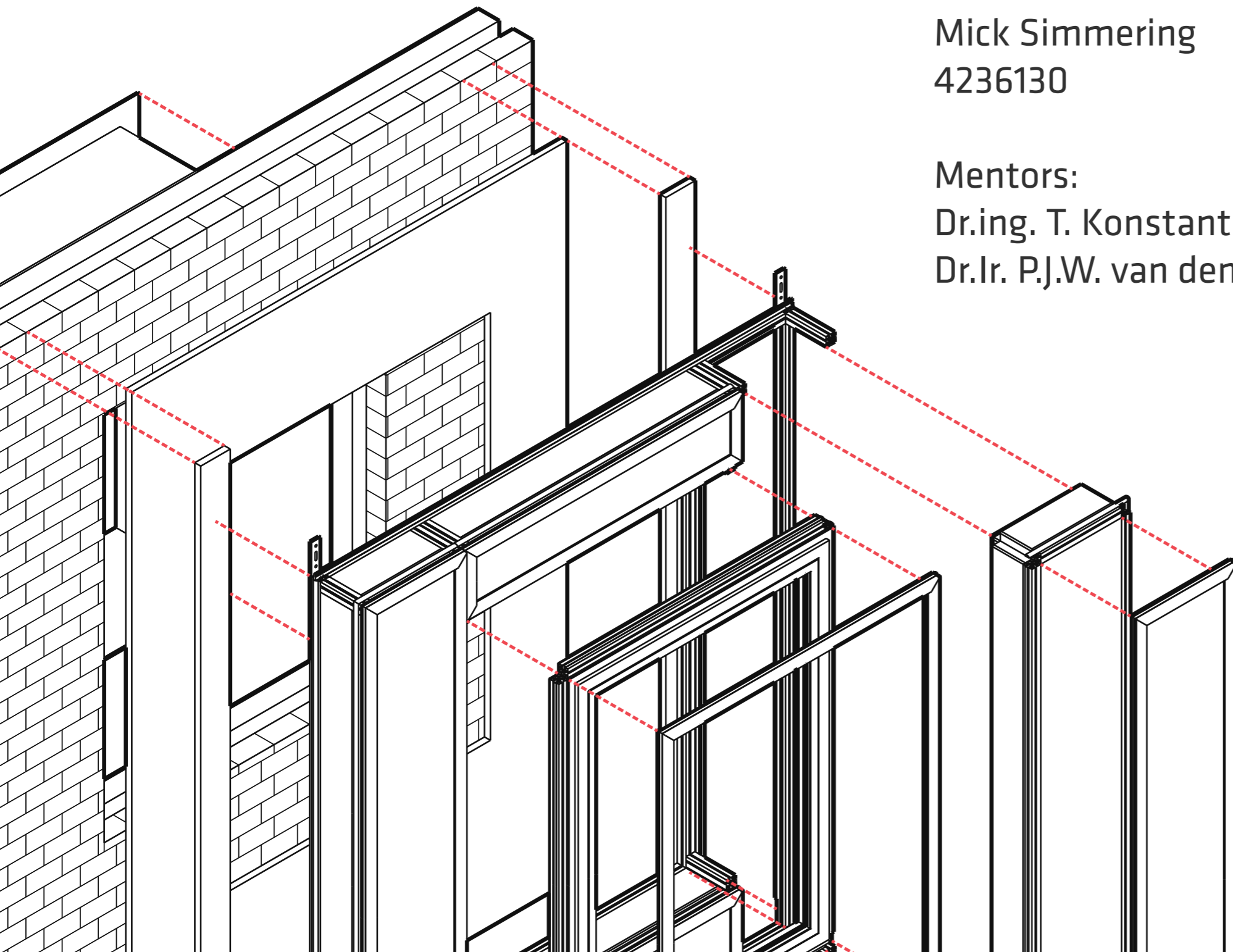


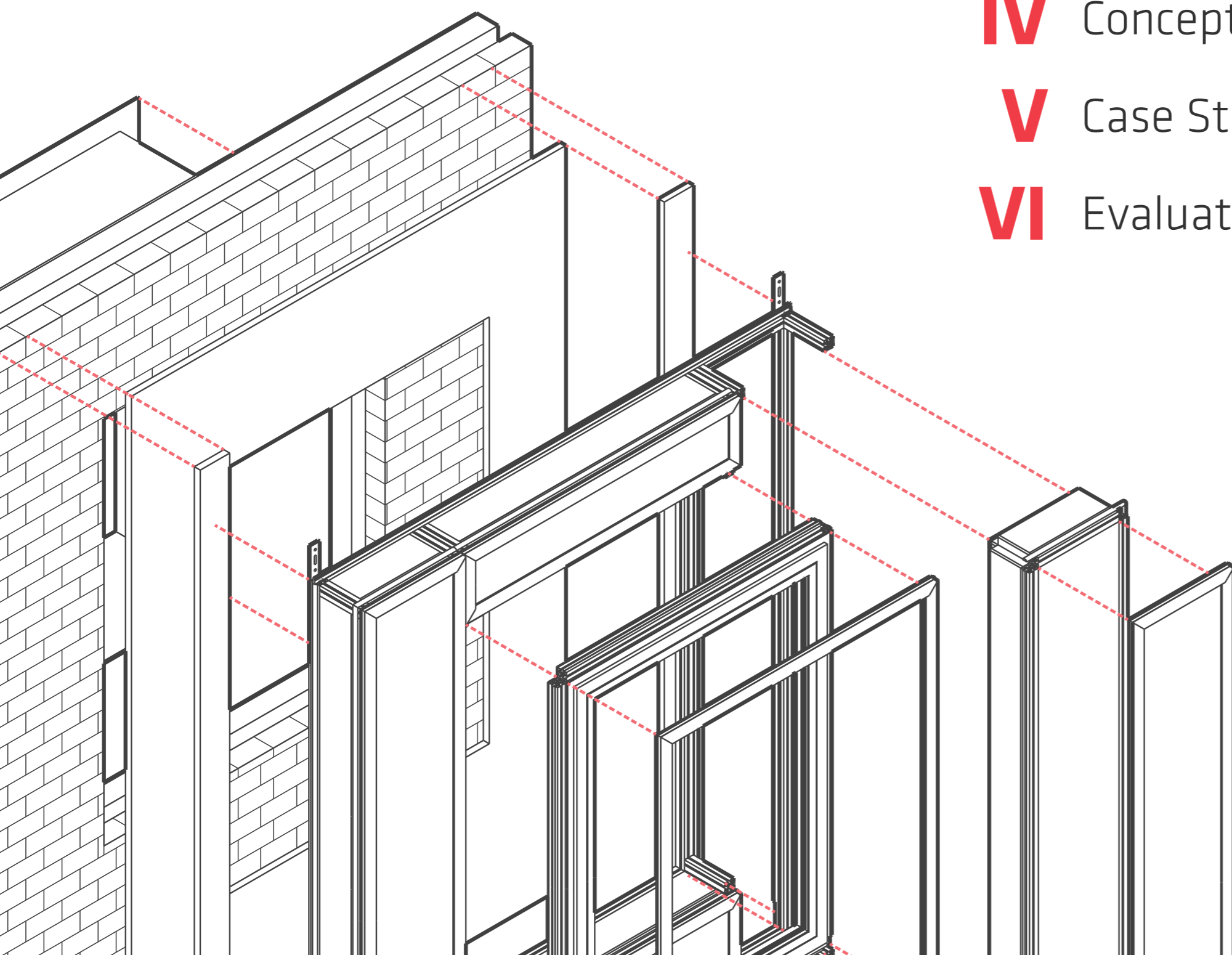
RE[∞]NOVATE

Upgradable Building Envelope System for
Energy Reduction Renovation of Dutch
Post-war Apartments

Mick Simmering
4236130

Mentors:
Dr.ing. T. Konstantinou MSc
Dr.Ir. P.J.W. van den Engel





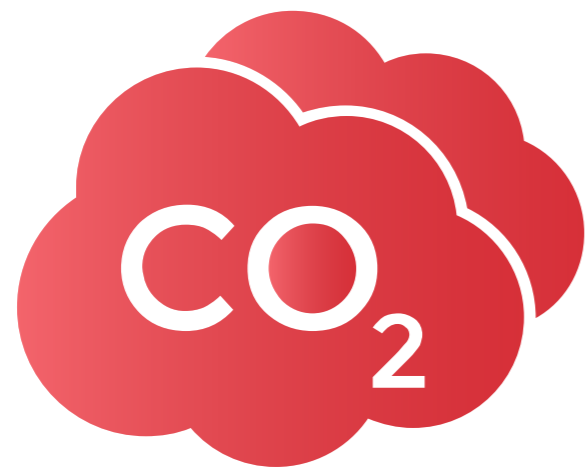
- I Problem Statement & Study Design
- II Literature Review
- III Design Methodology
- IV Concept Production
- V Case Study Application
- VI Evaluation & Conclusions



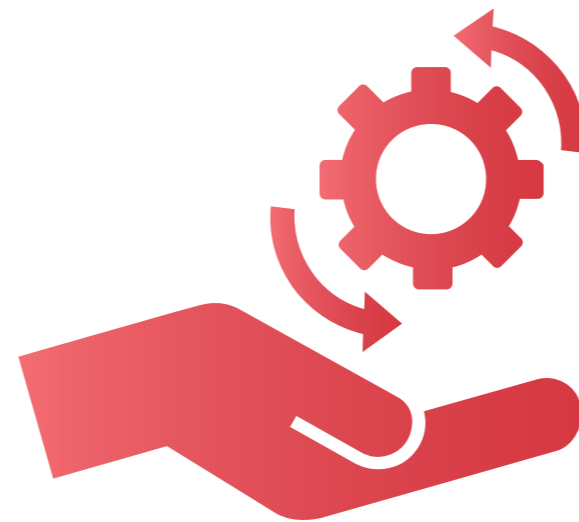
PROBLEM STATEMENT & METHODOLOGY



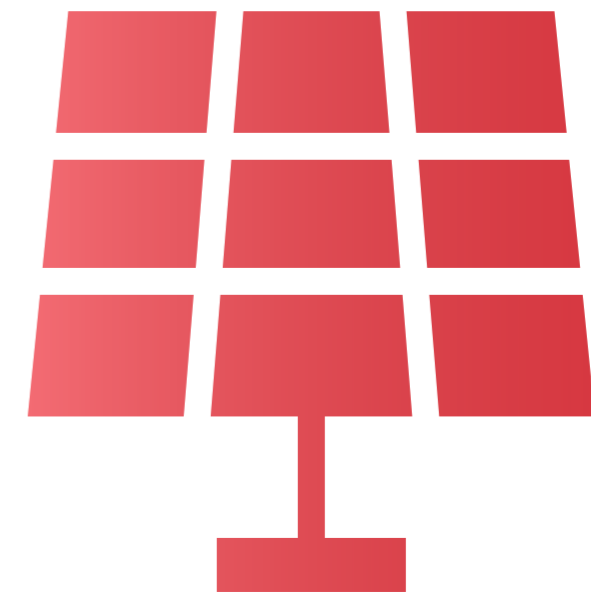
20-20-20 EU Goals for 2020



-20%

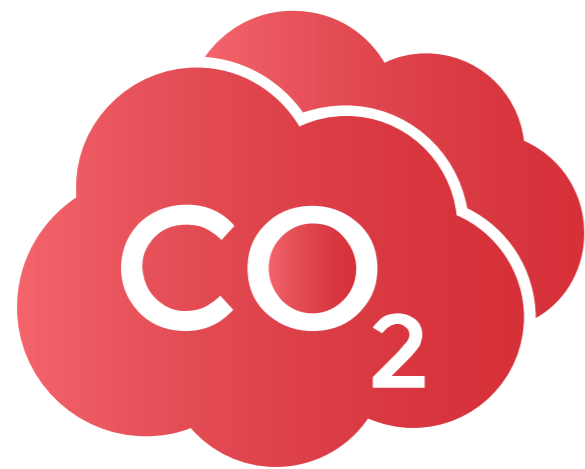


+20%



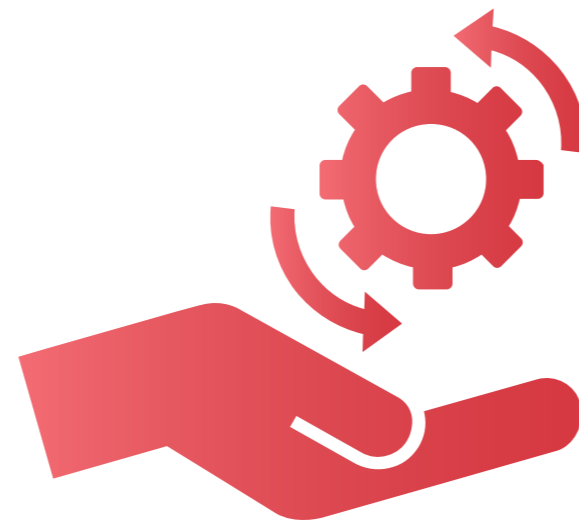
+20%

20-20-20 EU Goals for 2020



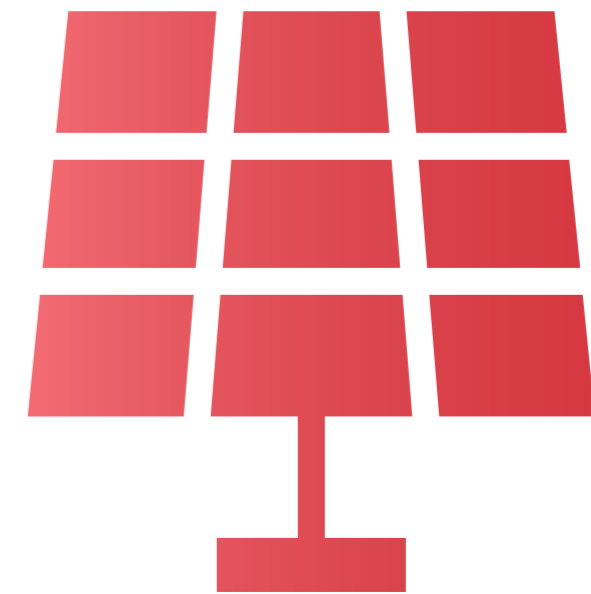
-20%

0%



+20%

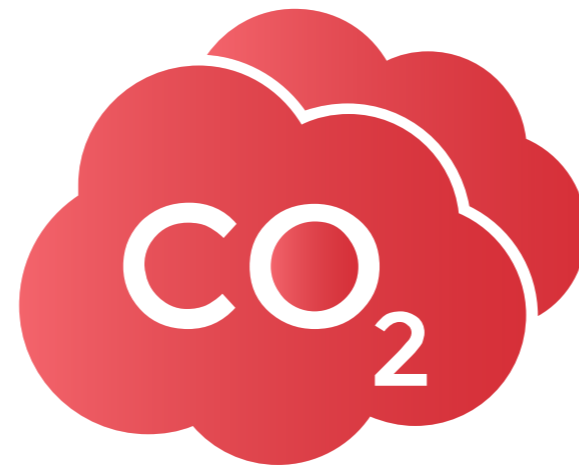
?



