Innovation in Renovation

Optimizing interior insulation application workflow

Presented by:

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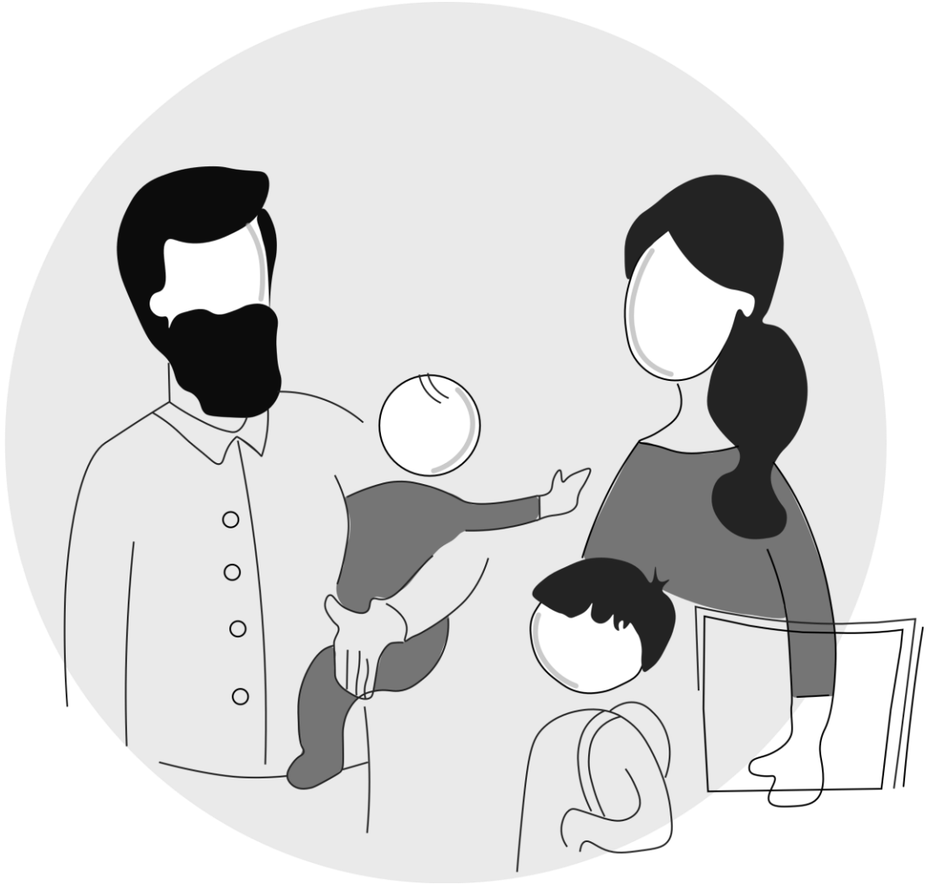
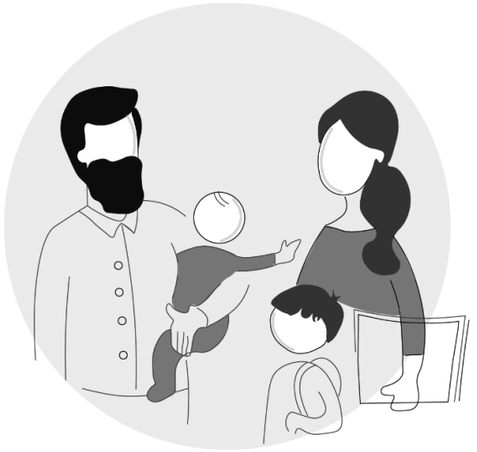
Thaleia Konstantinou



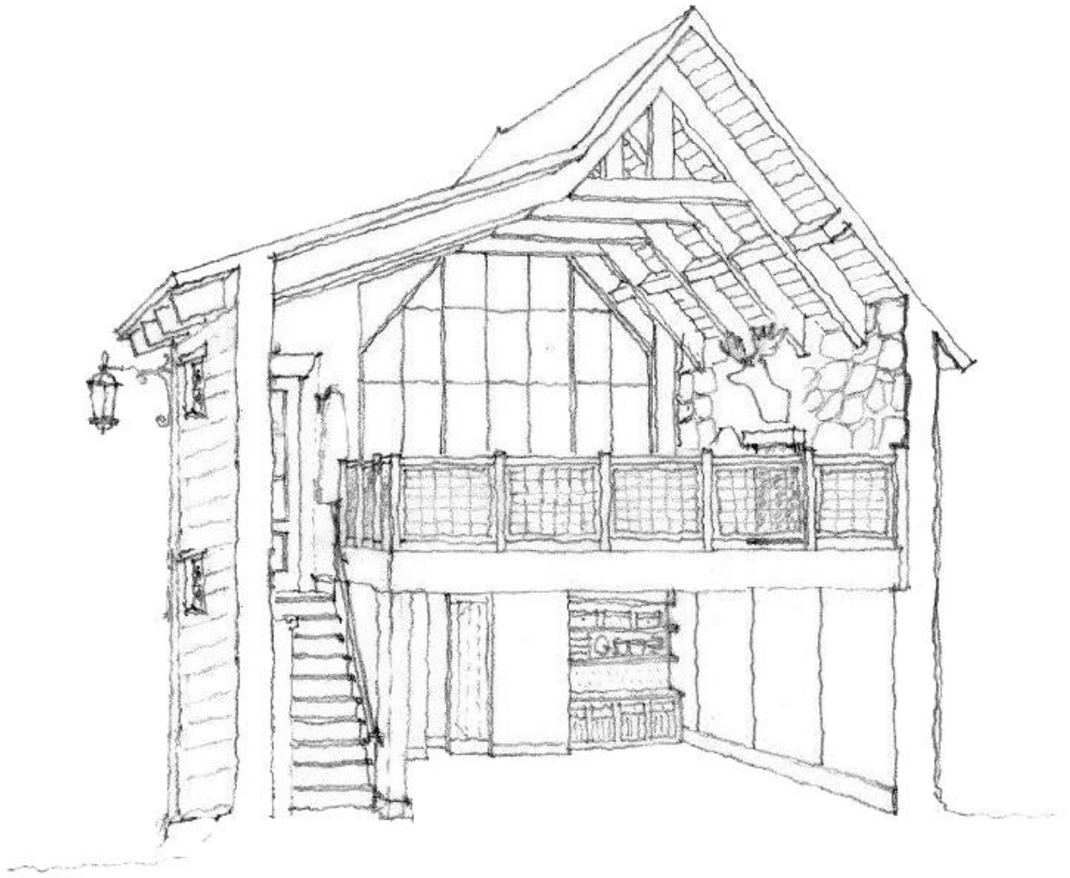


Amsterdam Canal house |
http://elles.nl

Insulate

Lower energy bills

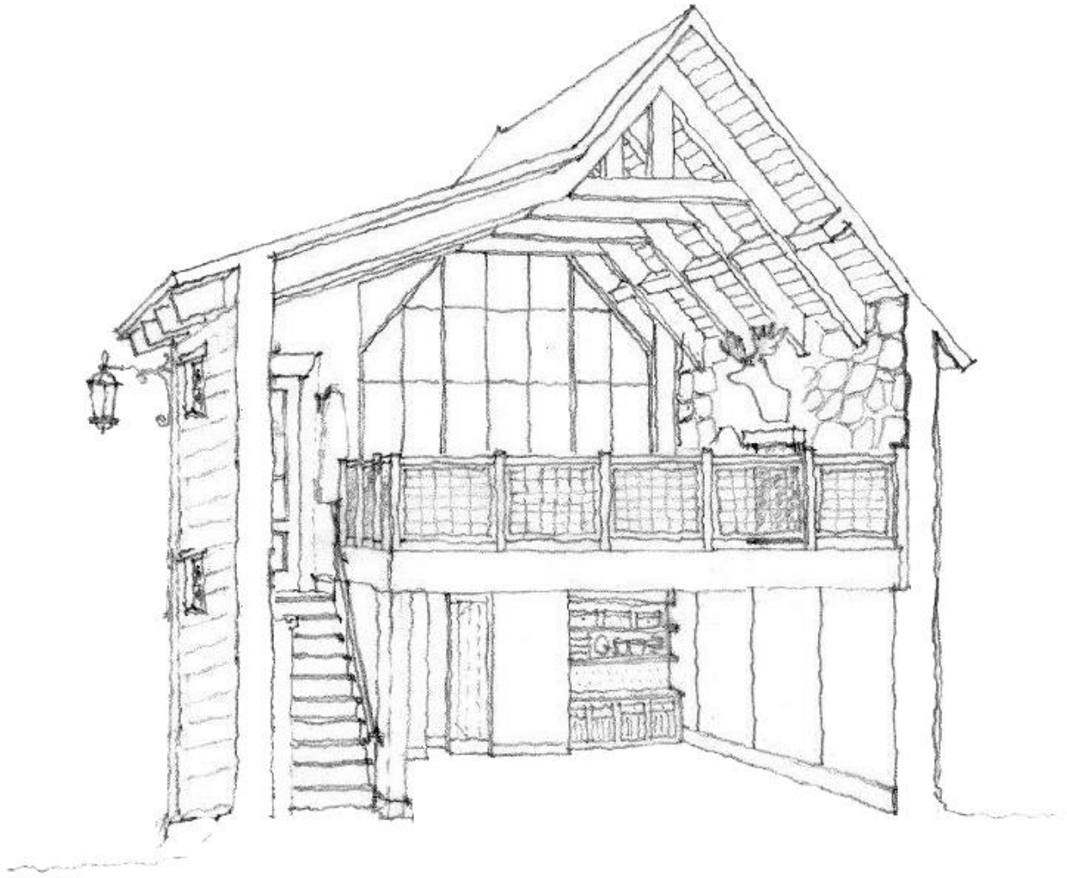
Sustainable living



Protected building

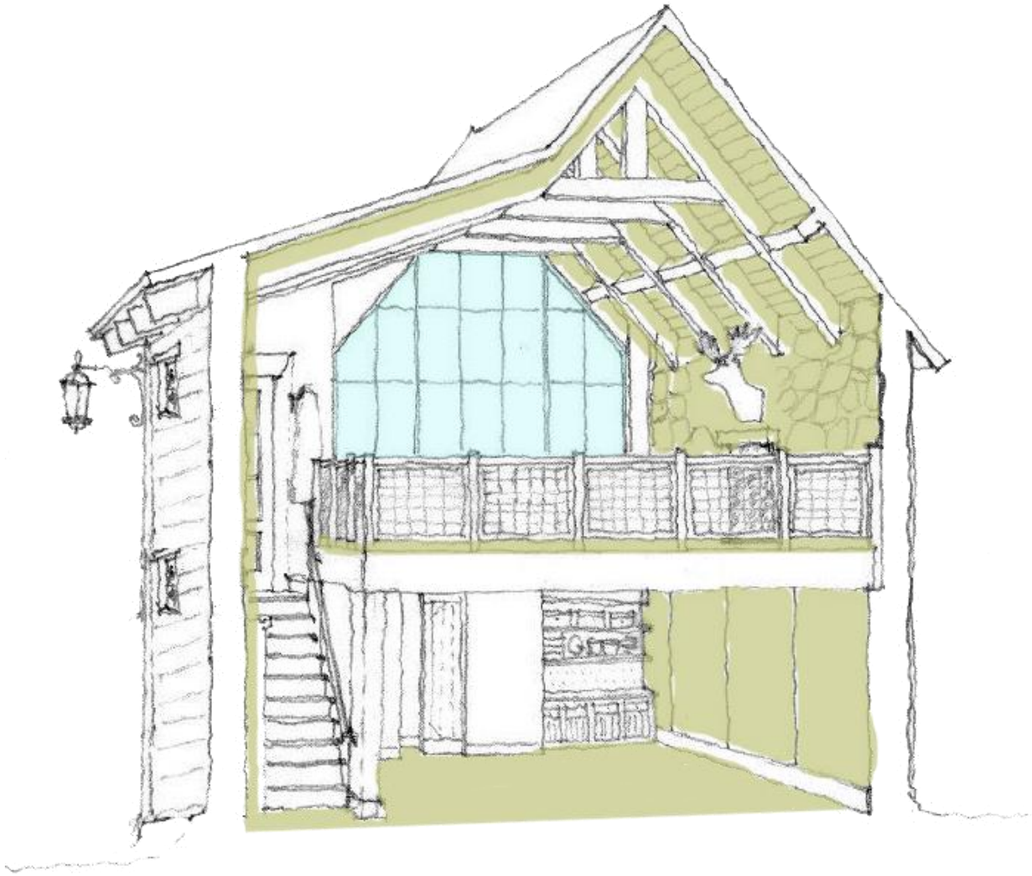
No exterior interventions

Limited space



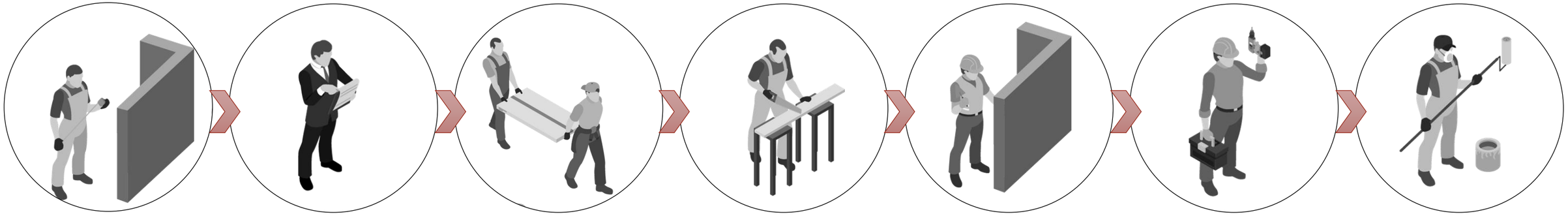
Protected building

Interior insulation application



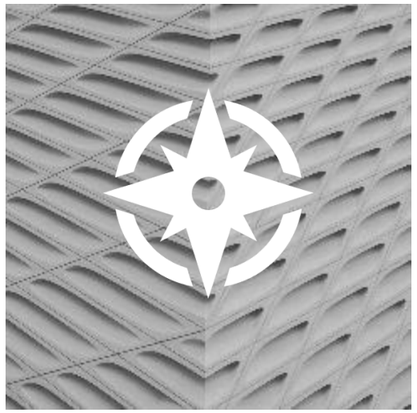
Insulation workflow

Current on site workflow



Measurement	Material selection	Procurement	Sizing	Preparation	Fitting	Finish

Problem statement

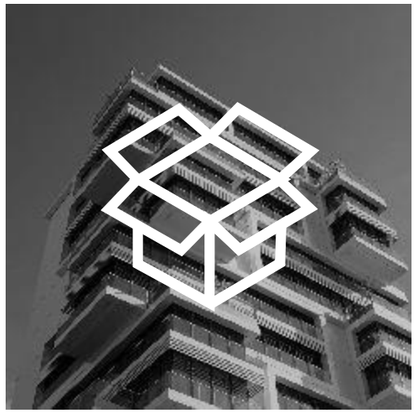


Varying interior treatments

Occupant discomfort

On-site time

Risk of condensation



Space required

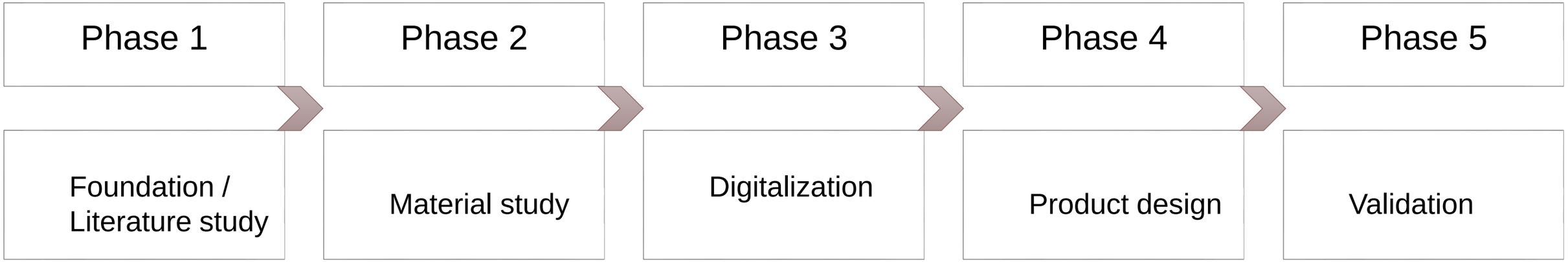
Research question

How can the advancements in insulation material and technologies help to optimize the energy renovation process of interior envelope?

Aim

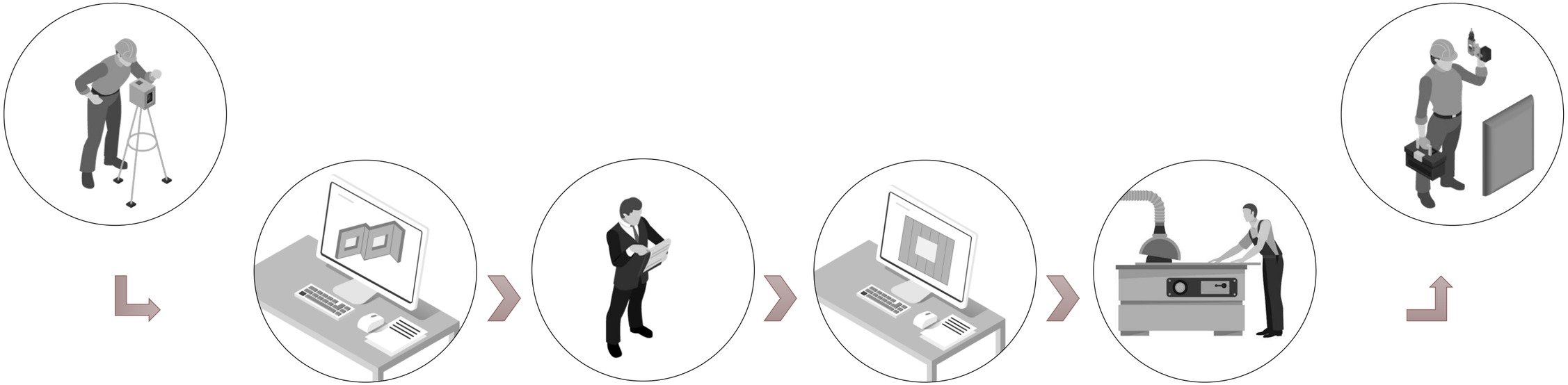
To create a model workflow for the renovation process of existing protected buildings by adopting super insulation material and technological advancements to aid production and assembly.

Research methodology

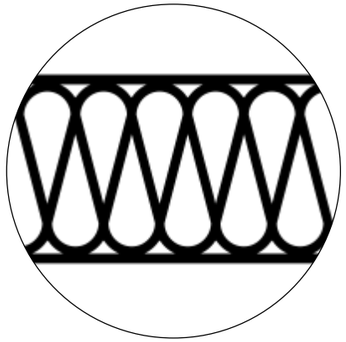


Proposed workflow

Off site workflow



Area of optimization

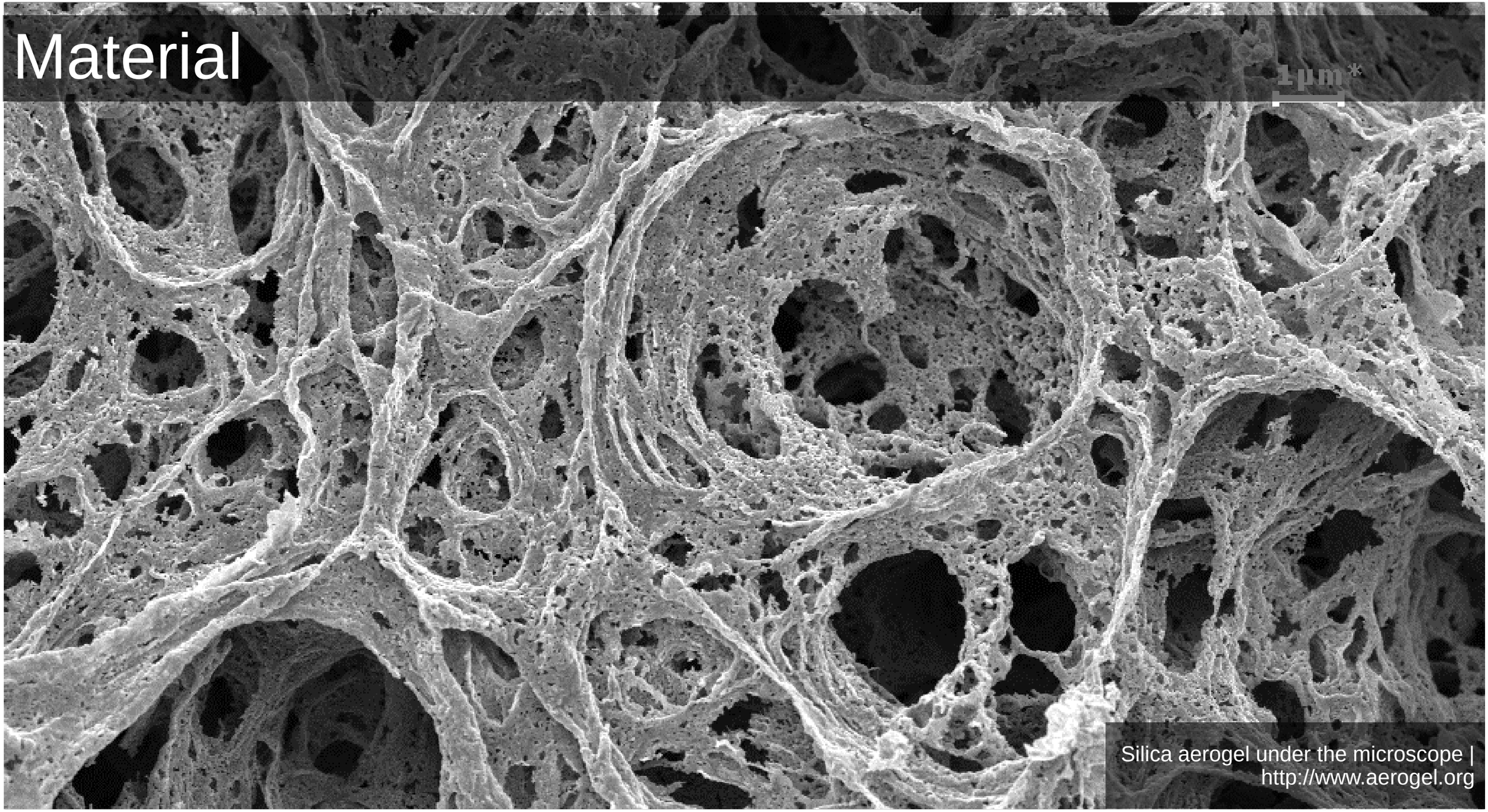


Material

Process innovation

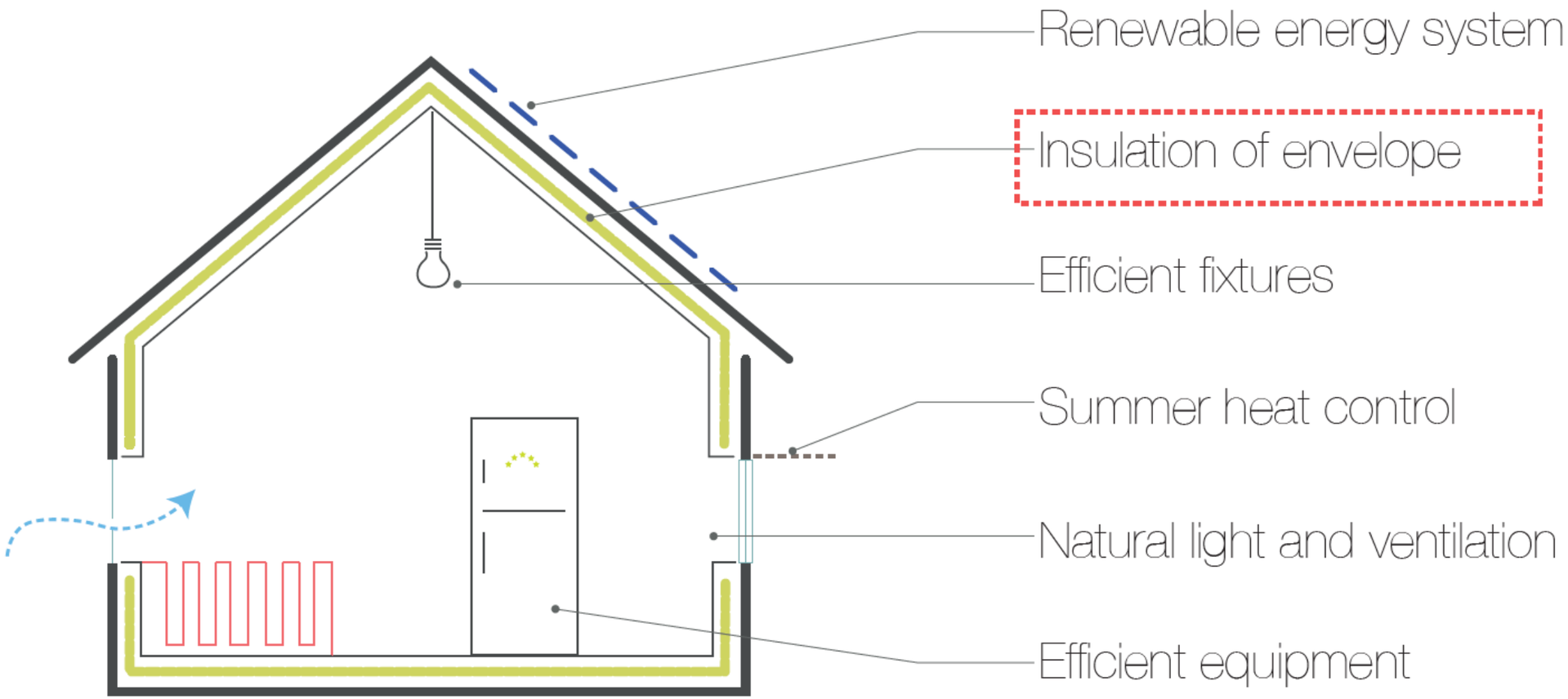
Product design

Material



Silica aerogel under the microscope | http://www.aerogel.org

Measures of energy efficiency

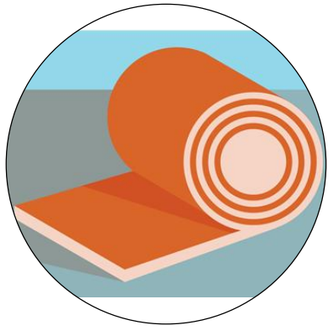


Insulation of envelope

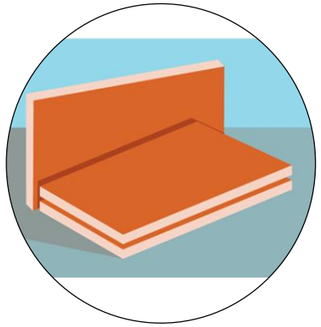
Heating energy reduction

	Thermal load (kwh/m2)	Heating energy (kwh/m2)	Heat reduction
At 60 % WWR			
Uninsulated wall with single glazing	140.13	129.73	
Uninsulated wall with double glazing	104.57	94.54	35.19
Insulated wall with double glazing	71.4	61.13	33.41
At 40% WWR			
Insulated wall with double glazing	62.00	54.00	
At 80% WWR			
Insulated wall with double glazing	81.29	68.67	

Common wall insulation material

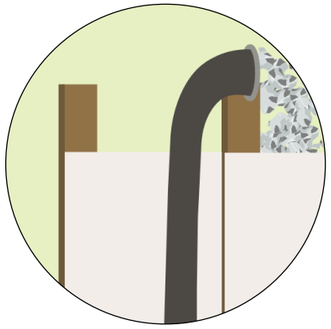


Batt/roll



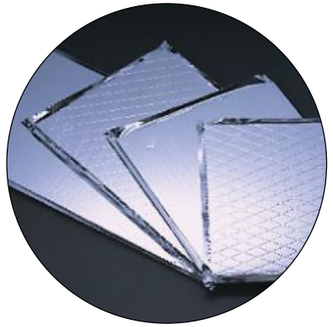
Rigid

Spray foam



Loose fill

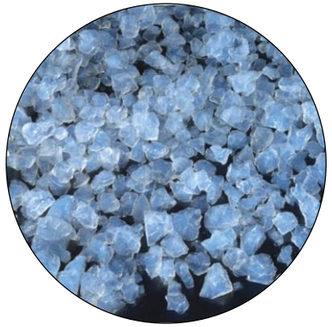
Superinsulation material



Vacuum Insulation panel

Aerogel blanket

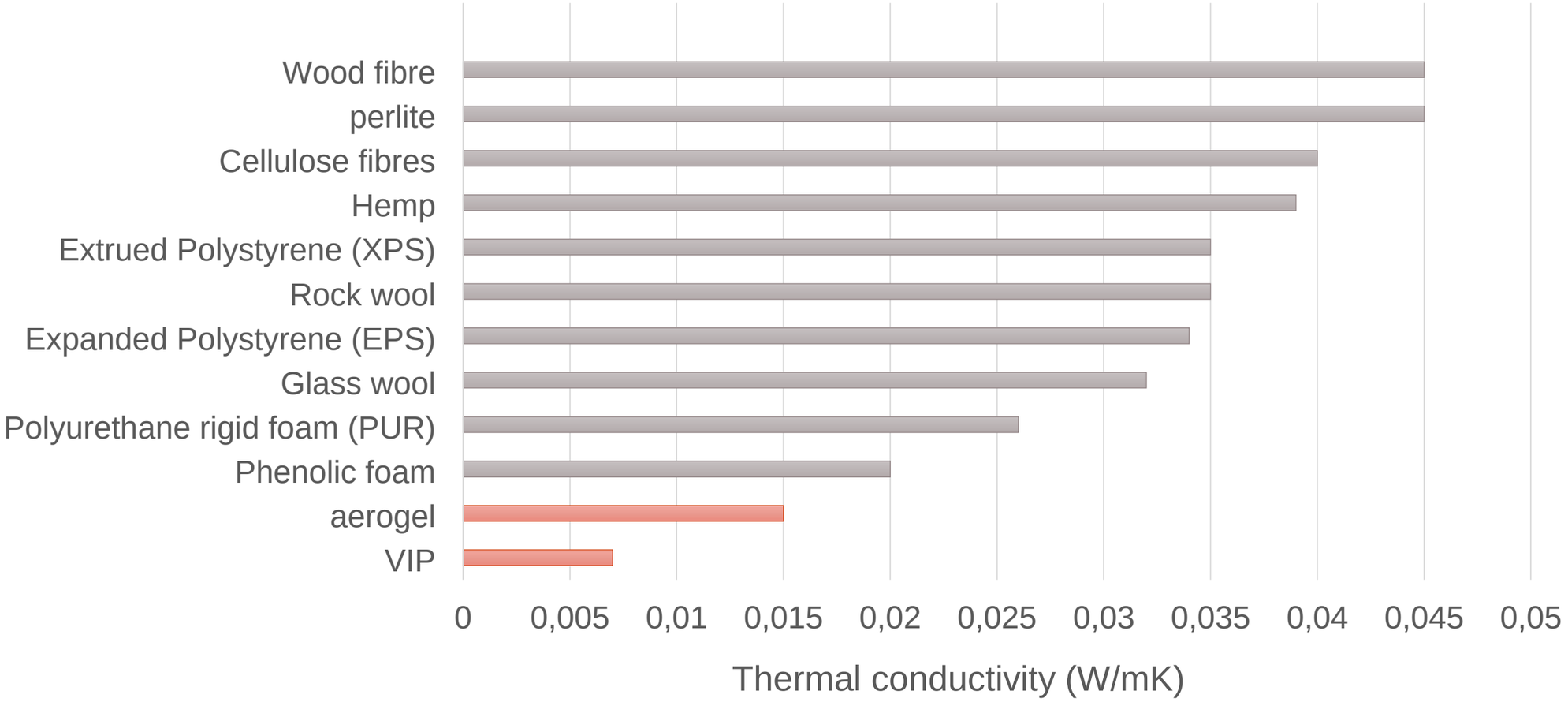
Aerogel boards



Aerogel granules

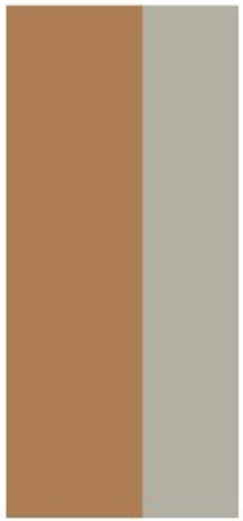
Aerogel plaster

Thermal conductivity

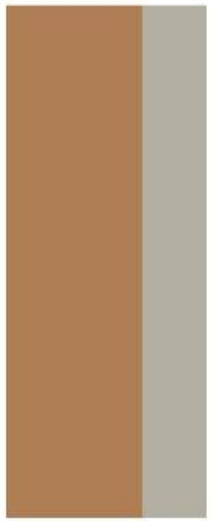


Insulation material

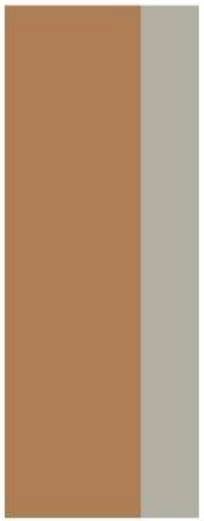
Relative thickness



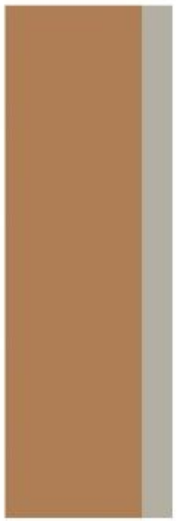
140mm wood fibre



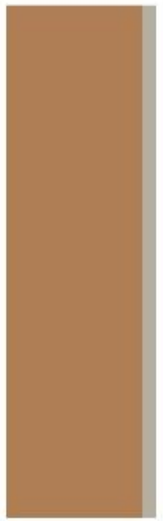
100mm EPS/XPS



80mm PUR



40mm Aerogel



20mm VIP

Insulation material

Advantages over common insulation material

- 50% - 80% space saving due to slimmer profiles
- Material saving
- High thermal performance
- Non –toxic content

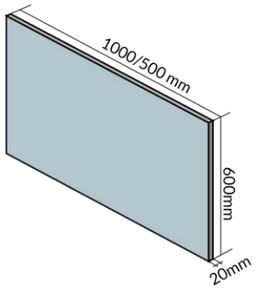
Superinsulators

Material properties

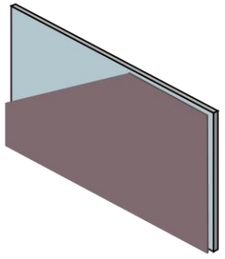
- Thermal performance
- Fire resistance
- Vapour permeability
- Physical form
- Area of application
- Average life and end-of-life
- Challenges

Vacuum Insulation Panel (VIP)

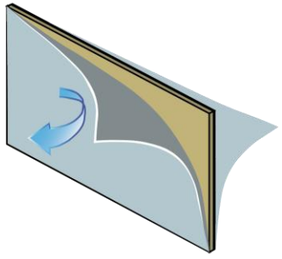
Description
Vacuum Insulation panels are super insulation that have a highly porous rigid core, generally of fumed silica, and wrapped in an gas-tight envelope from which air has been evacuated. These rigid panels 10mm to 50mm thick and commercially available in sizes of 1000mm/ 500 mm x 600mm. They are suitable for use on exterior walls, interior walls, cavity space, floors an compact roofs, door and window reveals.



