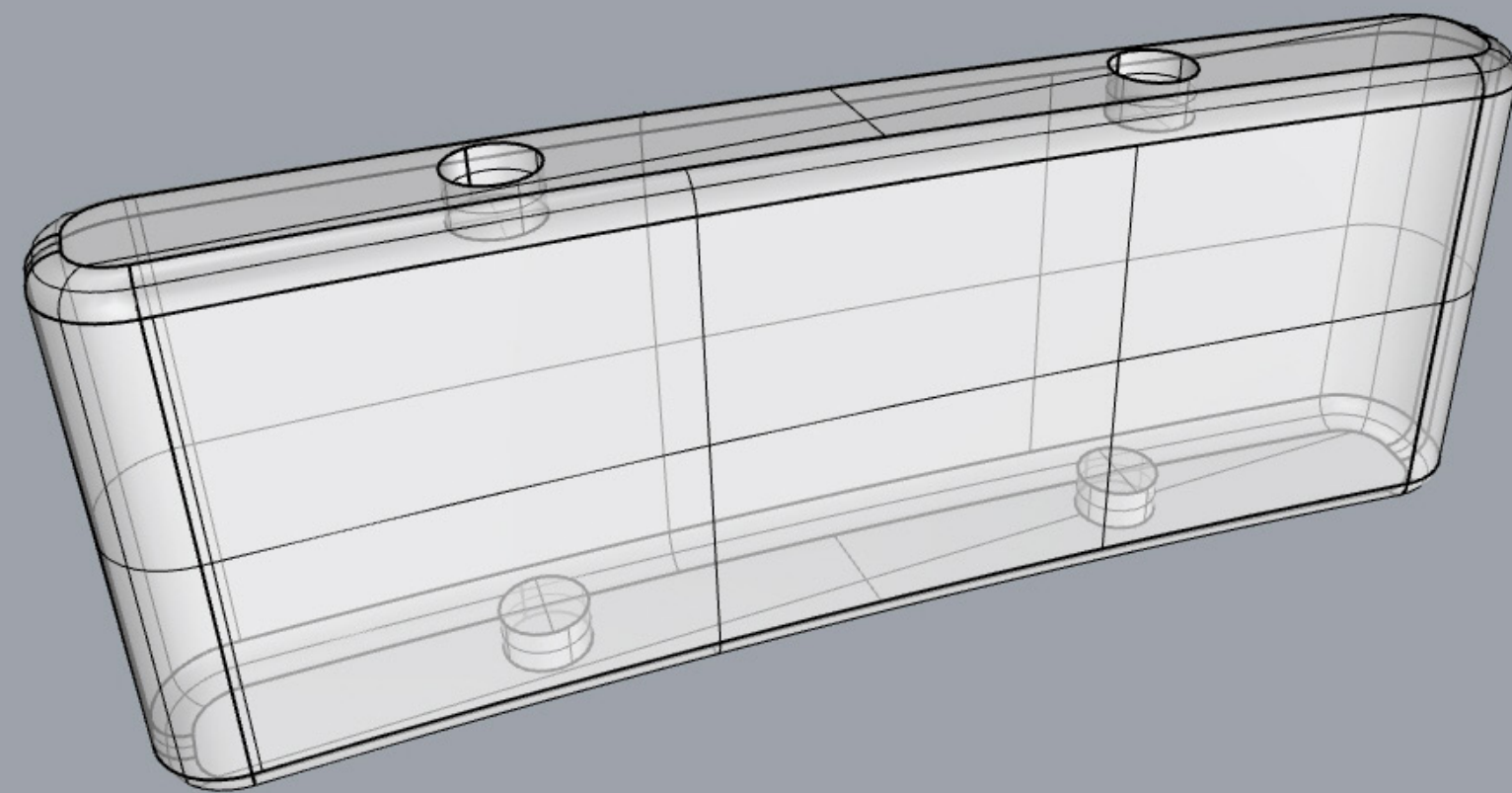
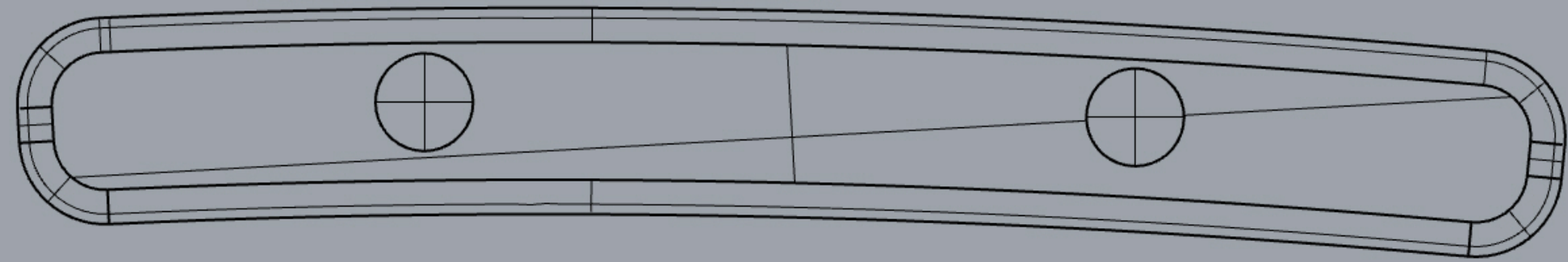
Notes:

- 6 cm is erg klein voor interlocking element
- maak iets van paar cm. is dat voldoende voor een steen van 45 cm breed en 17 hoog