+20%

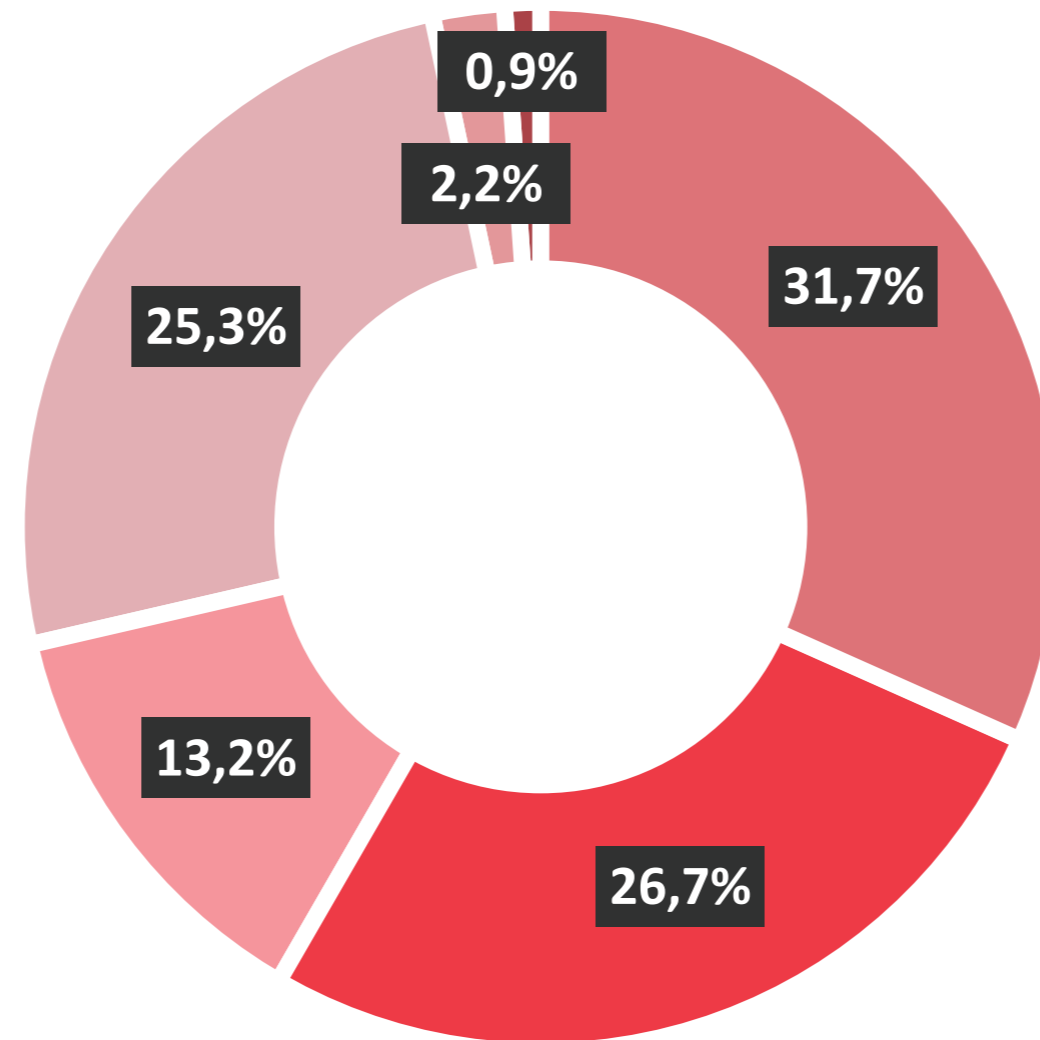
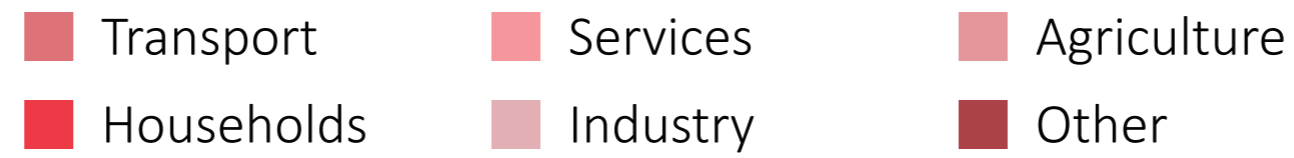
5.5%

EU Goals for 2050

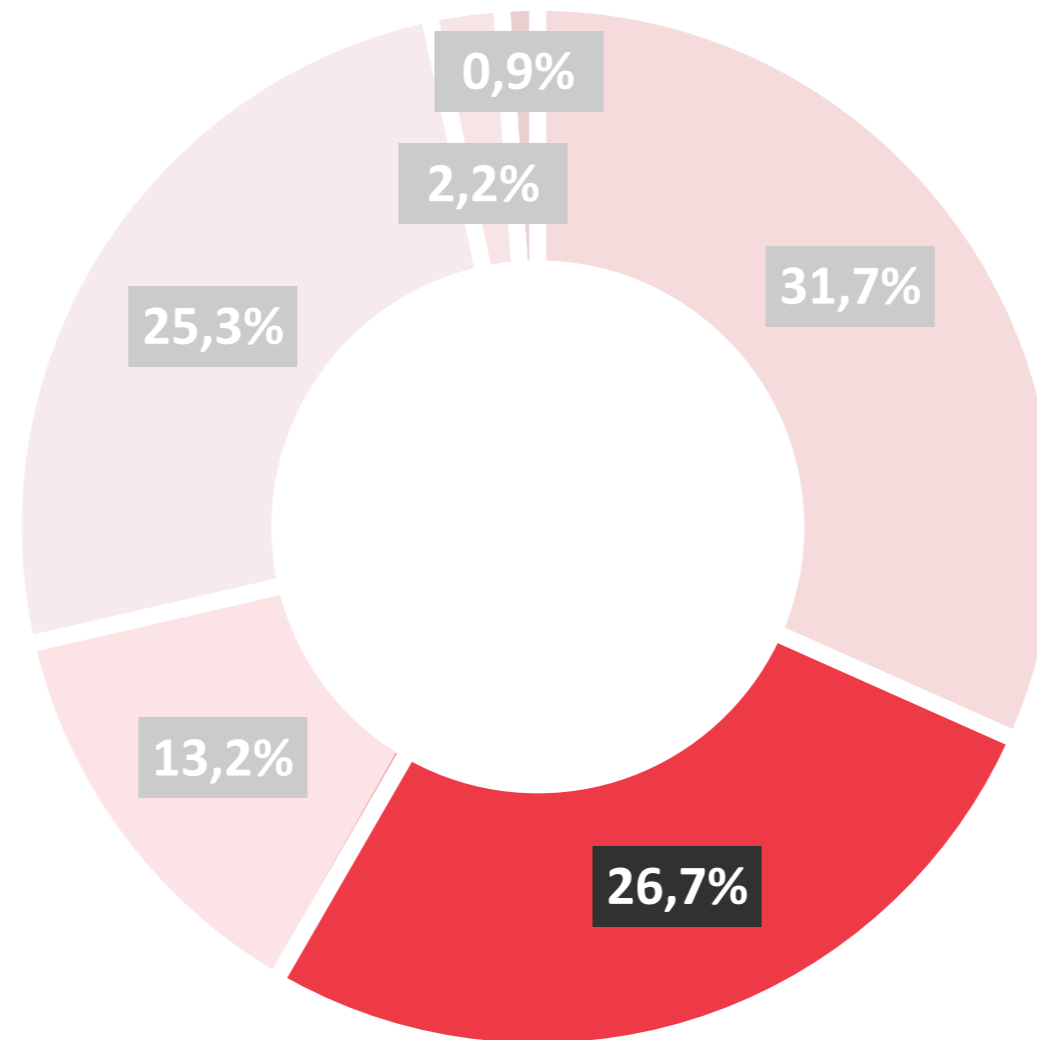


-90%

Energy Consumption All Sectors



Households



EPBD Regulations for New Buildings (2020)

nZEB - Nearly Zero Energy Building

“A building that produces nearly as much energy as it consumes”

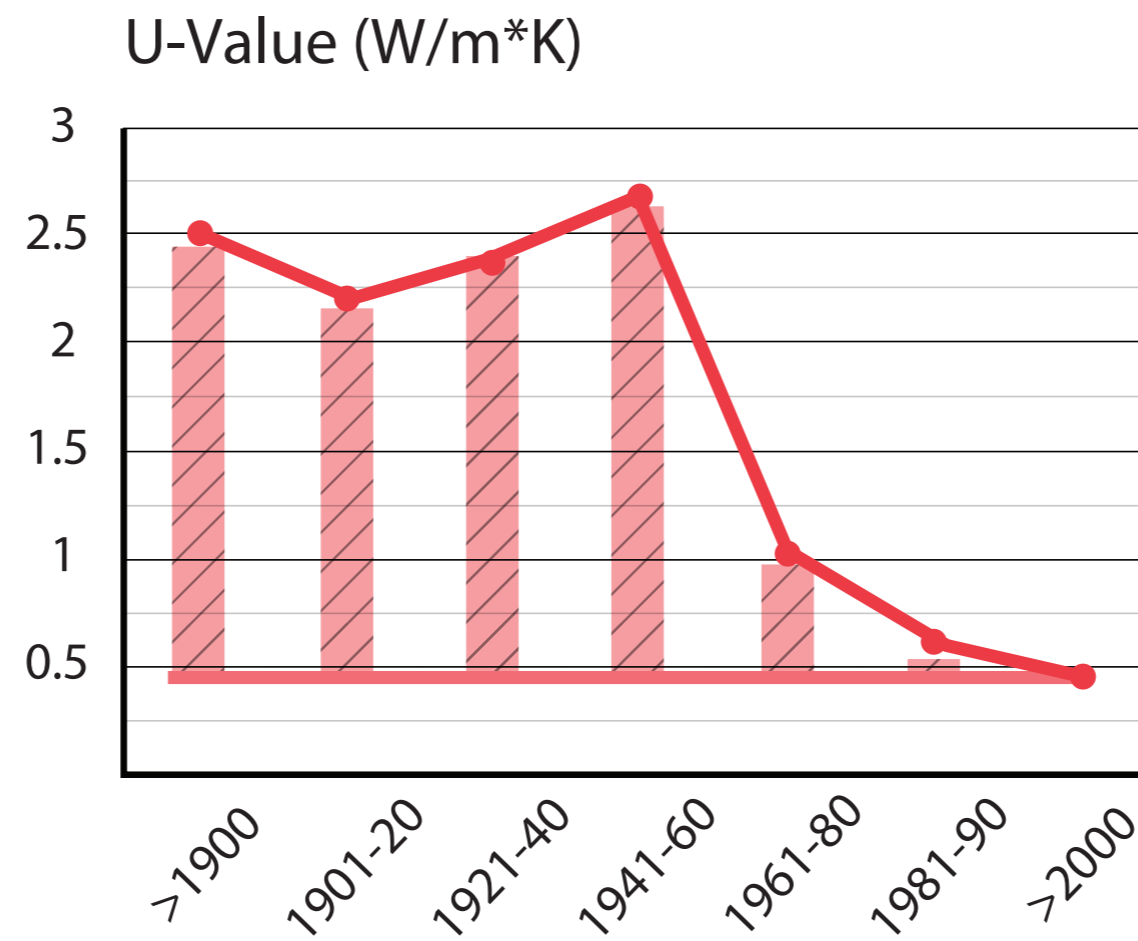
EPBD Regulations for New Buildings (2020)

nZEB - Nearly Zero Energy Building

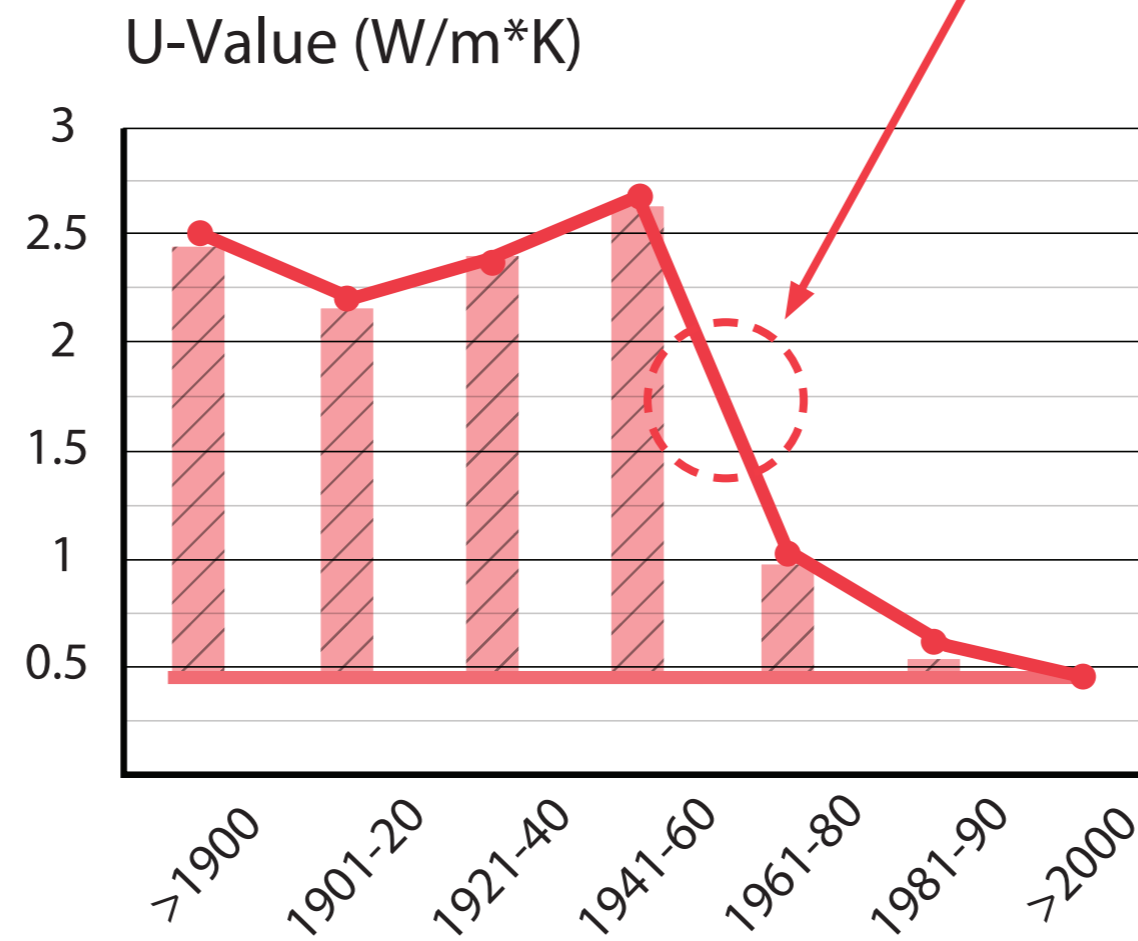
“A building that produces nearly as much energy as it consumes”