Rigid panel



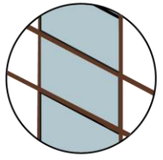
finish with tough impact boards



Air and water tight protective membrane

Thermal performance

Fragile



fixed in frame

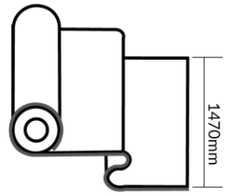
Life expectancy

flammable envelope, non-flammable core

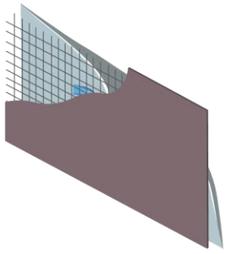
recyclable core/ non recyclable enve-

Aerogel Blankets

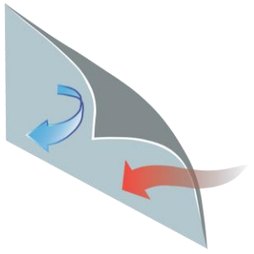
Description
Aerogel blankets are available in 5mm or 10mm thickness as flexible blankets in the 10 meter rolls that are 1470mm wide. The aerogel component of Spaceloft® is synthetic amorphous (non-crystalline) silica with PET/glass fibre and additives



flexible blanket



finish with tough impact layer - gypsum, wood fiber, direct



air tight , water tight water vapour permea-

Thermal performance

handle with care

mechanical fasteners

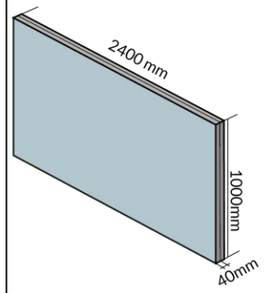
Life expectancy

C-s1,d0
Difficult to ignite

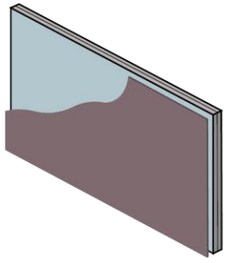
segregated into gel and fibers for recycle, reuse

Aerogel Blankets

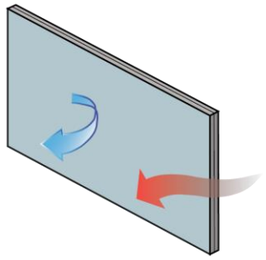
Description
The boards are aerogel blanket that come finished with 3mm Magnesium oxide boards. These are available in the size of 2400mm x 1000mm rigid board. They are suitable for use on exterior walls, interior walls, cavity space, floors an compact roofs, door and window reveals



rigid panel



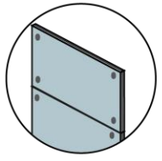
appy render ot paint to magnesium oxide board



air tight , water tight water vapour permea-

Thermal performance

handle with care



mechanical fasteners

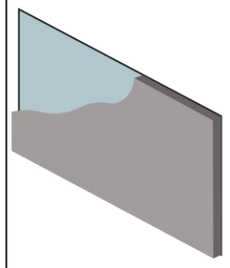
Life expectancy

C-s1,d0
Difficult to ignite

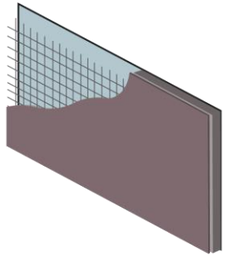
segregated into gel and fibers for recycle , reuse

Aerogel plaster

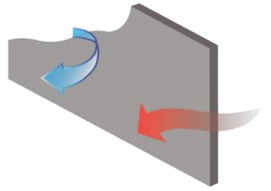
Description
Lightweight Aerogel granulate is the primary additive used in this high-performance lime-based insulating plaster.Aerogel plasters are not restricted by shape or size of the surface. Available as dry premix with cement, the render can be applied to the required thickness



rigid panel



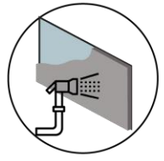
finish with wire mesh and gysum plaster and paint



air tight , water tight water vapour permea-

Thermal performance

keep dry



apply by hand or spray

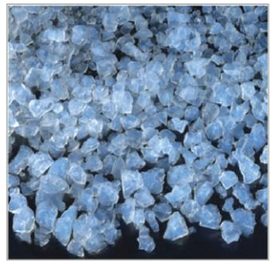
Life expectancy

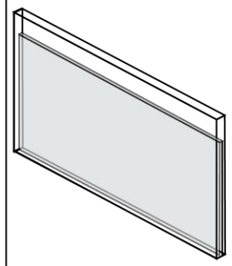
non flammable

broken and downcycled

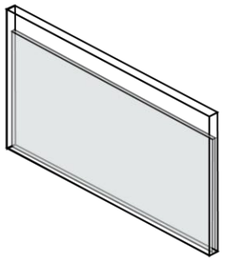
Aerogel granules

Description
Aerogels granules are 1mm to 5mm in size and can be loose filled in any container. Most commonly used in windows or skylight due to the high light transmission value.

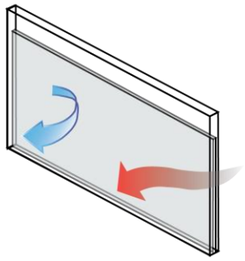




lose granules



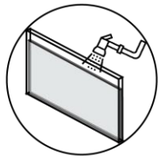
finish with casing friendly material.



air tight , water tight water vapour permea-

Thermal performance

keep dry



lose fill cavity spaces

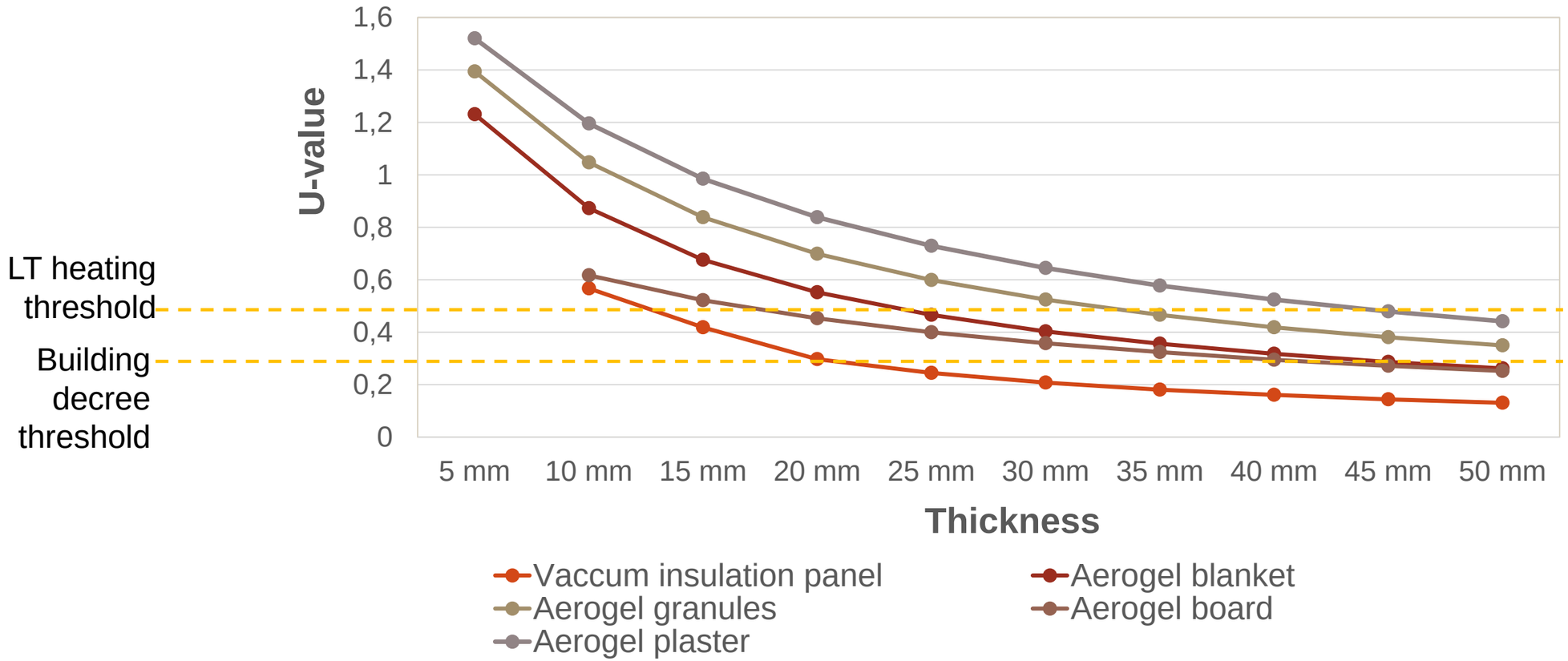
Life expectancy

non flammable

non additive grains directly reused

Interior insulation

Thermal performance with respect to thickness



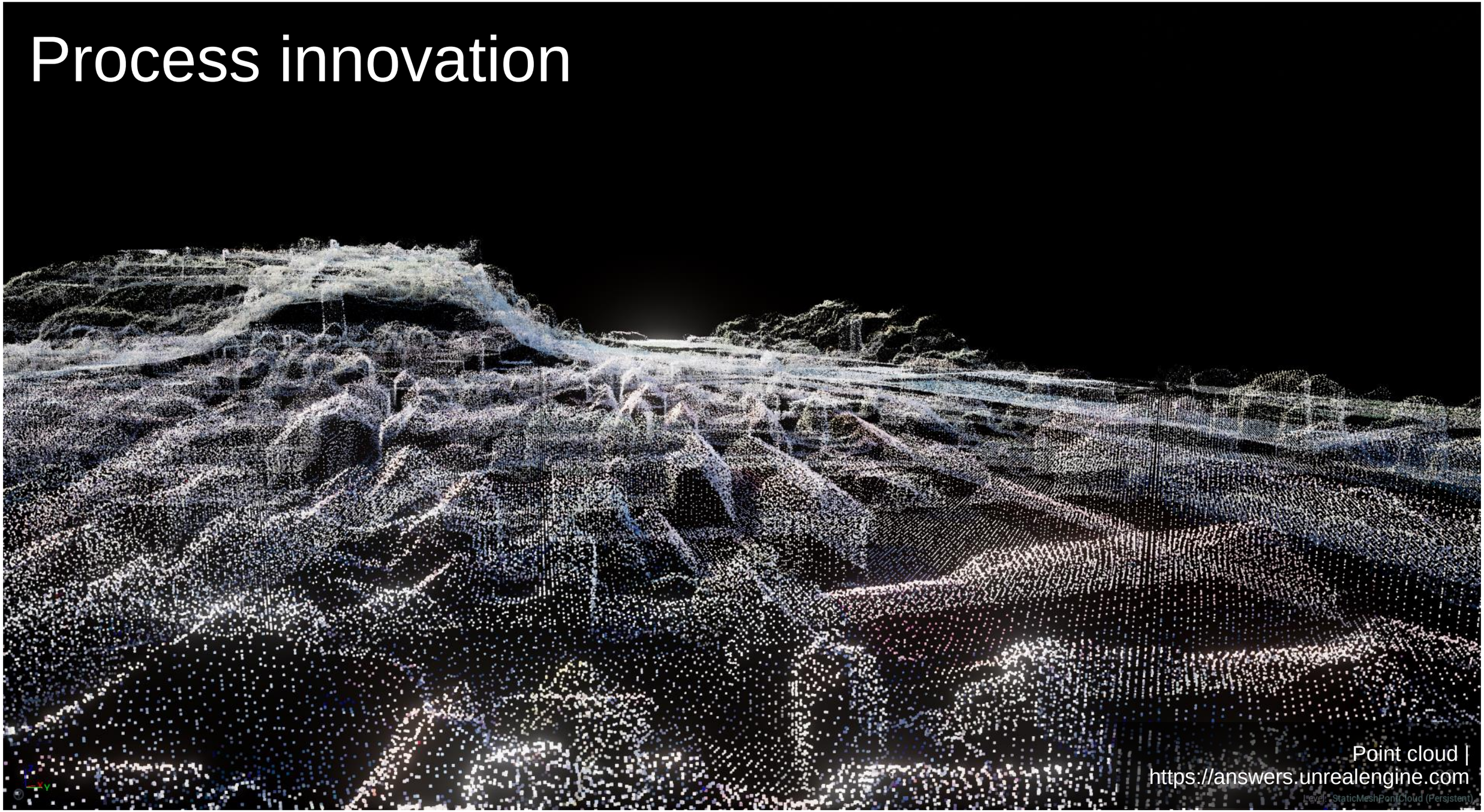
Conclusion

Material properties

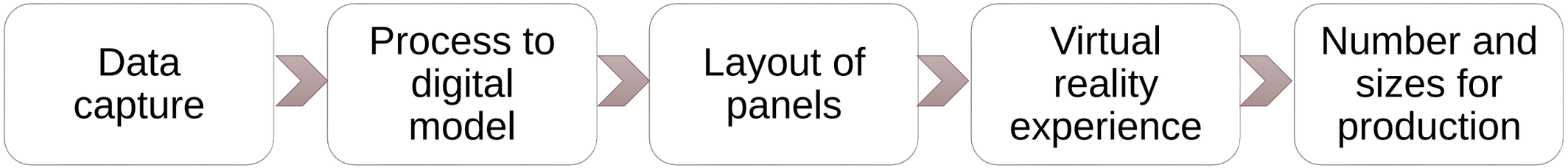
- VIP’s deliver lowest thermal conductivity and subsequently least thickness.
- The rigid panels can not be altered once produced.
- Their fragile nature demands extra care during handling.

- Aerogel blankets are the more sustainable material option amongst the superinsulators.
- Aerogel boards perform like blankets but are not suitable due to use of adhesive.
- Aerogel granules are best suitable for infill in transparent elements.

Process innovation



Process innovation



Process innovation

Equipment for data capture

Terrestrial laser scanning (TLS)

Total/Multi-Station

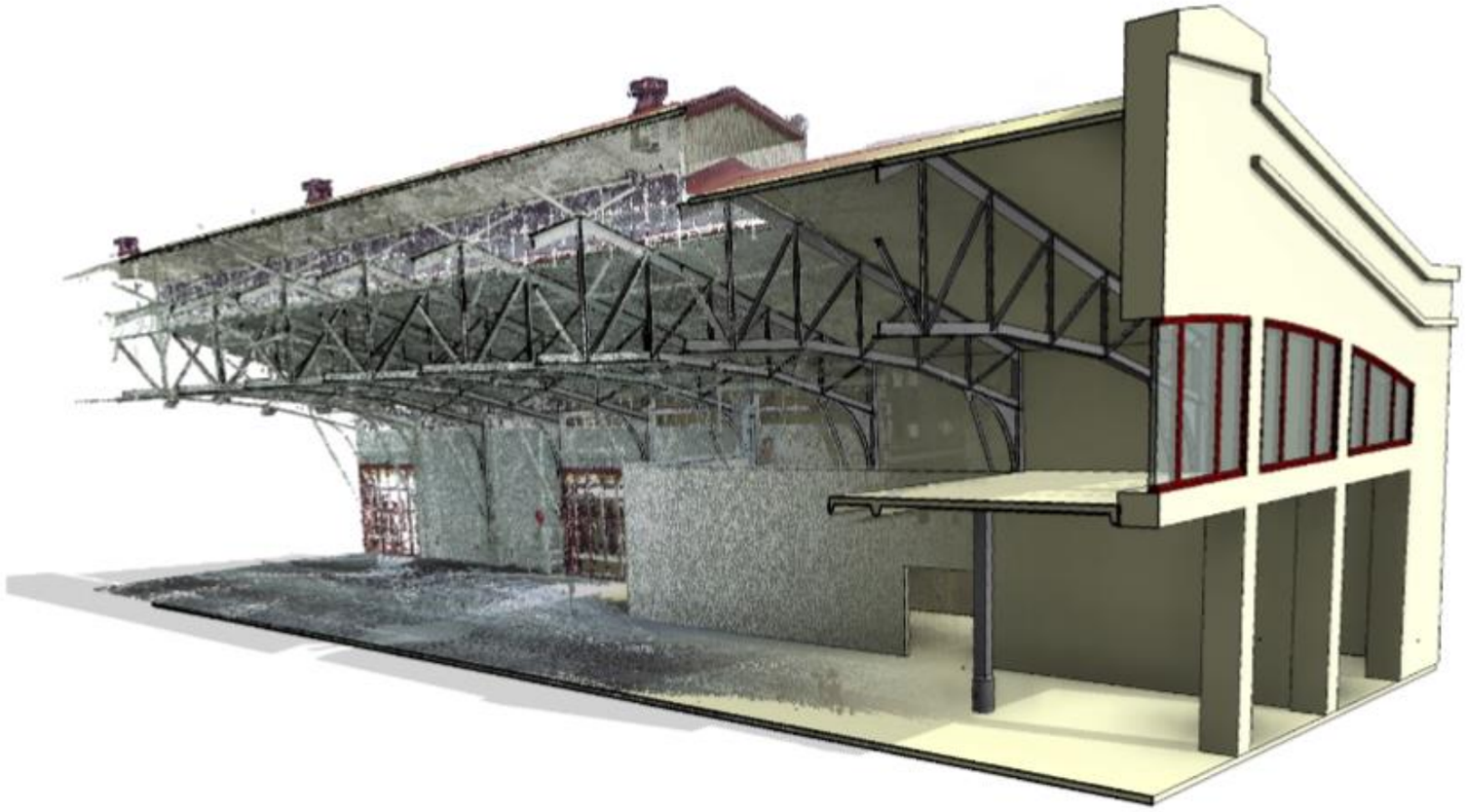
Global Navigation Satellite System

Simultaneous Localisation and Mapping

Structure from Motion Photogrammetry

Process innovation

Point cloud to BIM model



MANUAL_As-Built 2018 for Revit_EN.pdf

Process innovation

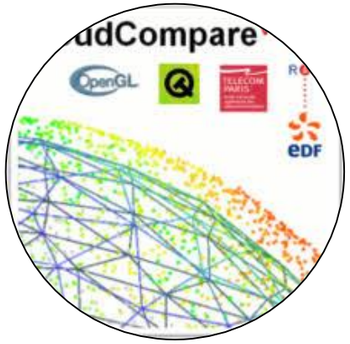
Software support

Autodesk Revit
TM

McNeel Rhinoceros
TM

Geomagic wrap
TM

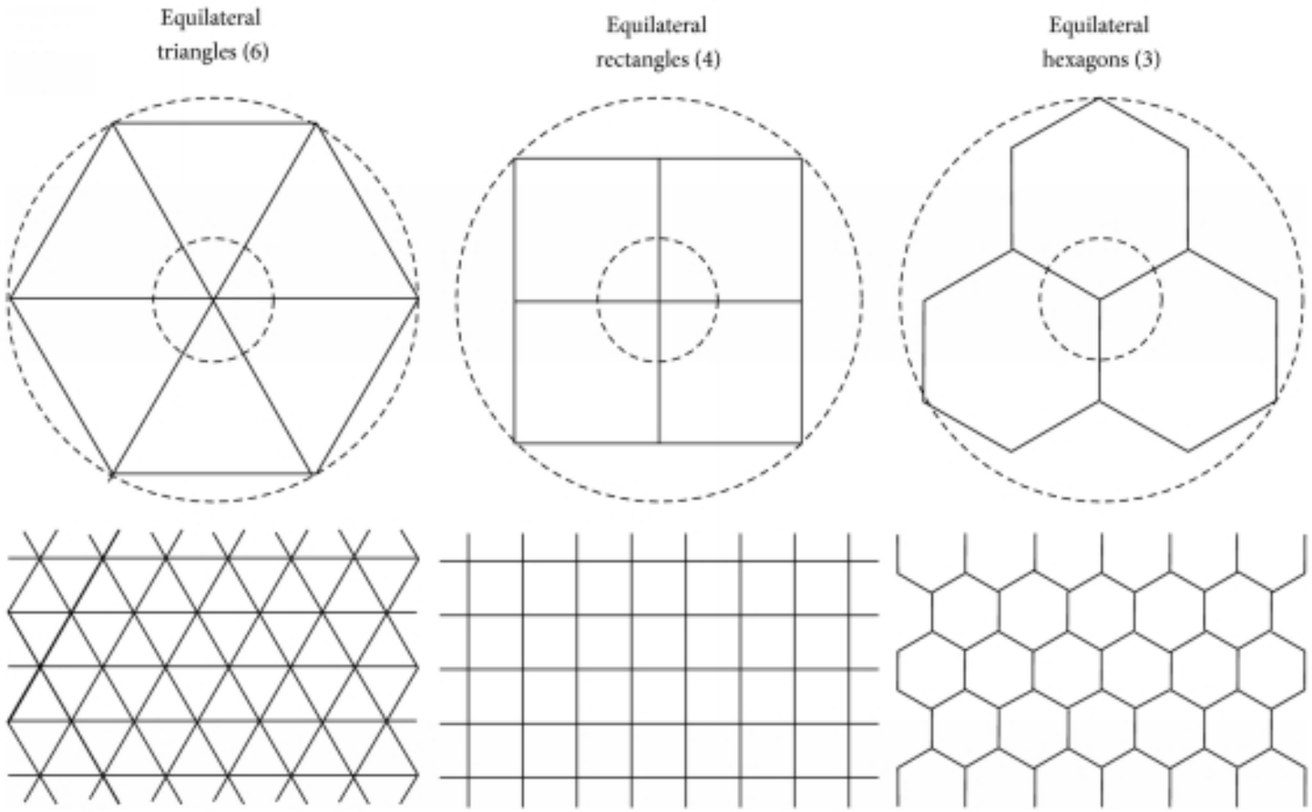
MeshLab - mesh
TM



CloudCompare
TM

Process innovation

Parametric tessellation for optimum layout



Study of the Control of Geometric Pattern Using Digital Algorithm.pdf

Process innovation

Virtual environment

www.livehome3d.com/useful-articles/vr-in-home-design

Process innovation

Virtual environment

Process innovation

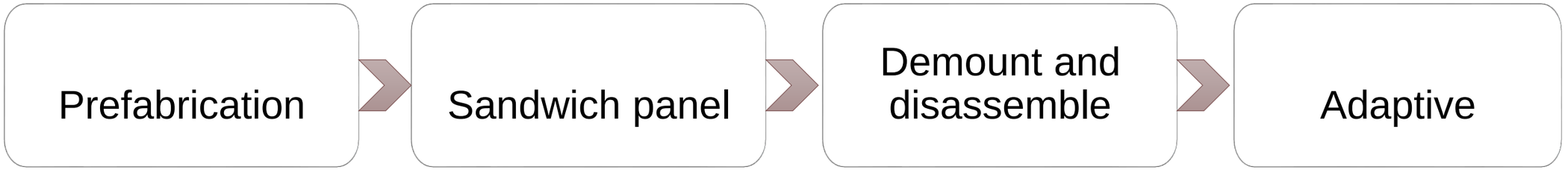
Conclusions

- Laser Scanning (TLS) allows for rapid interior surveying
- For a thorough scan, it is recommended to take multiple scans from different positions
- Scan resolution determines the level of detail captured
- Management of the acquired points is done through specialised software to create BIM model that require extra knowledge and skill
- In the future interoperability with BIM model and data exchange could be reached
- Virtual reality experience integrates occupants opinions into the final output of renovation
- It is a crucial step to aid accurately dimensioned fabrication

Product design

Prefabricated façade panels |
https://www.taylormaxwell.co.uk/offsite-components

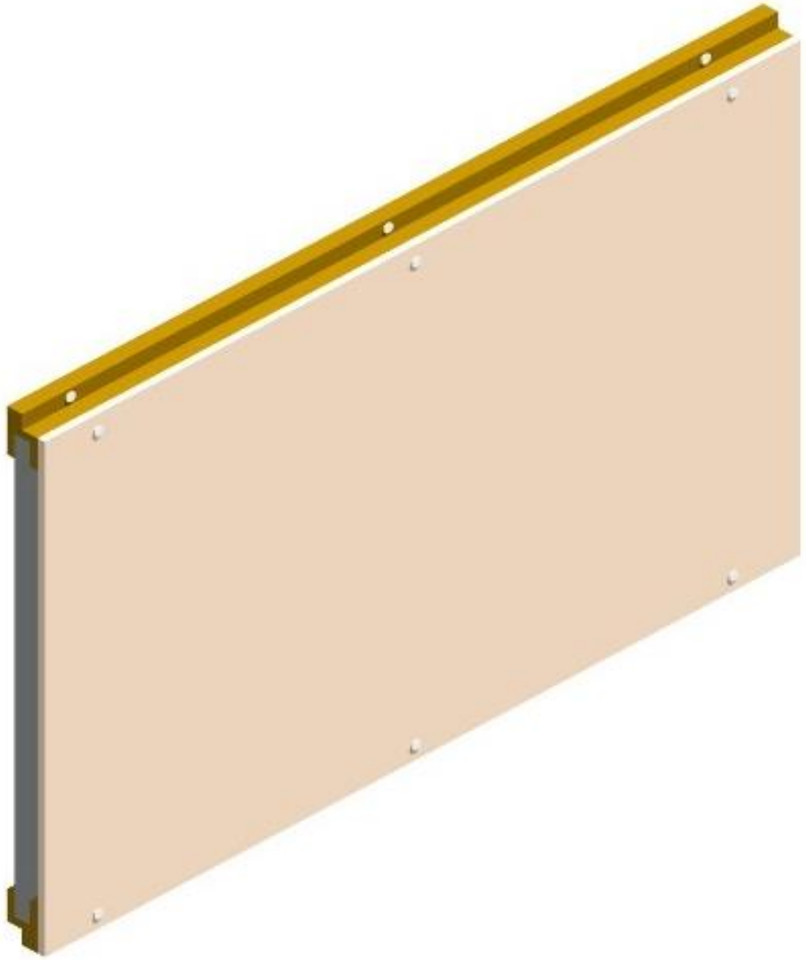
Product design

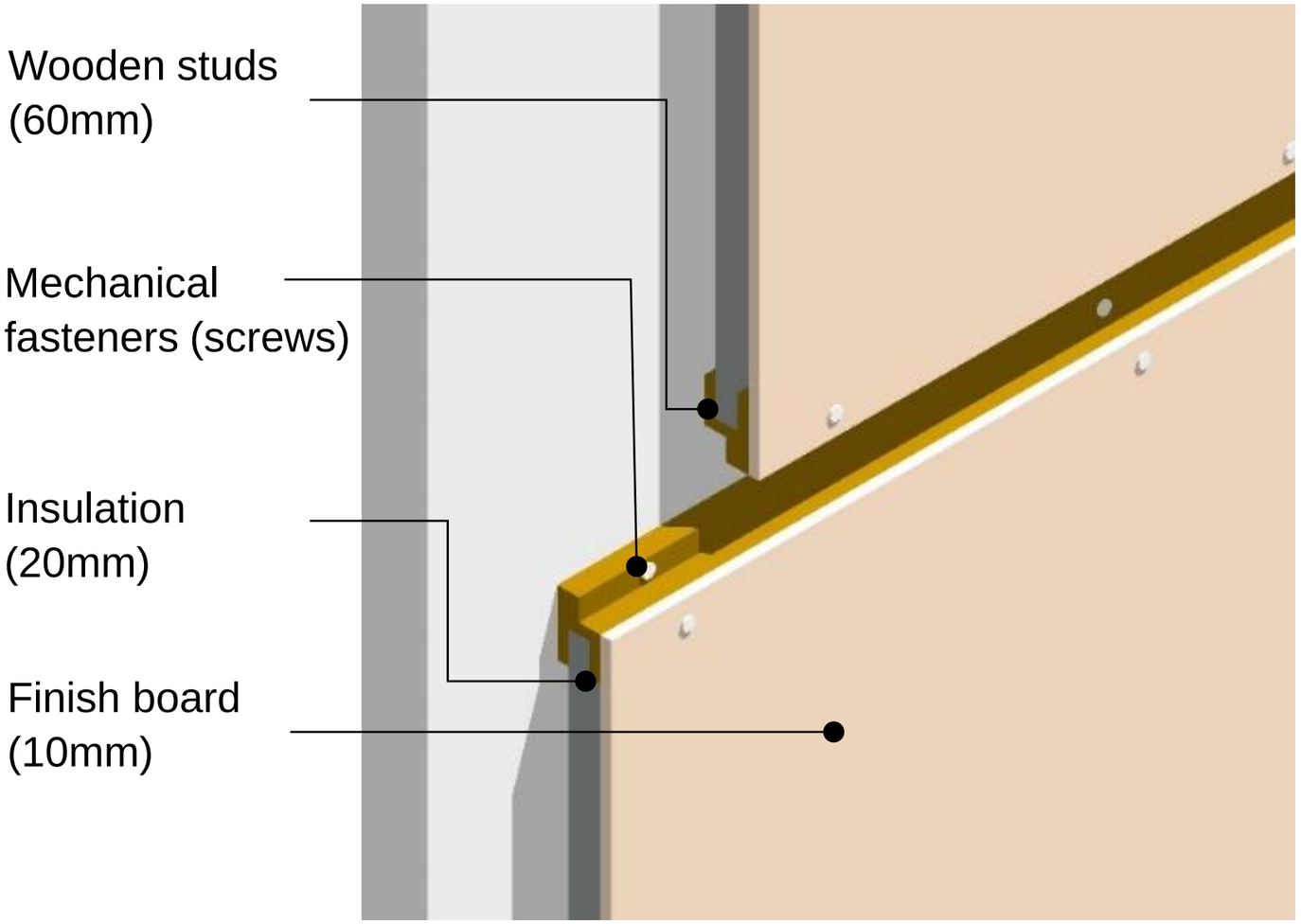


- Thematic diagram?