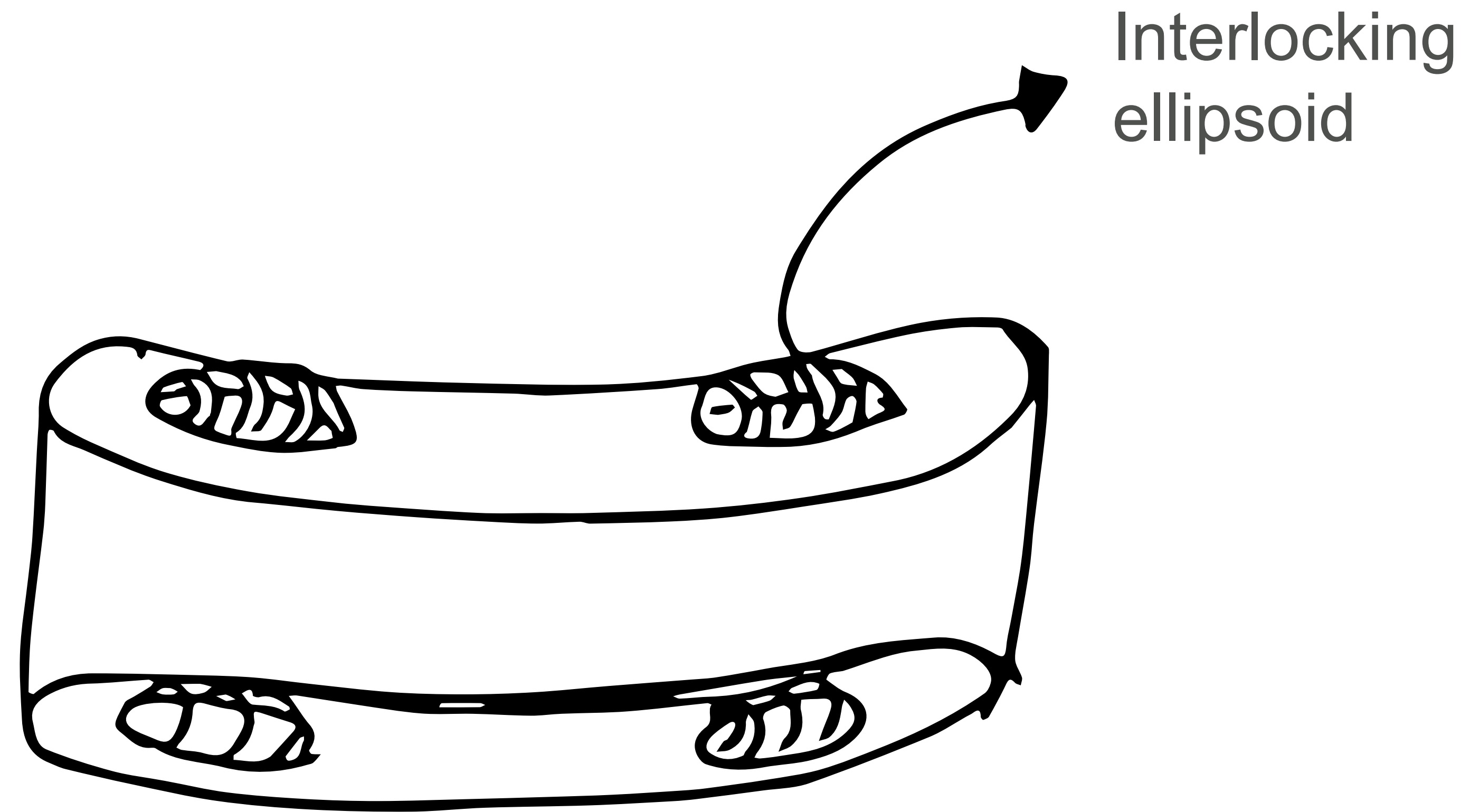
Curved and larger component



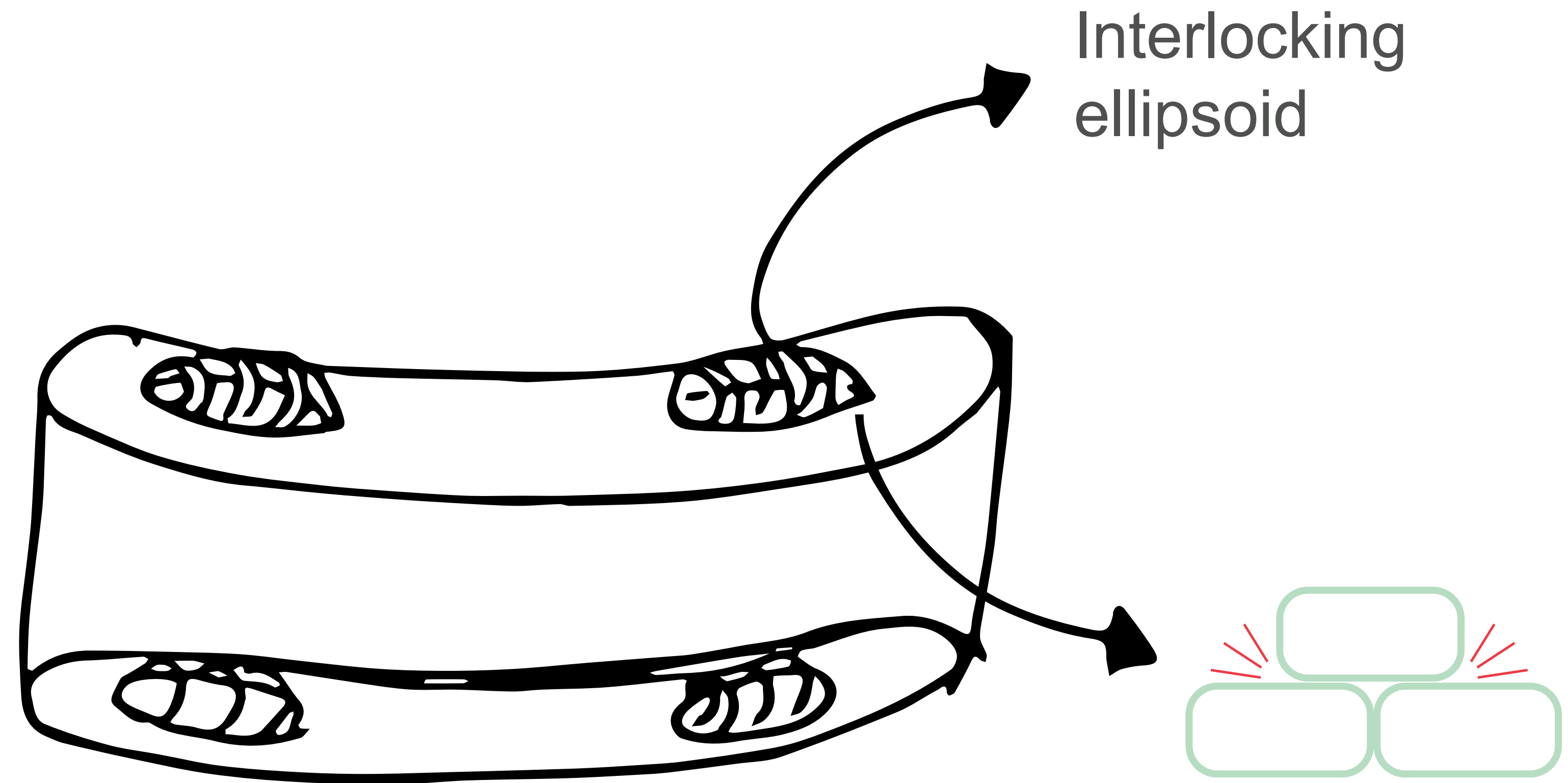
Interlocking spheres too small



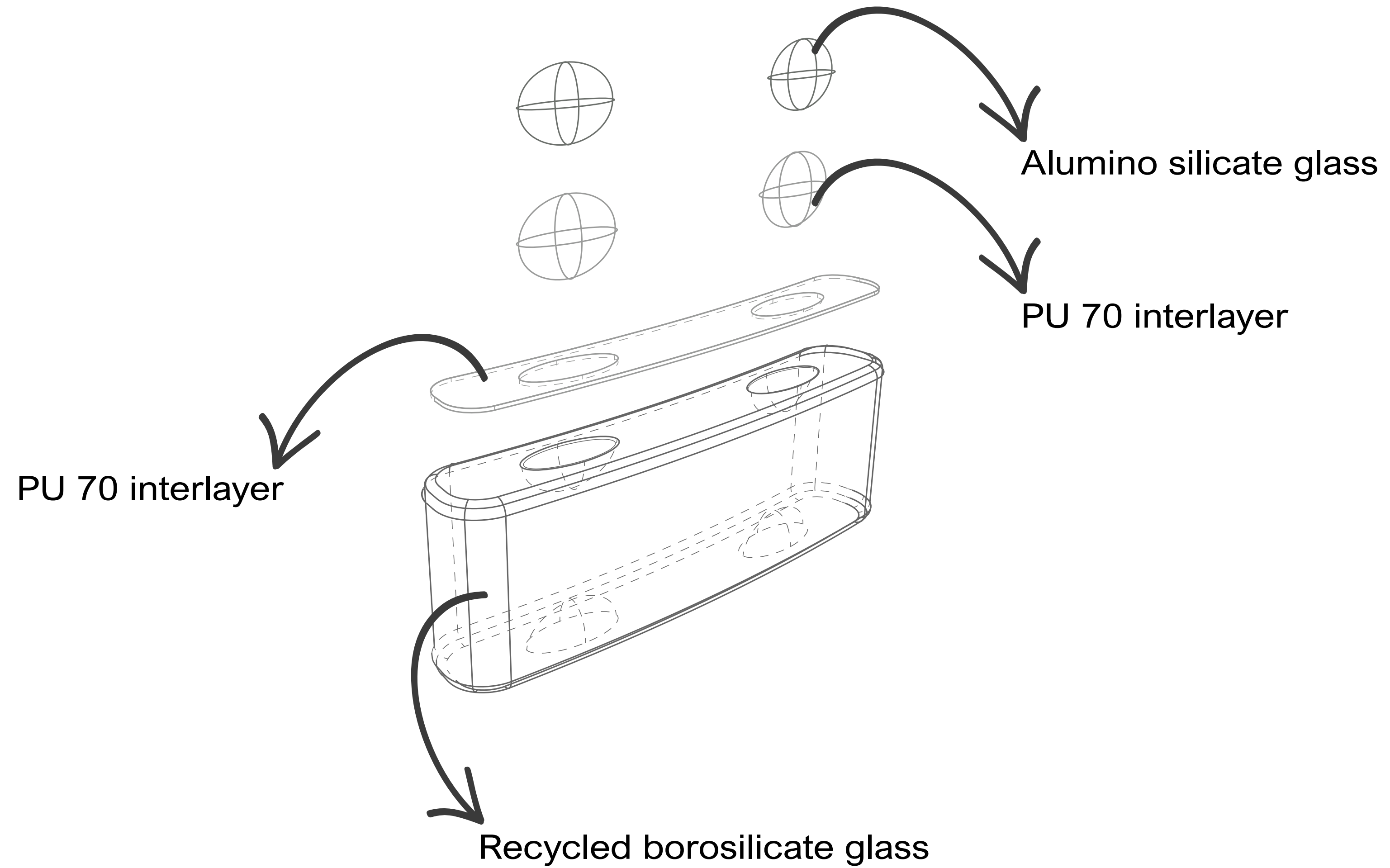
More surface area for shear force