Renewal Rate 1%

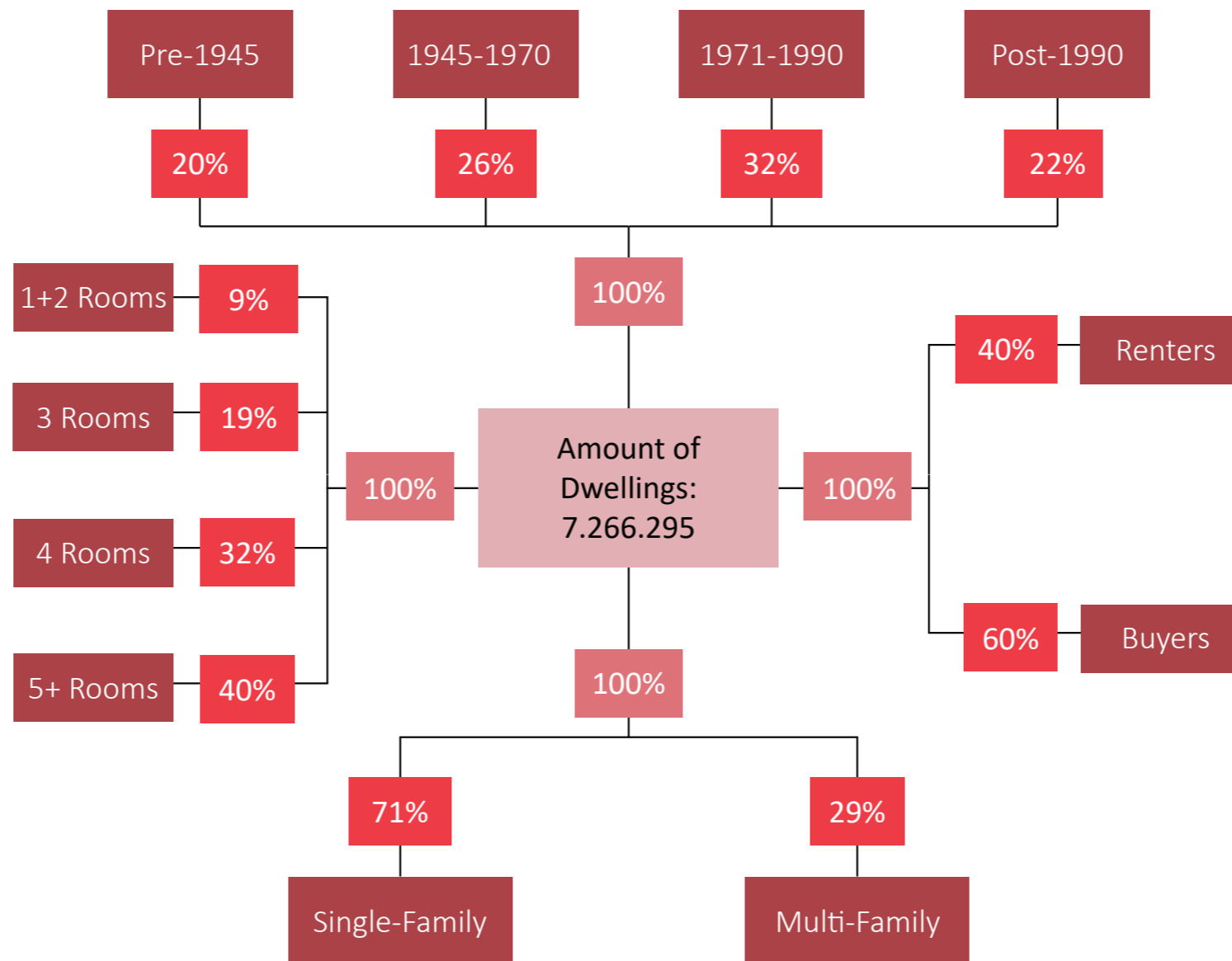
Thermal Resistance through the Years



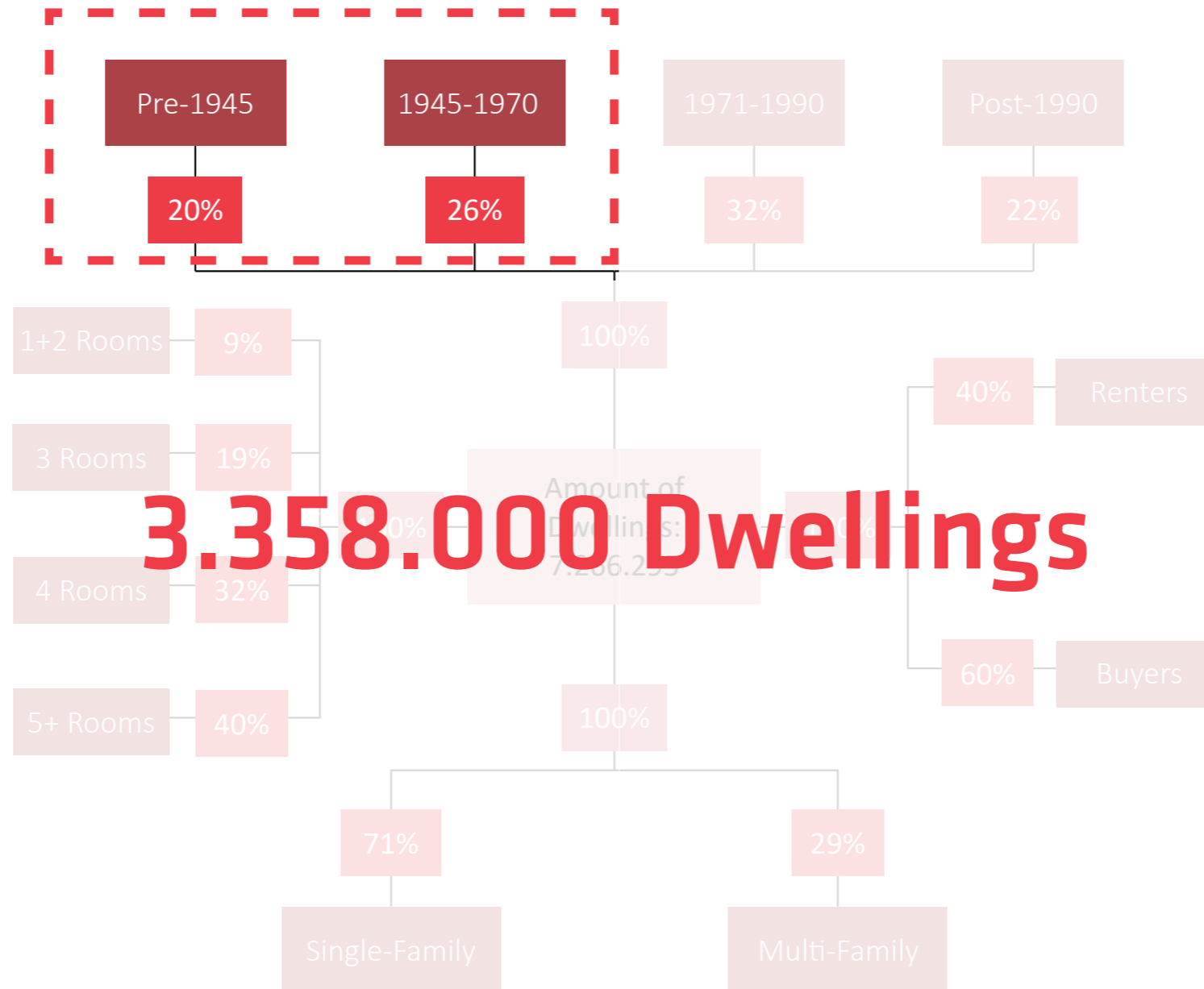
Energy Crisis



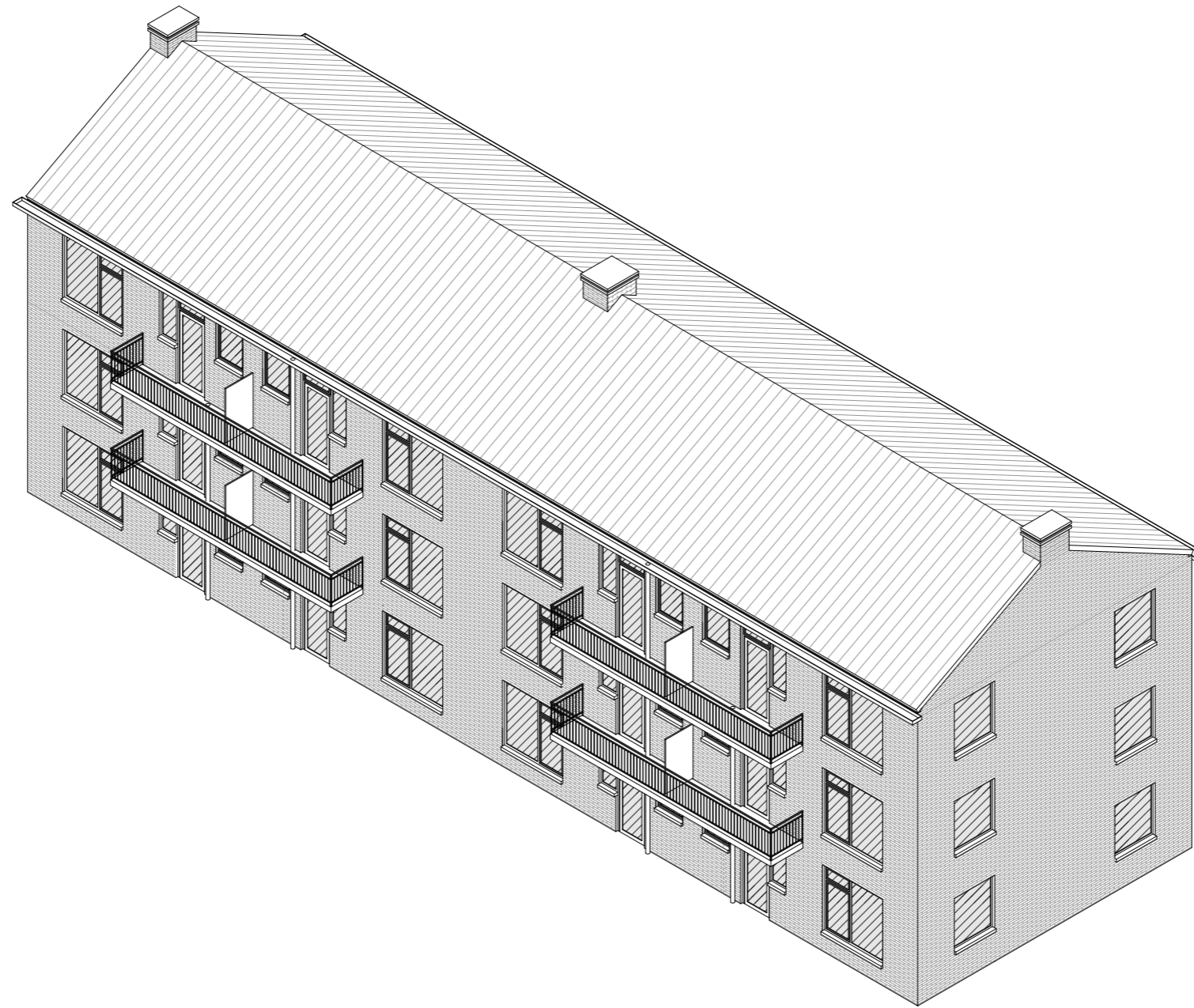
Old Stock?

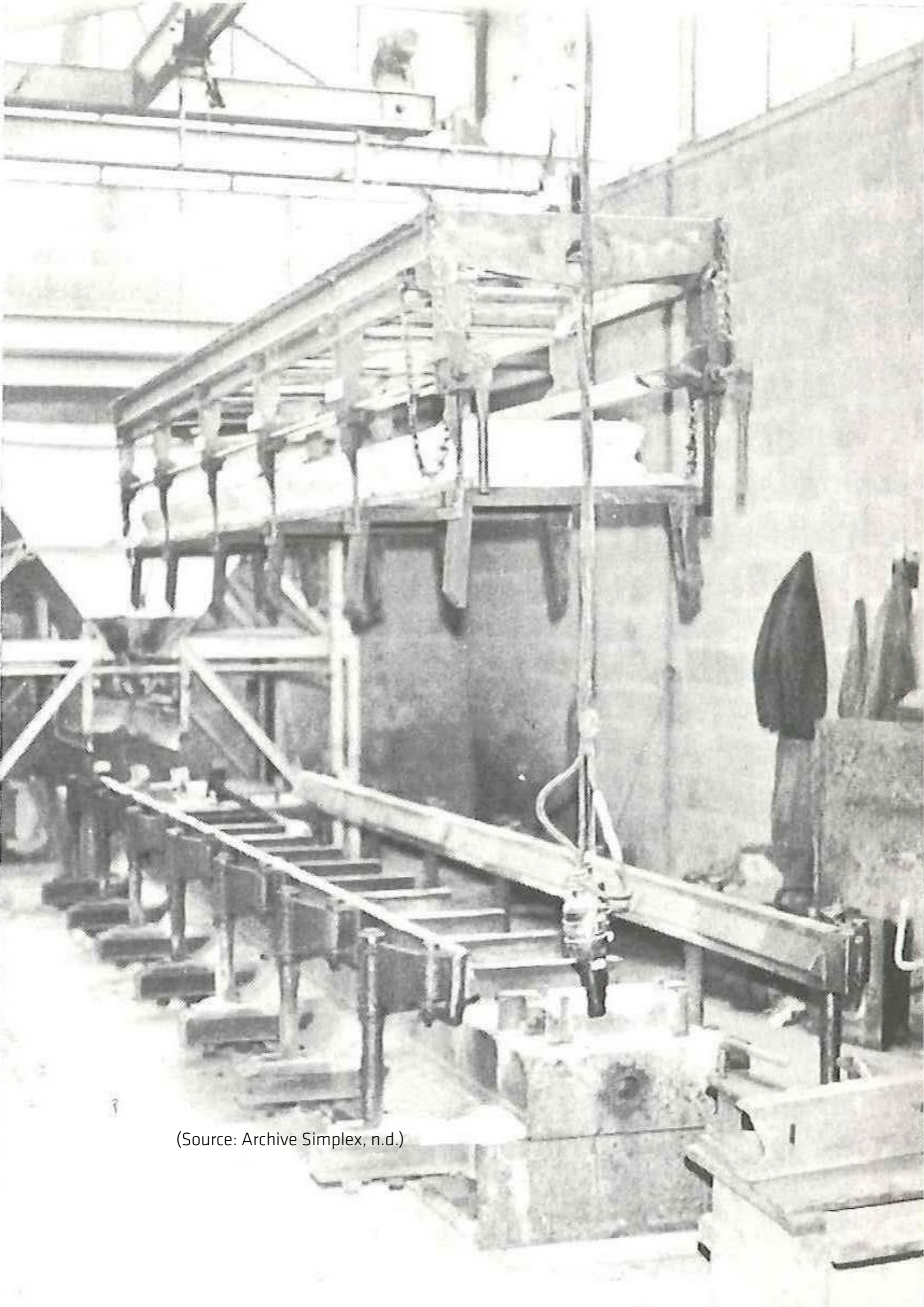


Old Stock?