Product design

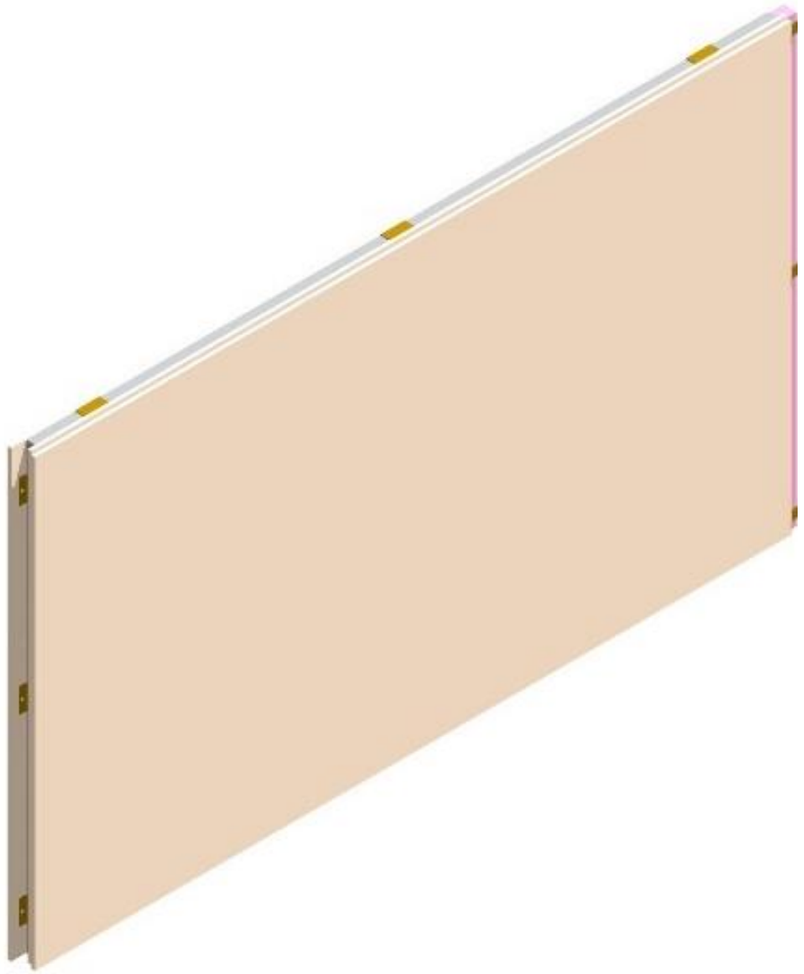
Design option 1 – shiplap joinery

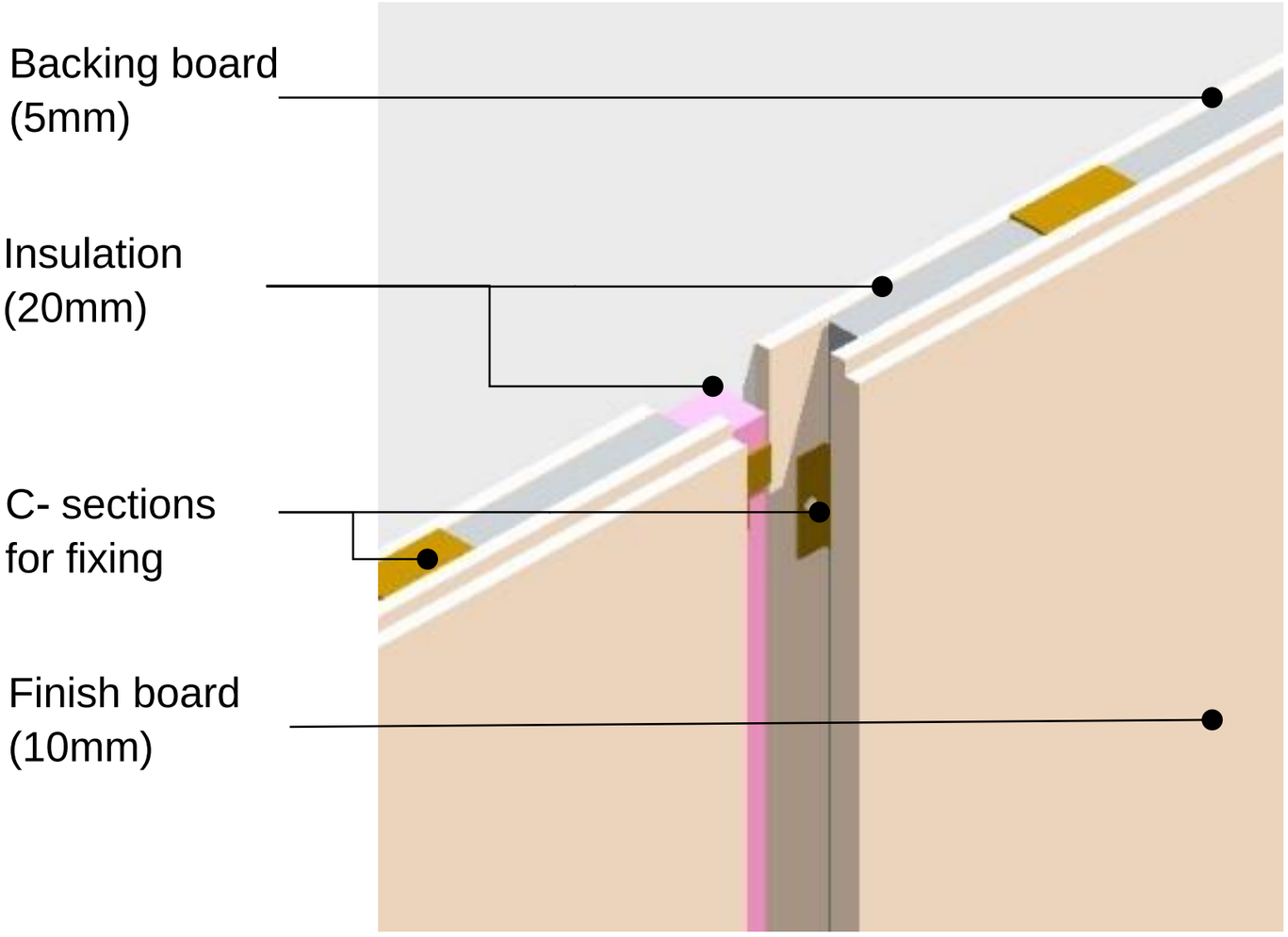




Product design

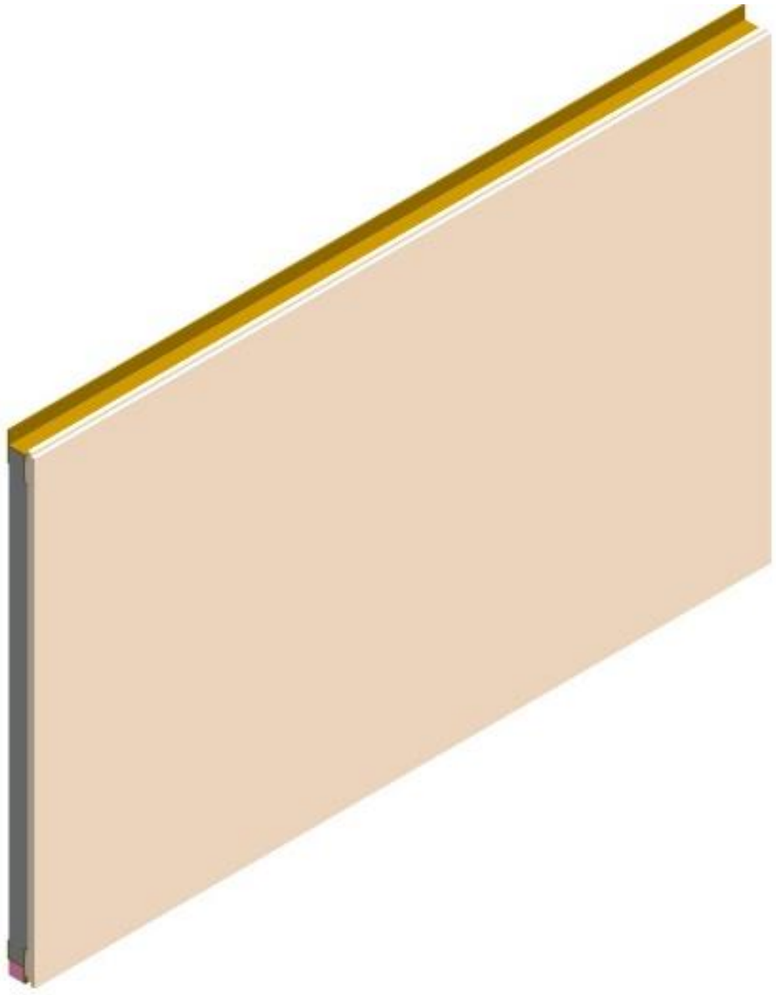
Design option 2 – tongue and groove joinery

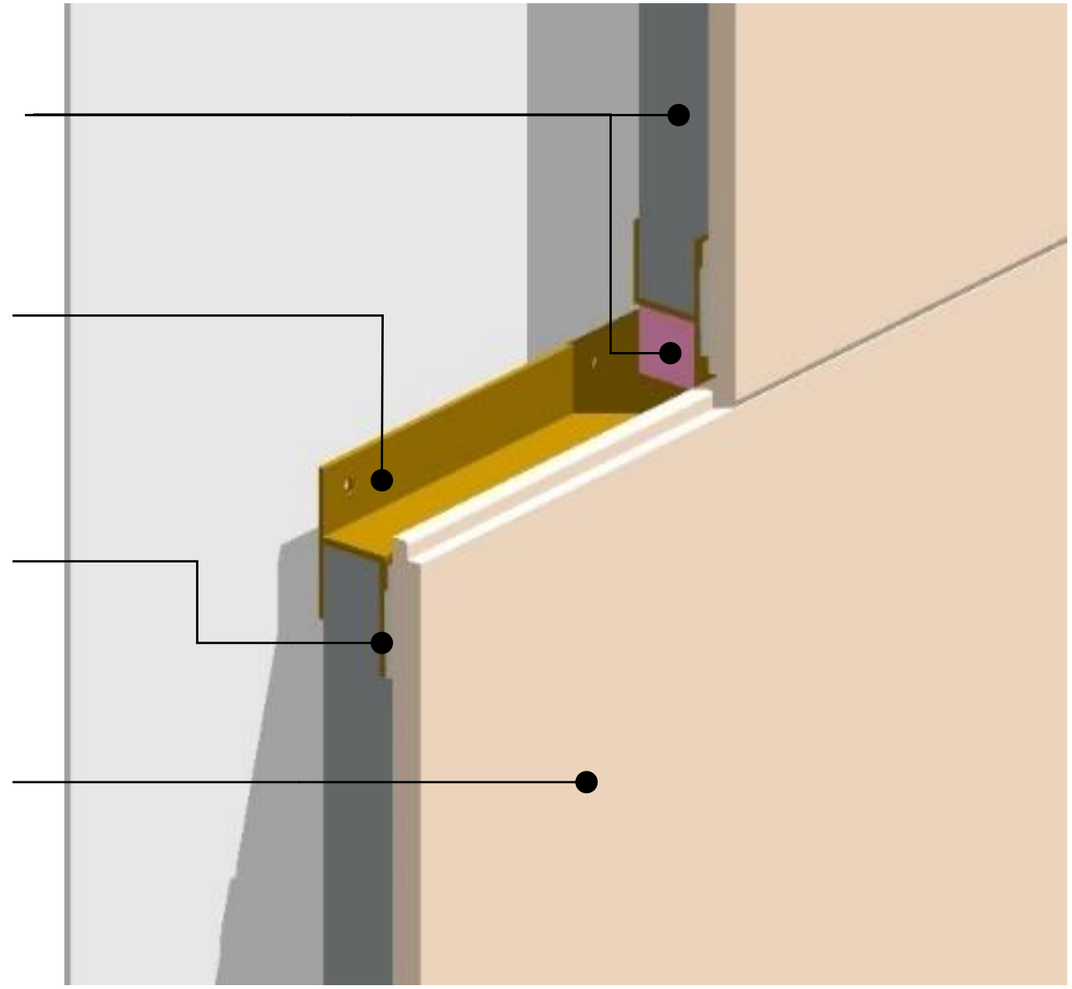




Product design

Design option 3 - shiplap joinery

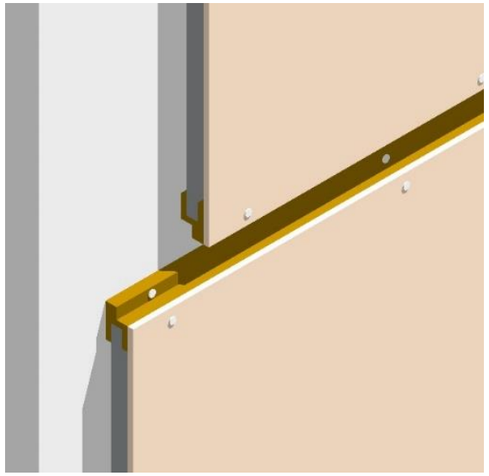




Product design

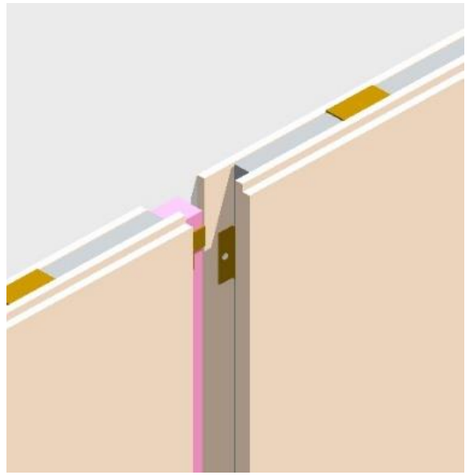
Comparison

Design option 1



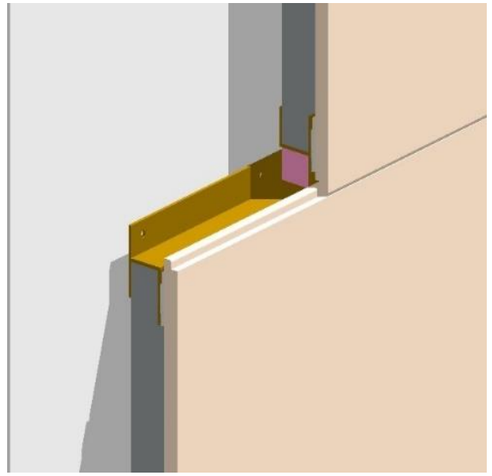
- Easy to assemble an install
- wooden frame adds to the thickness of the panel

Design option 2



- Discontinuous smaller C-sections reduce thermal bridges
- Too many elements make the assembly complex
- The backing material is not functionally required

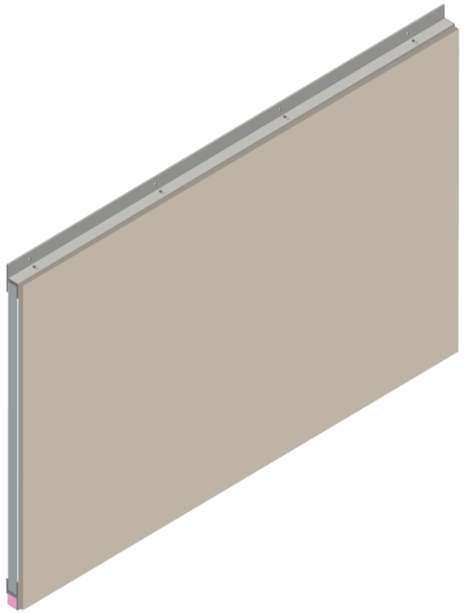
Design option 3



- Slimmest section of the panel
- Lesser area of contact for thermal bridging
- Easier to assemble and disassemble

Product design

Global solution



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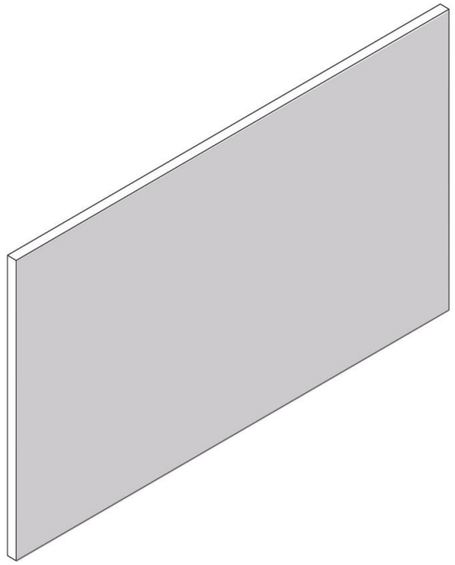
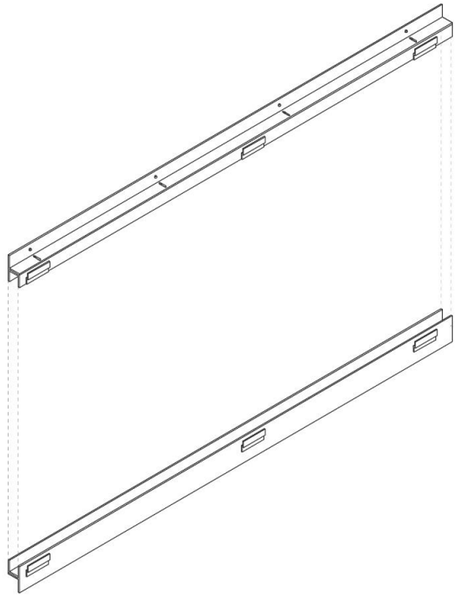