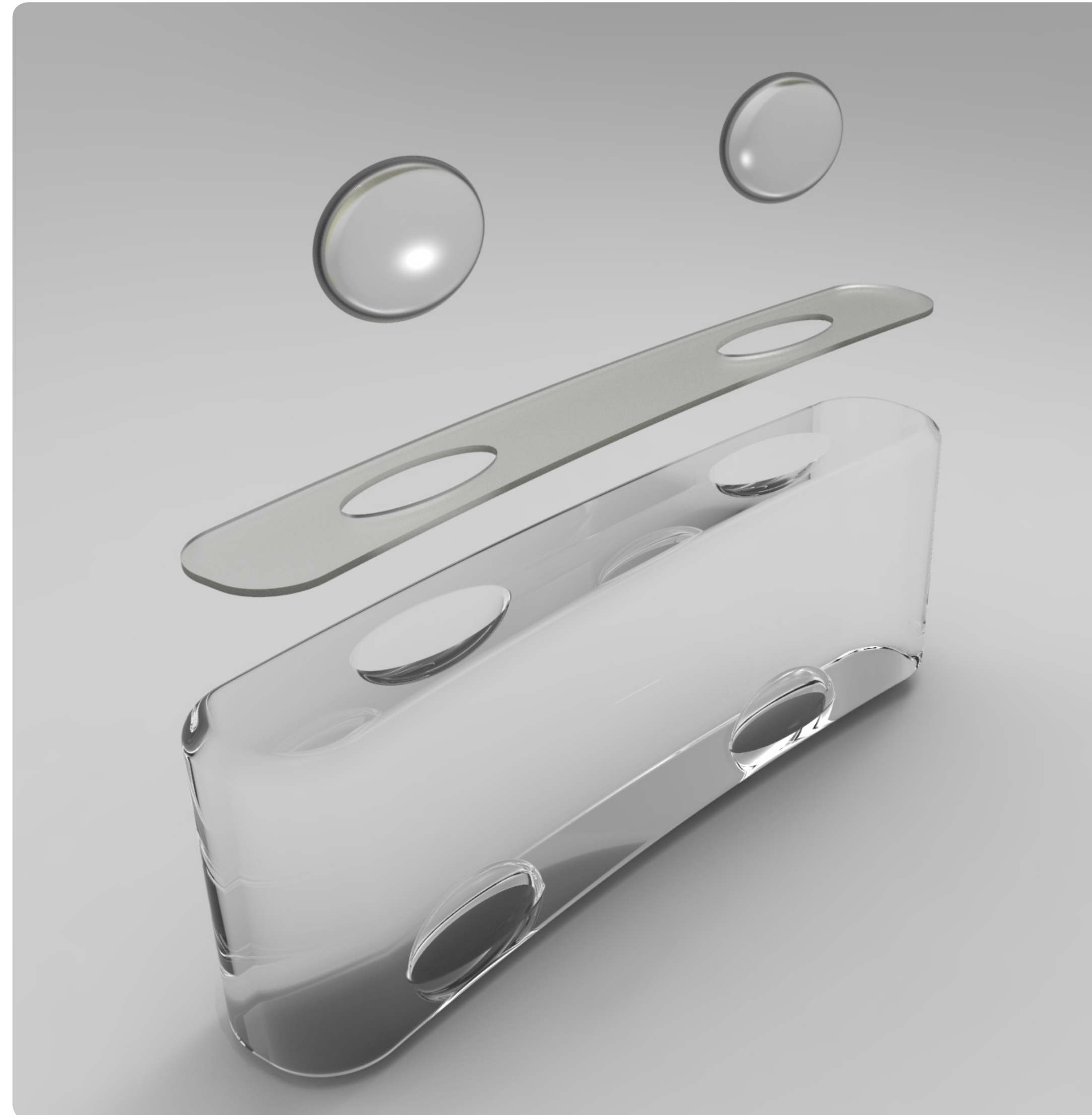
Shear key interlayer required



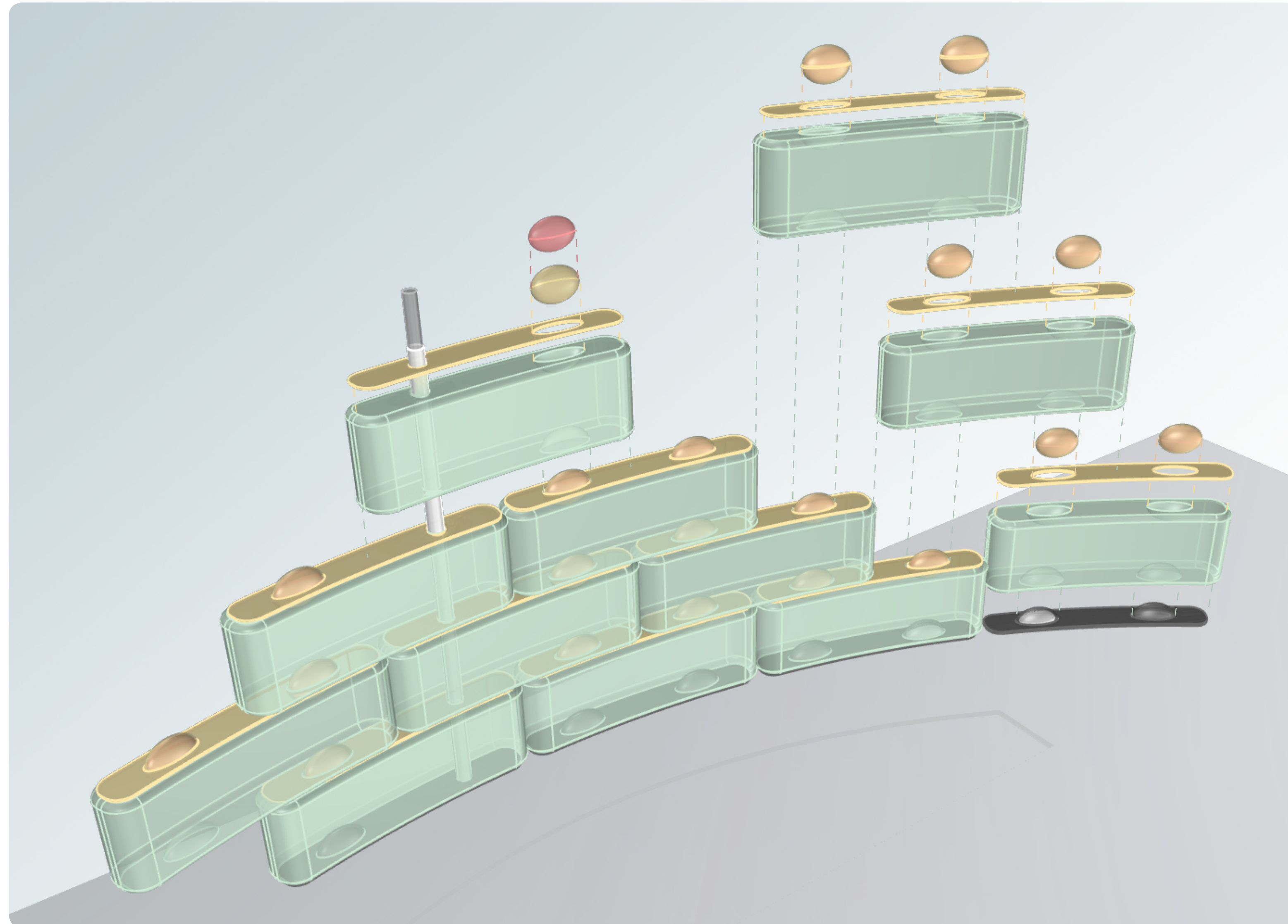
Final component design



Final component design

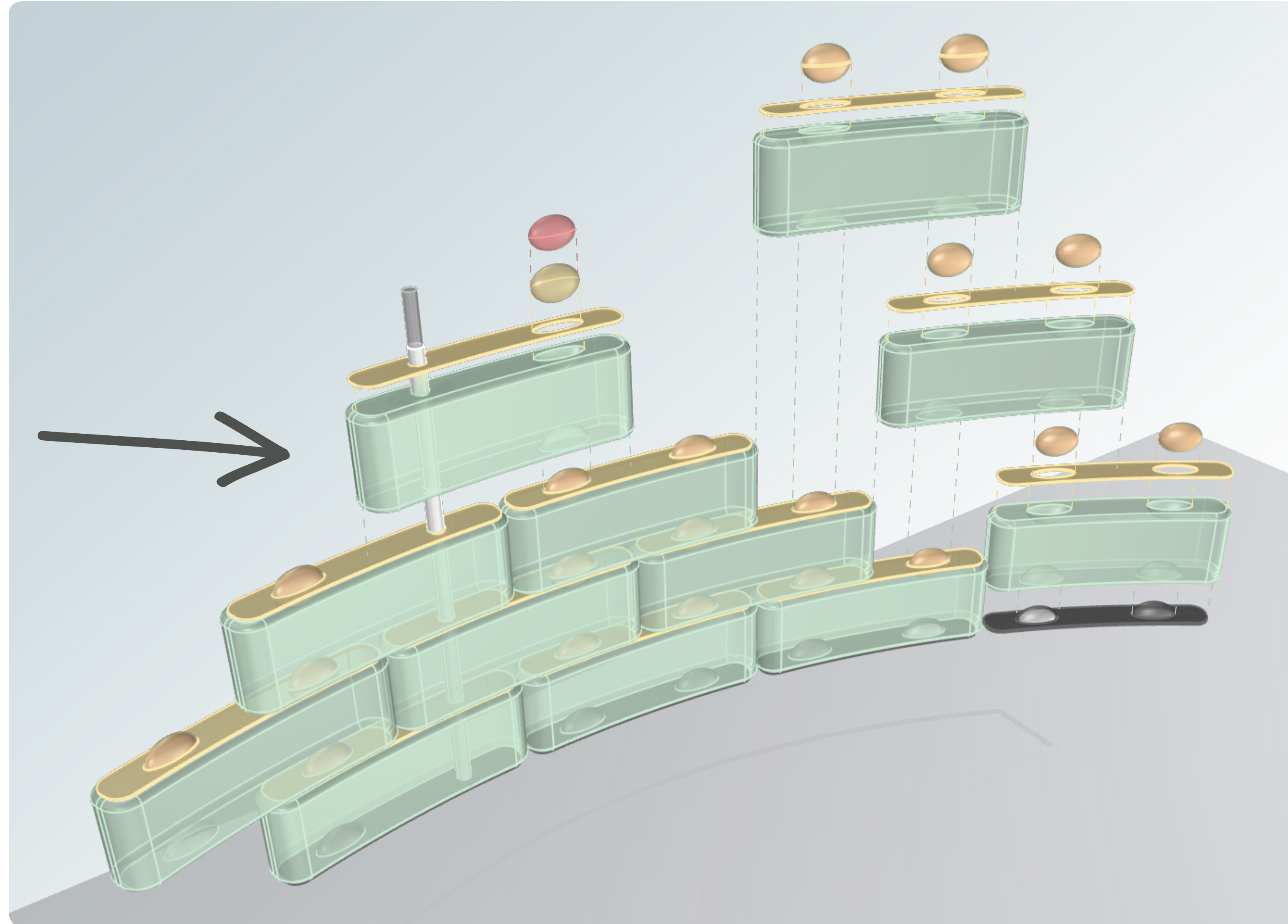