Post-war Apartments

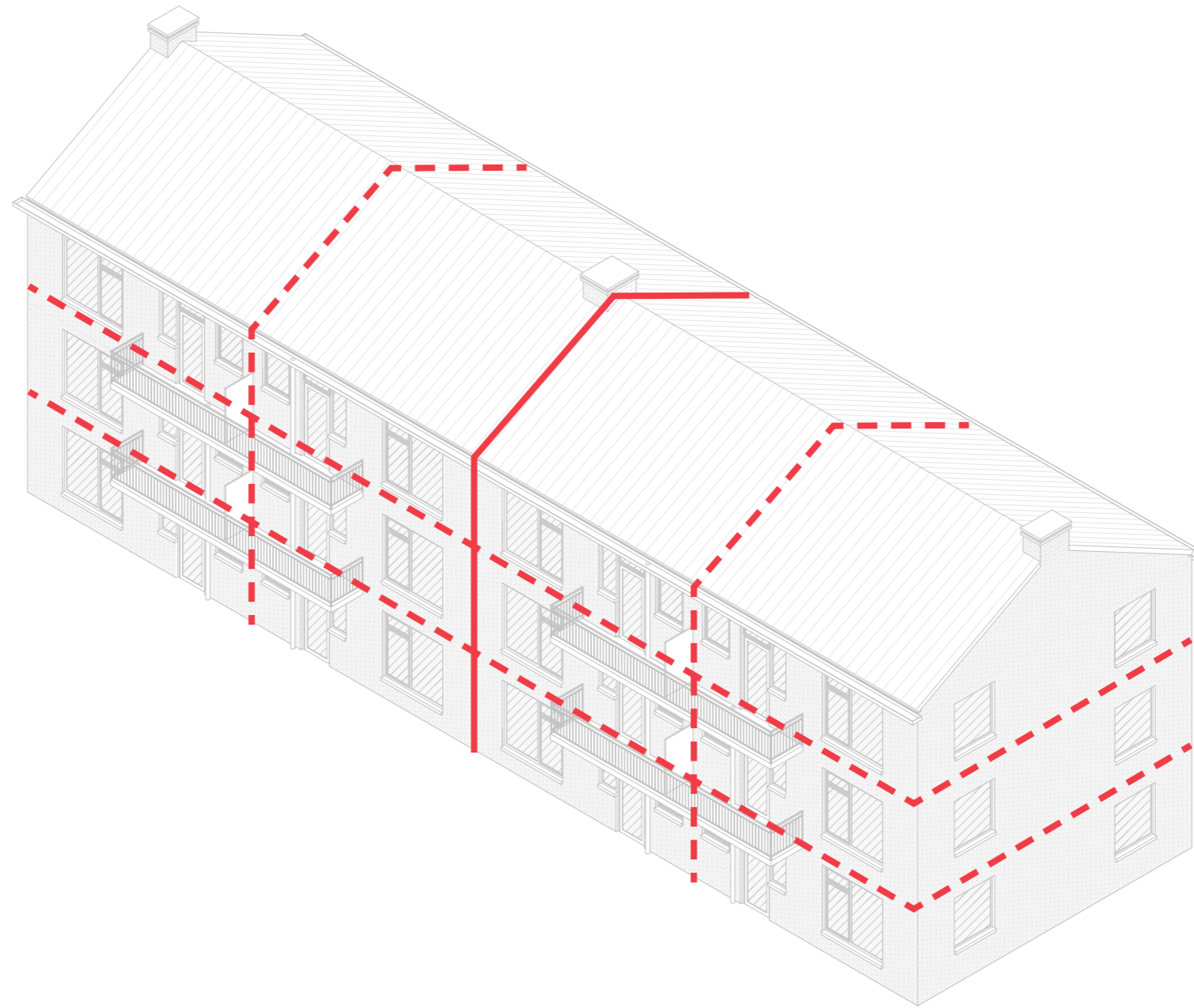




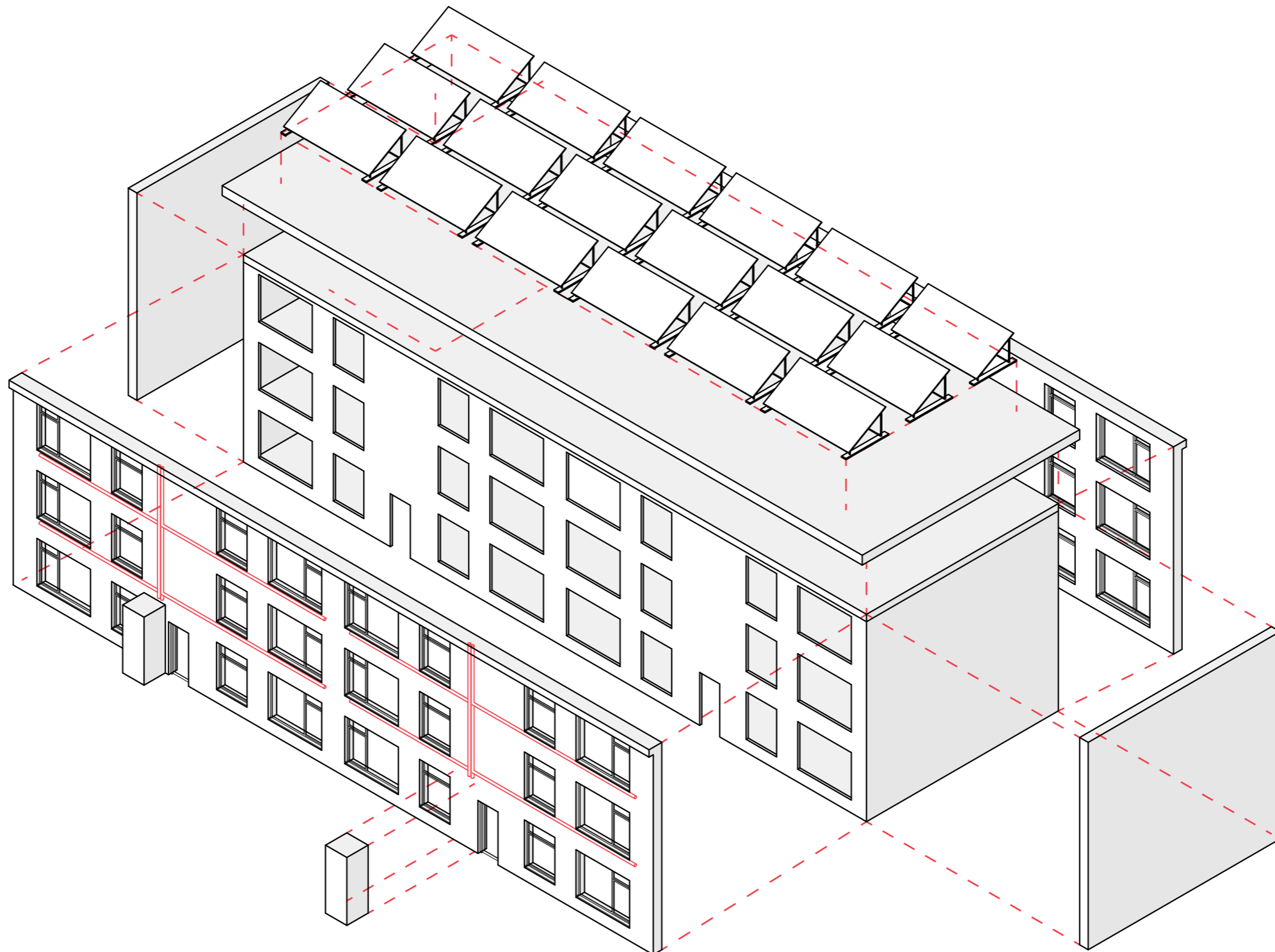
(Source: Archive Simplex, n.d.)



Ctrl C + Ctrl V



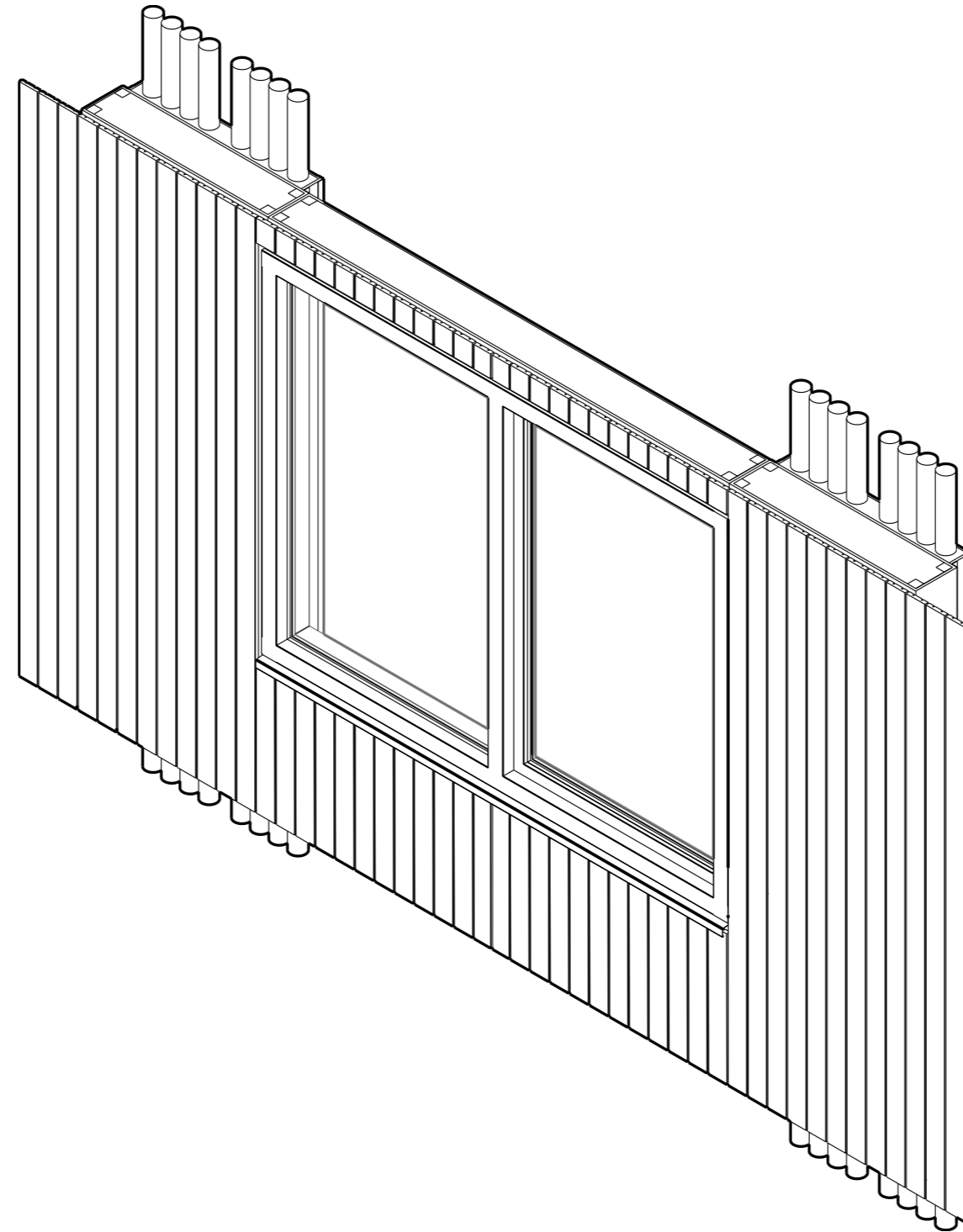
The Tactic





(Source: Akkerman, n.d.)