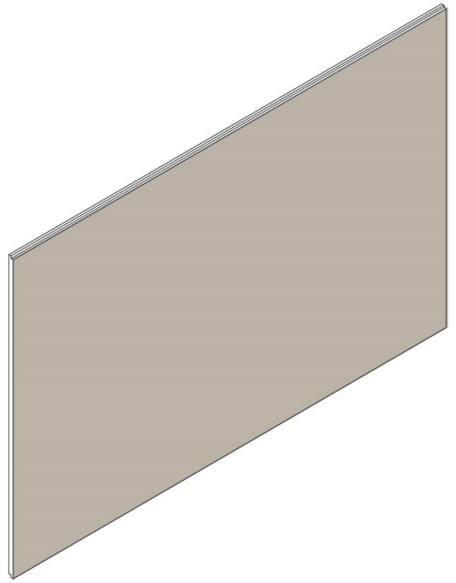
Vacuum insulation panel

+



Channel

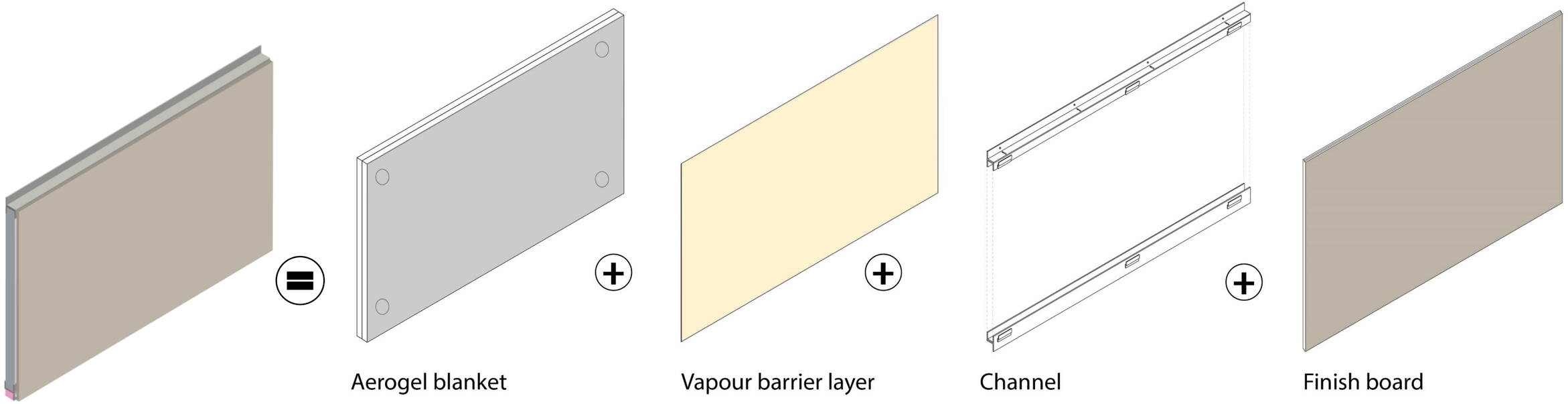
+



Finish board

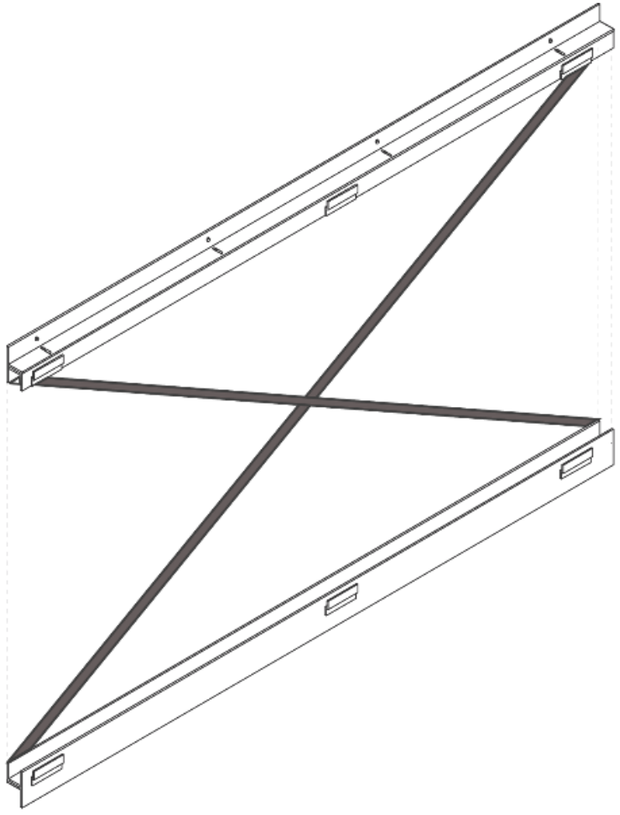
Product design

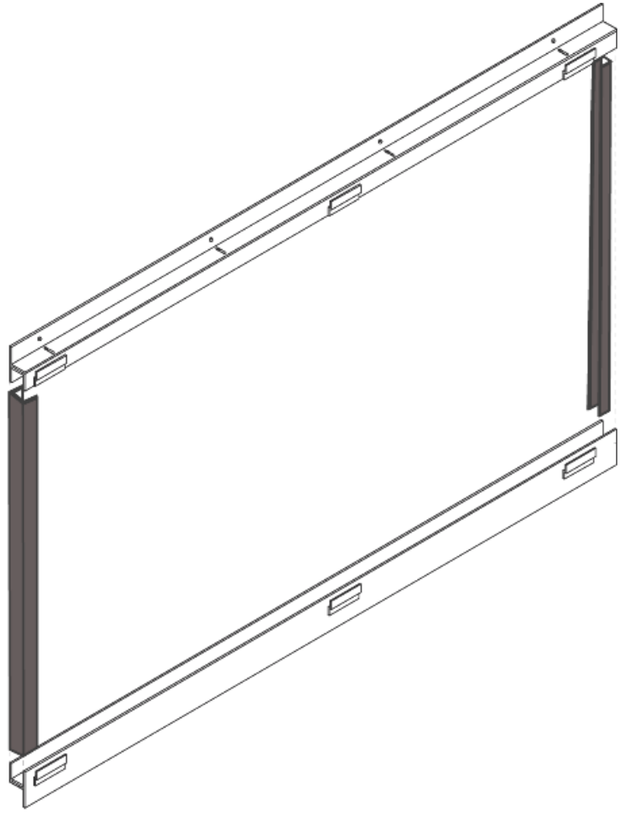
Global solution



Product design

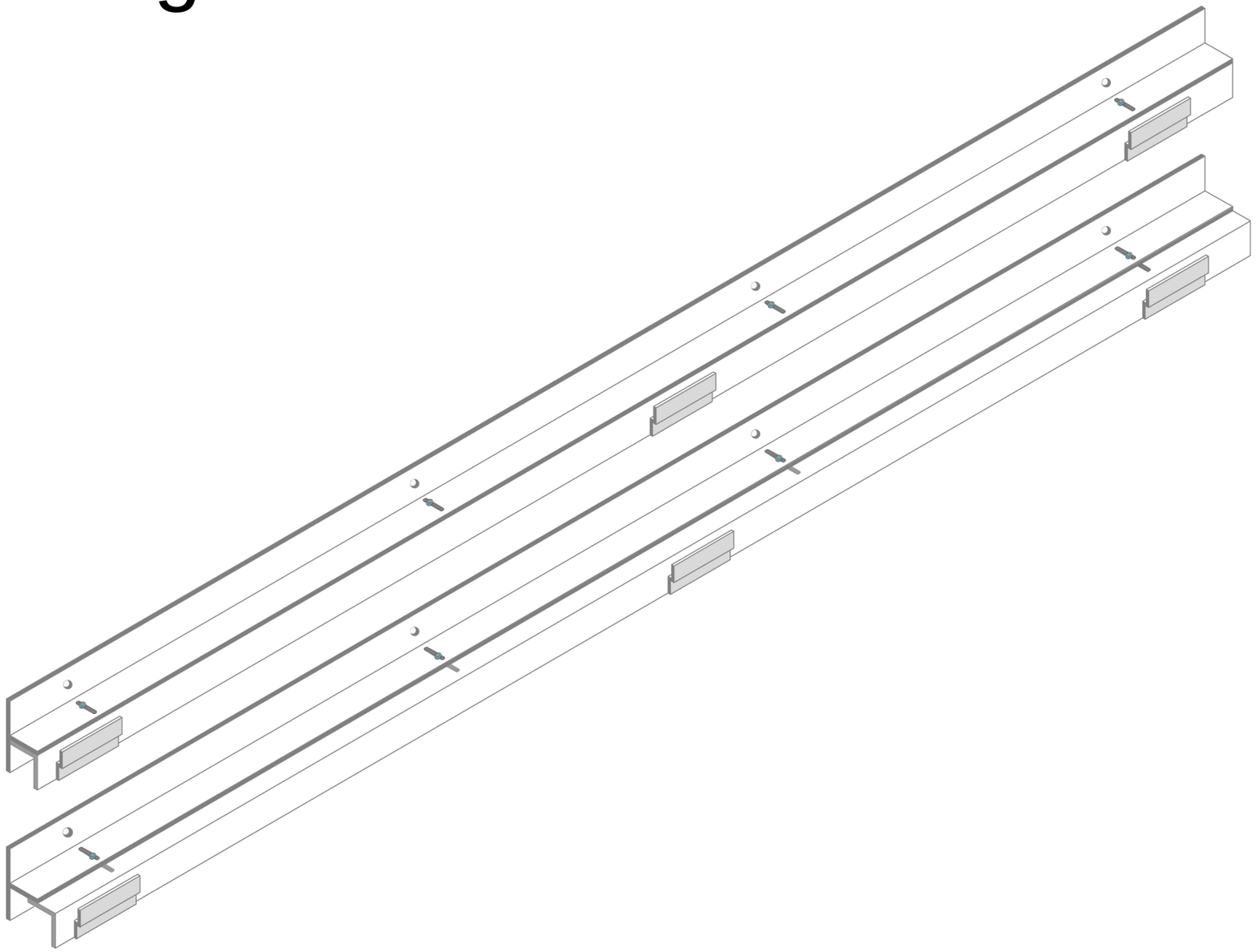
Additional bracing





Product design

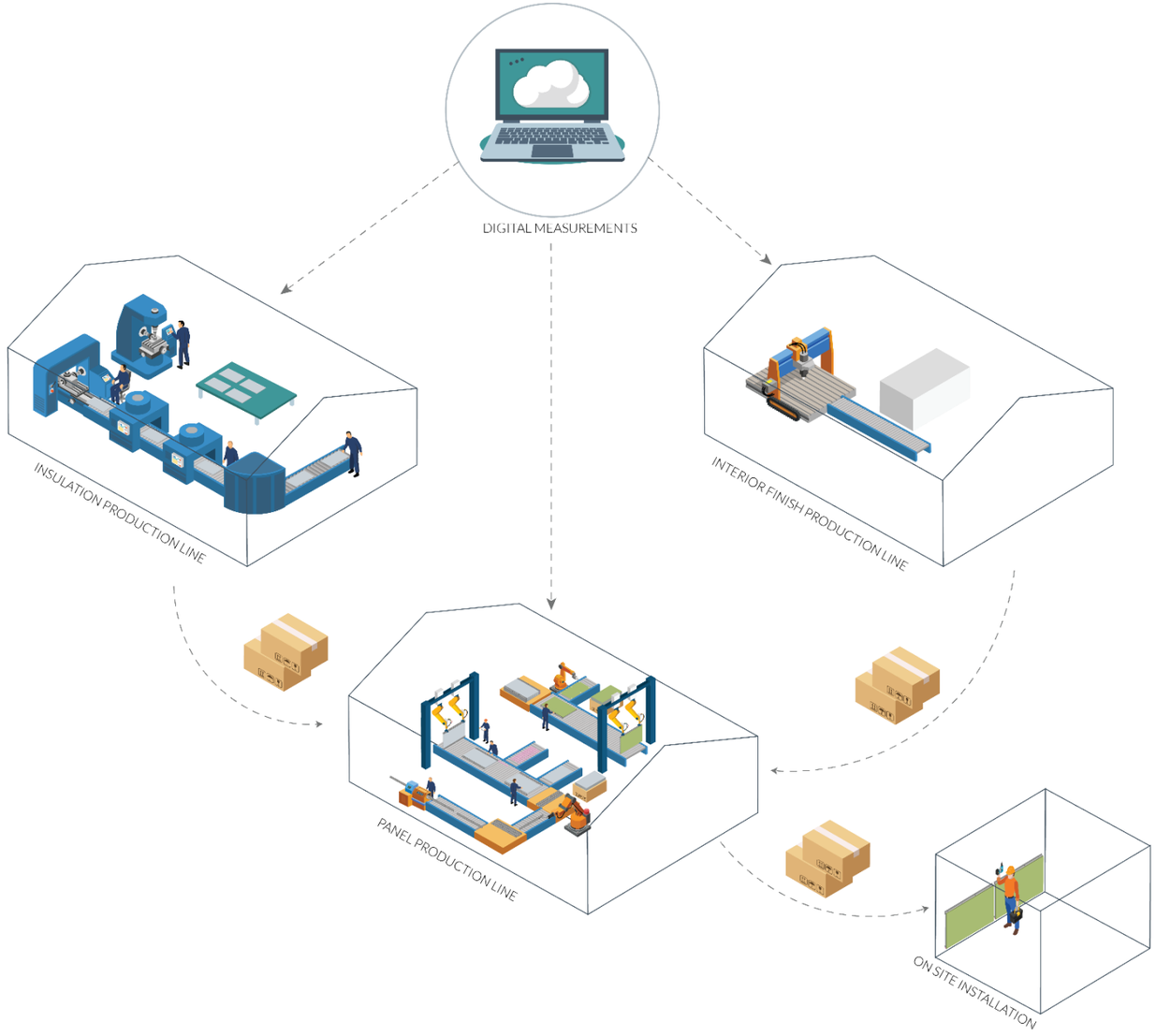
Adaptability



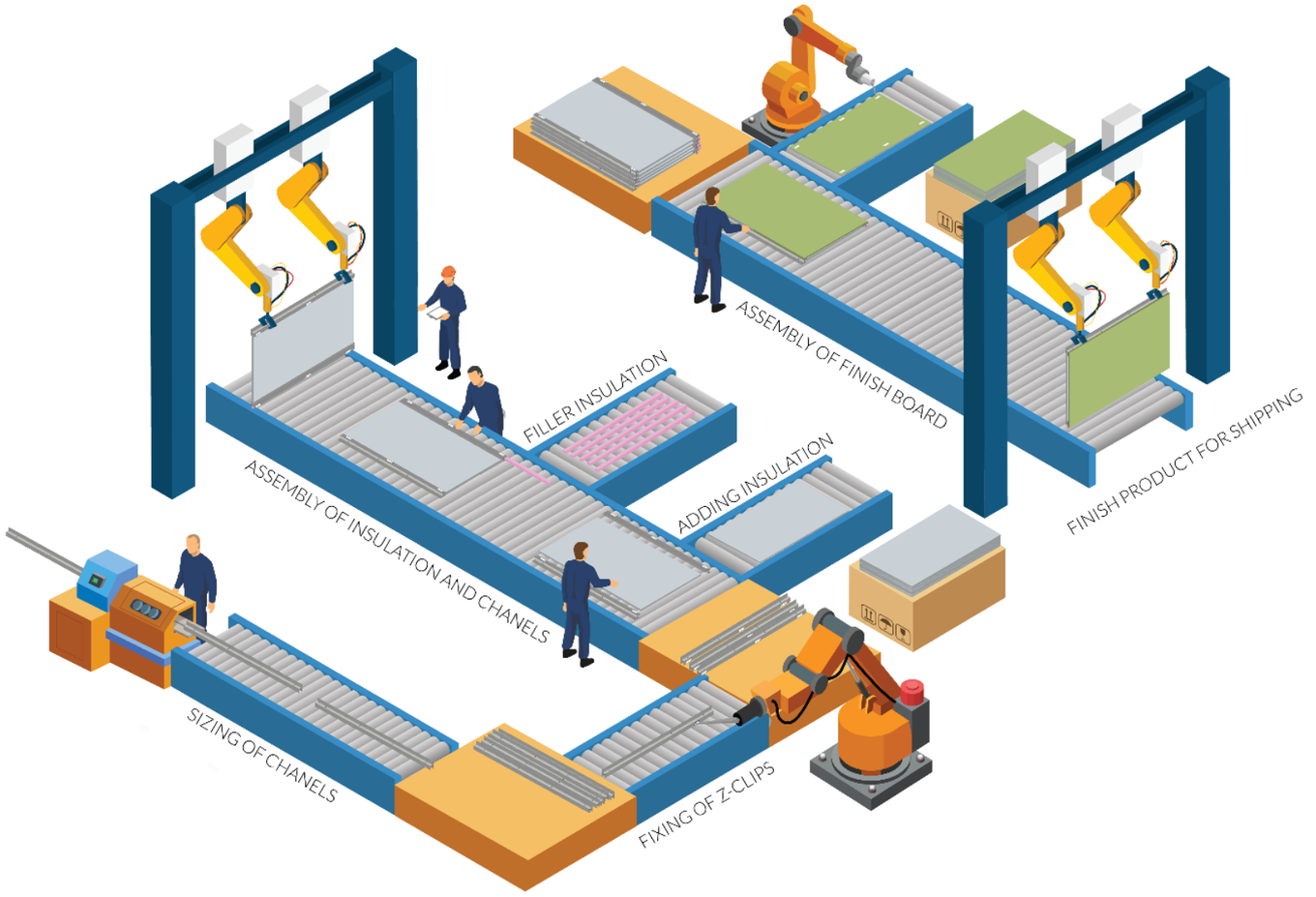
Product design

Adaptability- changing skins

Production process



Production process



Product design

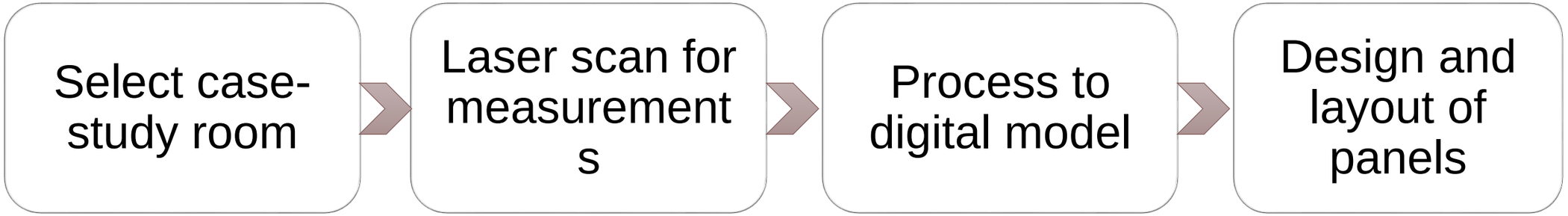
Conclusion

- A design approach of prefabricating a finished insulated wall panel to save on site time for fixing each element
- No glue or adhesive use make the product more complex to manufacture but ensure re-usability of elements. Hence a longer life cycle
- The adaptive channel make it convenient to integrate the design with different insulation material.
- Stylize the finish as per user requirement.

Demonstration of workflow

Case study

Proposed workflow



Demonstration room

Laser scanner setup

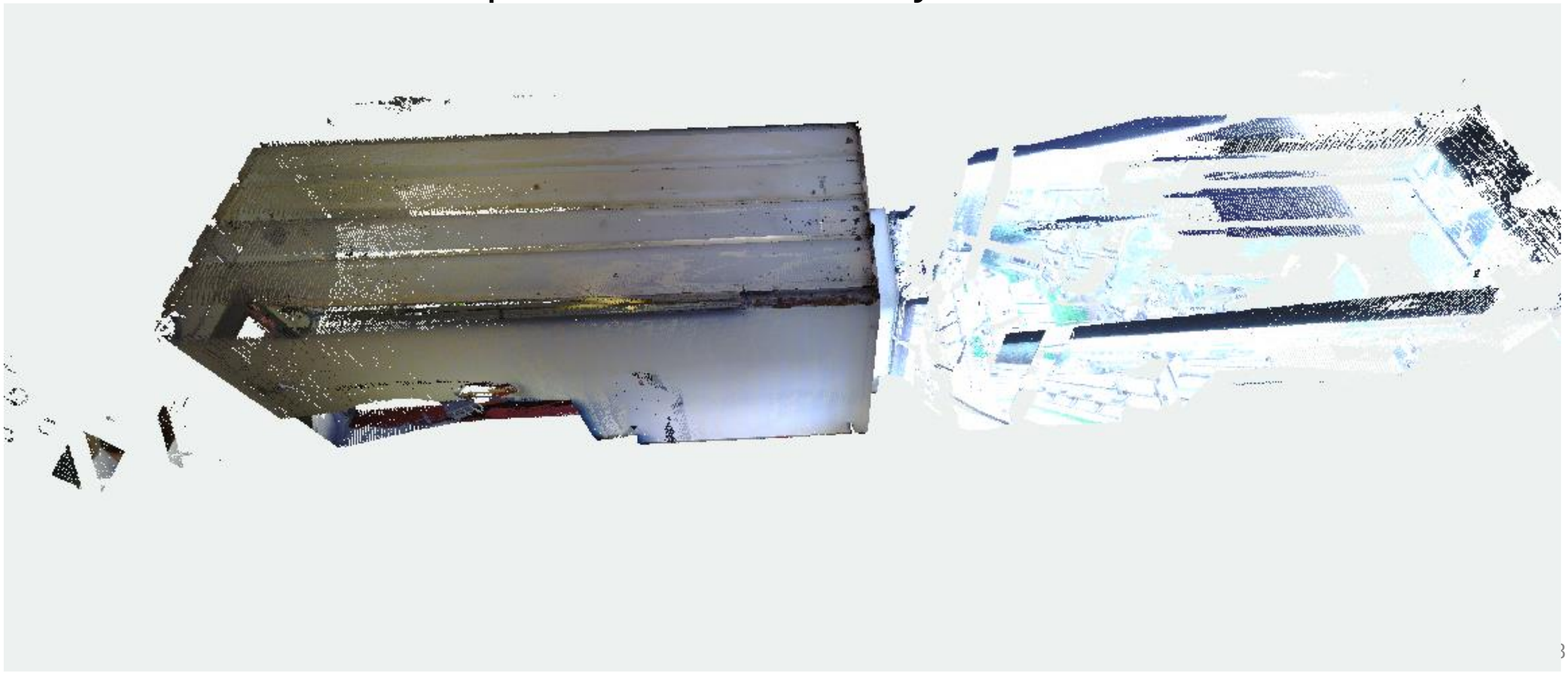
FARO Focus S

Demonstration room

Photographic capture

Demonstration room

Demonstration room as point clouds with stray noise



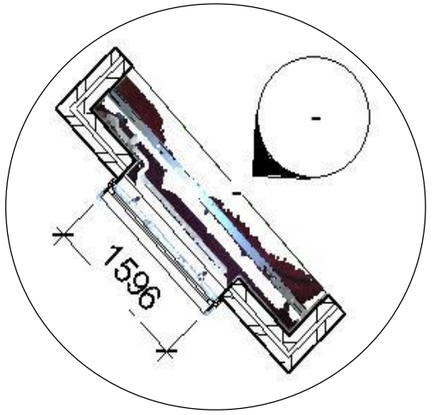
Demonstration room

Cropped to working area

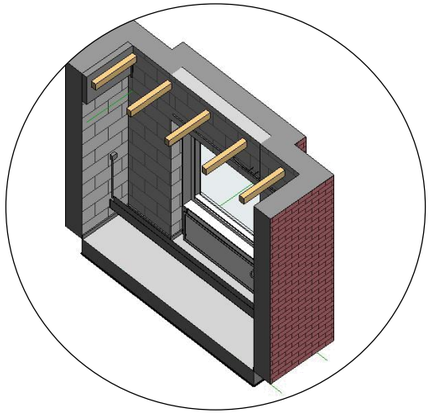
Conversion to digital model

Export from FARO SCENE software as point cloud data

Import into a 3D modelling software



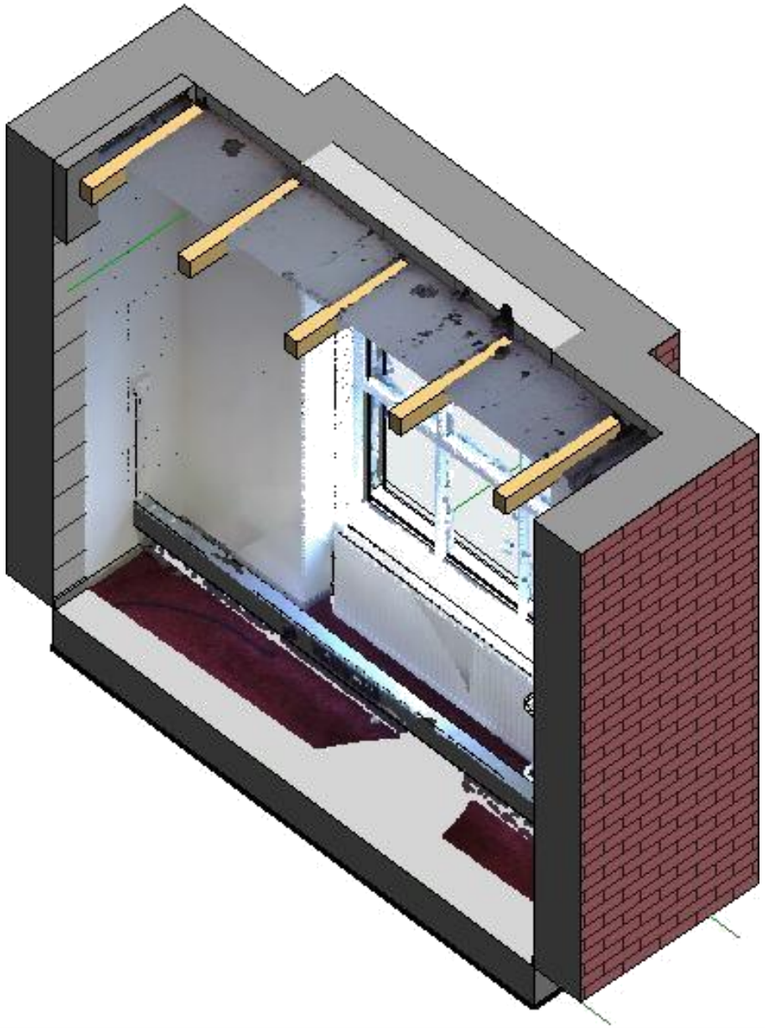
Use points as guides to draw over

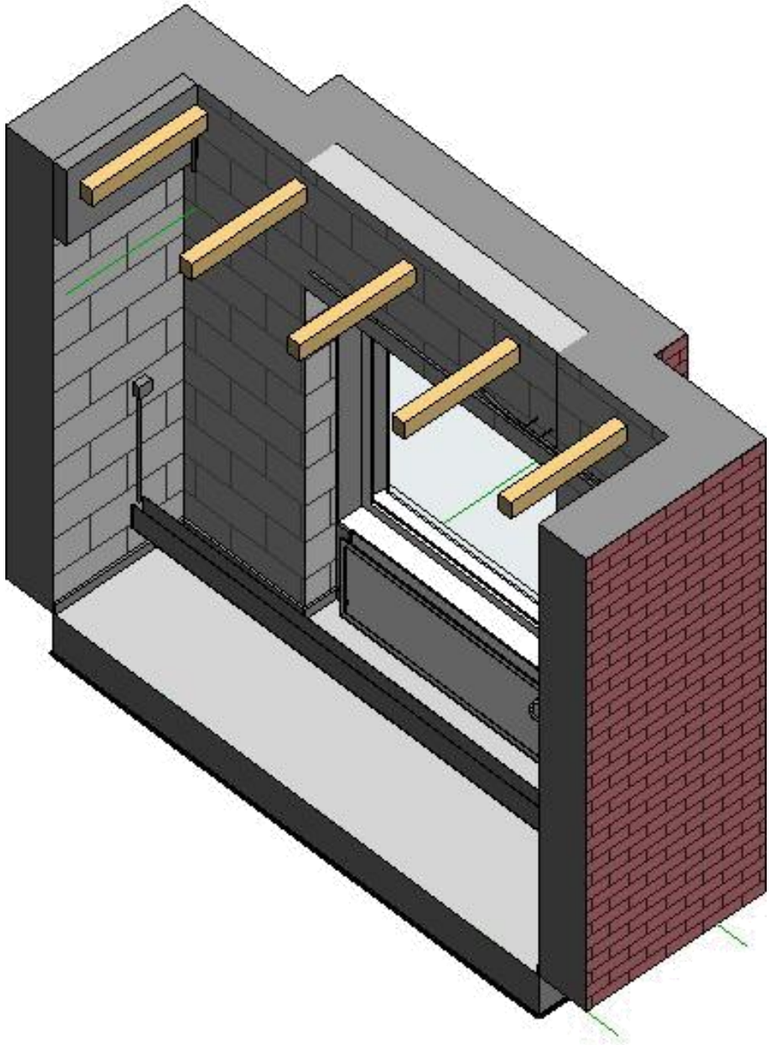


Switch off point cloud for reconstructed model

Digital Model

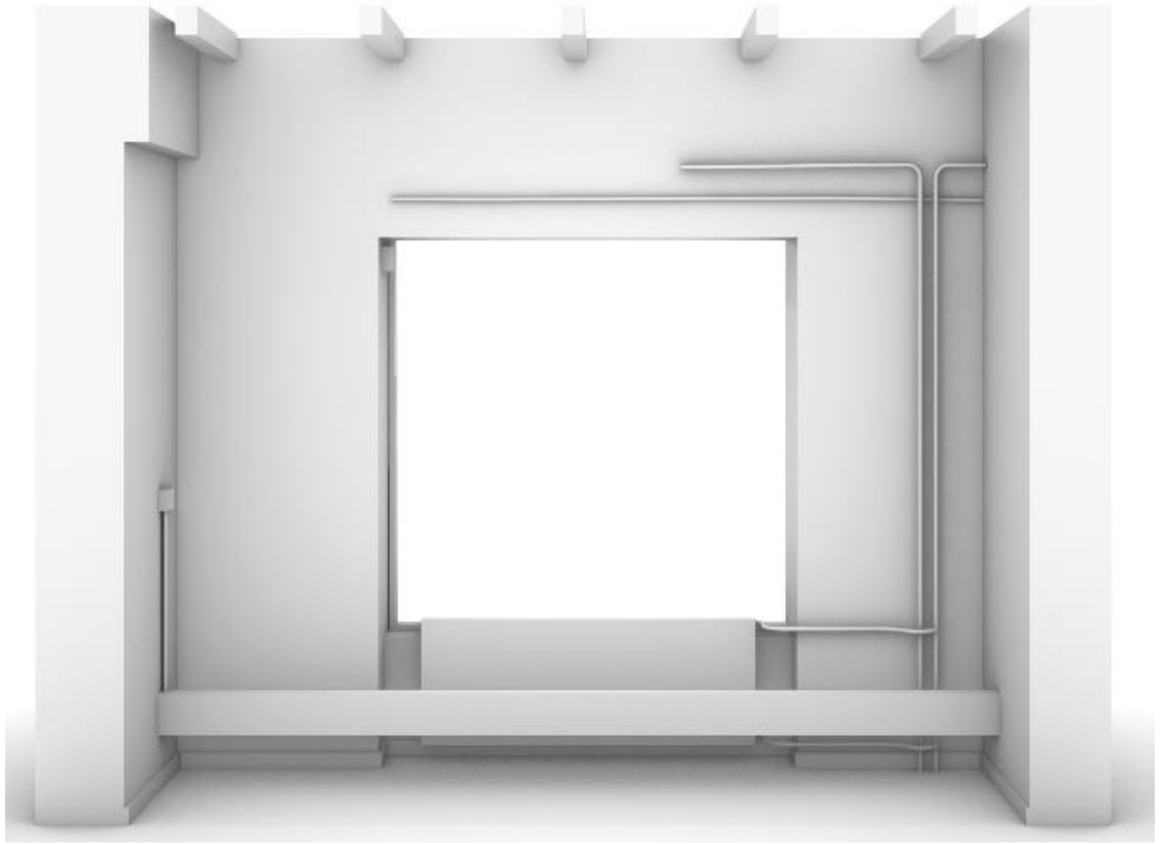
Reconstruction in Revit



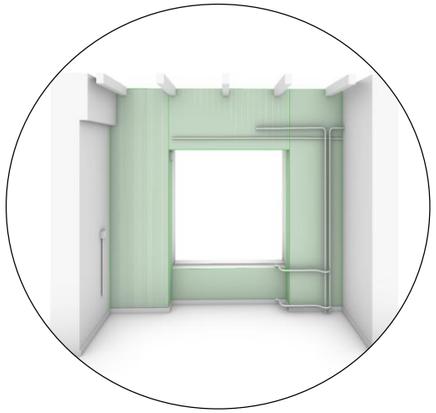


Digital Model

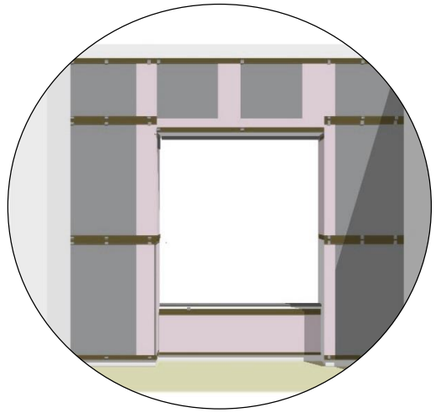
Reconstruction in Rhinoceros



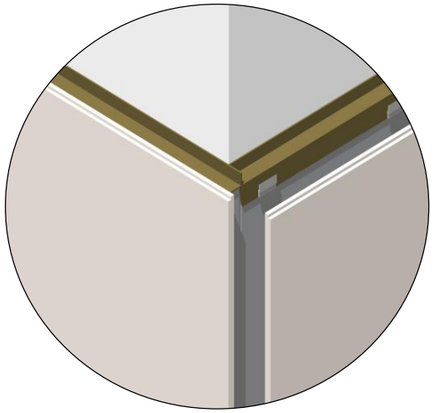
Panel layout



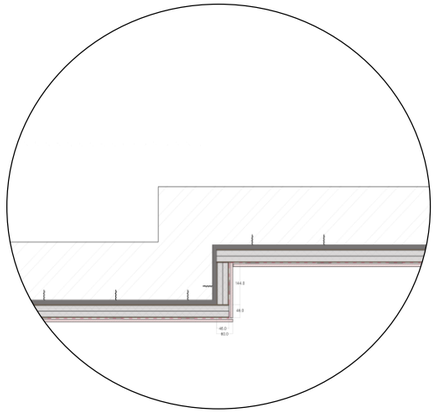
Identify external wall surface to insulate



Divide surface in panels as per commercially available insulation sizes

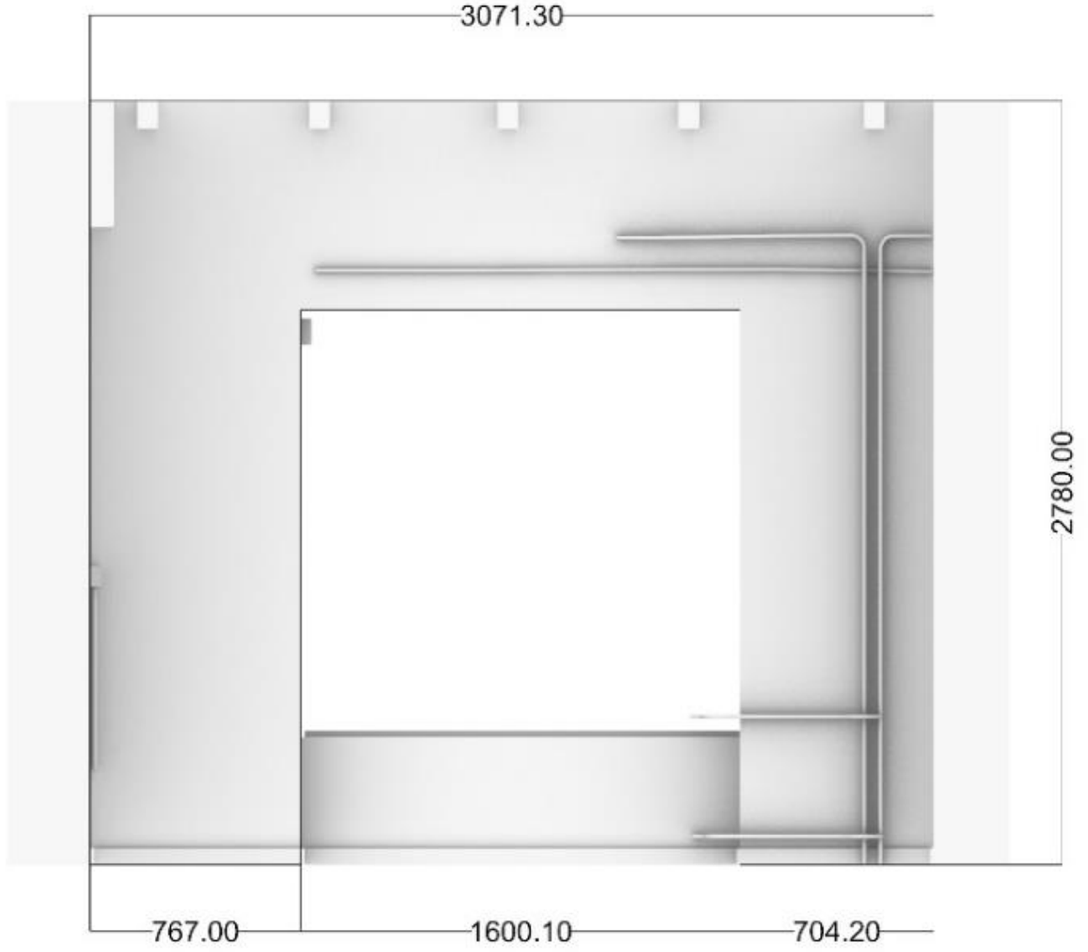


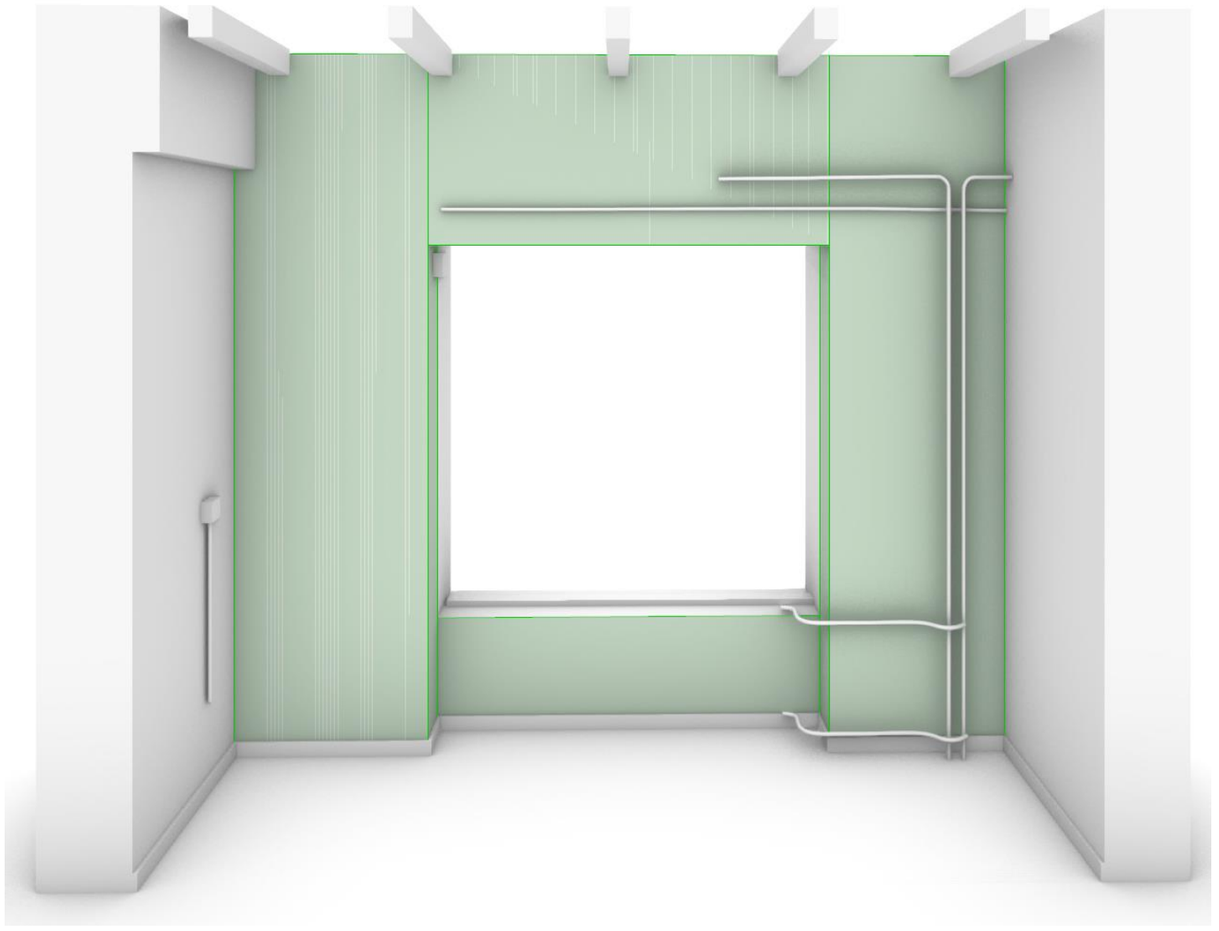
Resolve fixtures, connections and edge joinery