Assembly of interlocking components

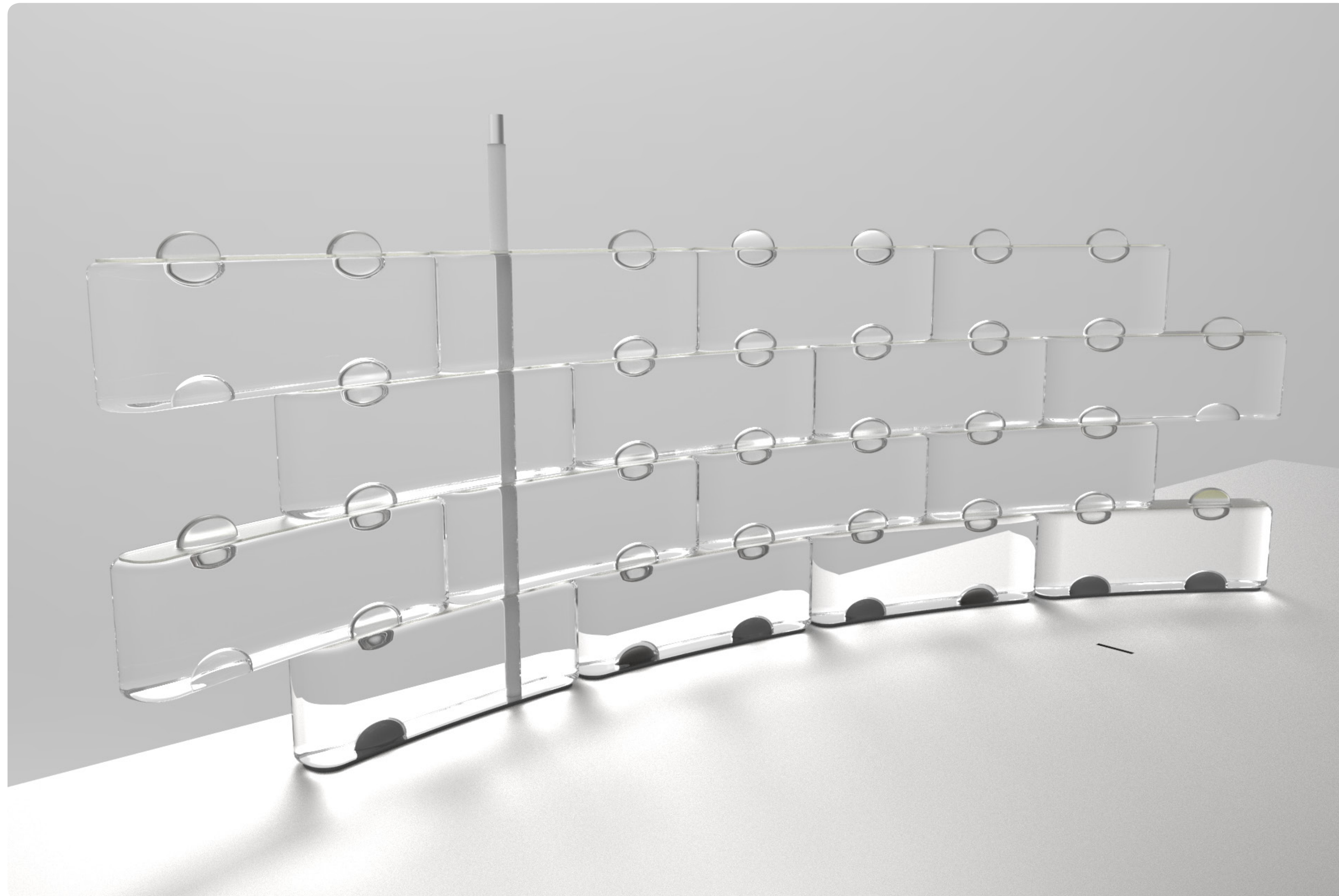


Assembly of interlocking components

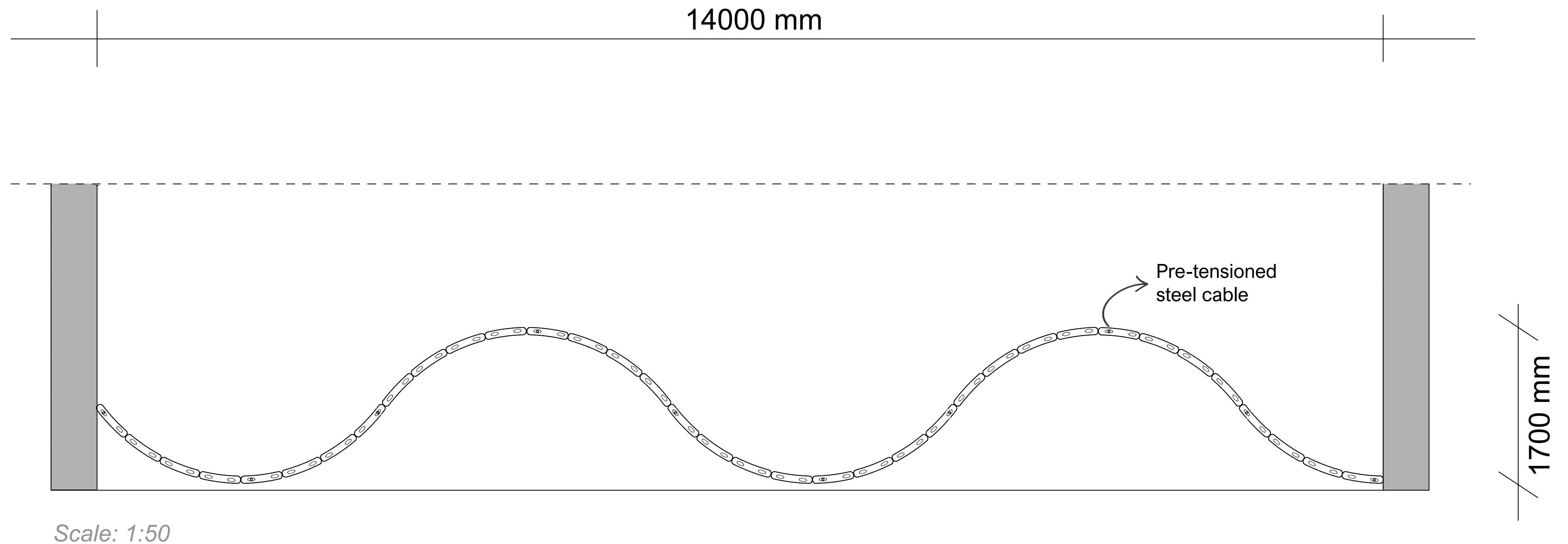
Different component with slender channel for pre-tensioned cable