Prefabricated Module 2ndSkin



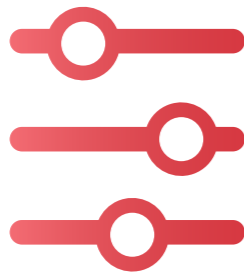
Prefabricated Module 2ndSkin



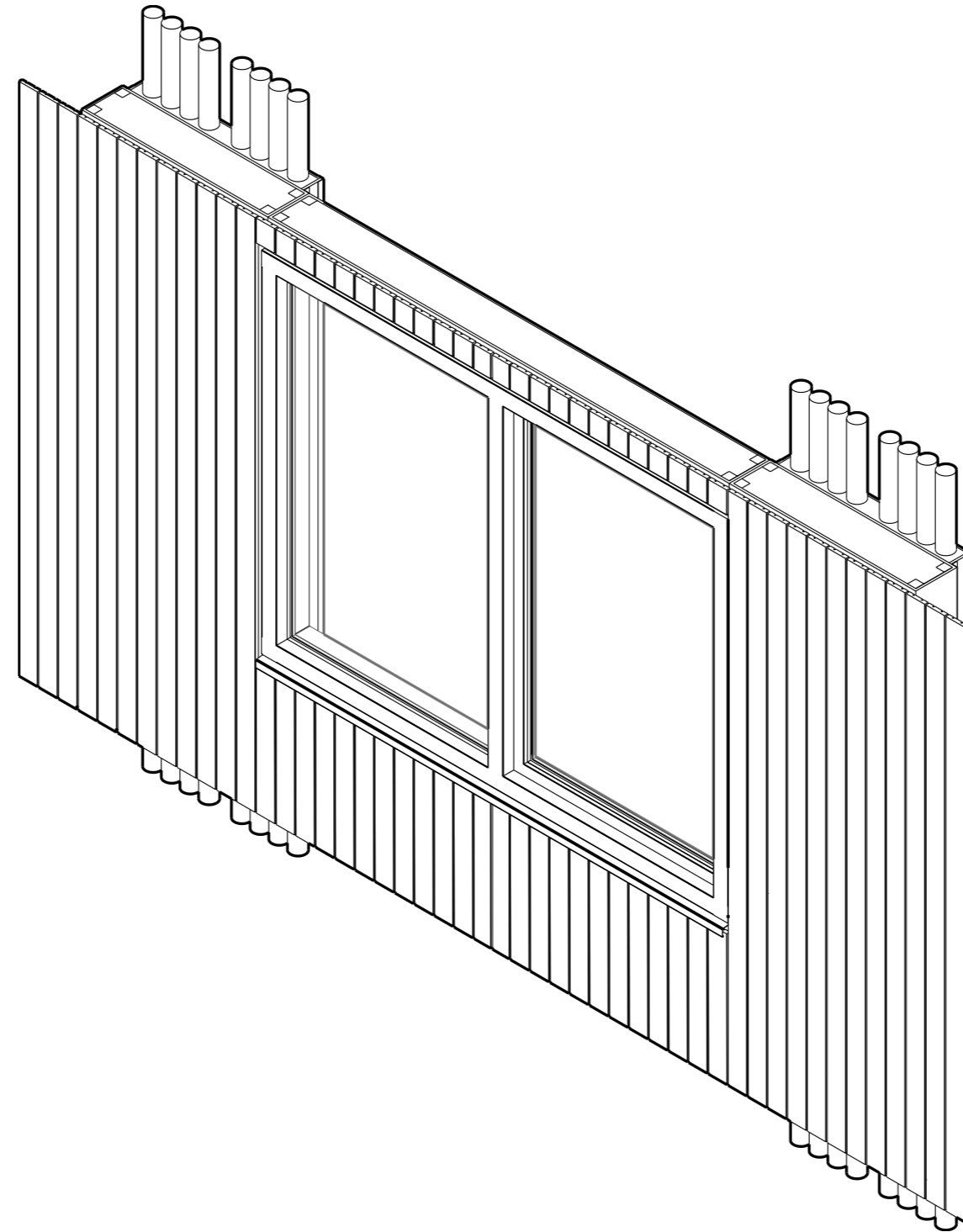
Unity



Maintenance



Options



Disturbance

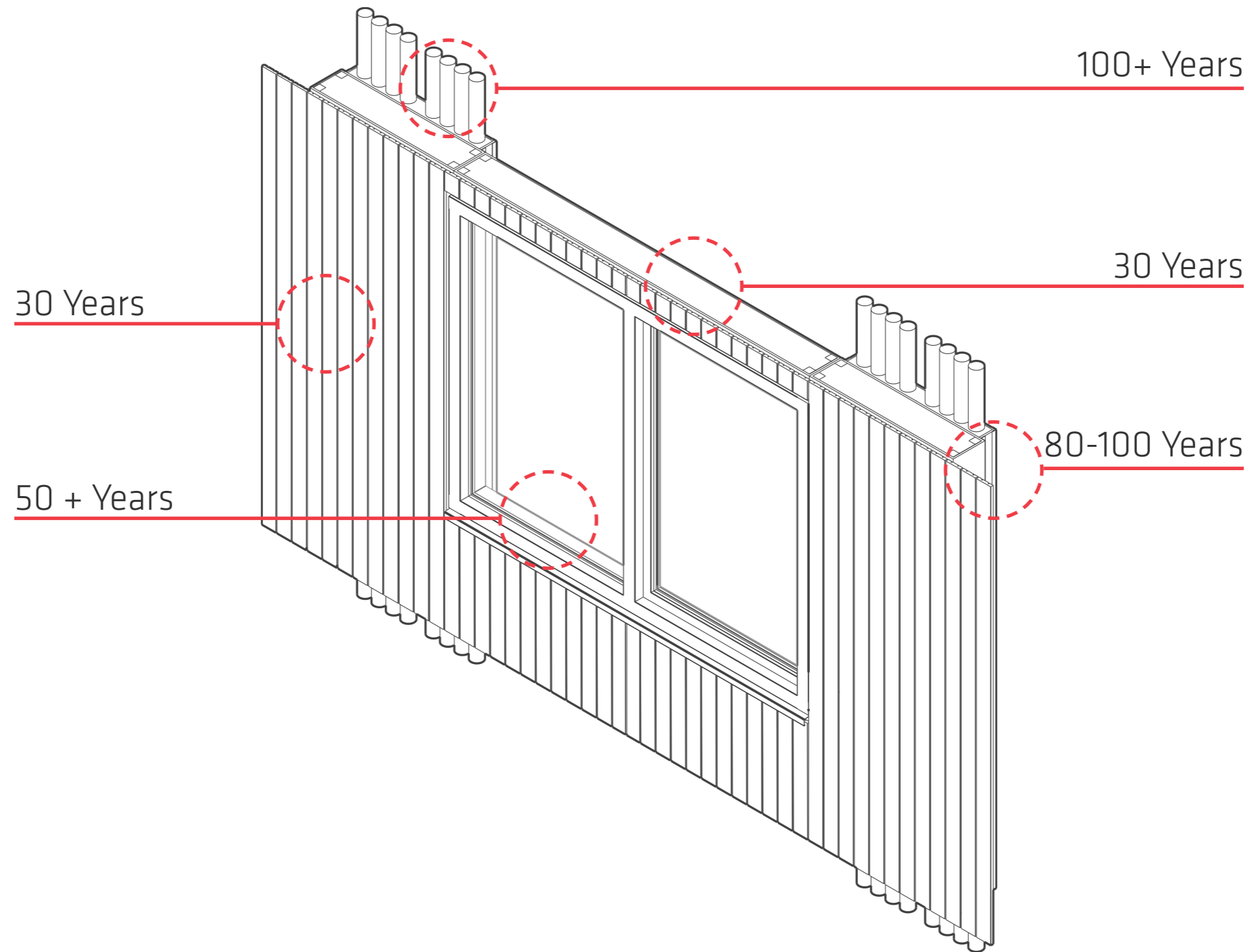


Time

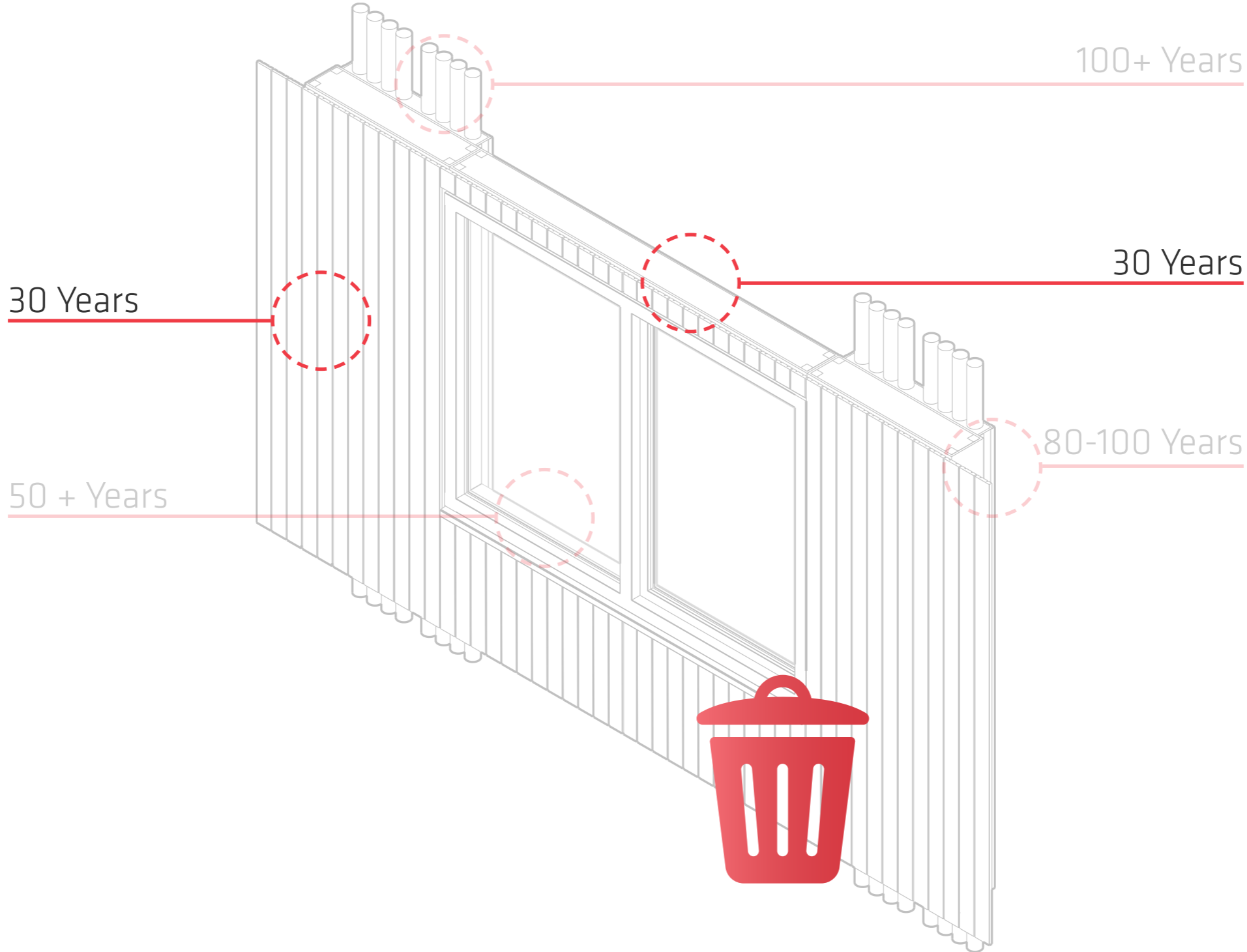


Quality

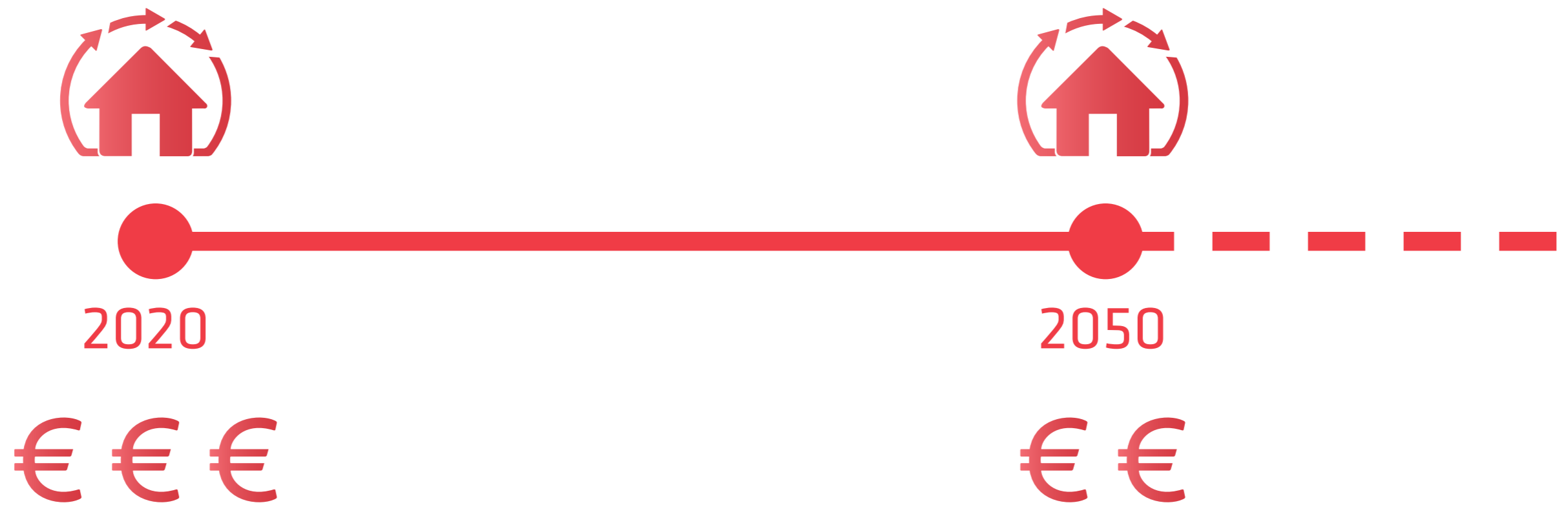
Service Life



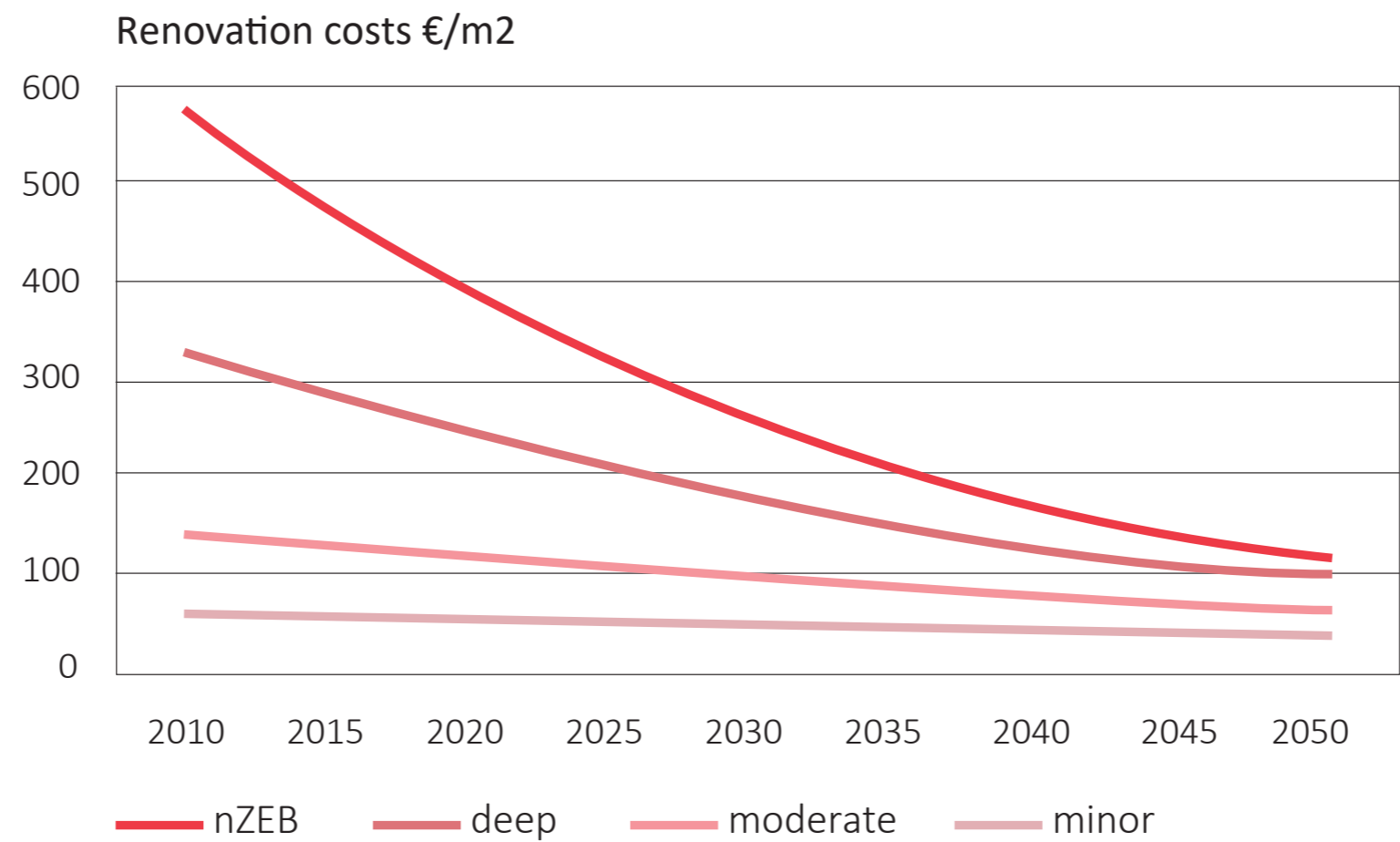
Weakest Link



Renovate Now, Redo when goals are reached



The “Learning Curve”