extract dimensions and send for production

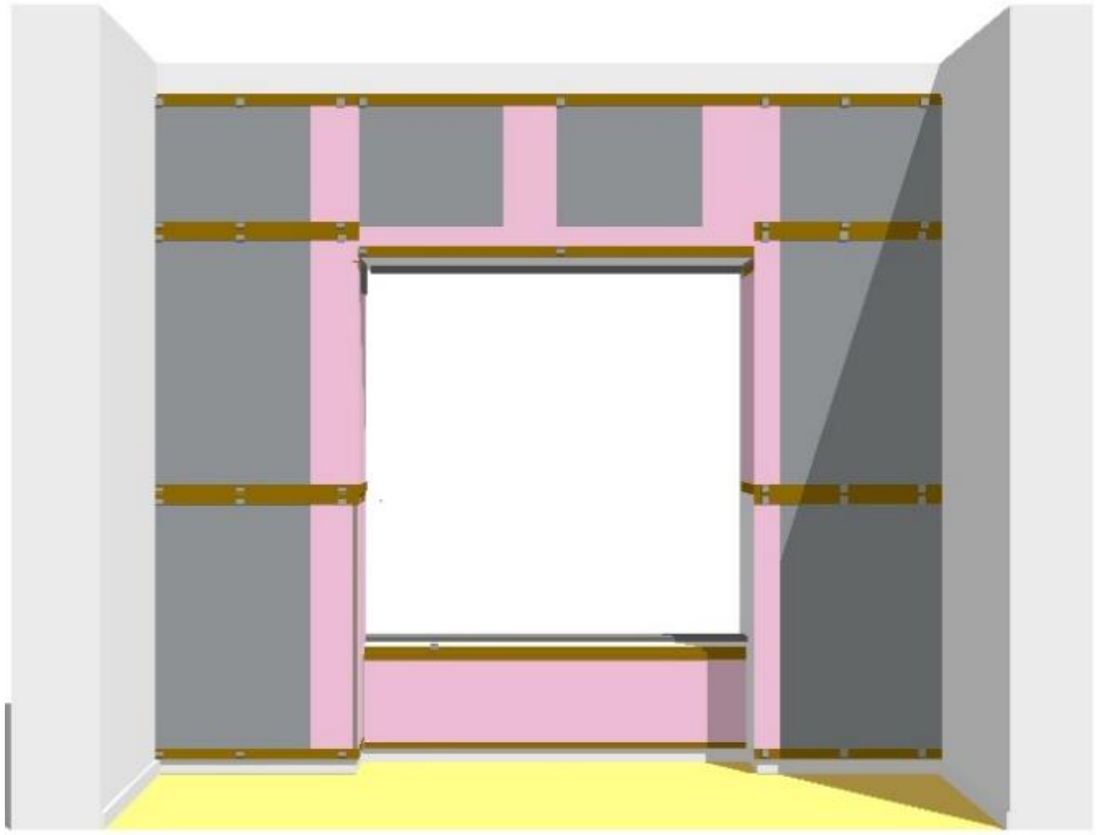
Target surfaces

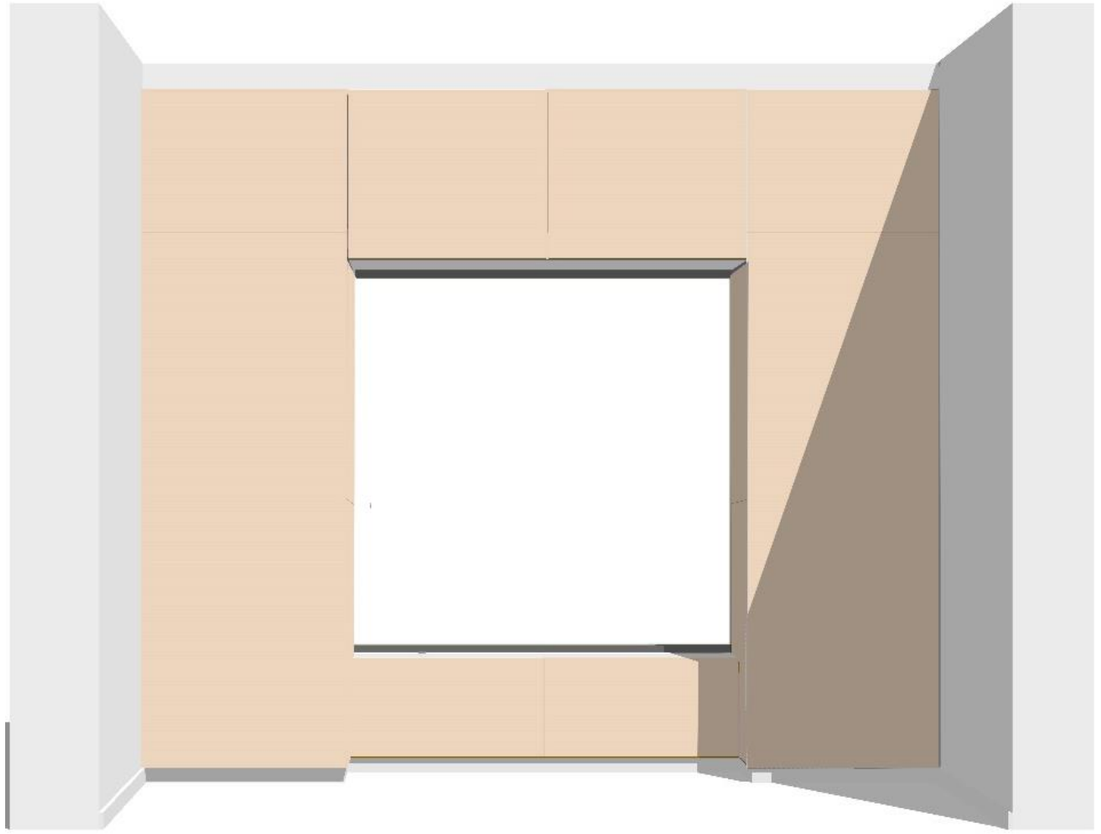




Surface division

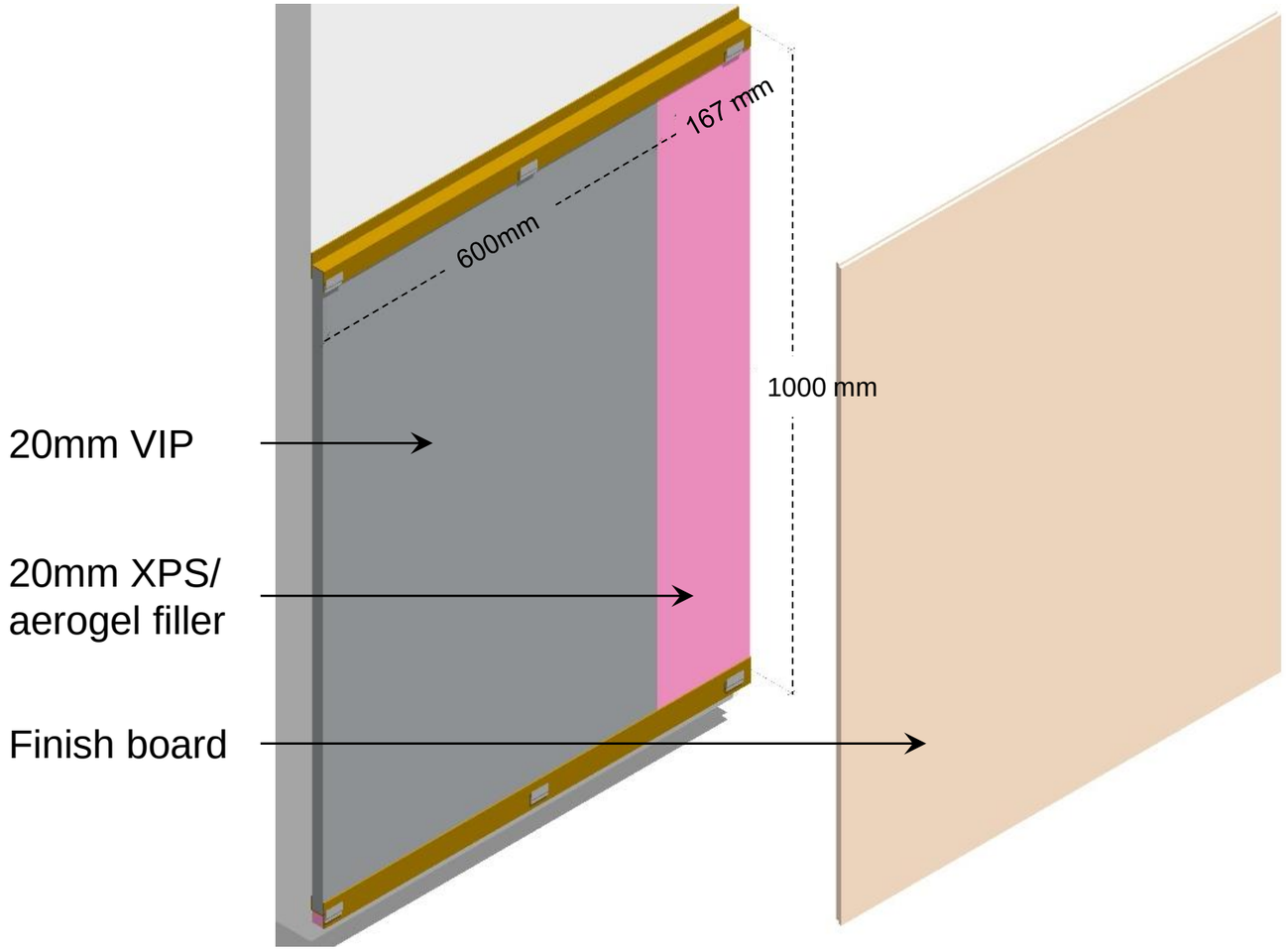
Layout option 1 – standard sized VIP’s with filler insulation





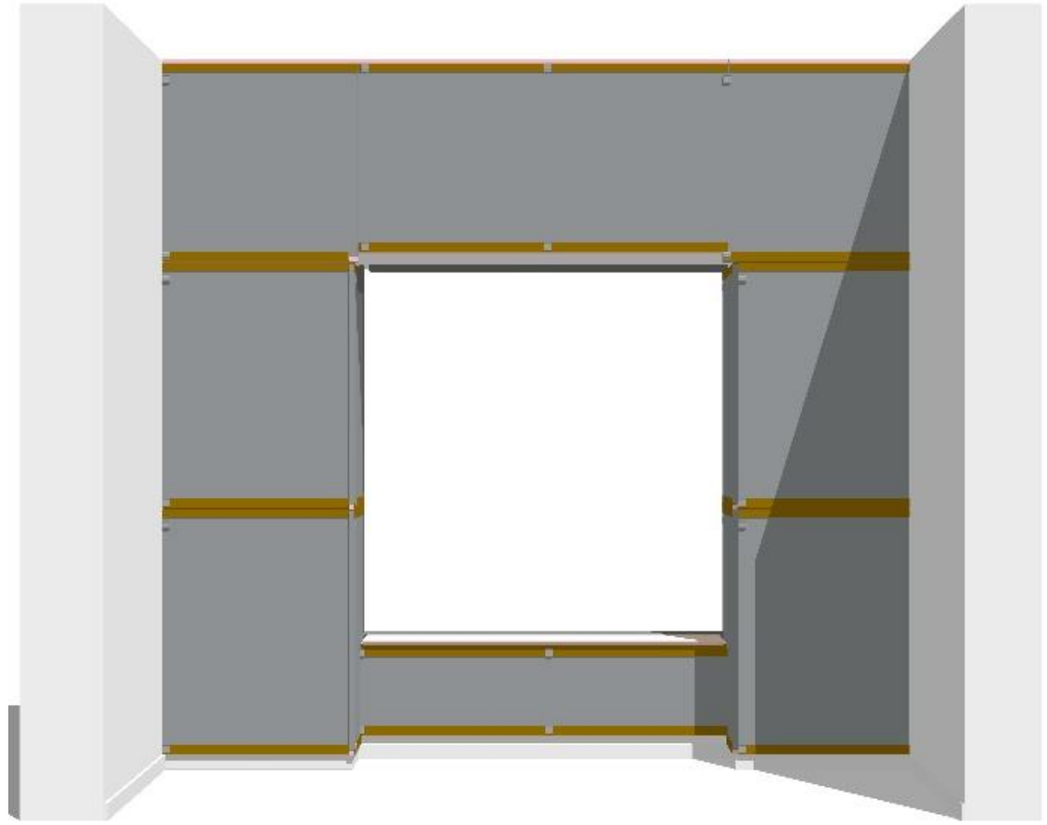
Surface division

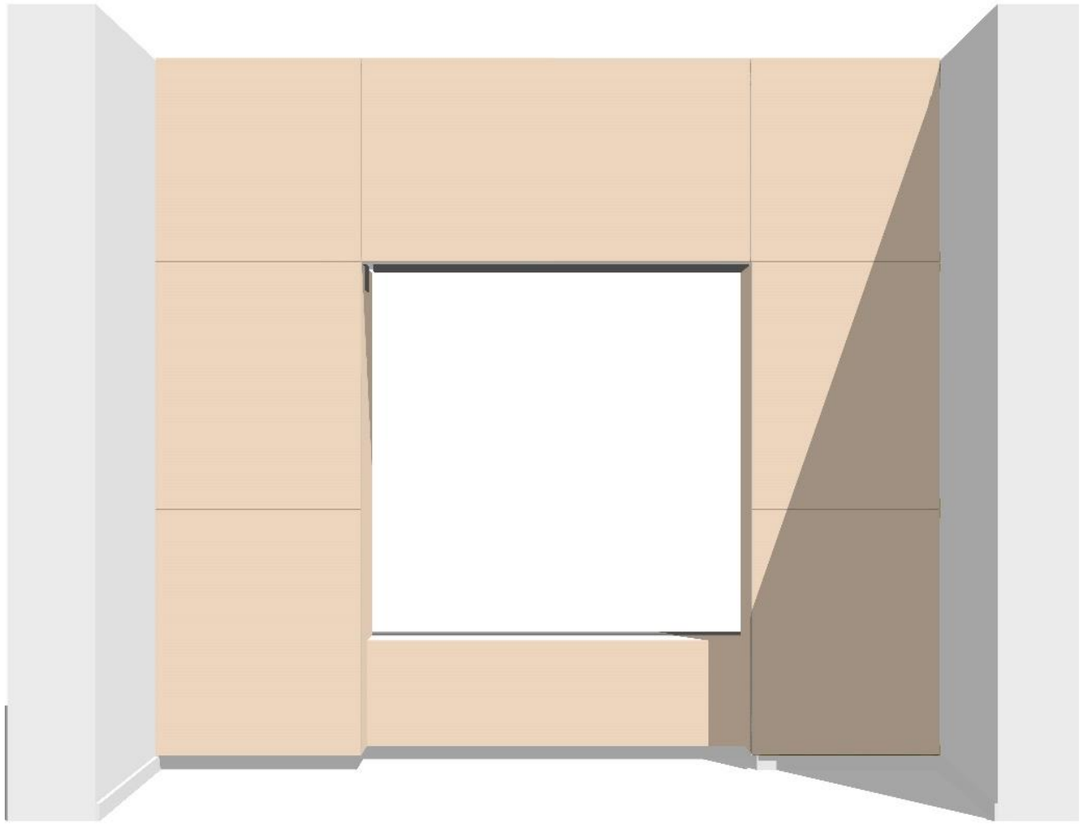
Layout option 1 – standard sized VIP’s with filler insulation



Surface division

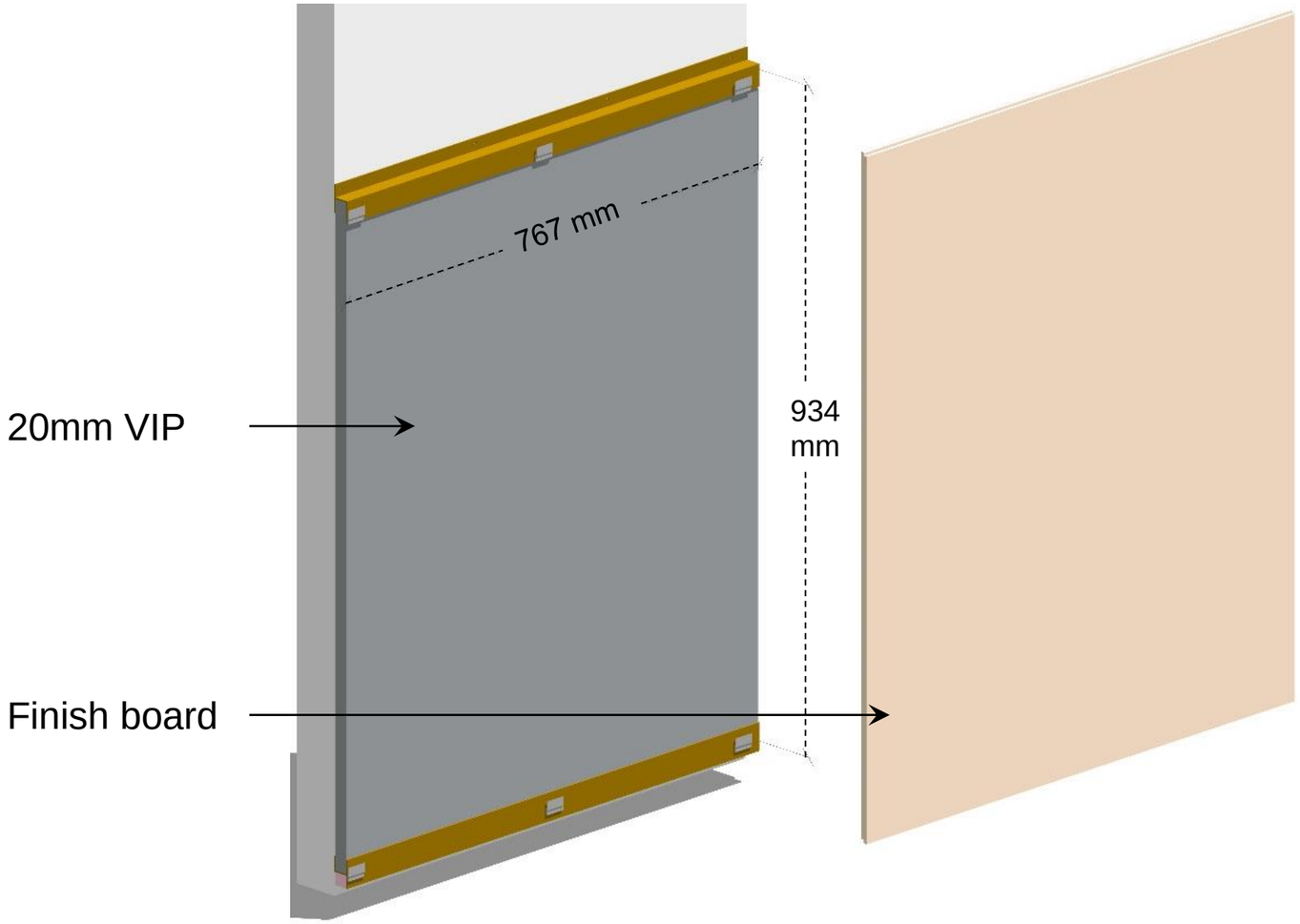
Layout option 2 - custom sized insulation





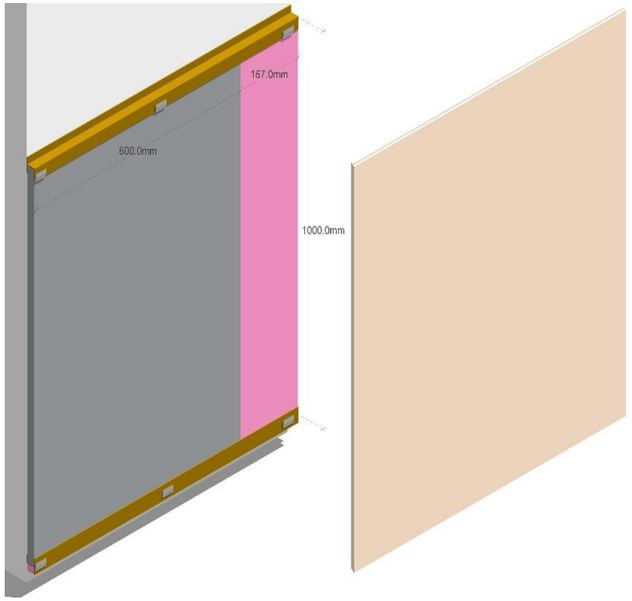
Surface division

Layout option 2 - custom sized insulation

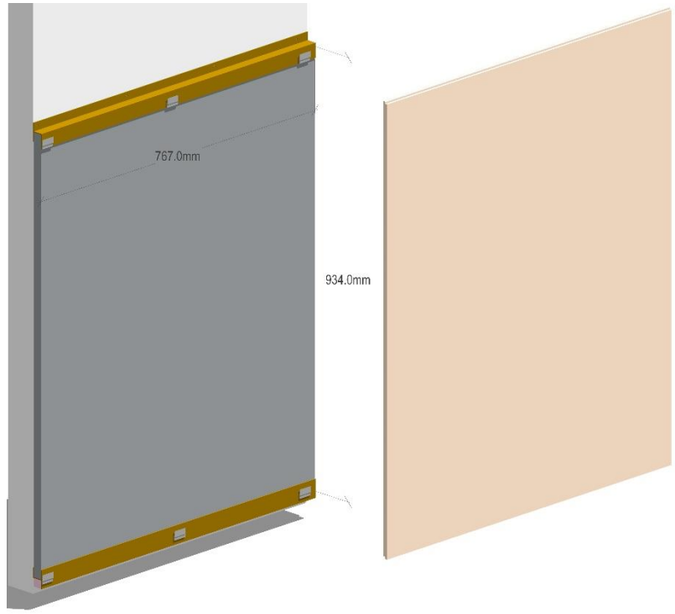


Surface division

Layout remarks



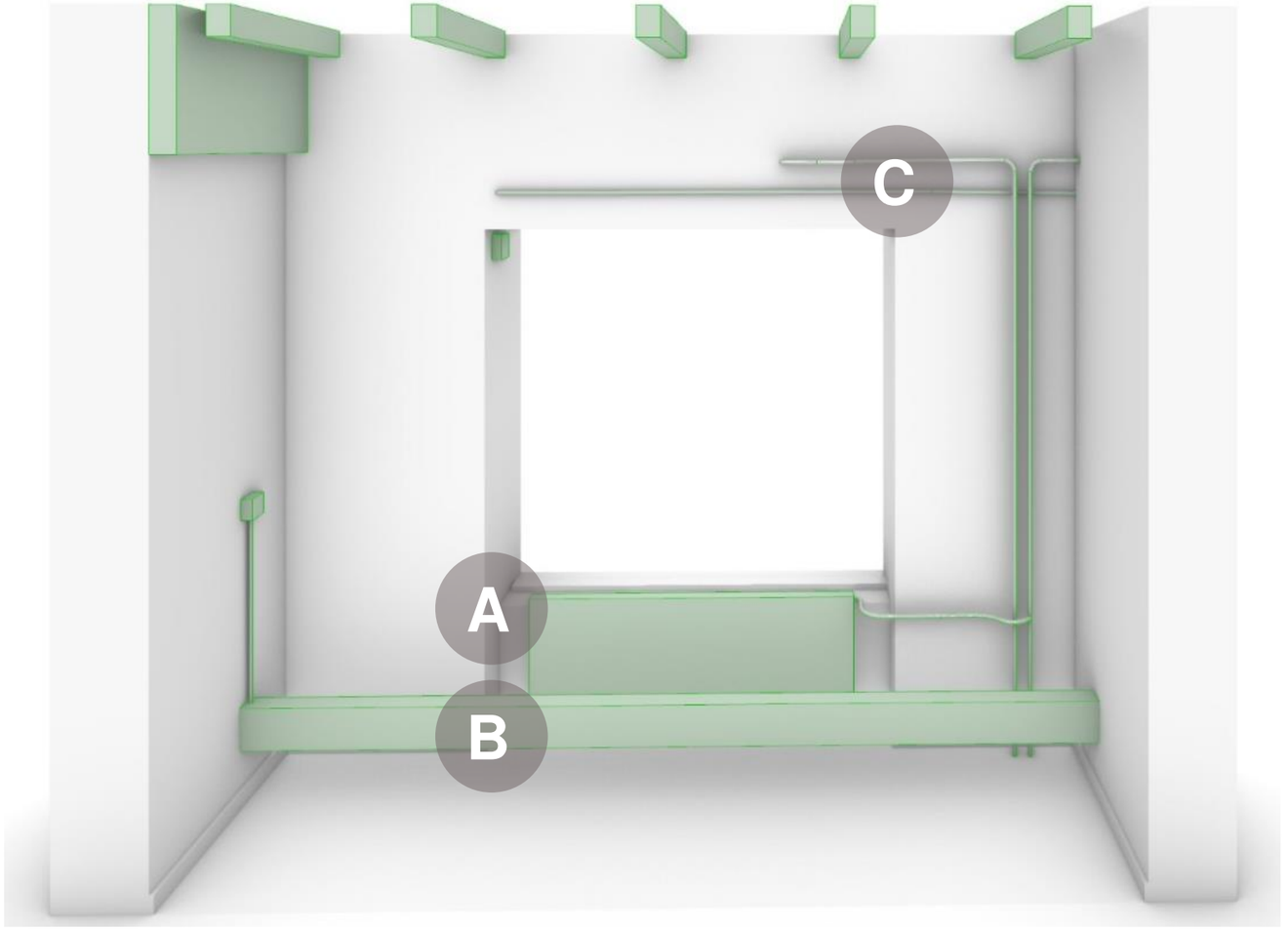
- Commercially available size of VIP’s hence economical
- U value of 0.43 with 20mm XPS or 0.34 with 20mm aerogel blanket or 0.28 with 25mm thick section
- Aligning is more difficult due to fixed sizes



- Customized VIP’s of the required size hence expensive
- U value of 0.29 W/m2K with 20mm of VIP
- Finish boards aligned to existing patterns

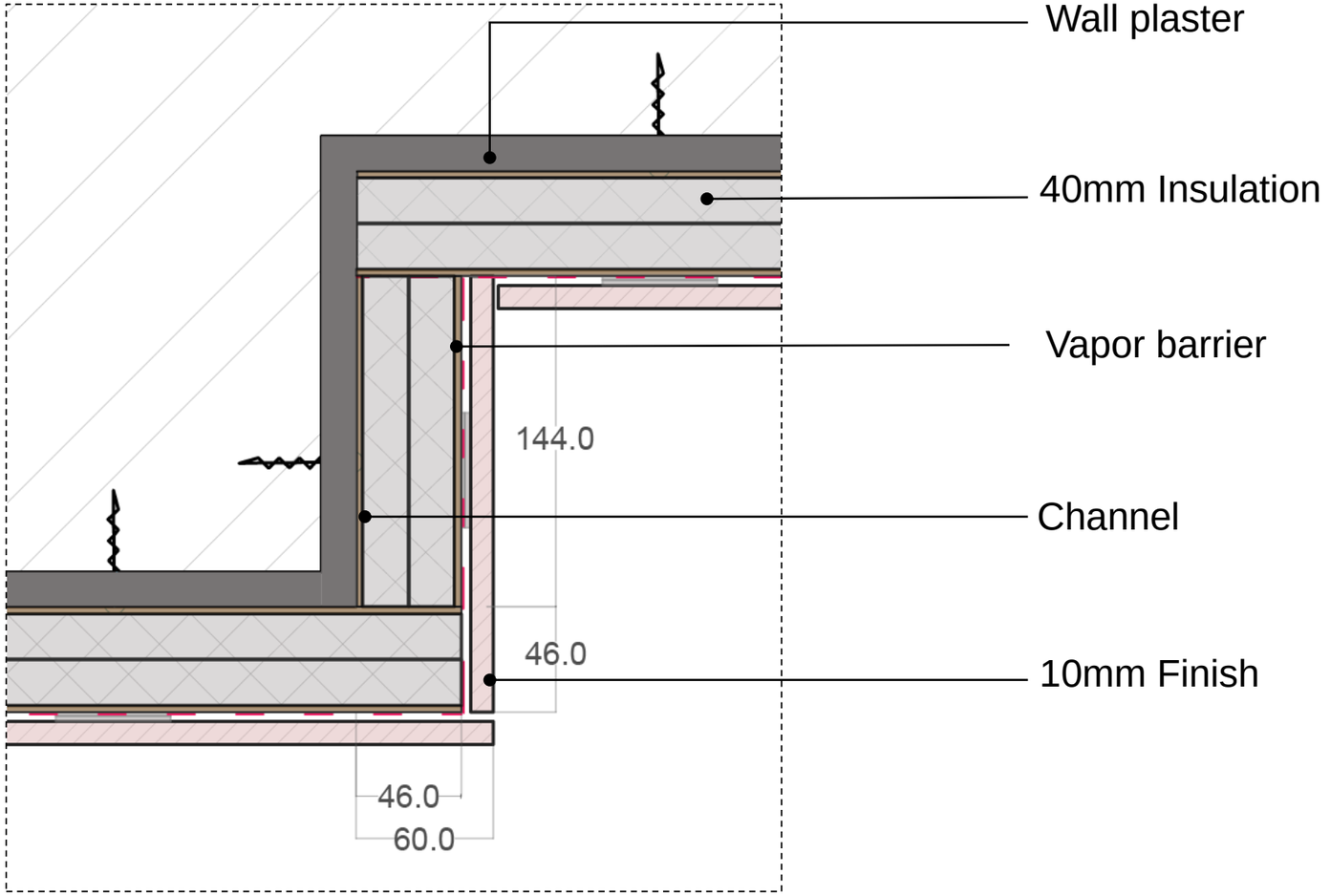
Case study

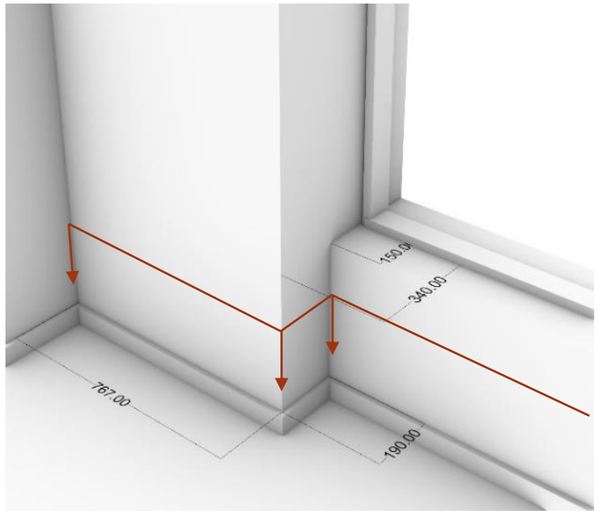
Solving connections



Connections

Detail A : Edge detail

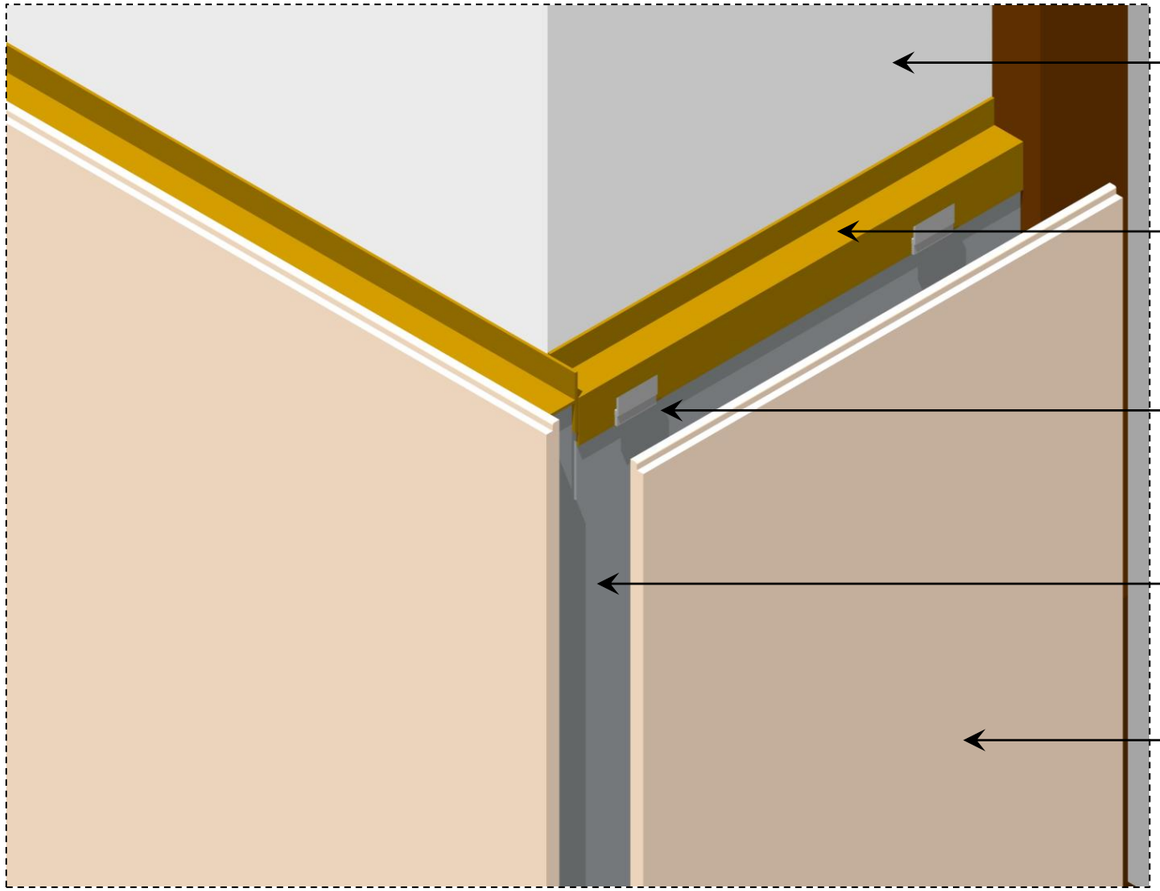


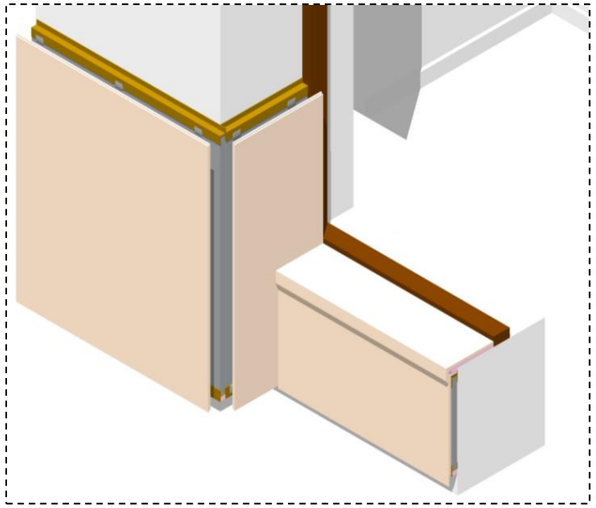


Section plane

Connections

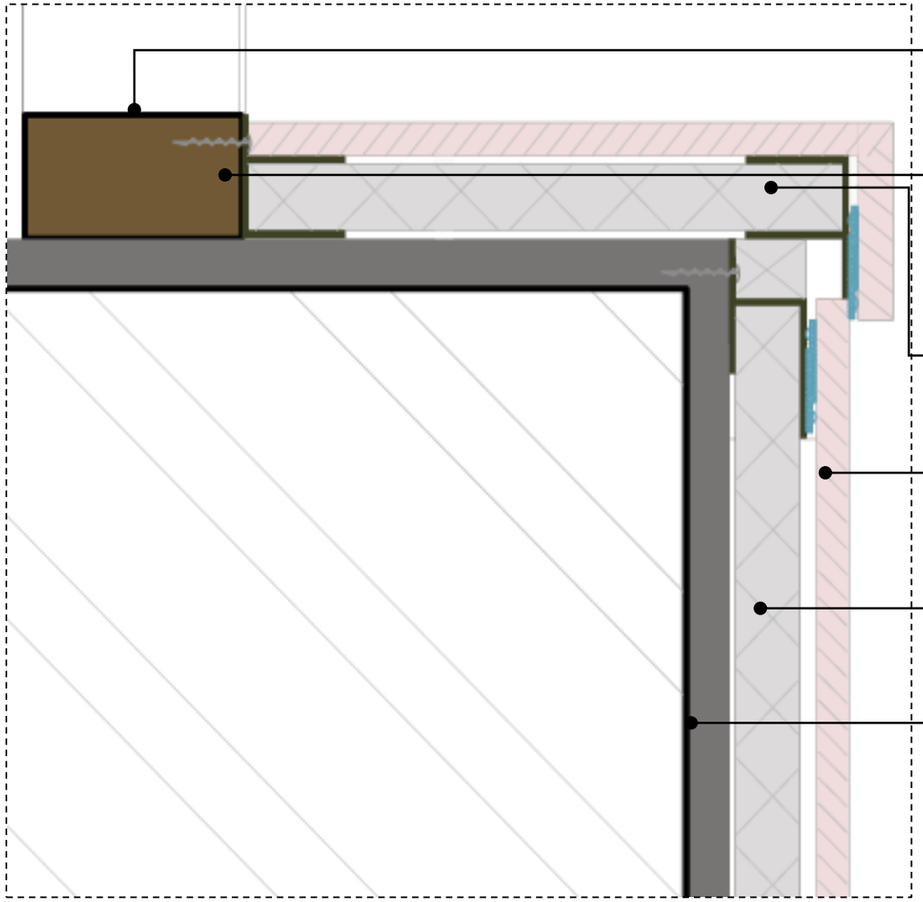
Detail A : corner connection in a butt joint assembly