Assembly of interlocking components



Top view component system in Casa da Música

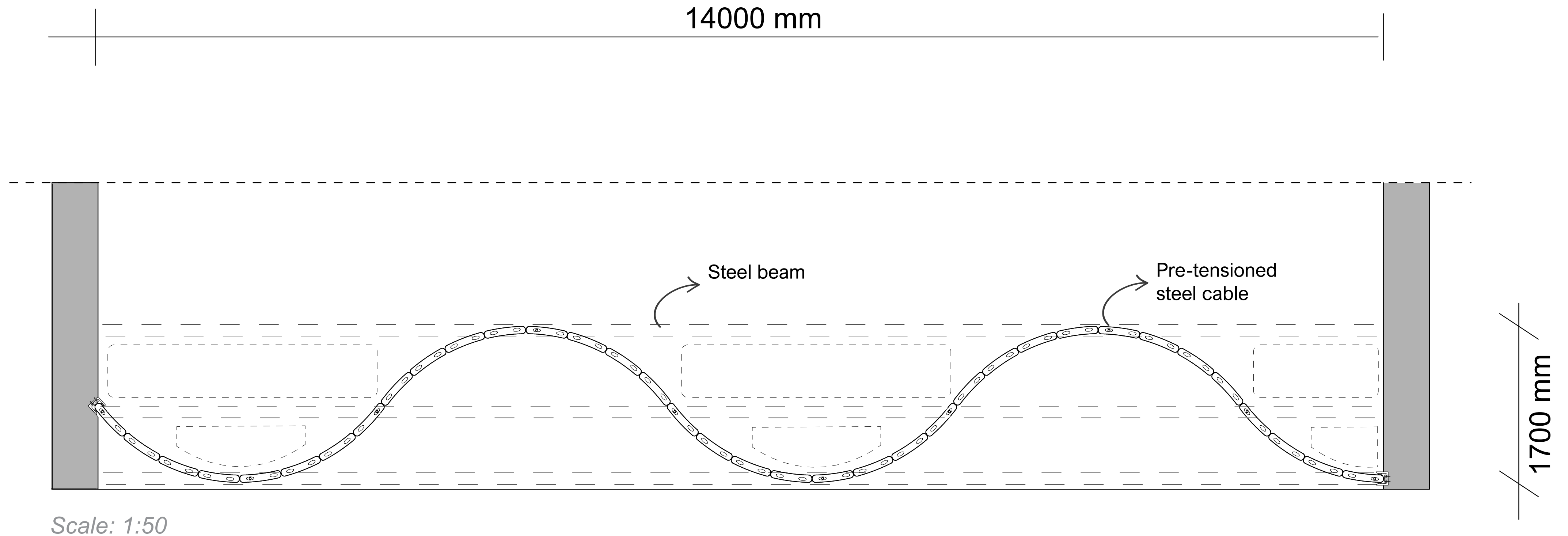


Component system in Casa da Música

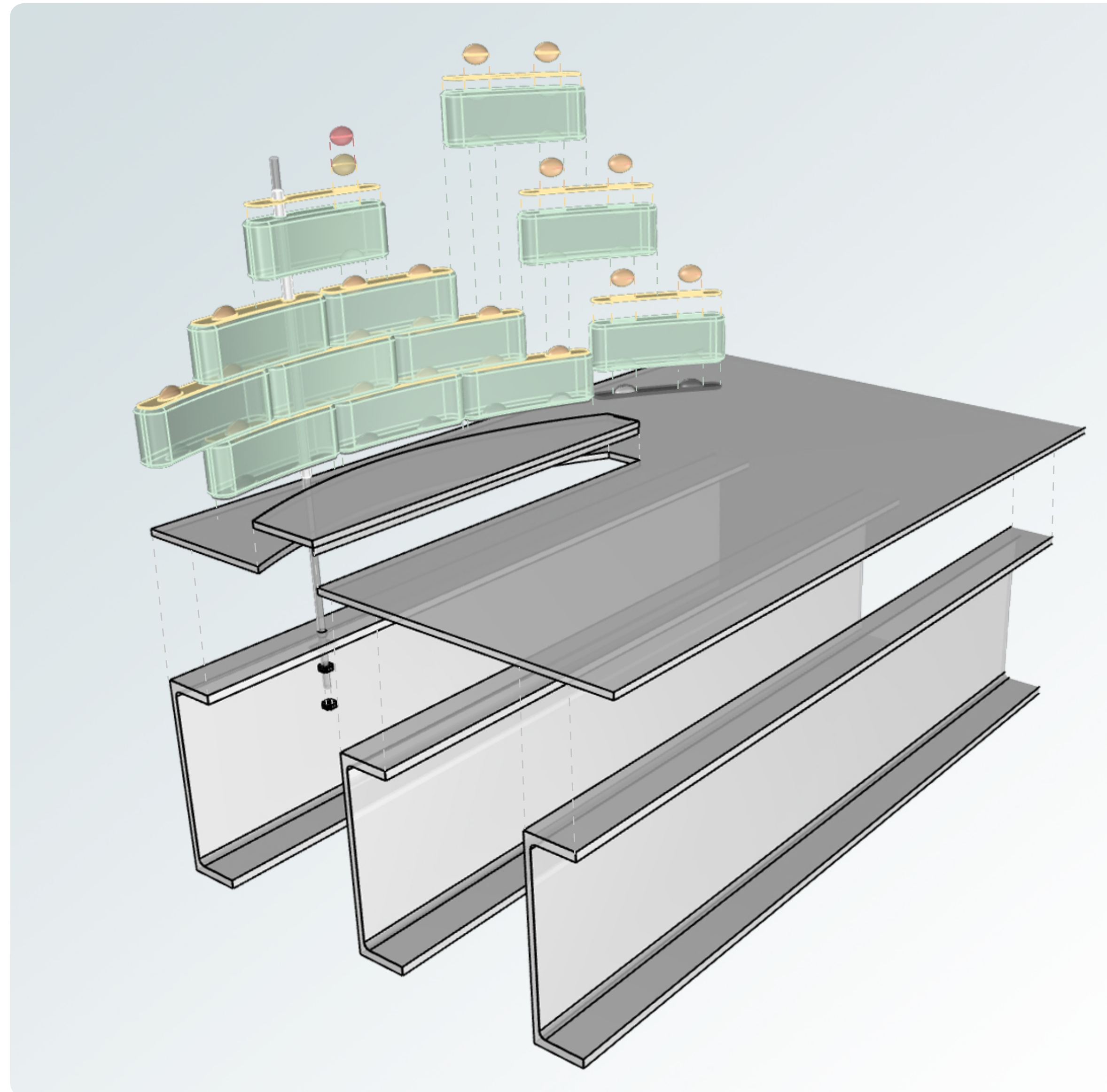


Fixing the facade to the building

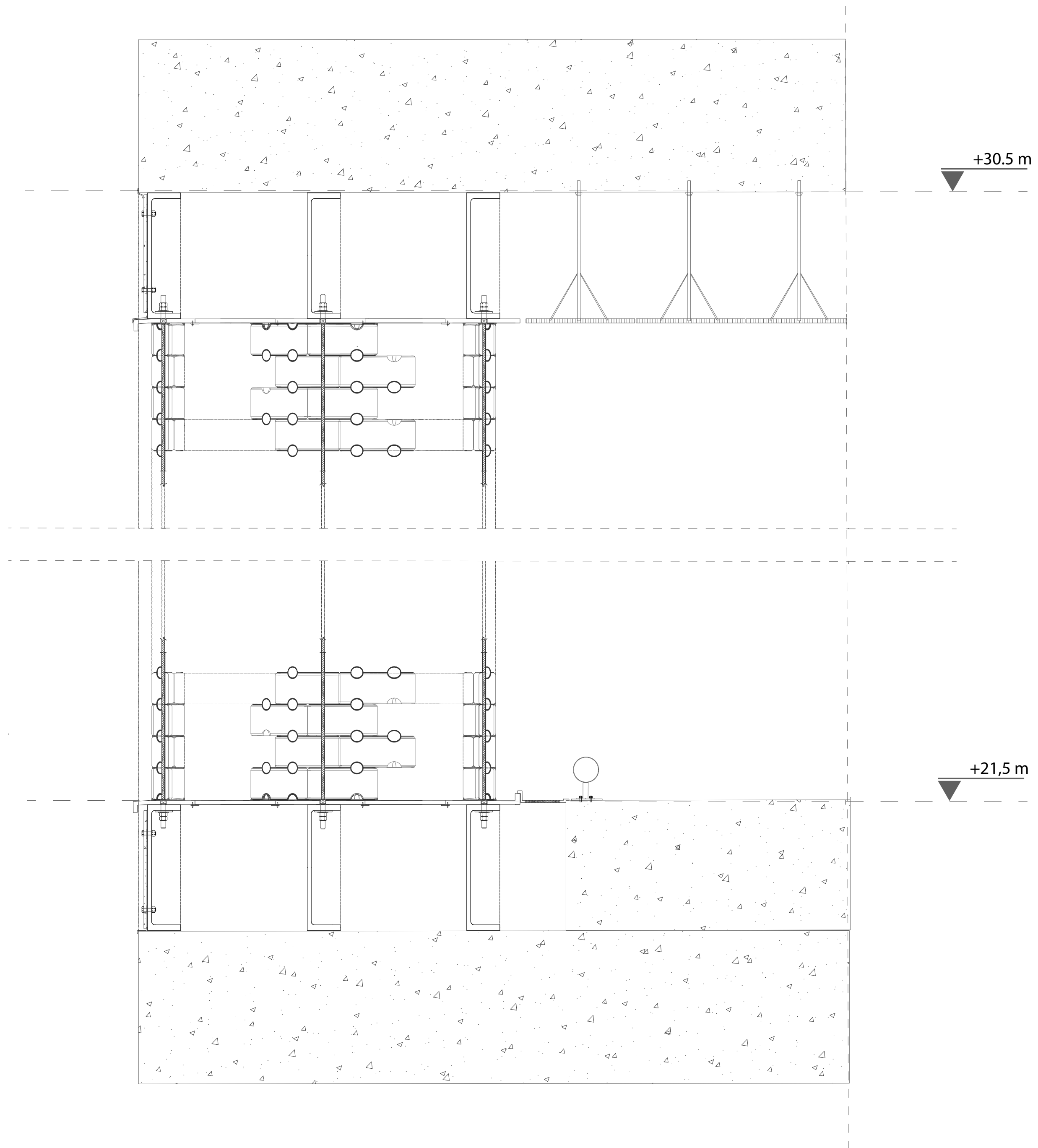
Three beams to carry the cables



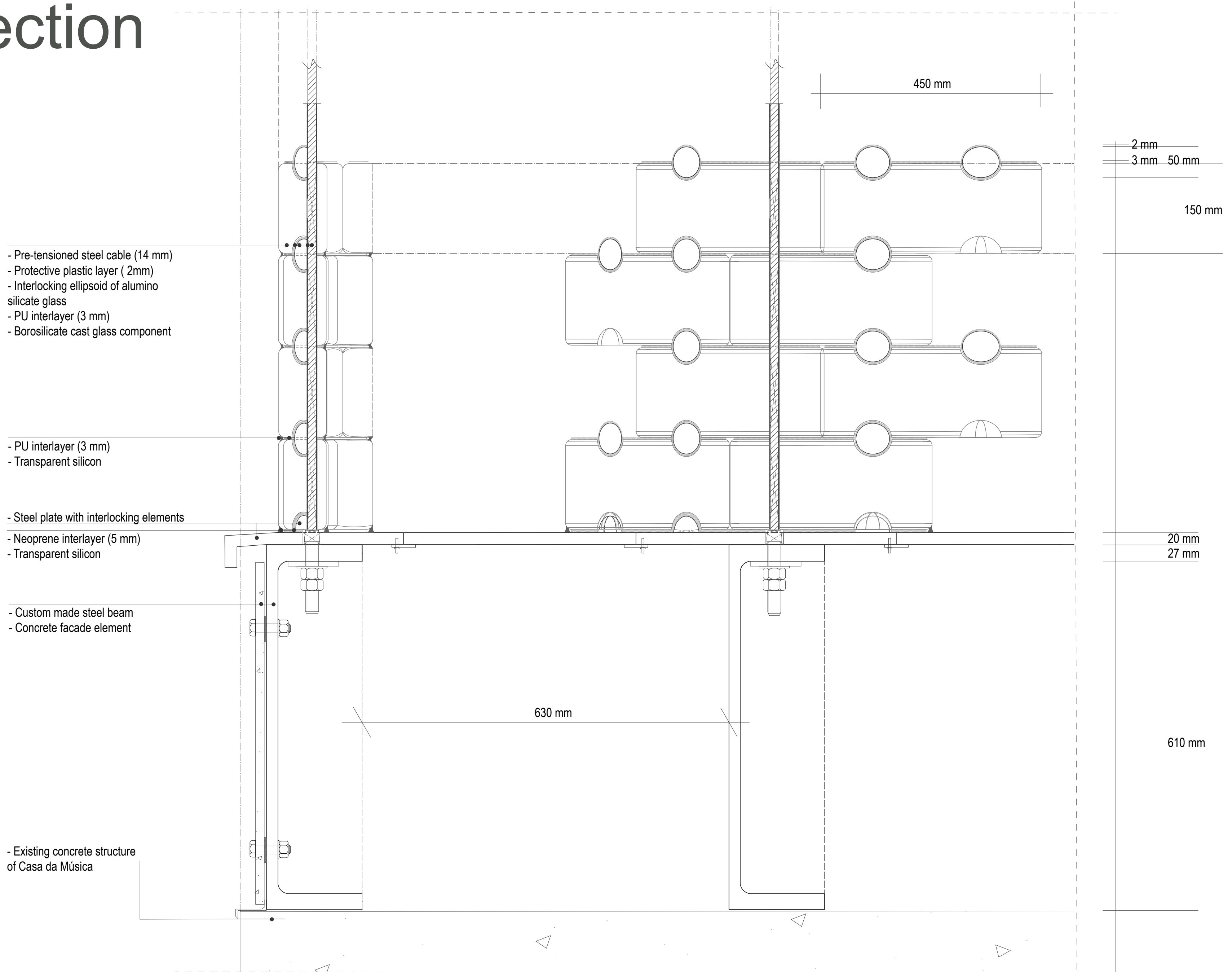
Exploded view system in Casa da Música



Vertical section 1:20



Vertical section 1:5



- Pre-tensioned steel cable (14 mm)
- Protective plastic layer (2mm)
- Interlocking ellipsoid of aluminosilicate glass
- PU interlayer (3 mm)
- Borosilicate cast glass component

- PU interlayer (3 mm)
- Transparent silicon

- Steel plate with interlocking elements
- Neoprene interlayer (5 mm)
- Transparent silicon