BPIE Scenarios

Scenario		0	3	4
Description	Unit	Baseline	Deep	Two-stage
Annual Energy Saving	<i>TWh/a</i>	365	2.795	2.896
2050 Saving as % of Today	%	9%	68%	71%
Investments Costs (Present Value)	<i>€ Billion</i>	164	937	584
Savings (Present Value)	<i>€ Billion</i>	187	1.318	1.058
Fast Decarbonisation				
<i>Annual CO₂ saving in 2050</i>	<i>MtCO₂/a</i>	742	932	939
<i>2050 CO₂ saved (% of 2010)</i>	%	71.7%	89.9%	90.7%
Slow Decarbonisation				
<i>Annual CO₂ saving in 2050</i>	<i>MtCO₂/a</i>	182	732	755
<i>2050 CO₂ saved (% of 2010)</i>	%	18%	71%	73%

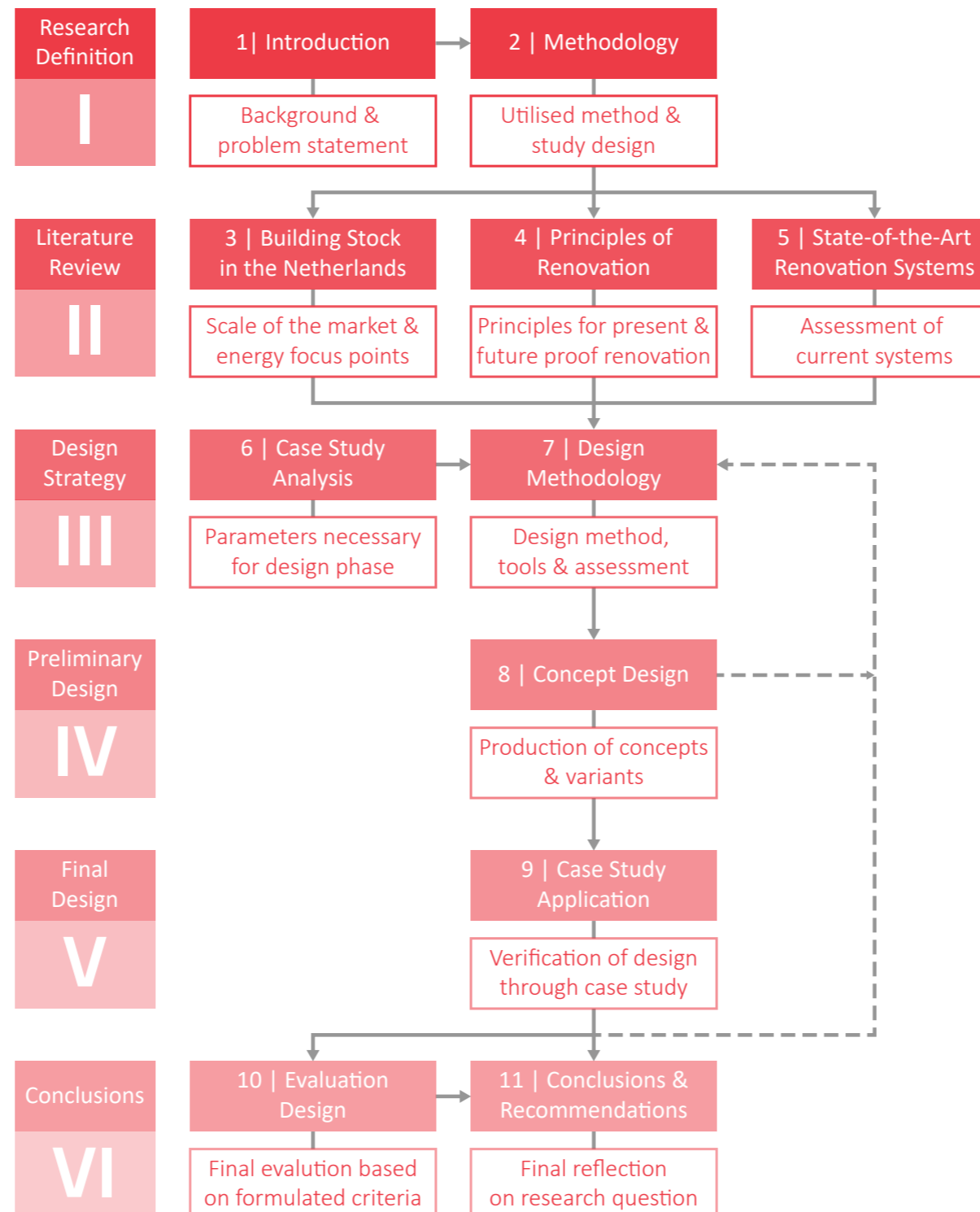
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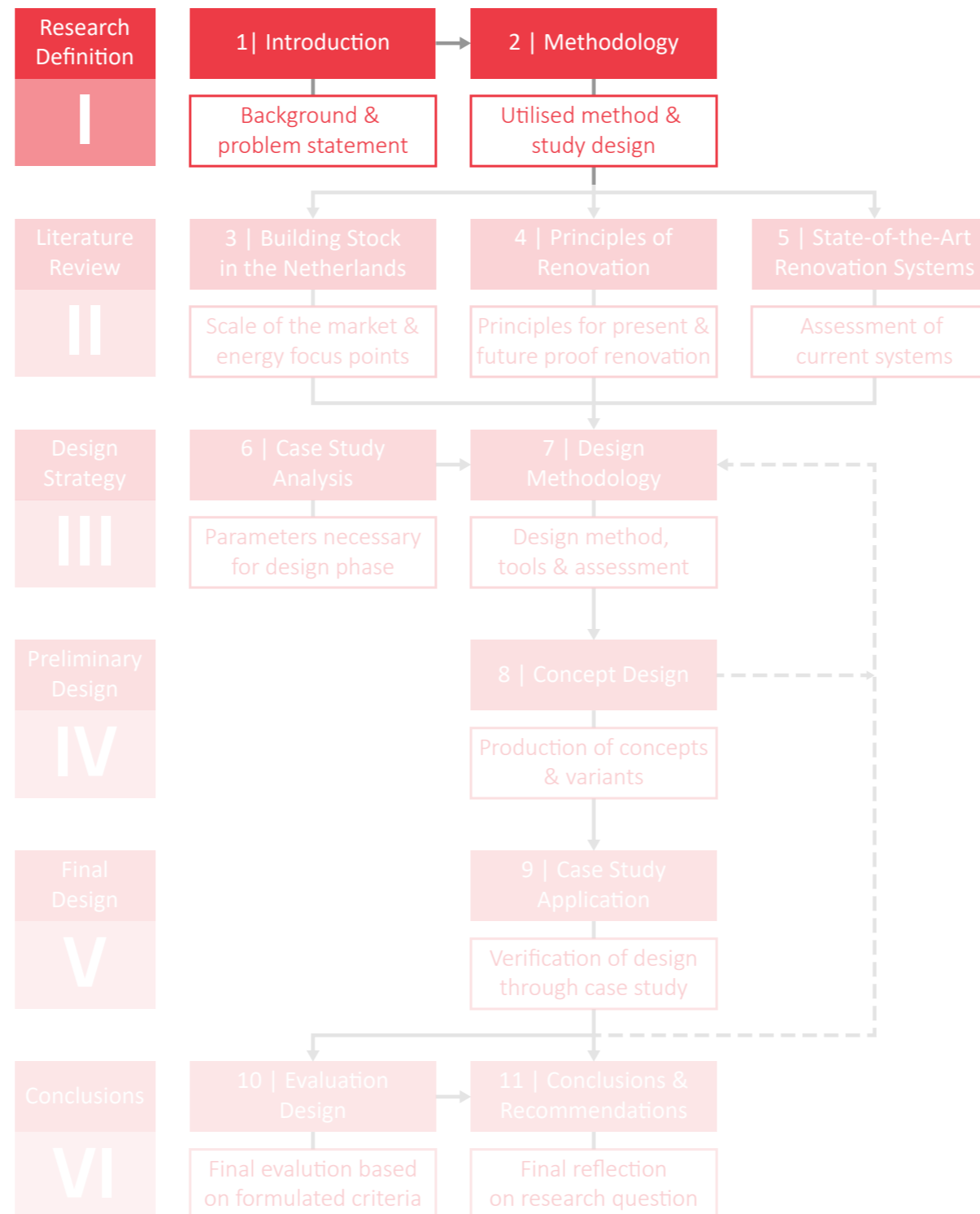
Research Question

*“In what way can a **prefabricated** building envelope system for **energy reduction renovation** of building envelopes of **Dutch post-war apartment blocks** be designed to be **future proof** by taking into account **service life** and **changing standards**?”*