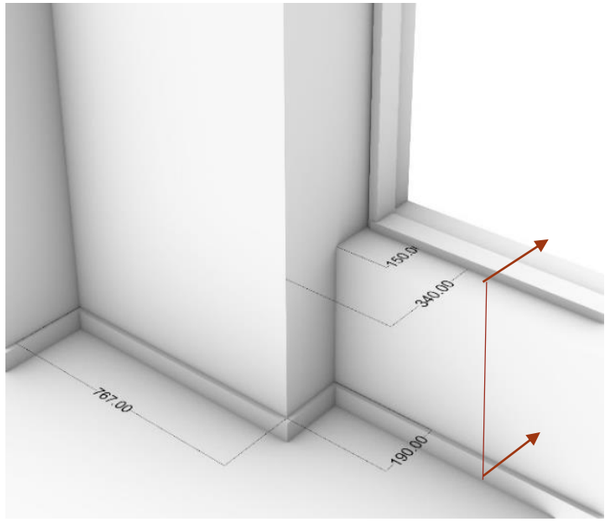




Connections

Detail B : Window reveal

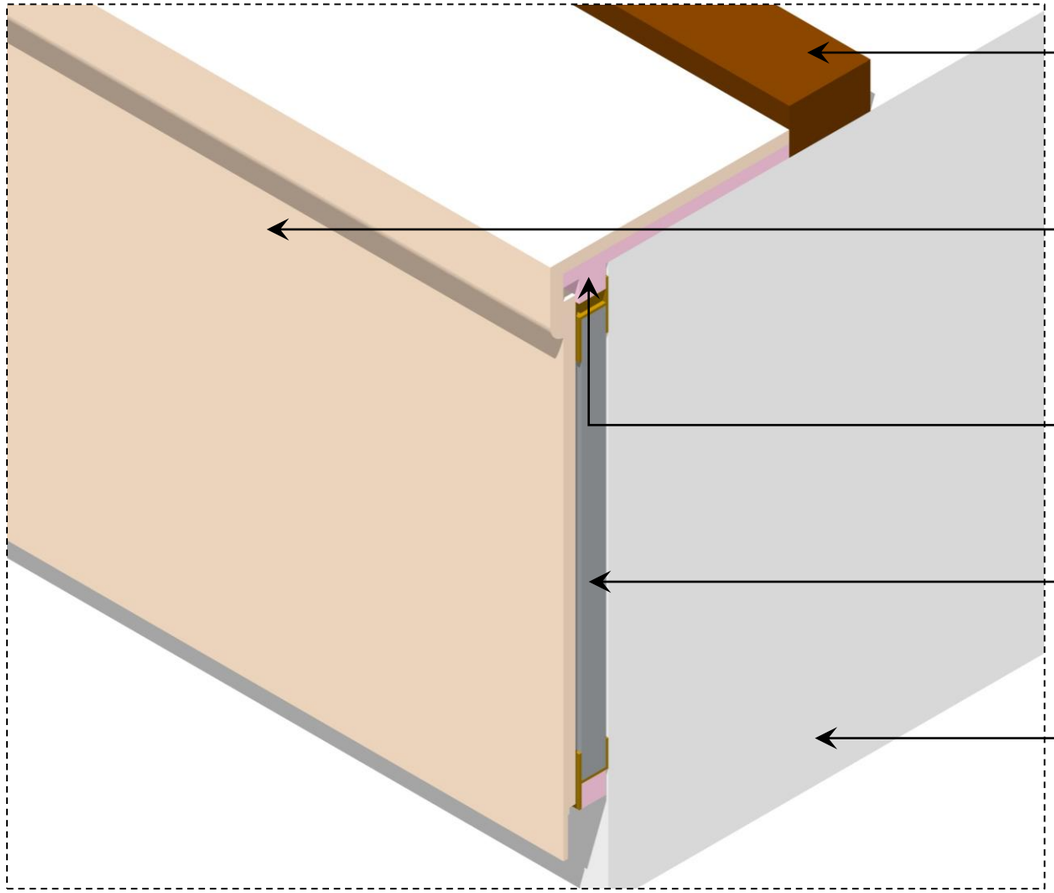




Section plane

Connections

Detail B: window reveal



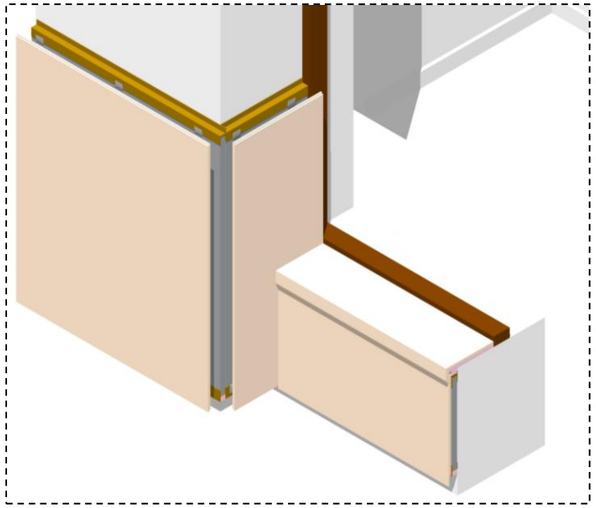
Window frame

10mm Finish

20mm XPS insulation

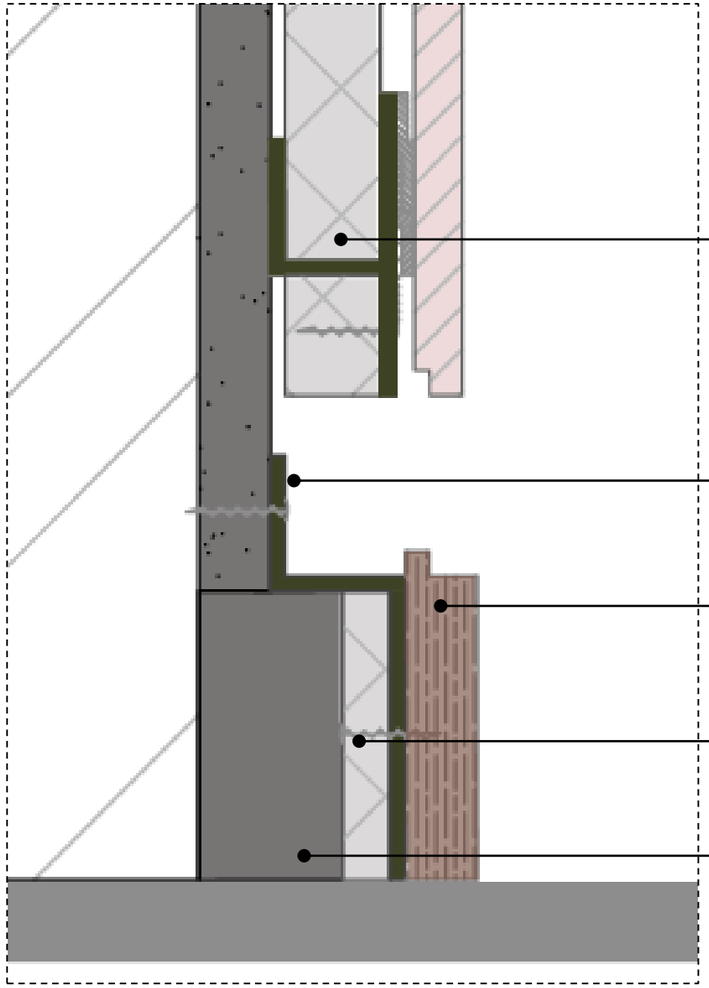
20mm VIP Insulation

Extern wall



Connections

Detail B : Skirting



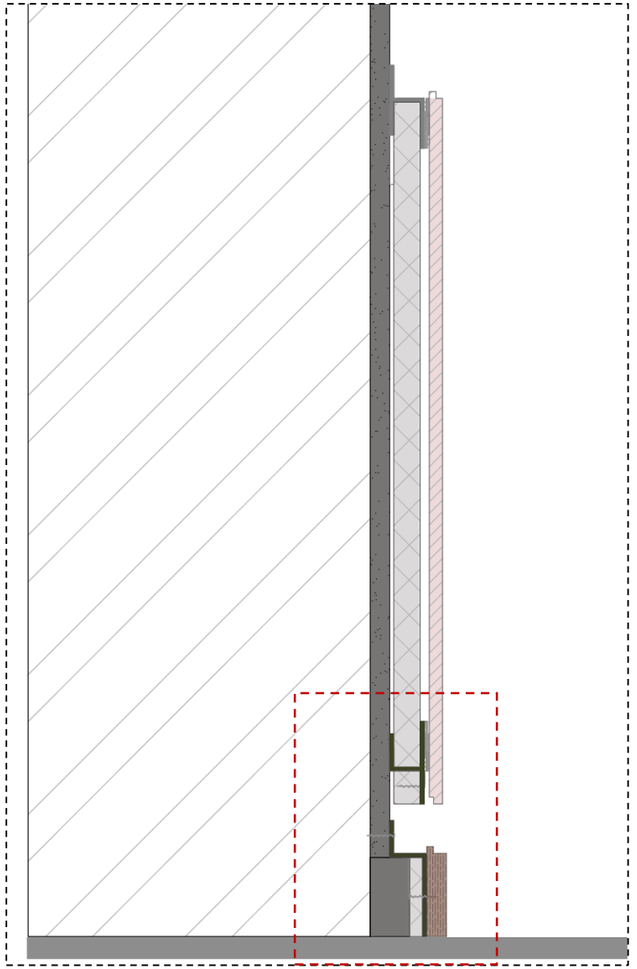
Wall panel slides on top of skirting

Channel fixed to wall

15 mm skirting finish

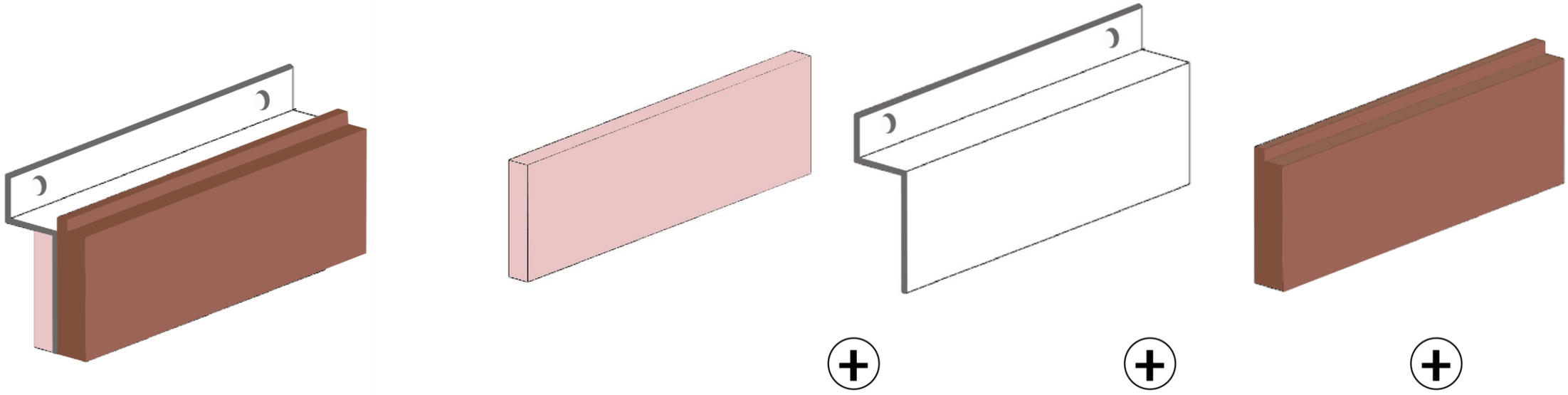
10mm insulation layer

Existing skirting



Connections

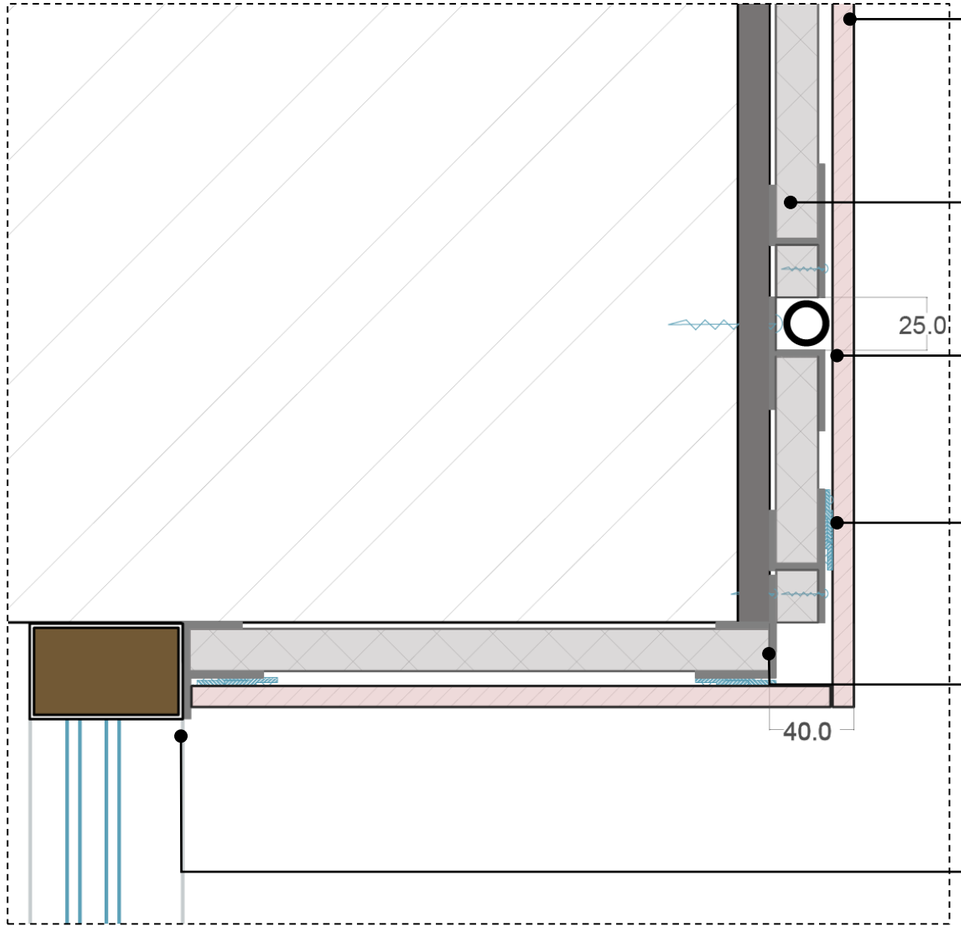
Detail B : Skirting panel assembly sequence



10mm insulation strip Channel Skirting finish

Connections

Detail C : Pipes option a



10mm finish board

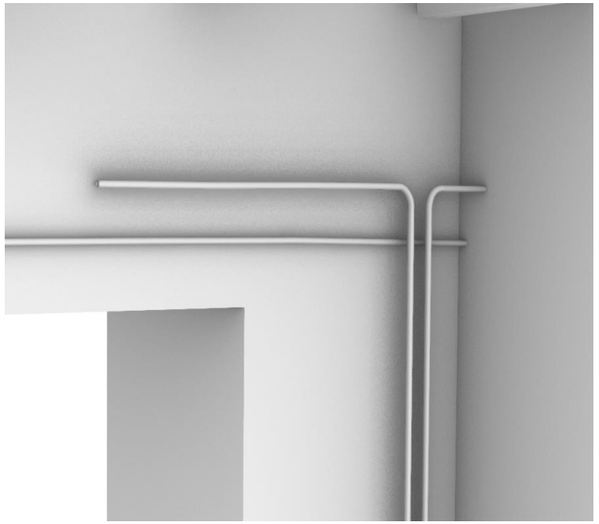
20mm Insulation

Pipe existing

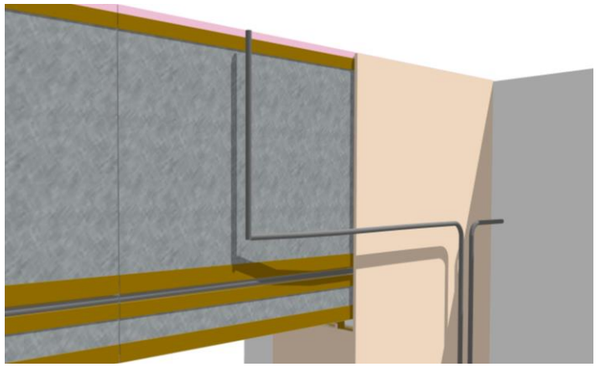
Z- clips

Channel fixed to wall

Channel fixed to window frame

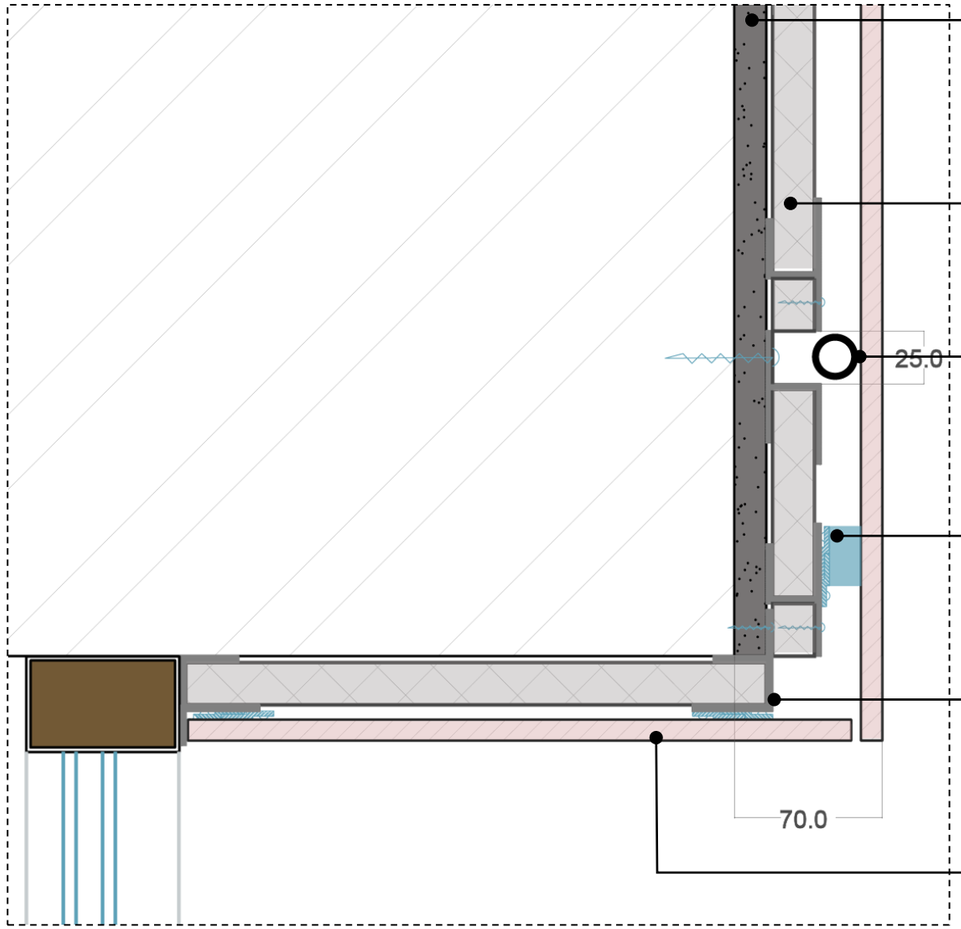


Section plane



Connections

Detail B : Pipes option b



Wall plaster

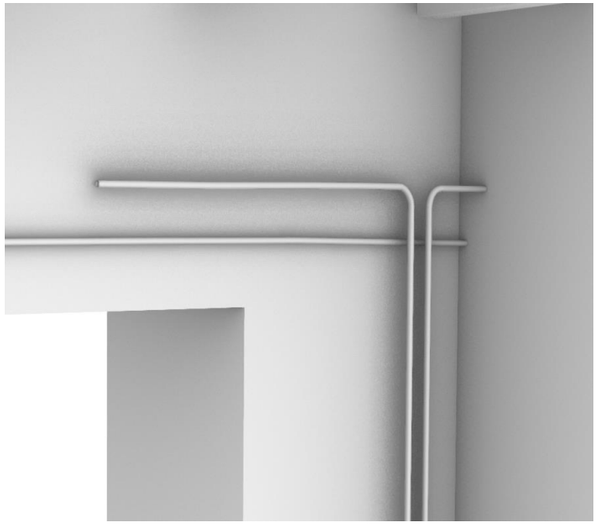
20mm Insulation

Pipe

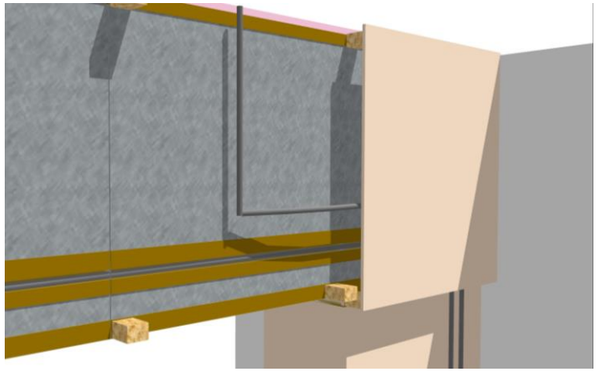
Z- clips and spacer

Channel fixed to wall

10mm Finish

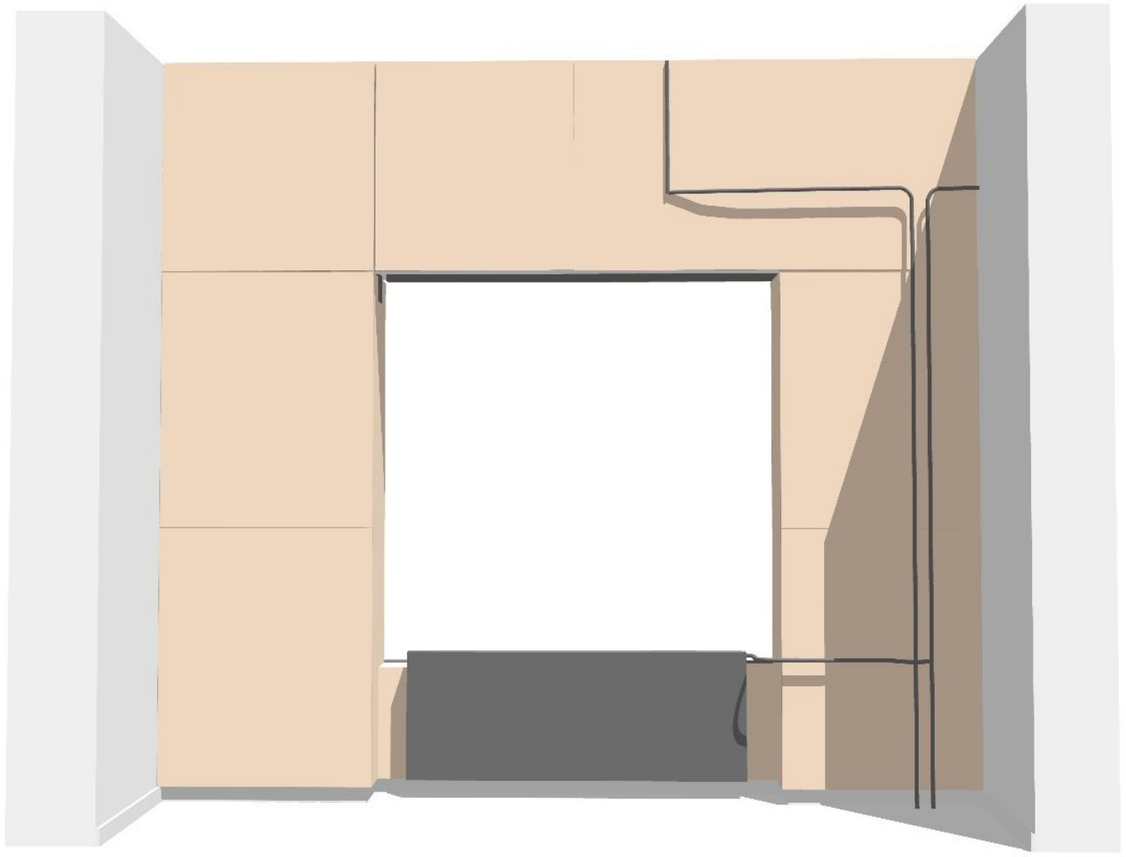


Section plane

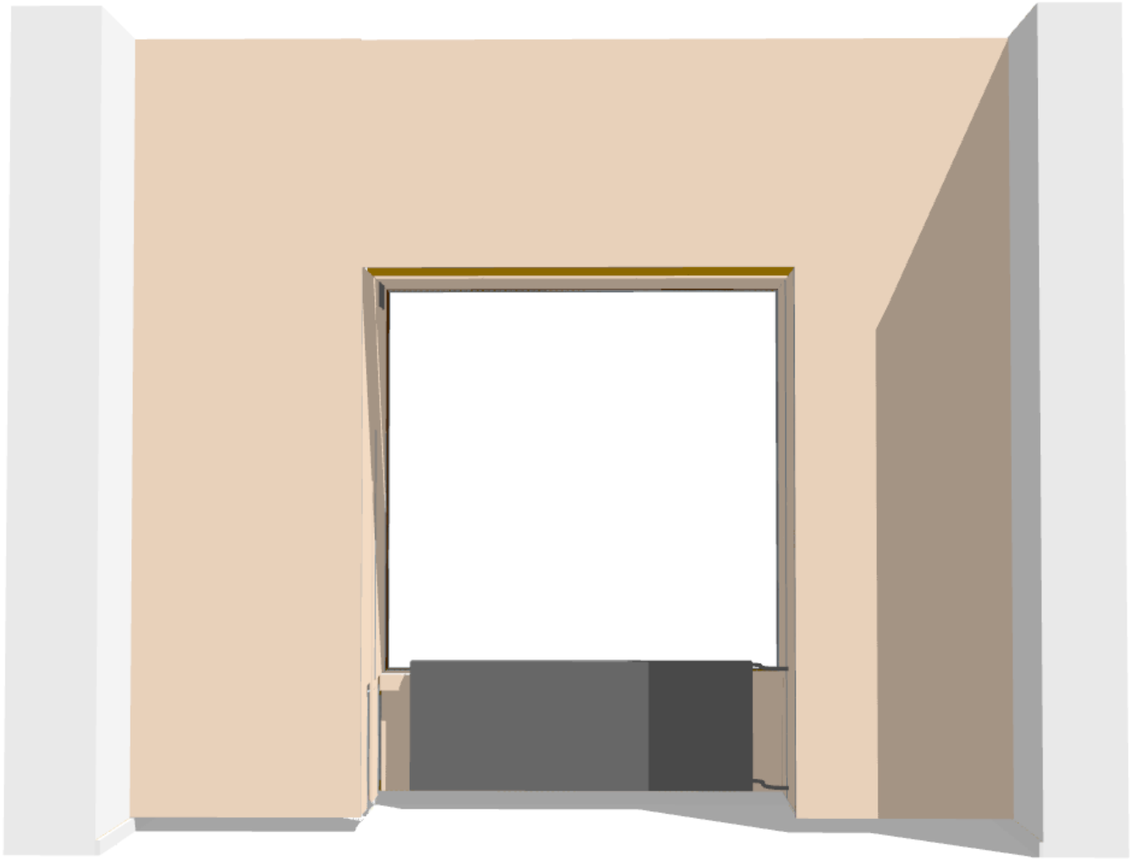


Connections

Layout with option a and b

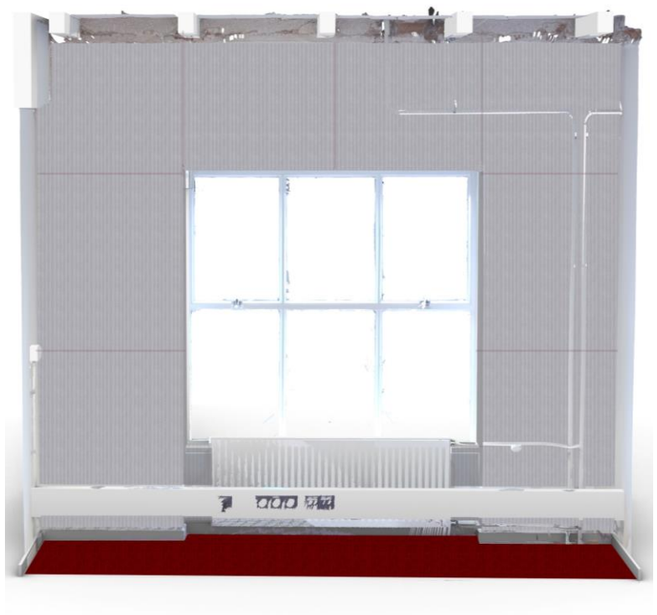


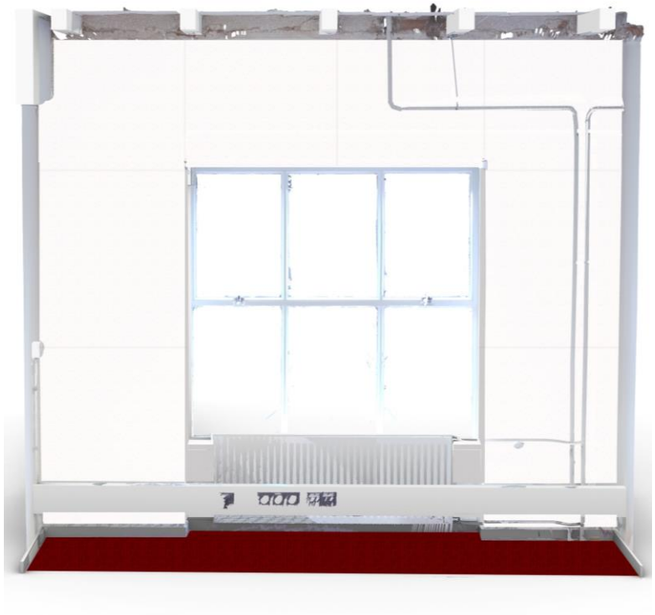
Visible pipes. Panel can slide behind existing pipes