- Custom made steel beam
- Concrete facade element

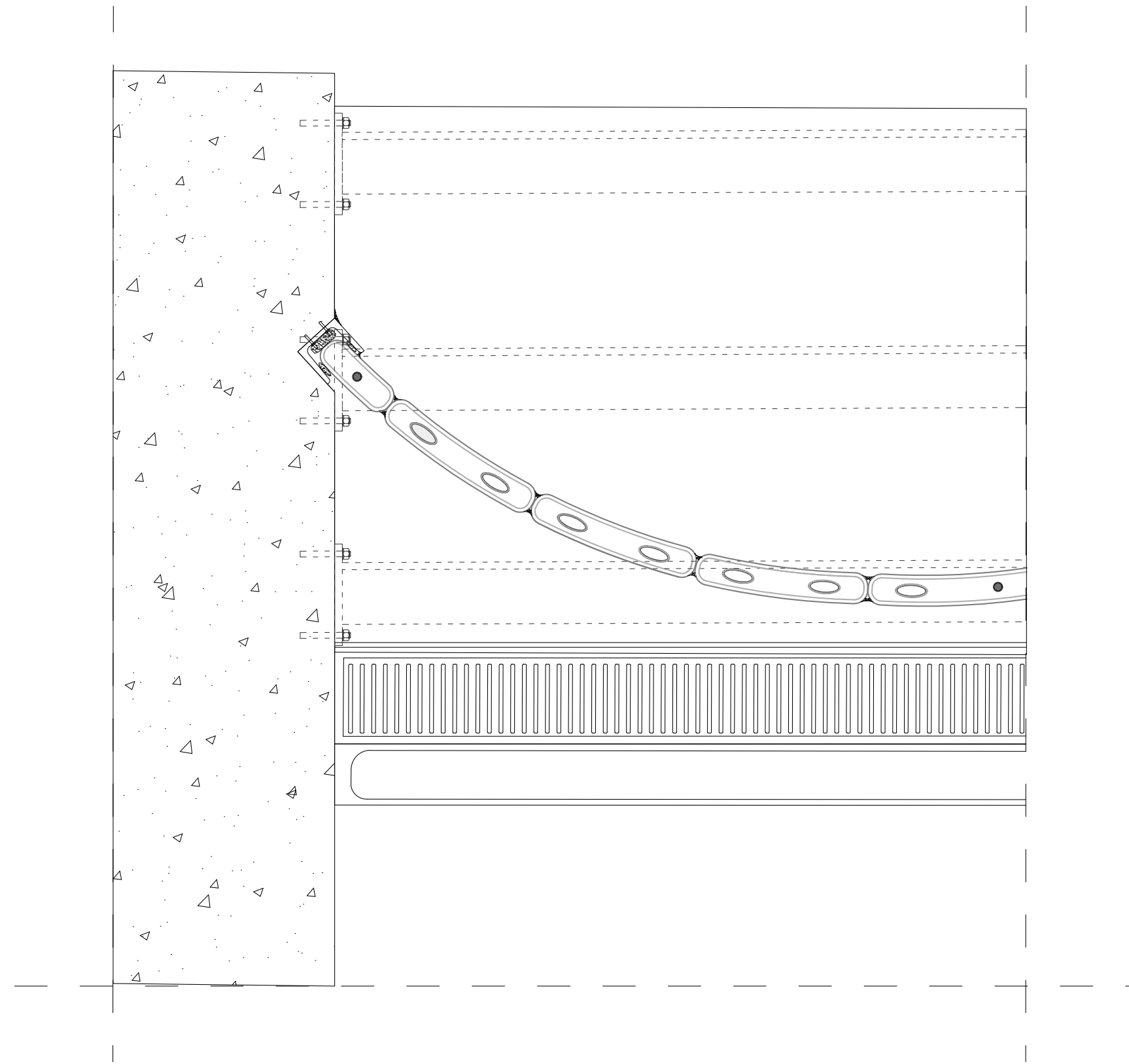
- Existing concrete structure of Casa da Música