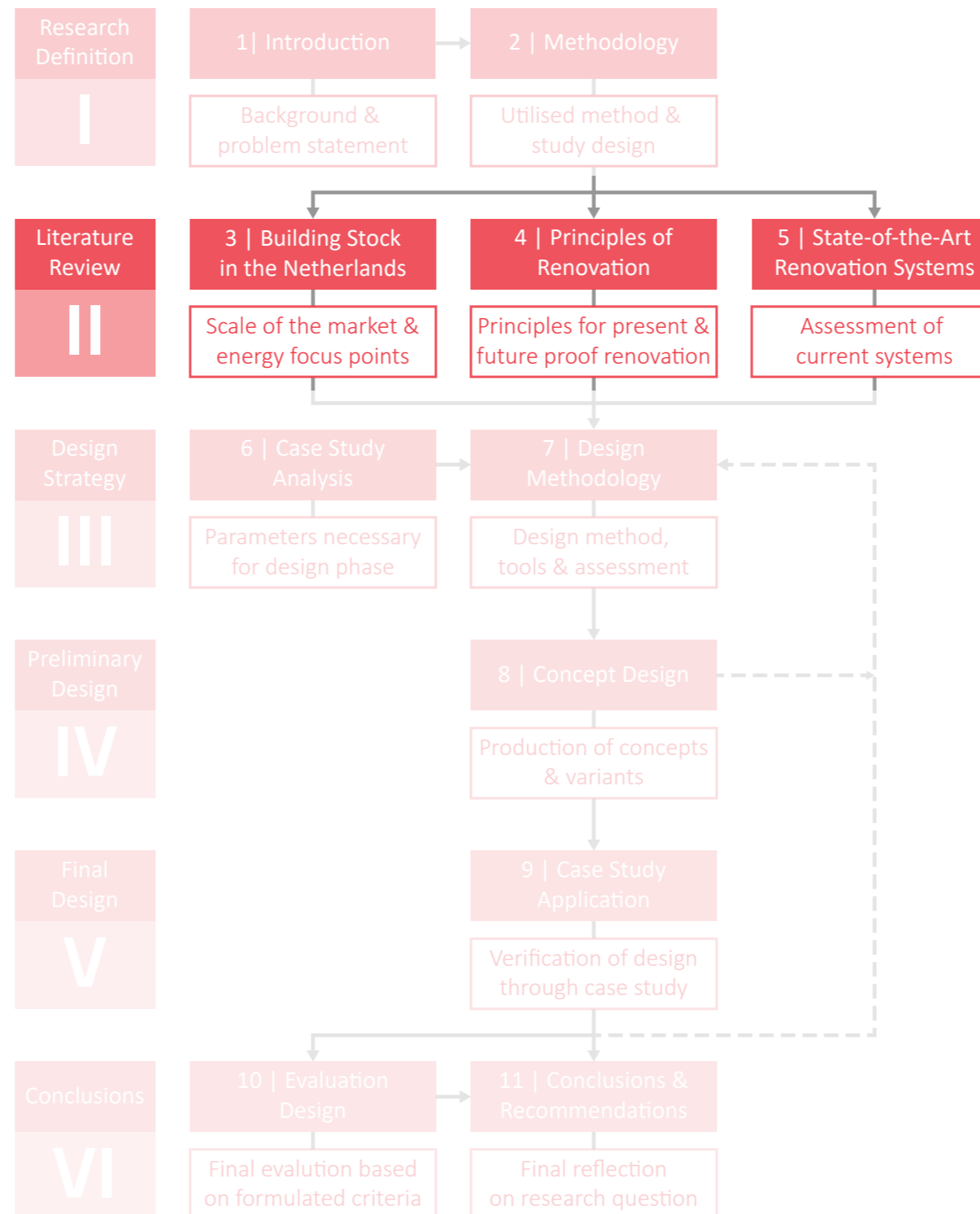
Study Design



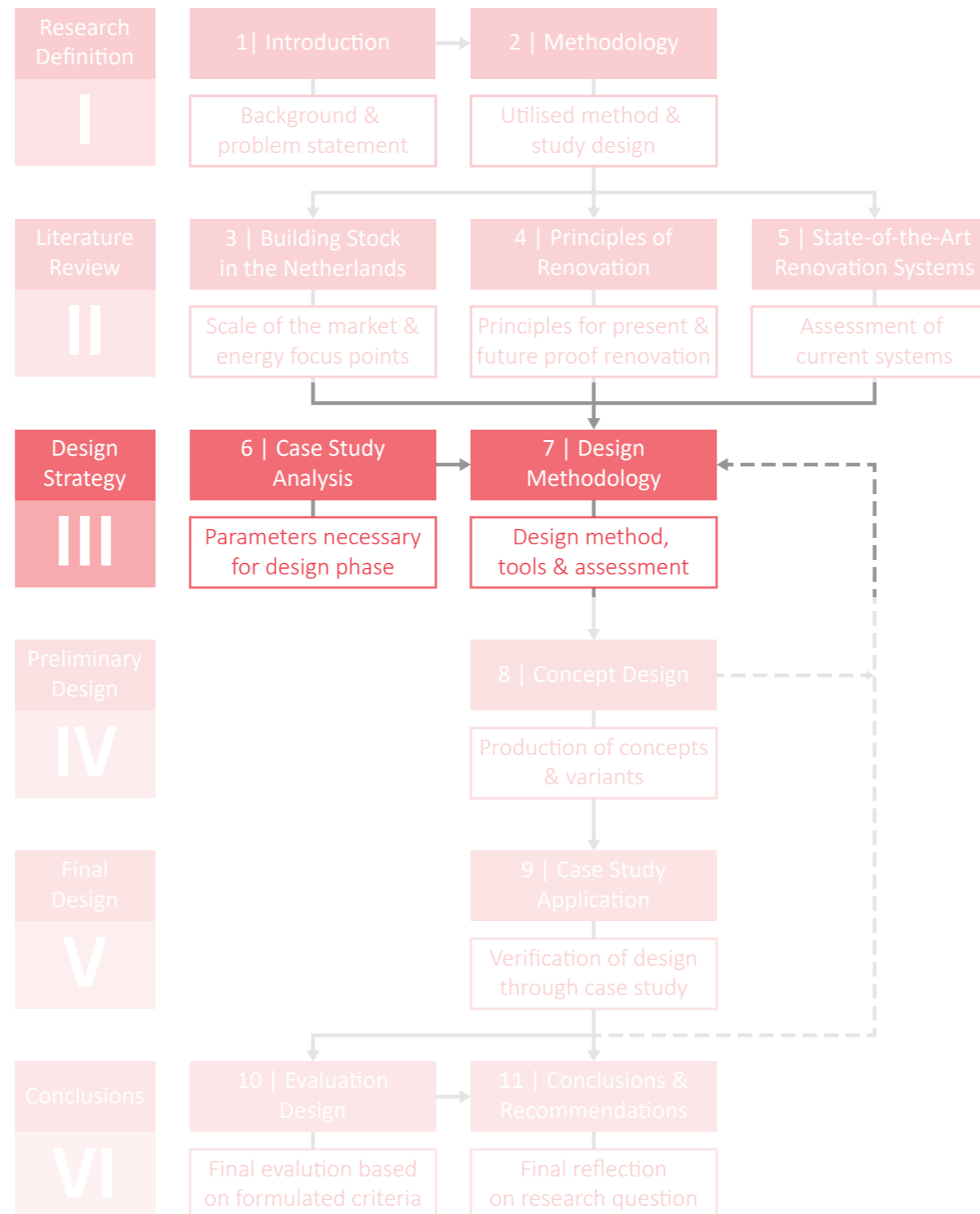
Set-up



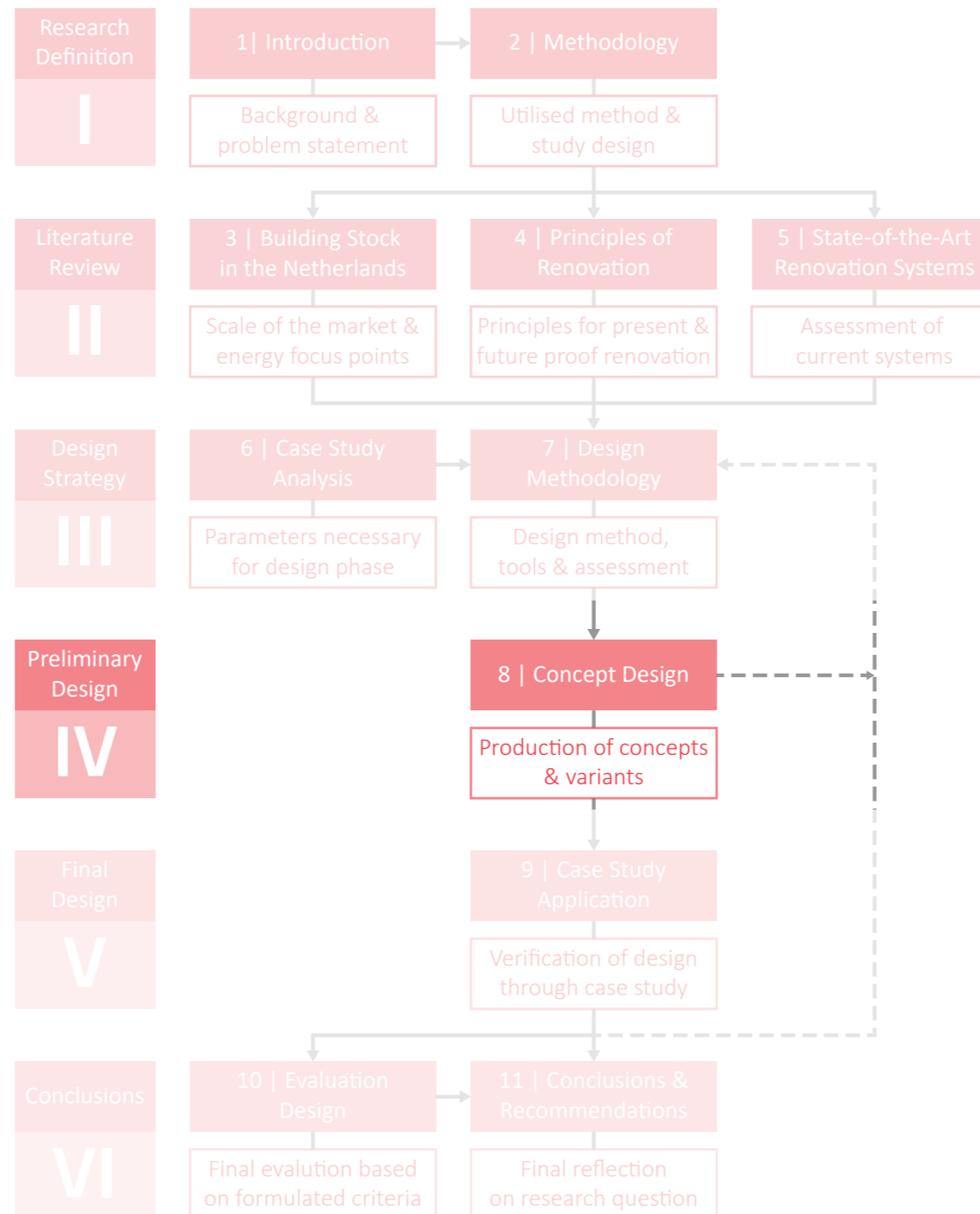
Gathering Knowledge



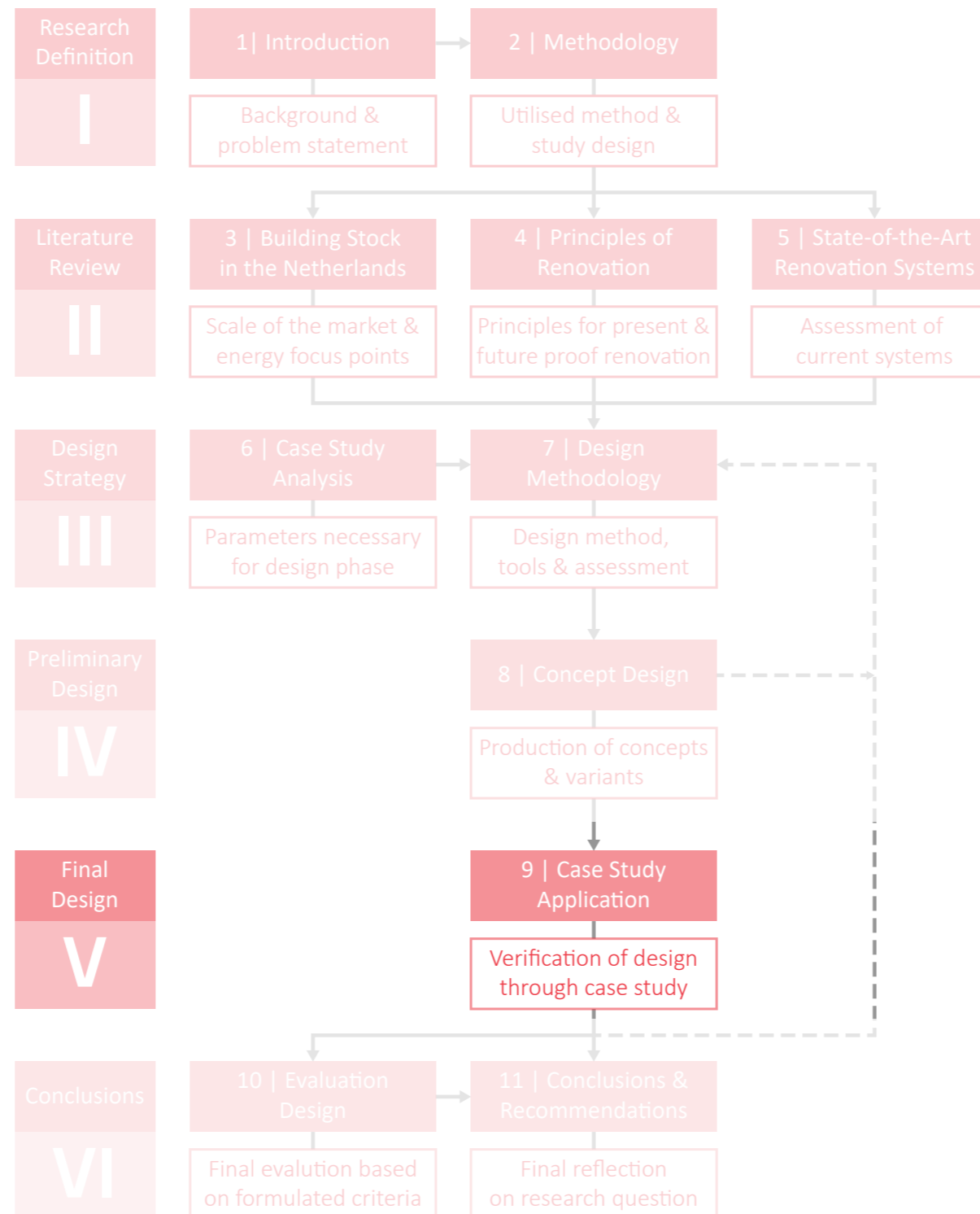
Design Strategy



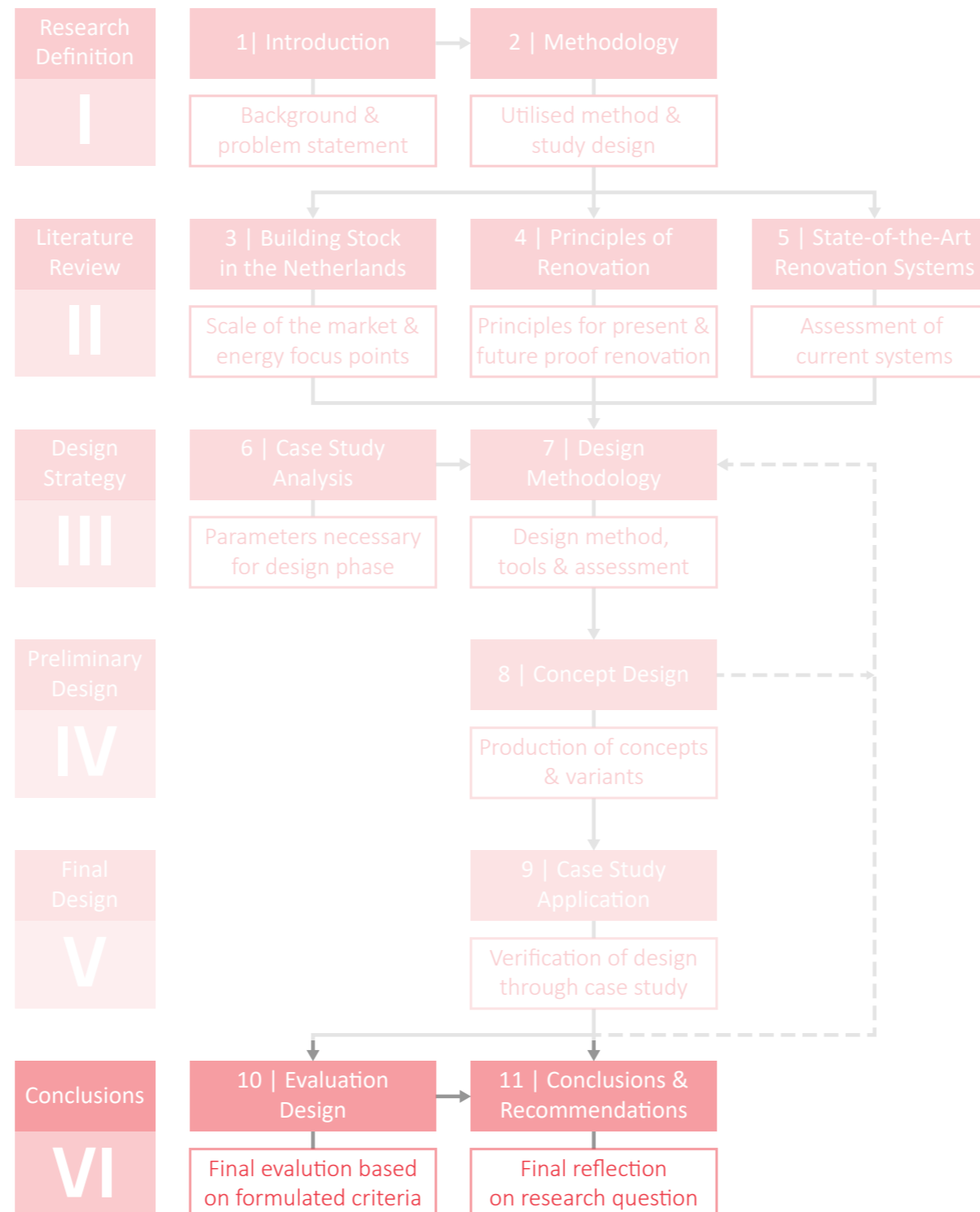
Concept Design



Proof of Concept by Application

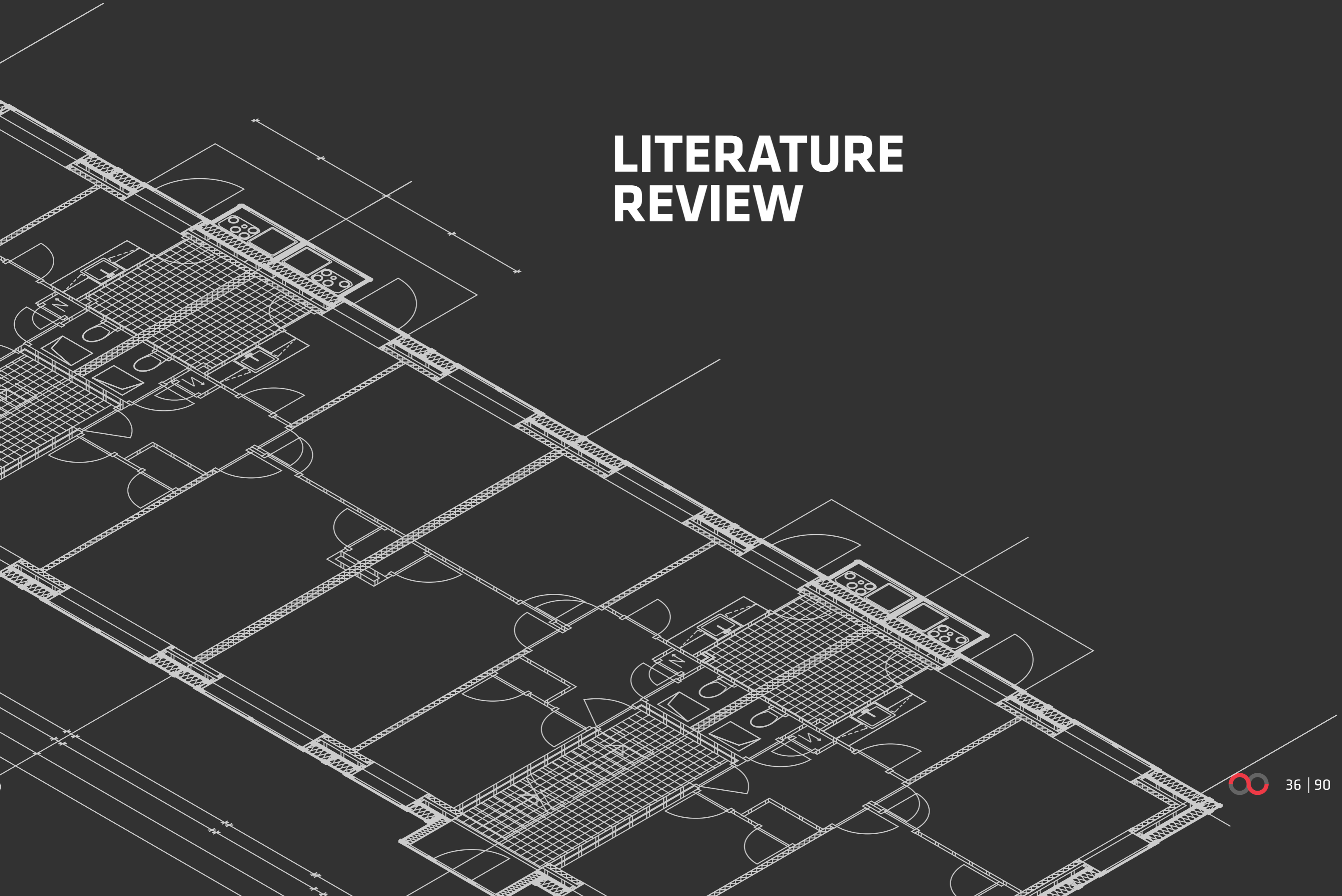


Evaluation & Conclusion



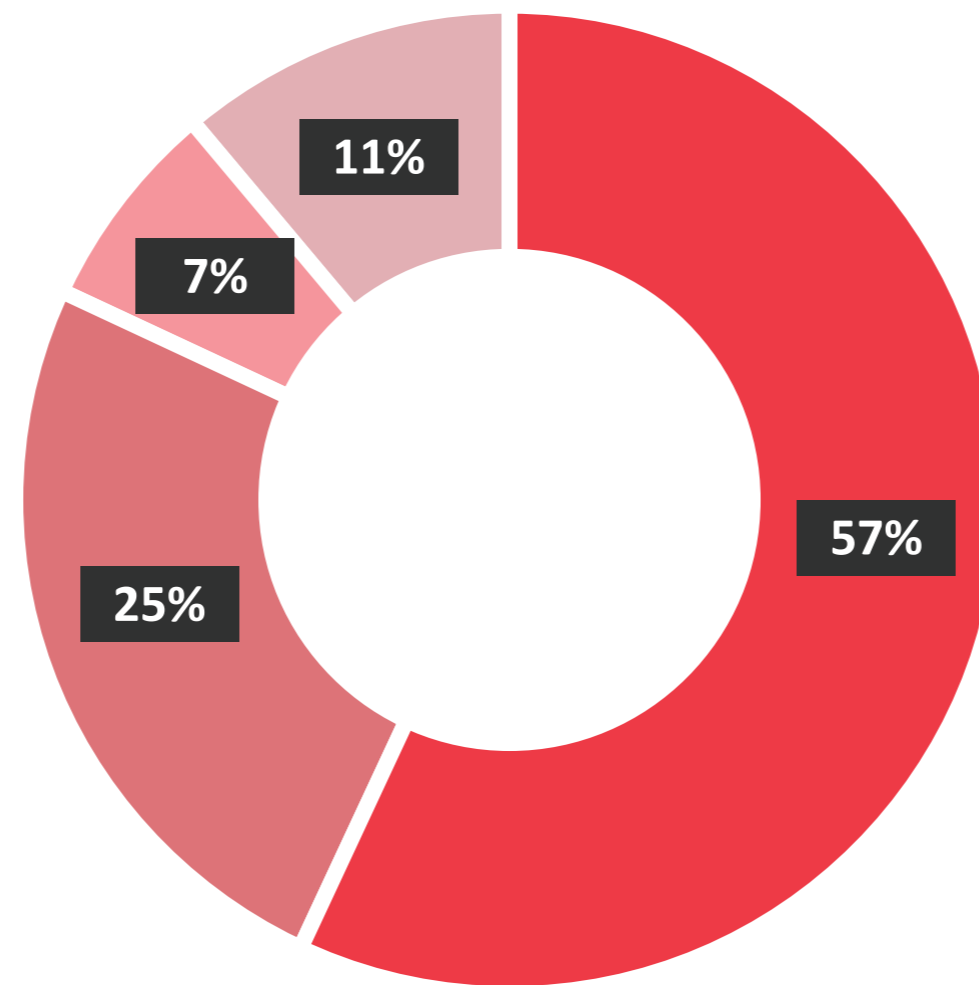


LITERATURE REVIEW



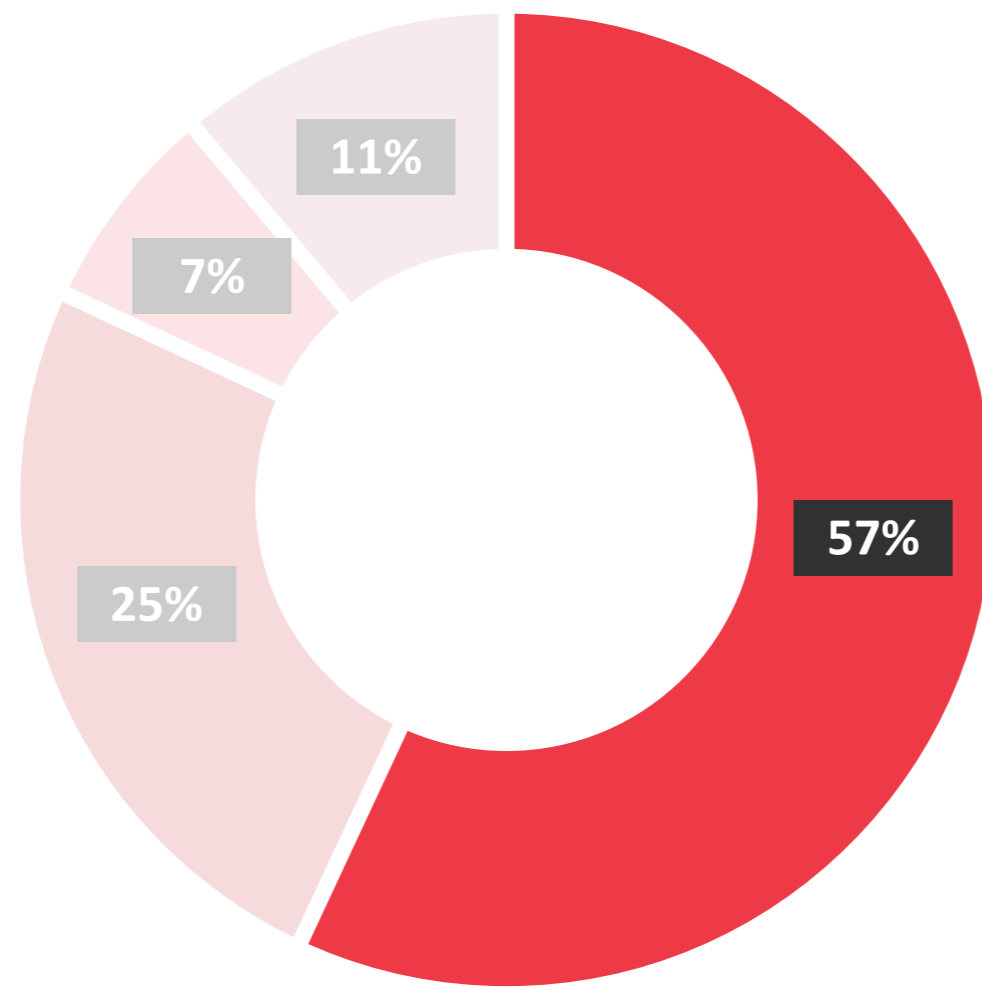
Energy Consumption per Household

- Space Heating
- Water Heating
- Cooking
- Electric Appliances



Space Heating

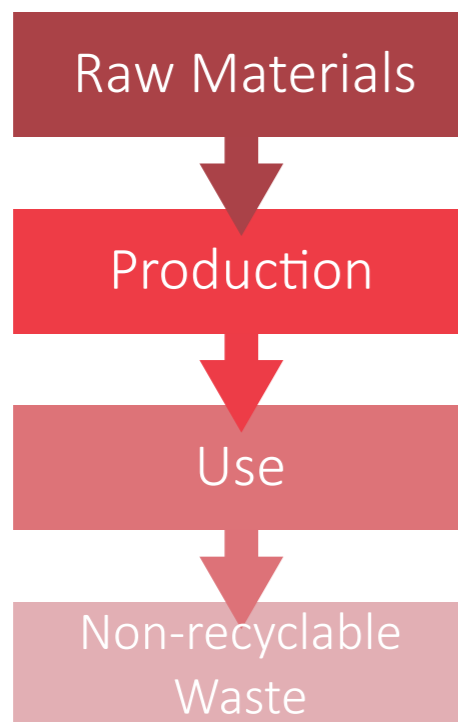
- Space Heating
- Cooking
- Water Heating
- Electric Appliances



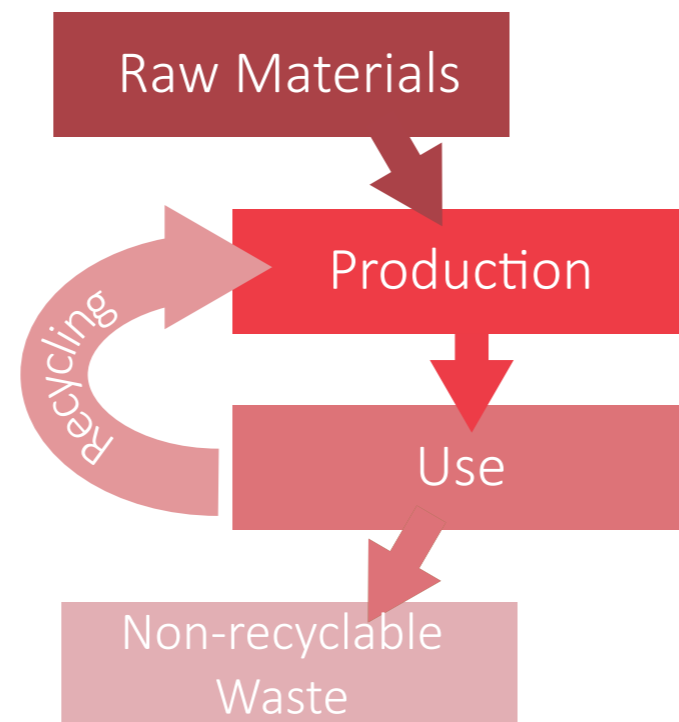


Circular Economy