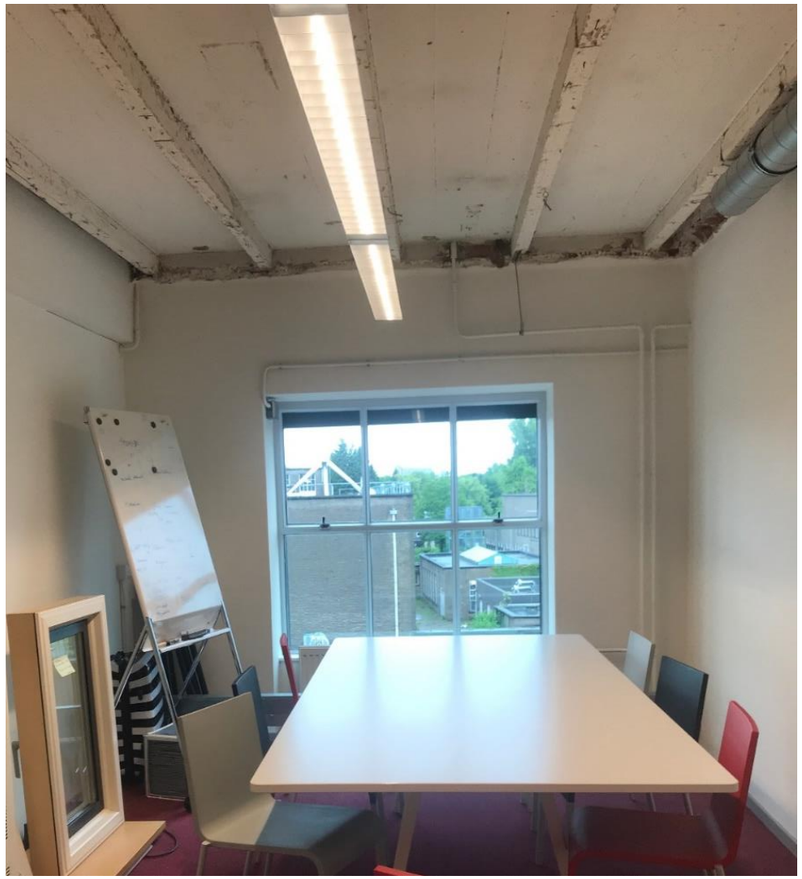
Hidden pipes. Panel cover is offset to include pipes in a cavity

Finishes

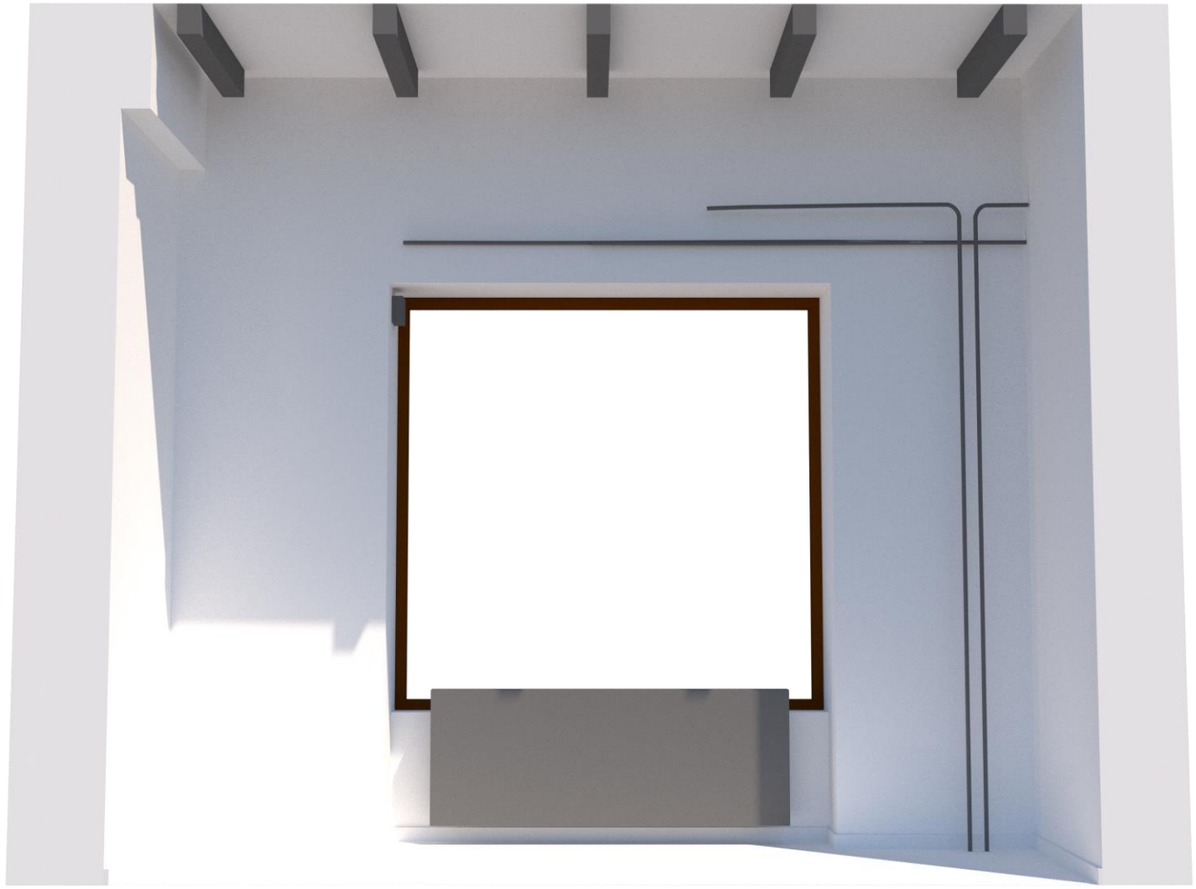




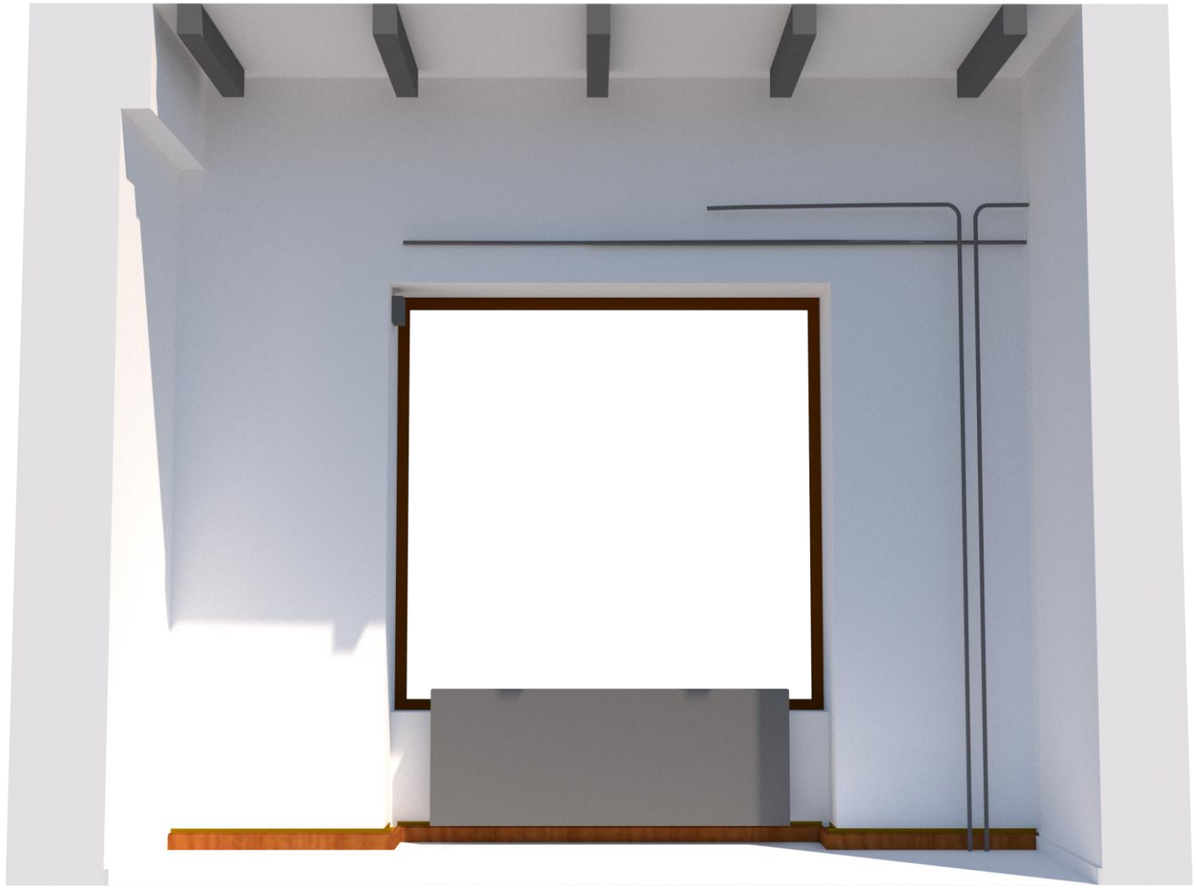
Visualization



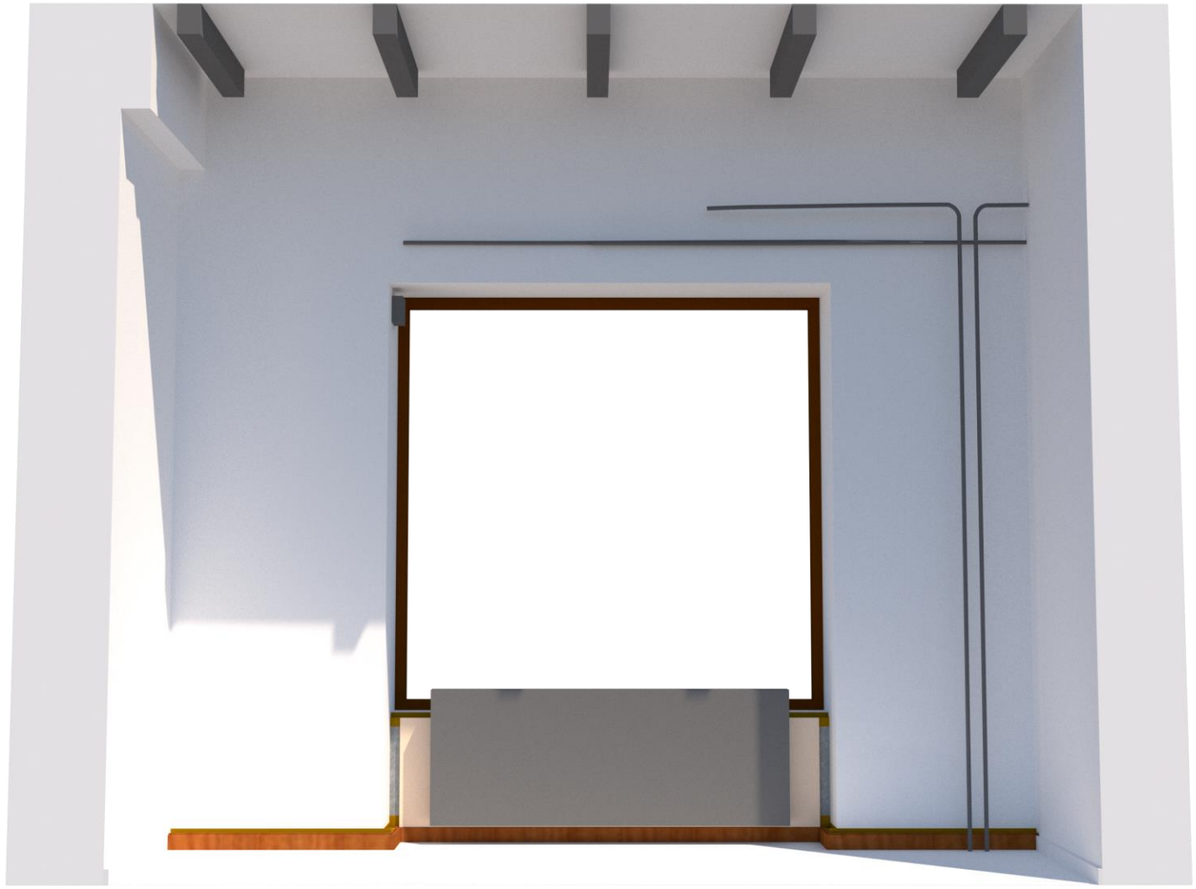
Assembly Sequence



Assembly Sequence



Assembly Sequence



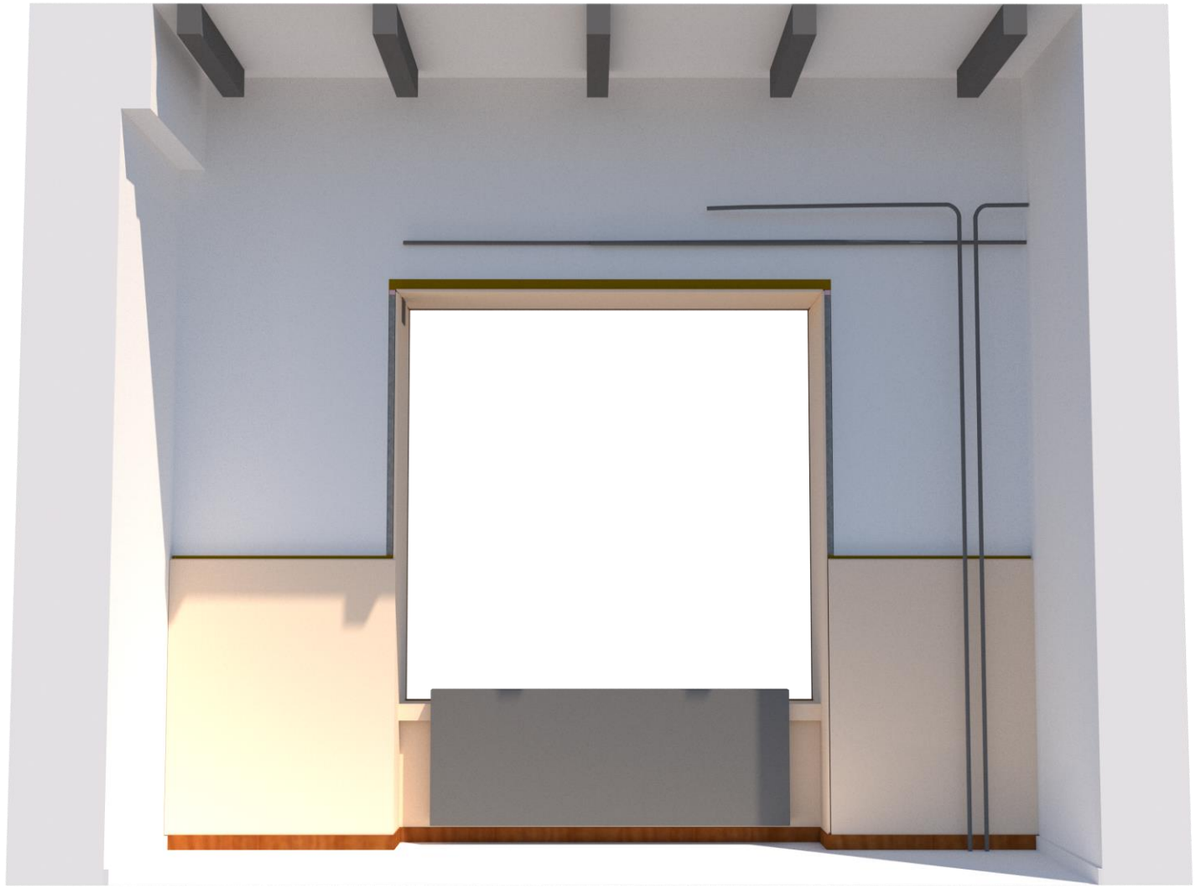
Assembly Sequence

Assembly Sequence

Assembly Sequence

Assembly Sequence

Assembly Sequence



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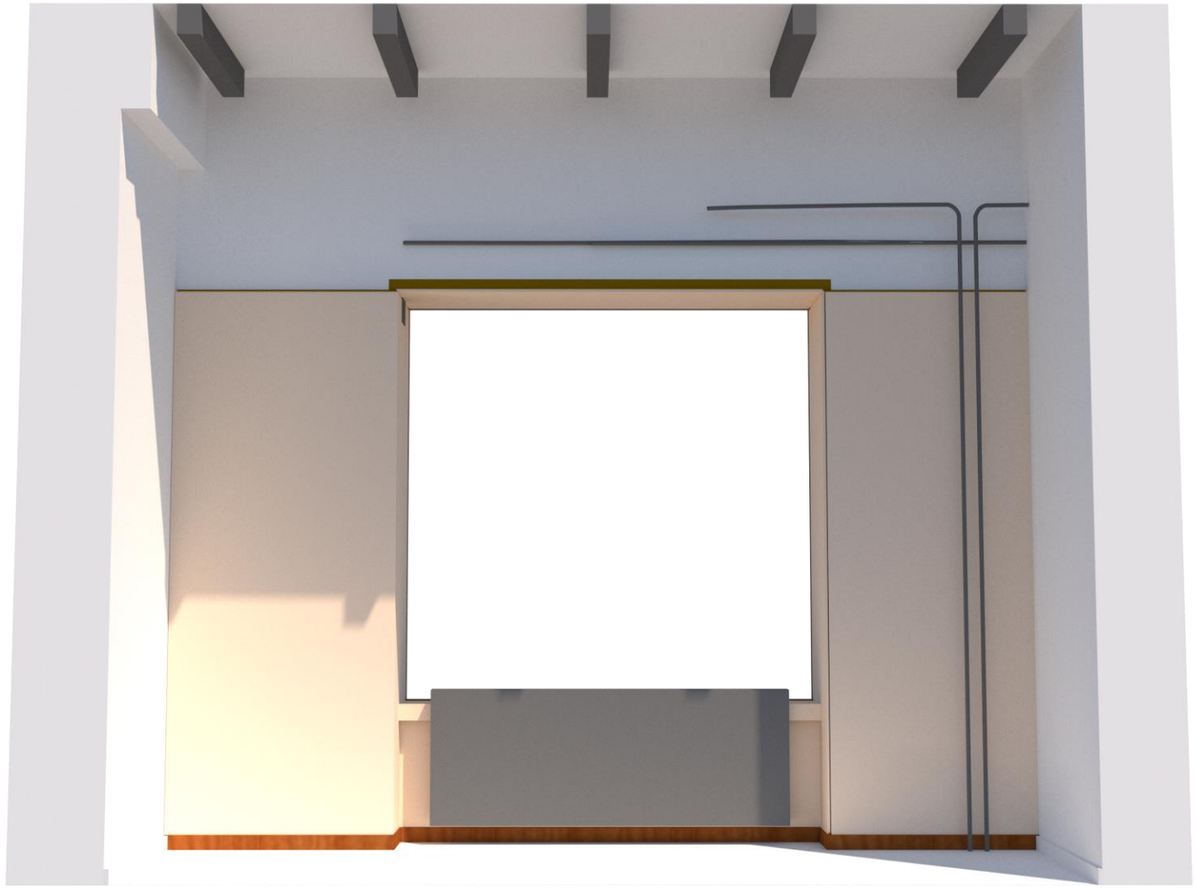

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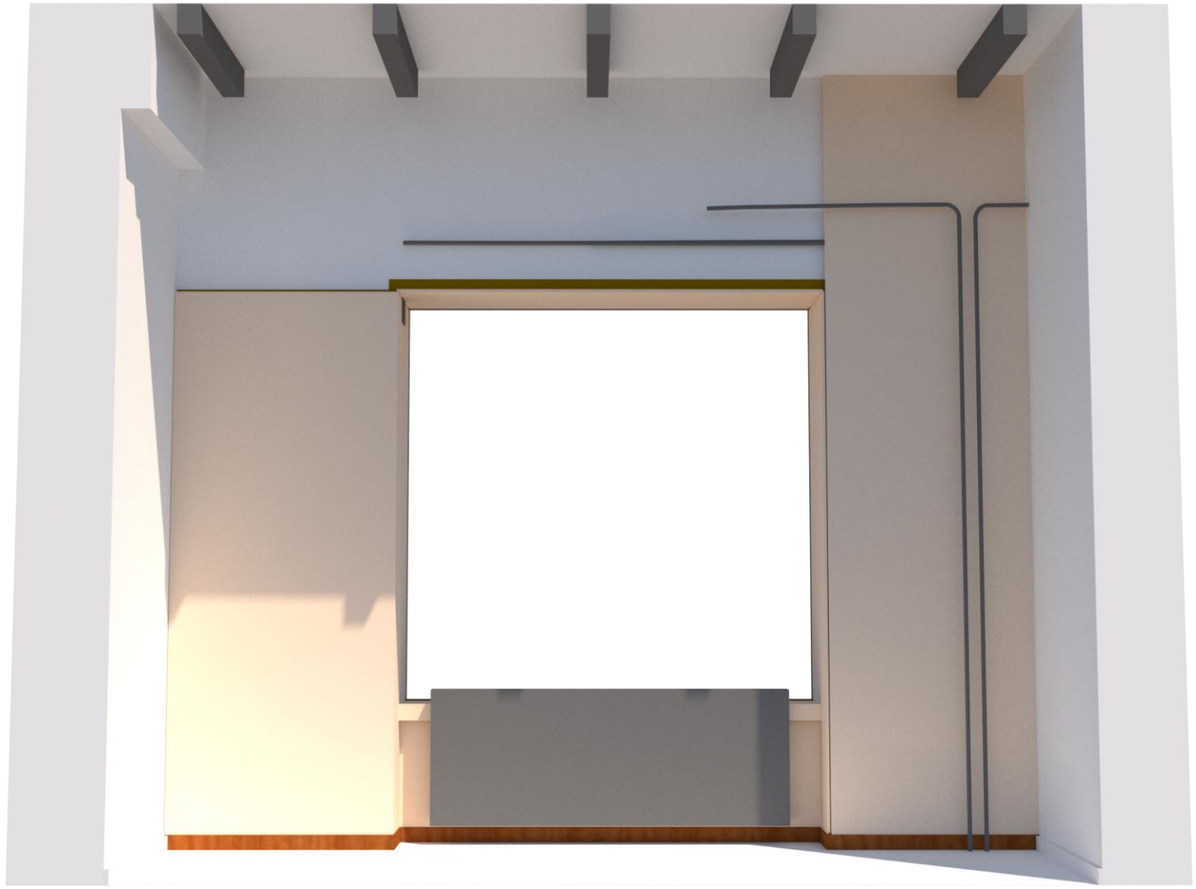

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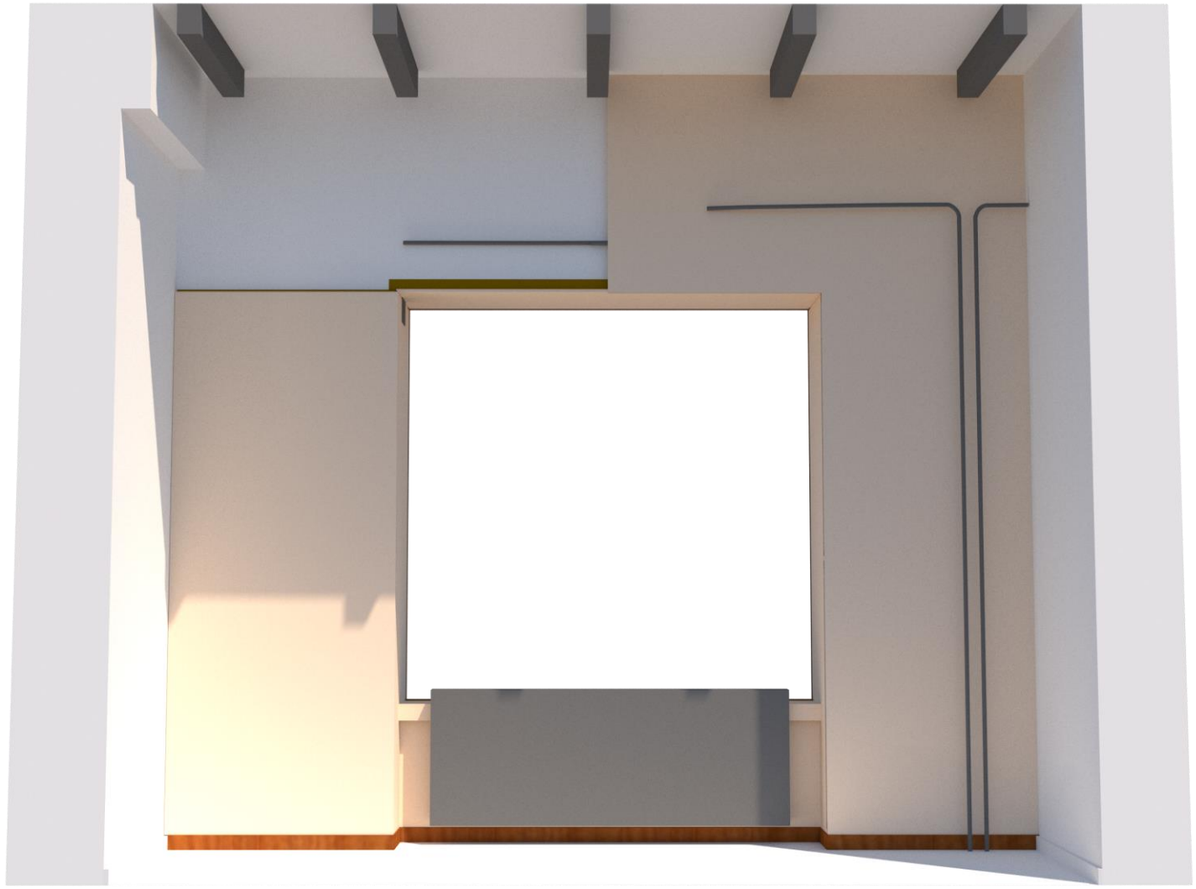
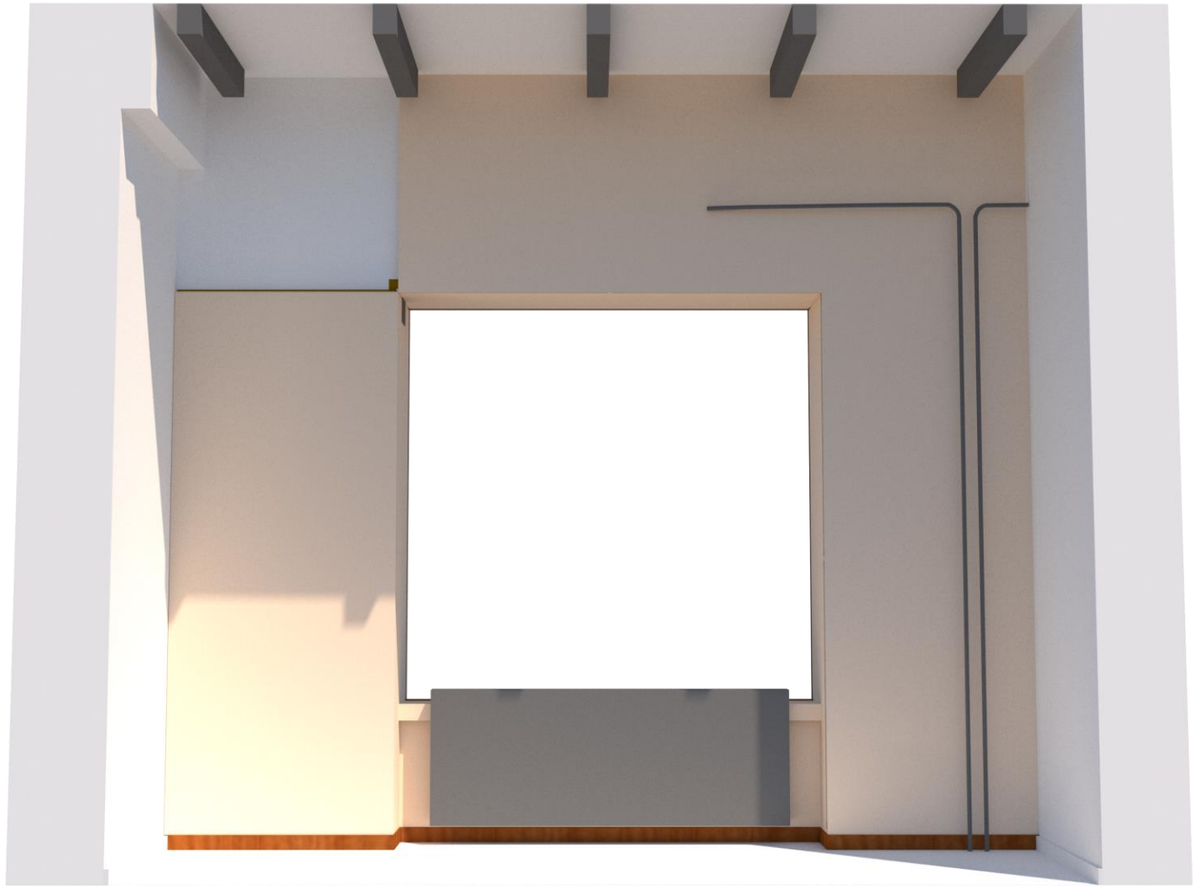
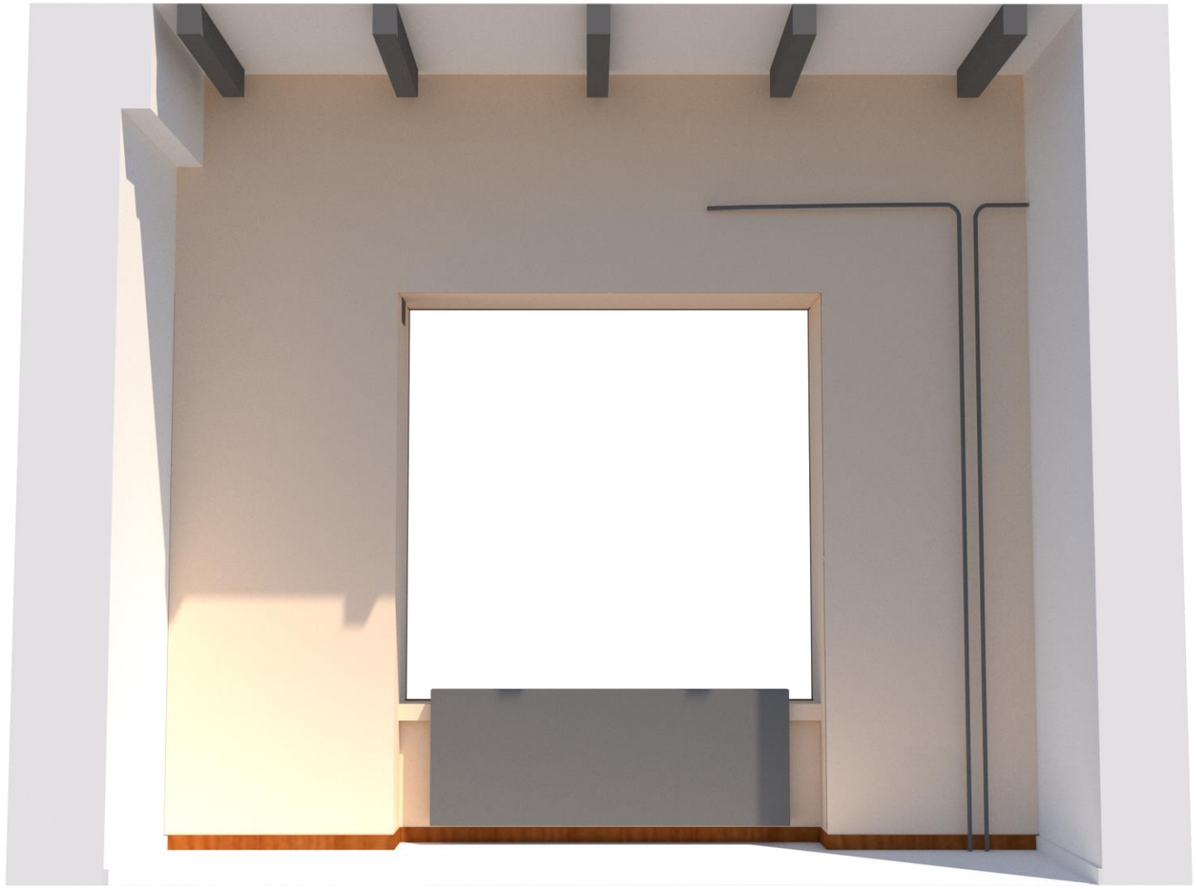