2 mm
3 mm 50 mm
150 mm

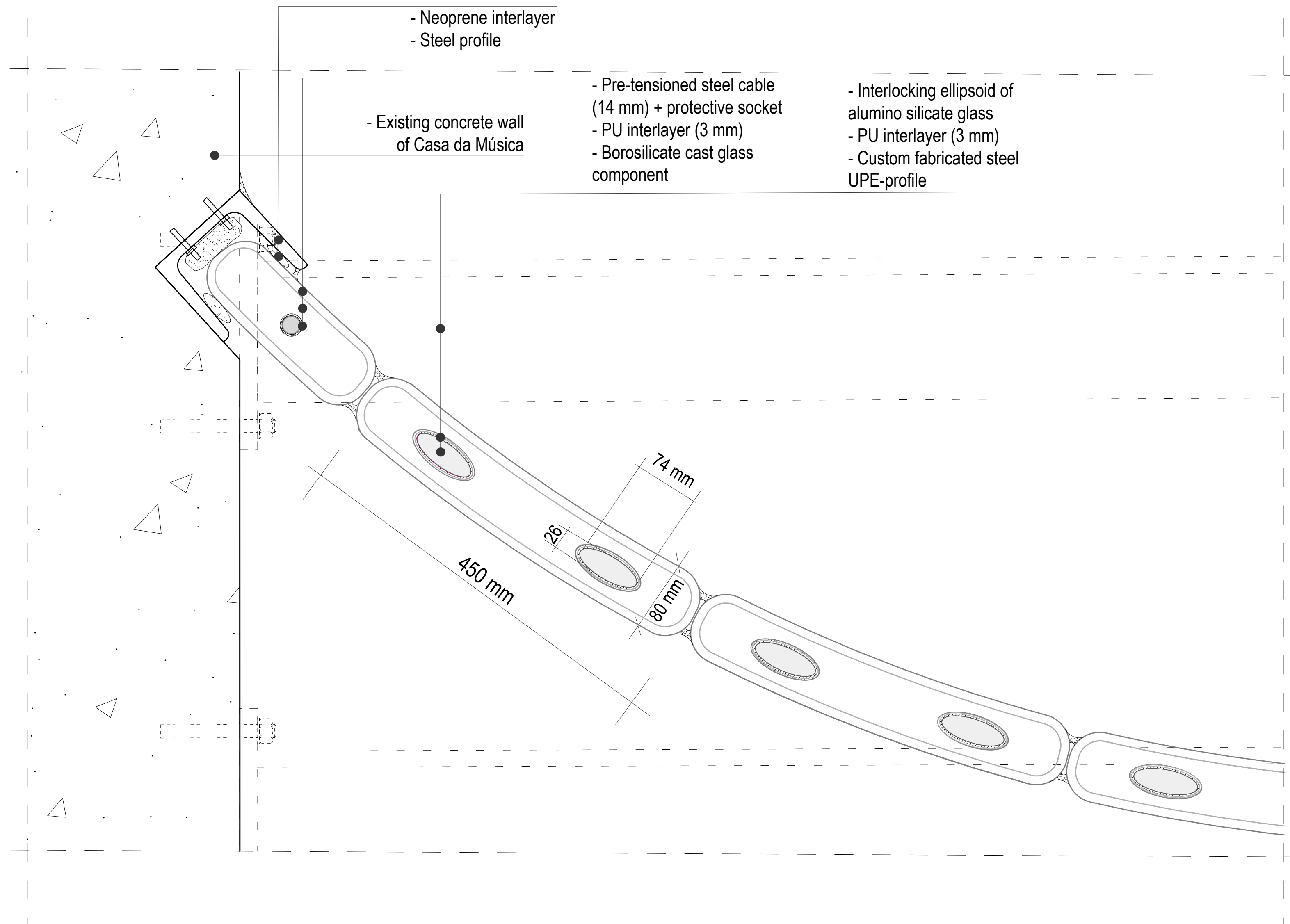
20 mm
27 mm

610 mm

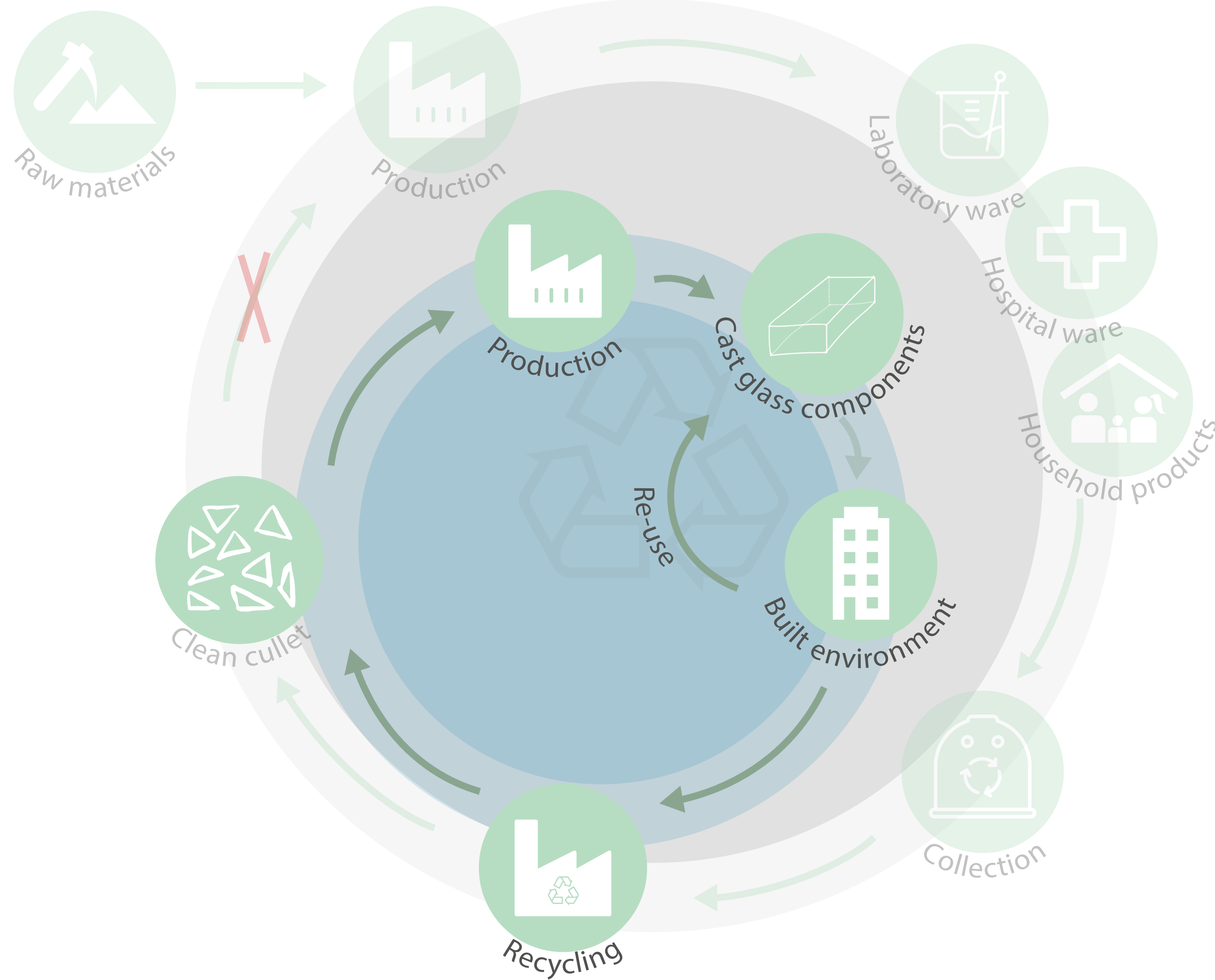
Horizontal section 1:20



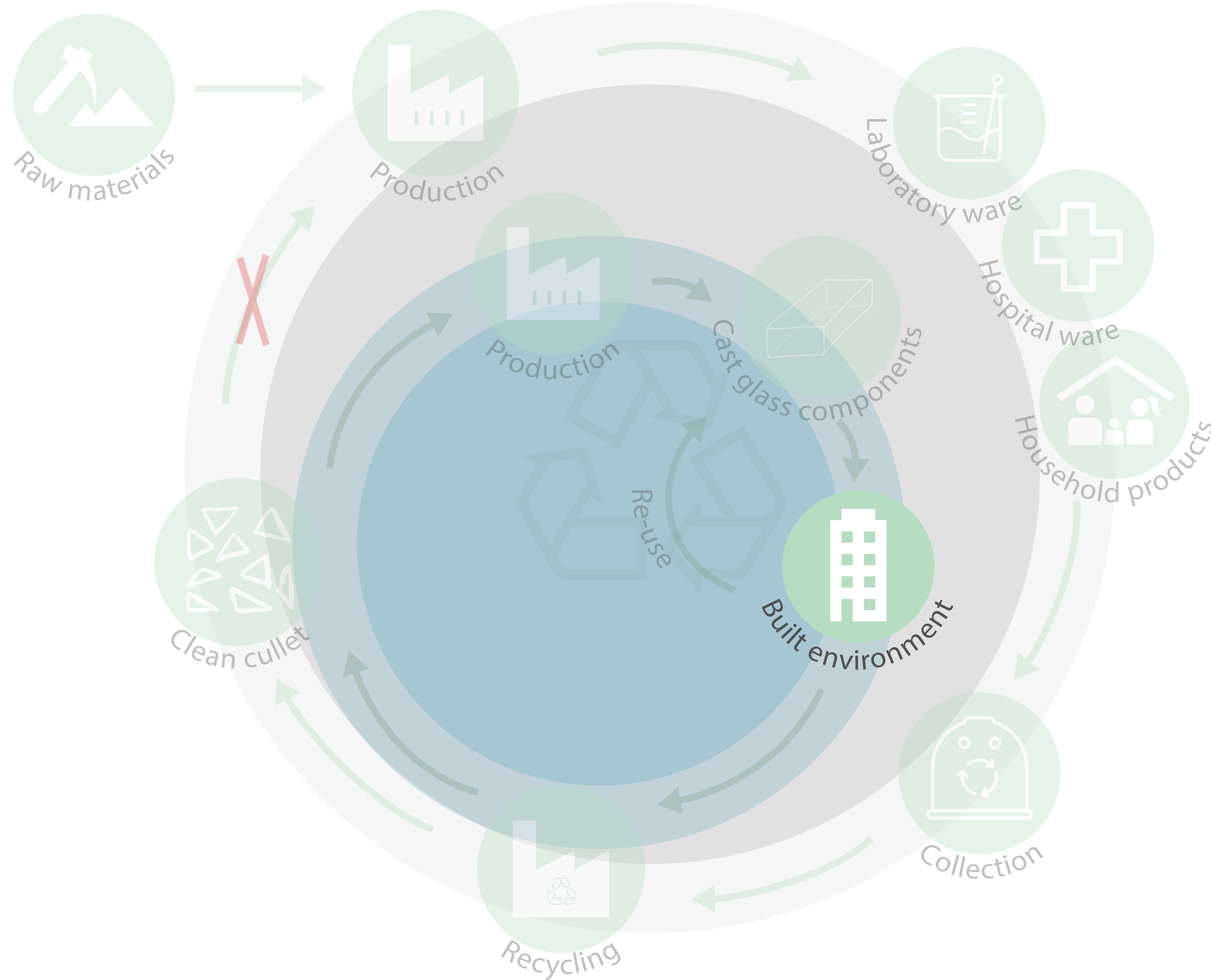
Horizontal section 1:5



Closed borosilicate glass loop



Built environment?





Built environment

- Public buildings
- Not aimed at private consumers



Probably not enough borosilicate glass waste for consumer market

- Public buildings are eye-catchers,
serve as showcases for:



Built environment

- Public buildings
- Not aimed at private consumers

→ Probably not enough borosilicate glass waste for consumer market

- Public buildings are eye-catchers, serve as showcases for:

→ Reusability

→ Recycling

End-of-life -- reuse & recycling

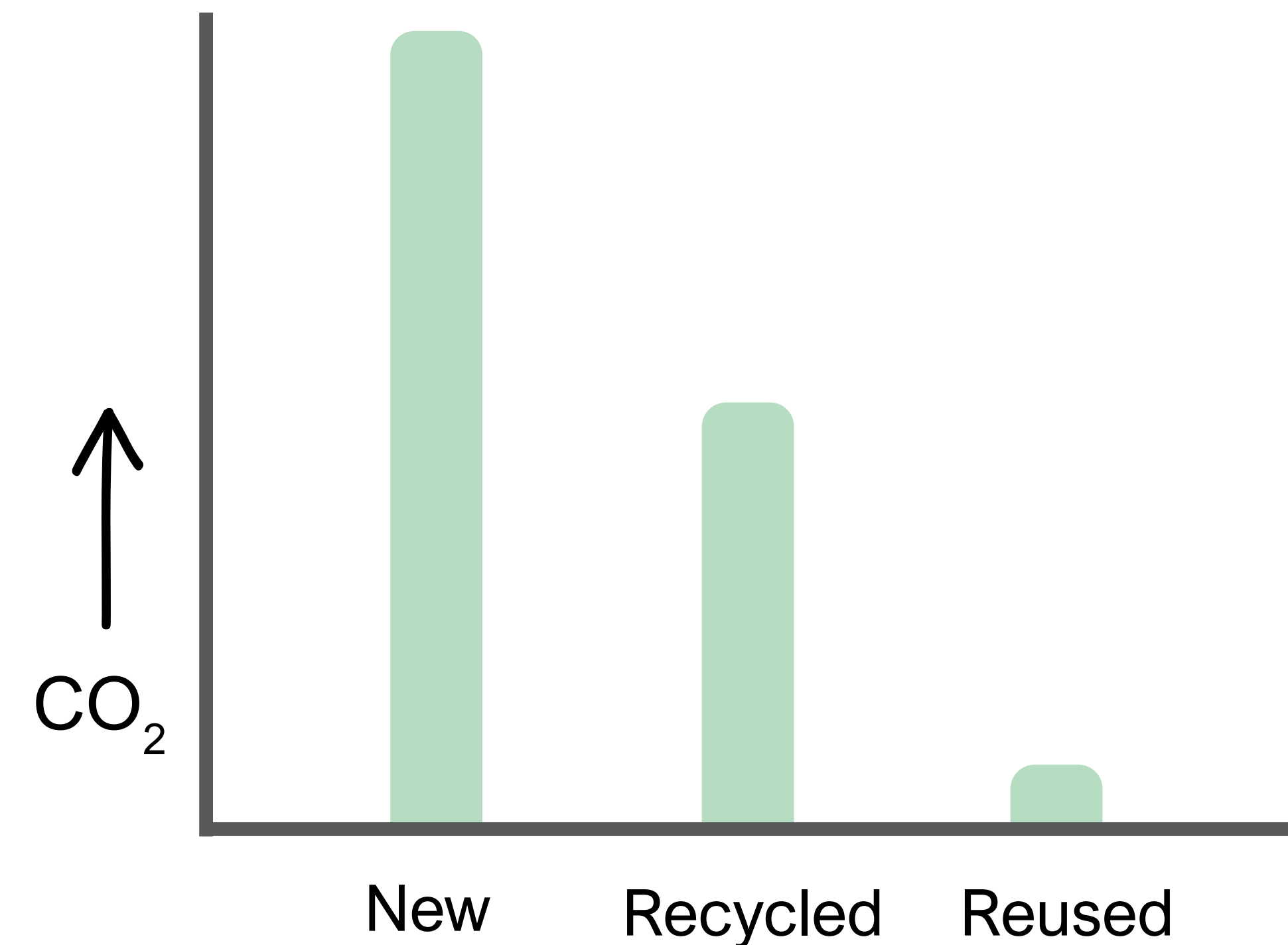
- Recycling of facade components

- Easy collection
- Less contamination
- Low CO₂ emissions

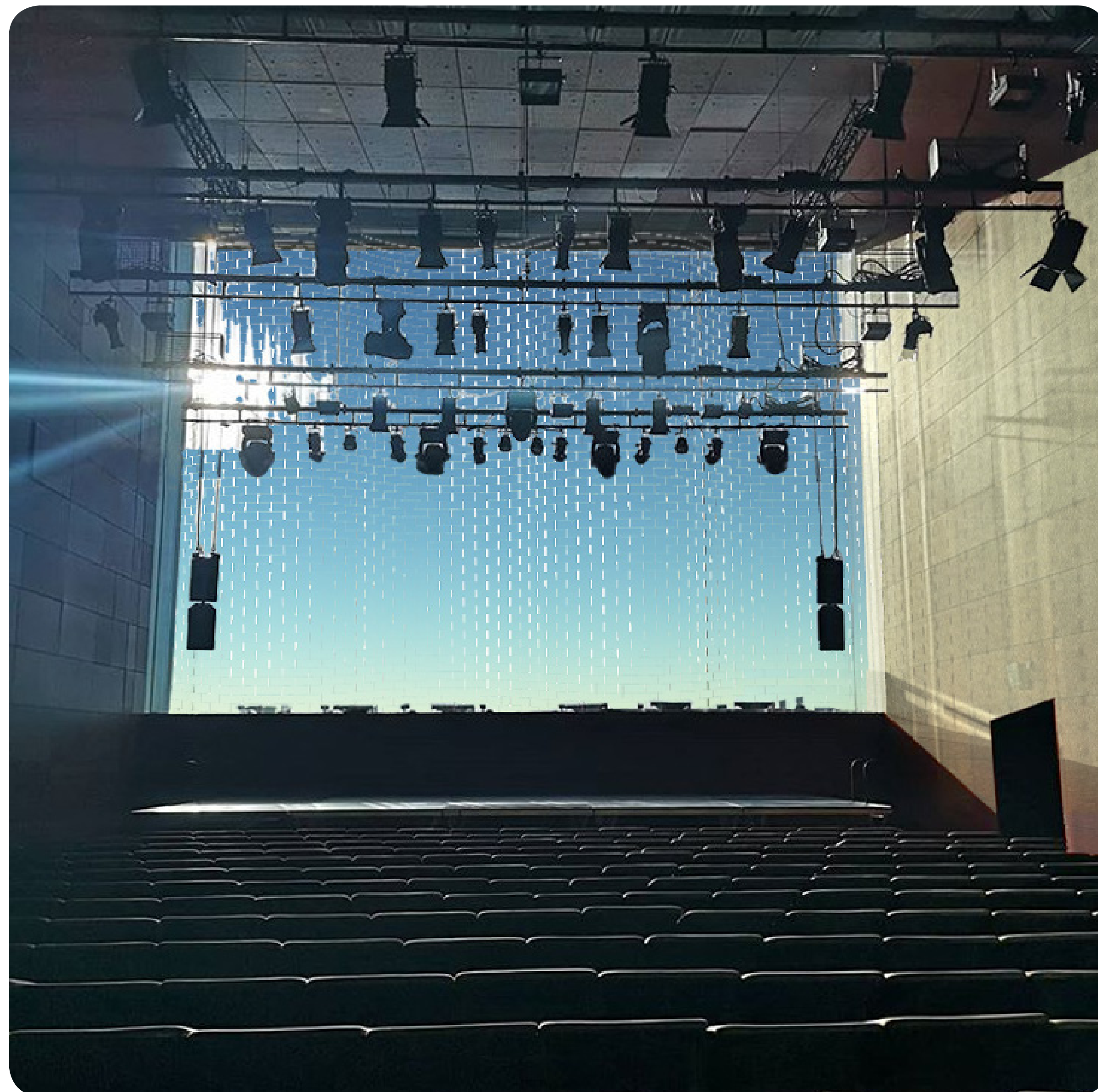
- Reuse of facade components

- Even lower CO₂ emissions
- Different configurations possible

CO₂ emission of cast glass component production




Showcase



Conclusions & recommendations design

Conclusions & recommendations design

- Dry-interlocking cast glass facade system is feasible
 - Application in case study building not ideal
 - Facade is heavy, but elevated
 - Not a lot of space for fixing the facade system
 - Consider application of facade early in design
 - Self-supporting facade seems feasible
- Investigating structural facade could be interesting

A 3D rendering of a laboratory rack holding several test tubes. The rack is made of a clear, transparent material and has a vertical rod in the center. The test tubes are arranged in a grid pattern, with some containing a dark liquid. The background is a plain, light gray surface. The text 'GENERAL CONCLUSIONS & RECOMMENDATIONS' is overlaid in the center of the image in a bold, white, sans-serif font.

GENERAL CONCLUSIONS & RECOMMENDATIONS

Borosilicate in the built environment

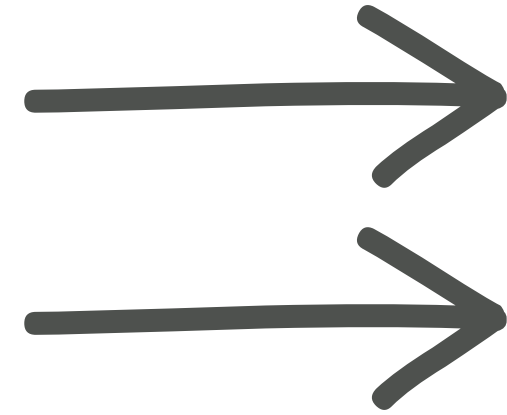
- Not frequently applied



expensive

Borosilicate in the built environment

- Not frequently applied
- Ends up as waste

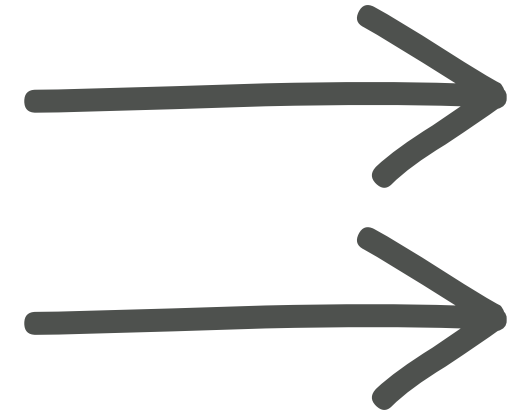


expensive

loss of high-quality glass

Borosilicate in the built environment

- Not frequently applied
- Ends up as waste



expensive

loss of high-quality glass

- Researched potential application




experiments & case study

Experiments

- Indicate good potential as material in the built environment

Experiments

- Indicate good potential as material in the built environment
- Preliminary nature of research  small number of specimens

Experiments

- Indicate good potential as material in the built environment
- Preliminary nature of research → small number of specimens
- For proper further evaluation → more specimens

Design

- Showed promising way of using high-quality glass properties

Design

- Showed promising way of using high-quality glass properties

- Though issues were observed



implementation should be
integral from the start

Vision

- Components not intended for consumer market

→ not enough waste

Vision

- Components not intended for consumer market

→ not enough waste

- Instead, application in public buildings

Vision

- Components not intended for consumer market

→ not enough waste

- Instead, application in public buildings

- Prominent buildings, so:

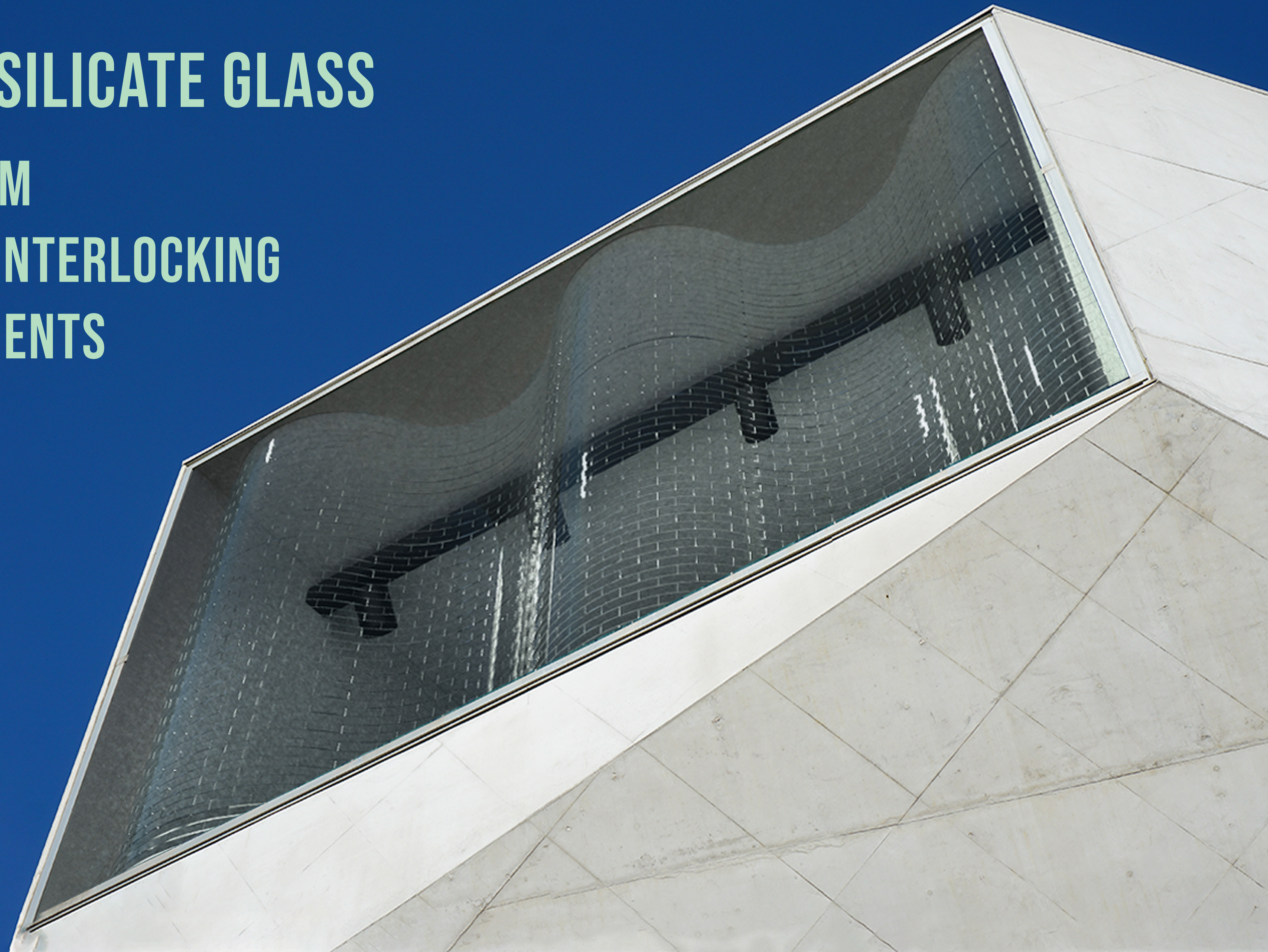
→ showcase of recyclability

→ expand applicability of recycled glass with unconventional design

RECYCLING BOROSILICATE GLASS FOR A FACADE SYSTEM ASSEMBLED OF DRY-INTERLOCKING CAST GLASS COMPONENTS IMPLEMENTED IN CASA DA MÚSICA

Eliza Scholtens - April 8th,
2019 - P5 Presentation

Tutors:
Faidra Oikonomopoulou
Tillmann Klein
Telesilla Bristogianni





RECYCLING BOROSILICATE GLASS
FOR A FACADE SYSTEM
ASSEMBLED OF DRY-INTERLOCKING
CAST GLASS COMPONENTS
IMPLEMENTED IN
CASA DA MÚSICA

Thank you

Eliza Scholtens - April 8th,
2019 - P5 Presentation

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