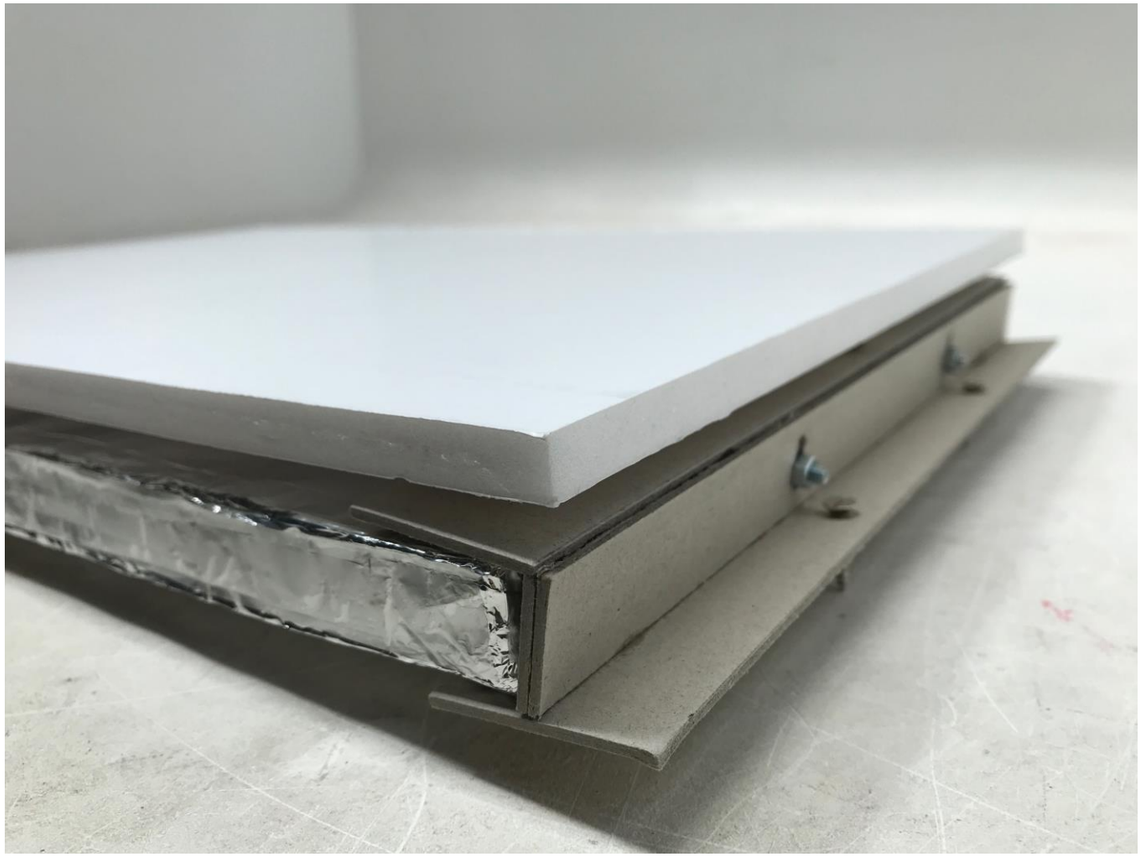
Assembly Sequence



Assembly Sequence



Mock up



Case study

Conclusion

- Laser scanning is a fast and accurate method for getting measurements.
- Creating a digital model from point cloud still requires development and machine learning
- Manual reconstruction lead to inaccurate measurements
- Typical connection details need to be modified as per site conditions
- Space constrains can help in material selection
- Budget constrains can help layout selection
- Visualizations and personalisation engages the occupants in the process

Research question

How can the advancements in insulation material and technologies help to optimize the energy renovation process of interior envelope?

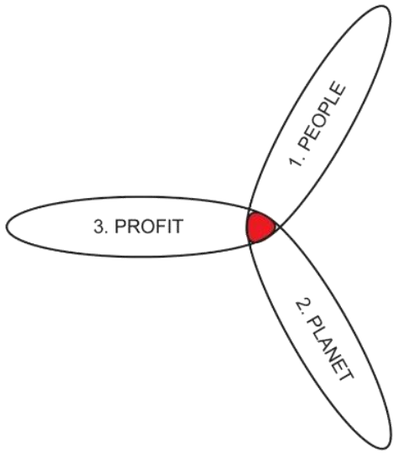
Conclusion

- The process of insulation of the envelope has challenges of preparation, condensation, spaces and discomfort to overcome.
- Superinsulators save crucial floor space without compromising on the thermal performance. Current drawback is cost.
- Technological advancements with machine learning provide the means to automate process and reduce processing time. At the moment this can take longer than manual process.
- Processing need to be further optimized.
- Production techniques such as prefabrication decrease the onsite assembly time.
- Design for demounting disassembly makes the product complex but is important for a sustainable development.
- Best suitable for large scale mass renovation to justify the associated high costs.
- Save space with the material, measurement time , application time, material use and wastage.

Sustainability assessment

PEOPLE

- Reduce the impact on occupants by reducing the time spent on site
- Prefabrication so that no work would be done on site
- Involve the people on a digital platform to see the impact on the interior spaces
- Liberty to choose the aesthetics



PLANET

- insulation material assessed on it’s impact on environment.
- Current researches into making them bio based with natural alternatives (cellulose)
- None adhesives fixing makes elements easier to separate at the end of product life for recycling.
- Adaptable design promotes reusability of the same product in different conditions making the final design ‘one product fits all’.

PROFIT

- high cost of superinsulators and scanning equipment for a single household is not feasible.
- the high demand lowers the supply cost.
- Prefabricated adaptive design require lesser material, lesser labour cost and no demolition costs.
- Reusable elements reduce cost for new production.
- ‘One assembly line produces all’

Thank you

Innovation in Renovation

Optimizing interior insulation application workflow

Presented by:

Ekta Kapoor

Mentored by:

Eric van den Ham
Thaleia Konstantinou

Introduction

Energy Agreement for Sustainable Growth

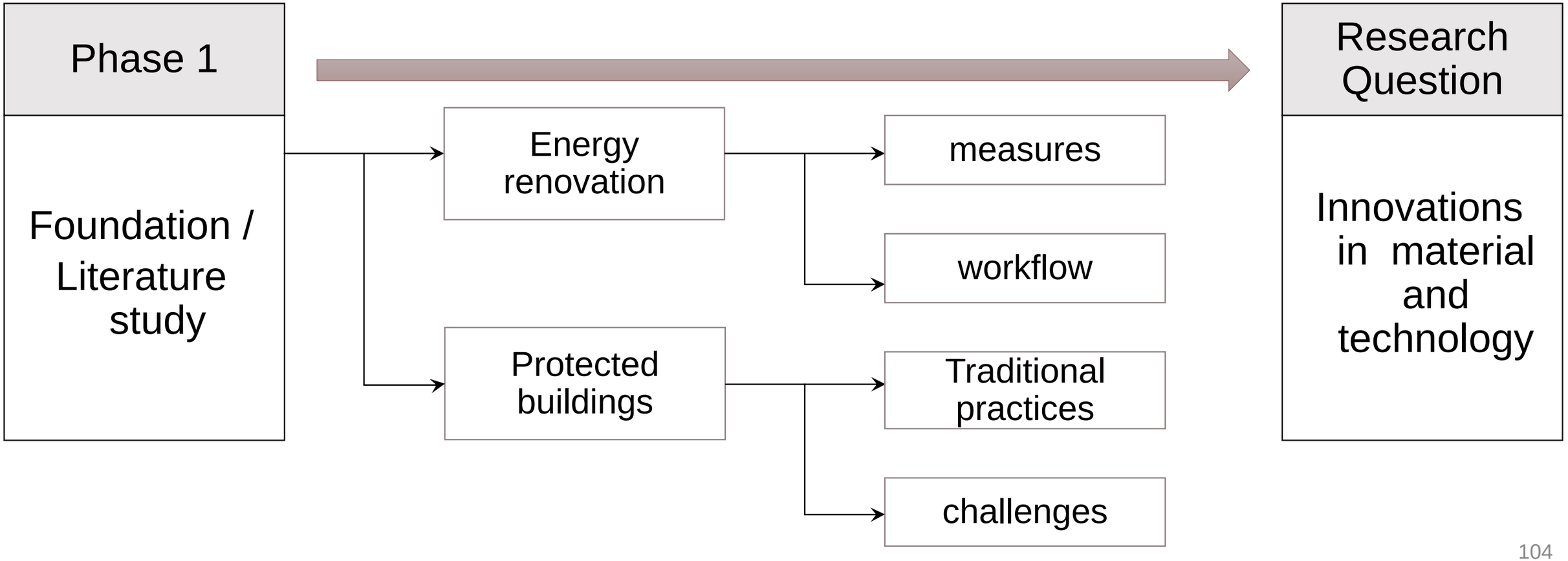
300,000	homes to be renovated by 2020
20 -30%	increase in energy efficiency in renovation houses
Label B	average label for energy efficient social housing

Introduction

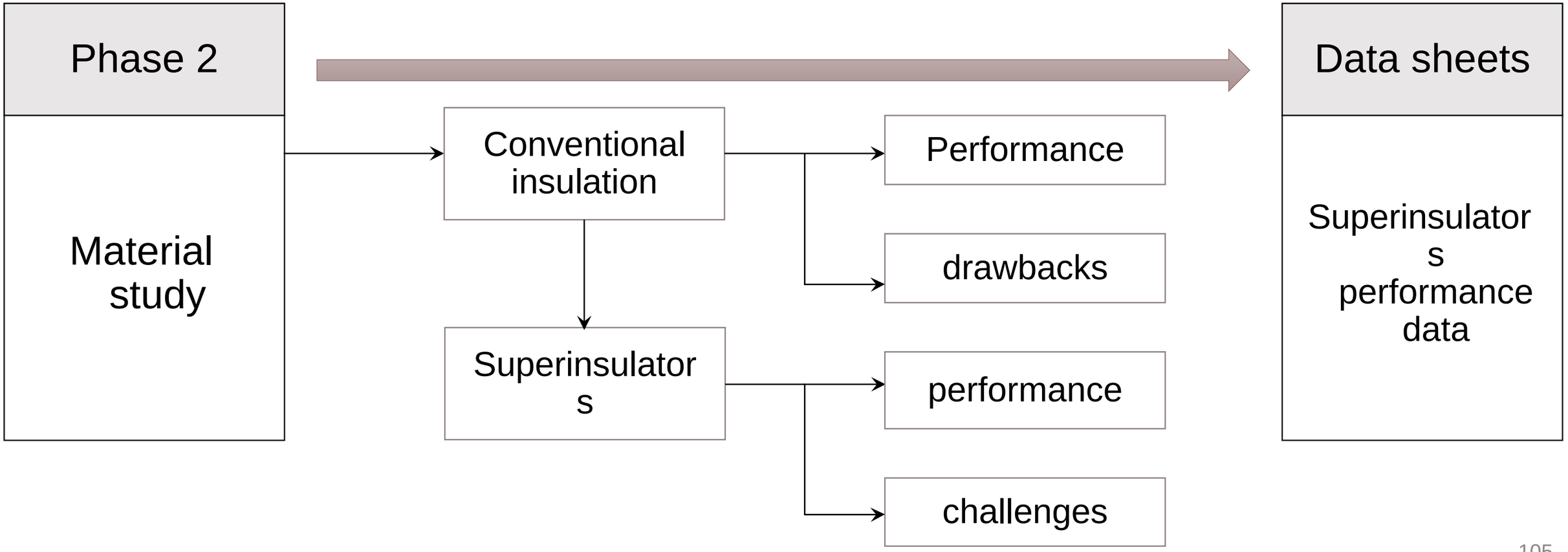
Current statistics

70%	homes have energy label C or lesser
1%	Existing building renovated every year

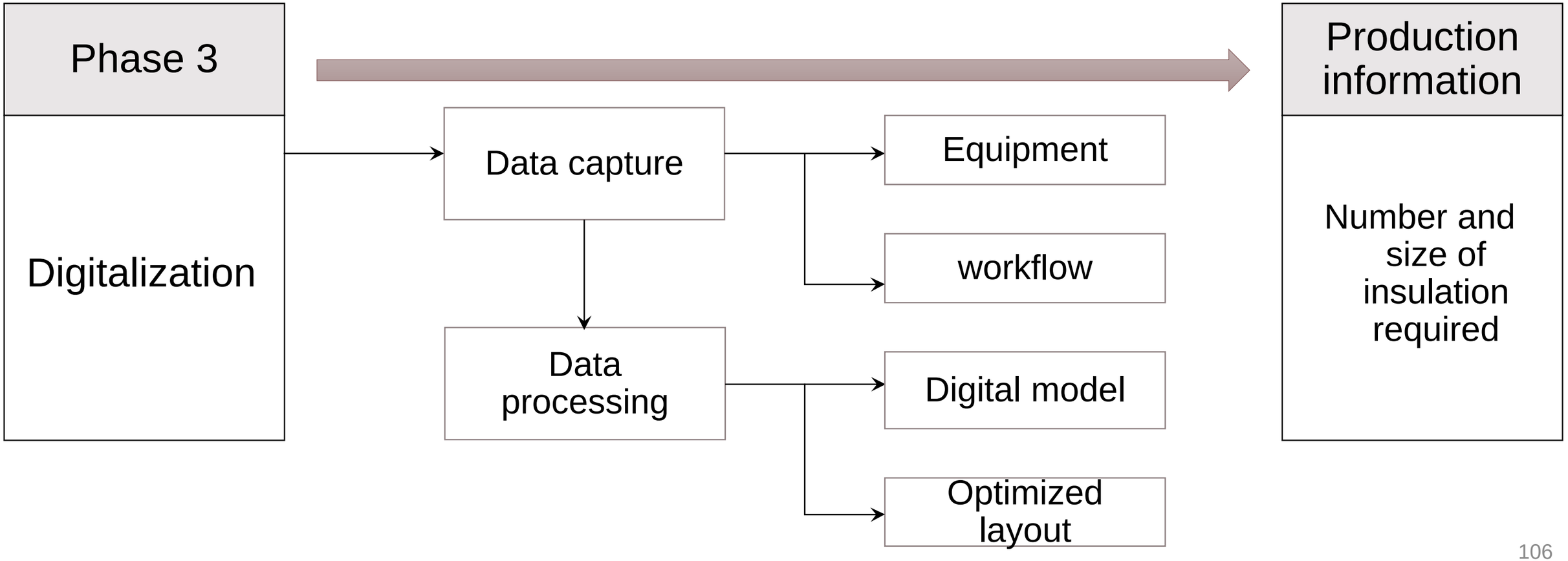
Research methodology



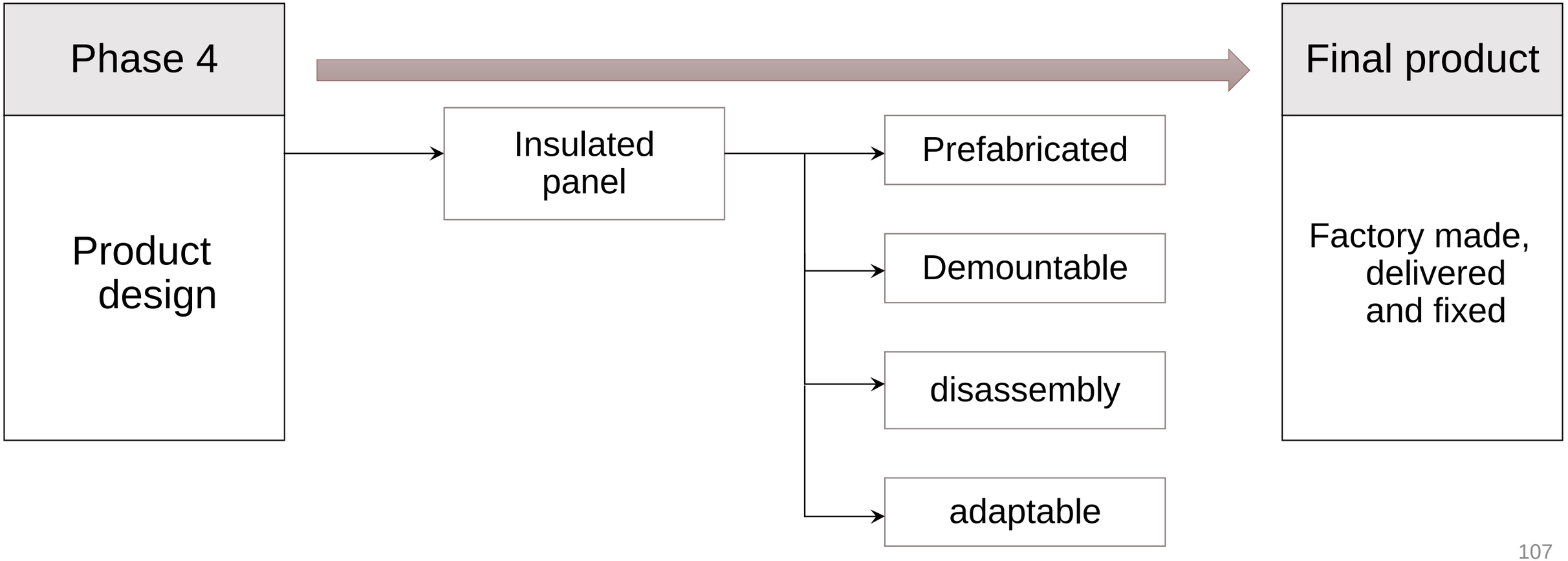
Research methodology



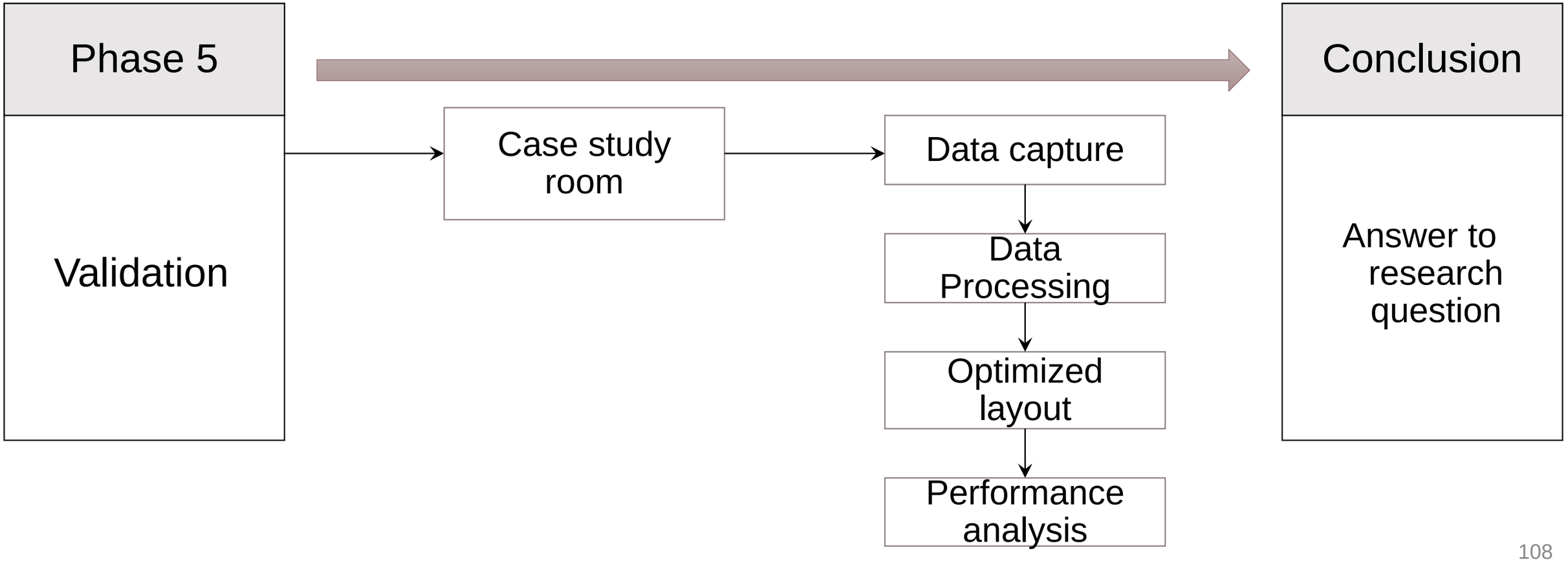
Research methodology



Research methodology



Research methodology



Moisture risk | 20mm Vacuum Insulation

case 1: 260mm brick wall

Thermal protection

U = 0,30 W/(m²K)

Interior insulation: No requirement*

excellent — insufficient

Moisture proofing

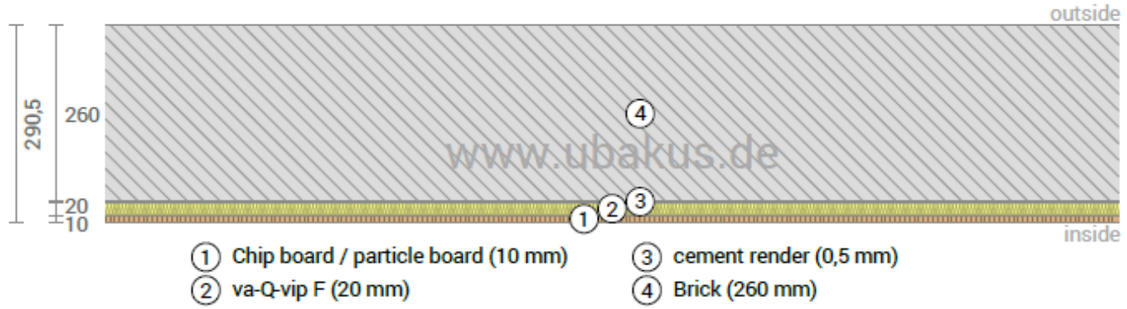
No condensate

excellent — insufficient

Heat protection

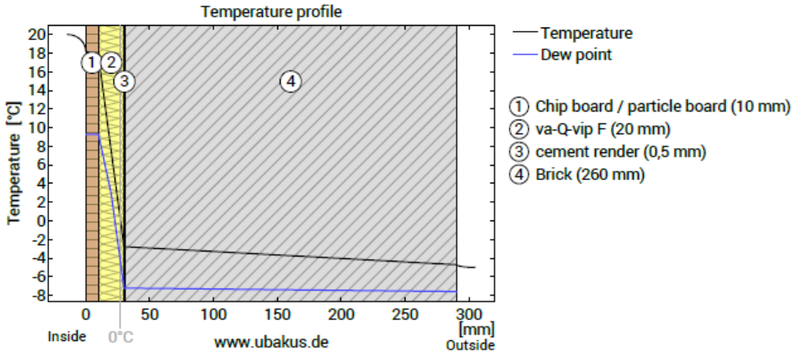
Temperature amplitude damping: 15
phase shift: 13,7 h
Thermal capacity inside: 41 kJ/m²K

excellent — insufficient



① Chip board / particle board (10 mm)
② va-Q-vip F (20 mm)
③ cement render (0,5 mm)
④ Brick (260 mm)

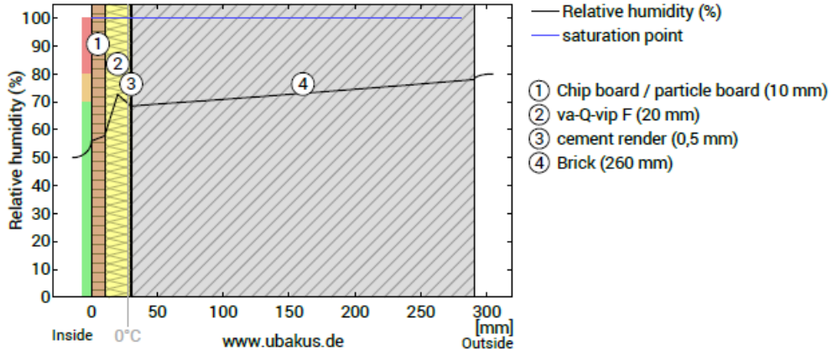
Temperature profile



Temperature and dew-point temperature in the component. The dew-point indicates the temperature, at which water vapour condensates. As long as the temperature of the component is everywhere above the dew-point temperature, no condensation occurs. If the curves have contact, condensation occurs at the corresponding position.

Humidity

The temperature of the inside surface is 18,2 °C leading to a relative humidity on the surface of 56%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



Moisture risk | 20mm aerogel blanket + Vapor barrier

case 1: 260mm brick wall

Thermal protection

U = 0,55 W/(m²K)

Interior insulation: No requirement*

excellent — insufficient

Moisture proofing

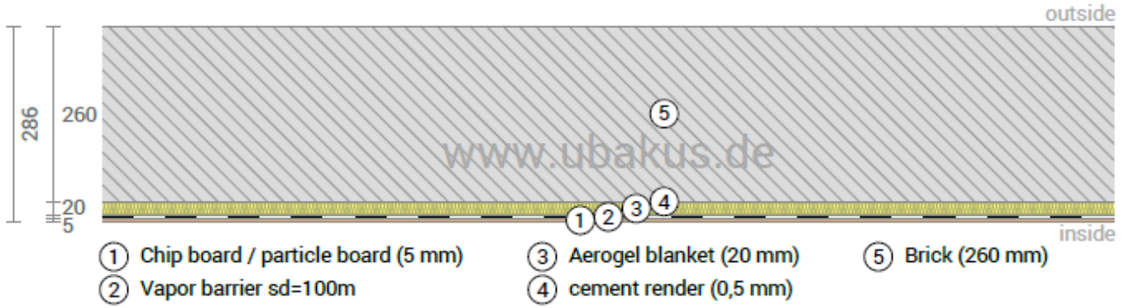
No condensate

excellent — insufficient

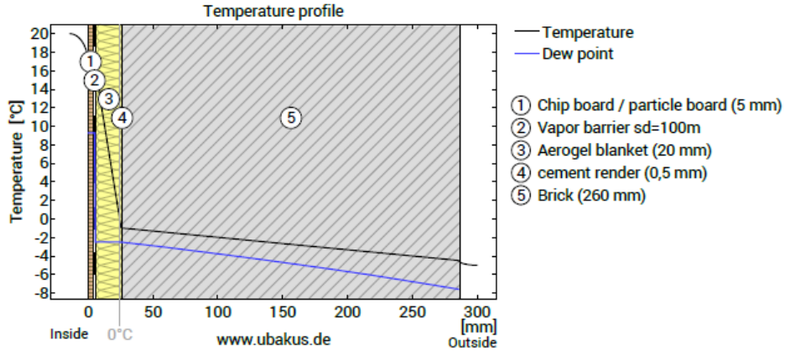
Heat protection

Temperature amplitude damping: 6,2
phase shift: 11,2 h
Thermal capacity inside: 58 kJ/m²K

excellent — insufficient



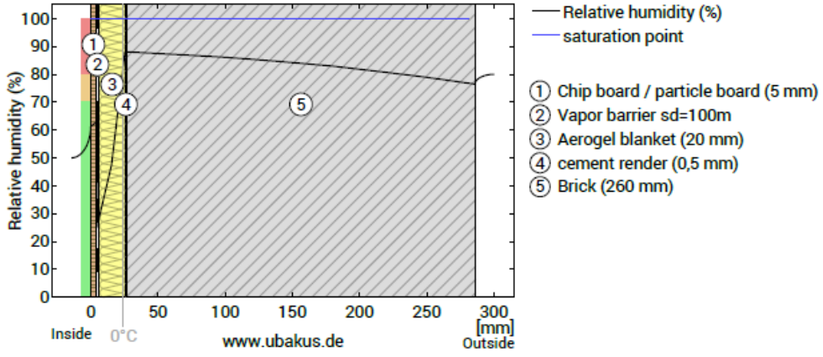
Temperature profile



Temperature and dew-point temperature in the component. The dew-point indicates the temperature, at which water vapour condensates. As long as the temperature of the component is everywhere above the dew-point temperature, no condensation occurs. If the curves have contact, condensation occurs at the corresponding position.

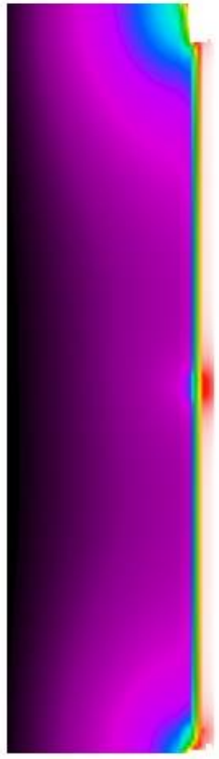
Humidity

The temperature of the inside surface is 16,8 °C leading to a relative humidity on the surface of 61%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.

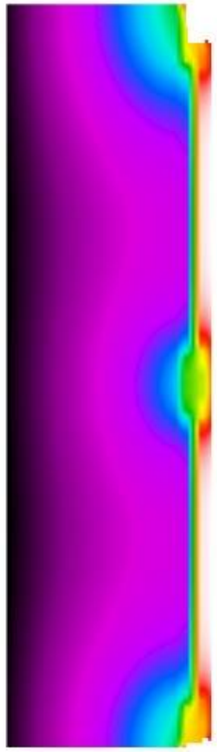


Product design

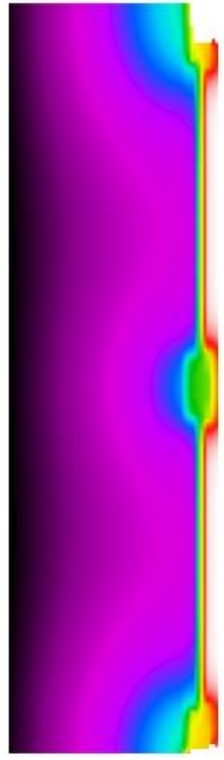
Thermal bridges – channel material



VIP with PVC channel



VIP with steel channel



VIP with steel channel with neoprene