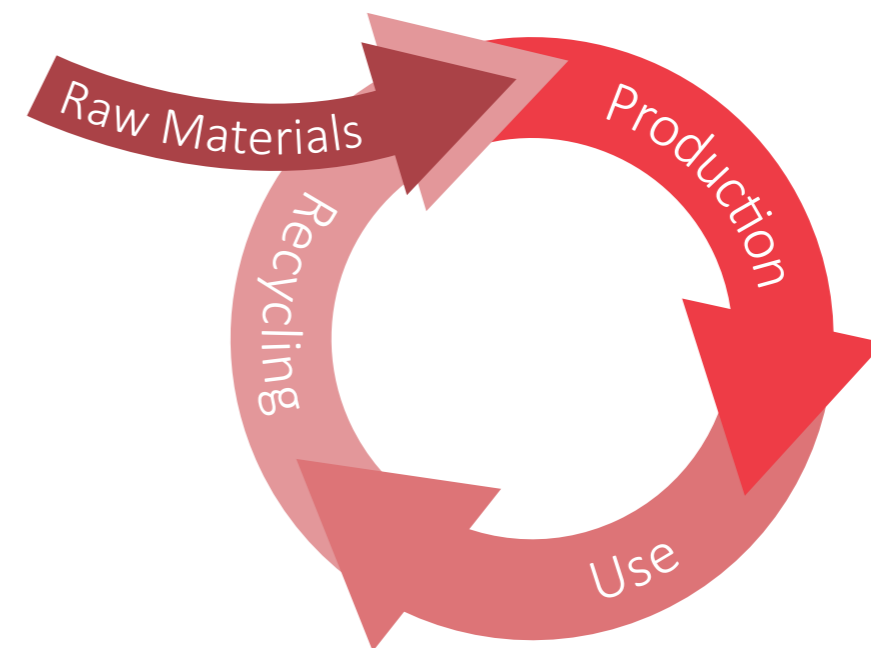
Linear Economy



Reuse Economy



Circular Economy





Comparison Assessment

Aspect	Grade Endis	Grade TES	Grade MeeFS	Average
Customisation	● ● ● ● ●	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○
Level of Prefabrication	● ● ● ○ ○	● ● ● ● ○	● ● ○ ○ ○	● ● ● ○ ○
Integration	● ● ○ ○ ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○
Sustainable Materials	● ● ● ○ ○	● ● ● ○ ○	● ● ○ ○ ○	● ● ● ○ ○
Structural Adjustments	● ● ○ ○ ○	● ● ● ● ●	● ● ● ● ●	● ● ● ● ○
Adaptability	● ○ ○ ○ ○	● ● ● ○ ○	● ● ● ○ ○	● ● ● ○ ○
Disturbance	● ● ● ○ ○	● ● ● ● ○	● ● ● ● ●	● ● ● ● ○
Construction Time	● ● ● ○ ○	● ○ ○ ○ ○	● ● ○ ○ ○	● ● ○ ○ ○
Upgradability	● ○ ○ ○ ○	● ○ ○ ○ ○	● ● ● ○ ○	● ○ ○ ○ ○
Maintenance	● ● ● ● ○	● ● ○ ○ ○	● ● ○ ○ ○	● ● ○ ○ ○

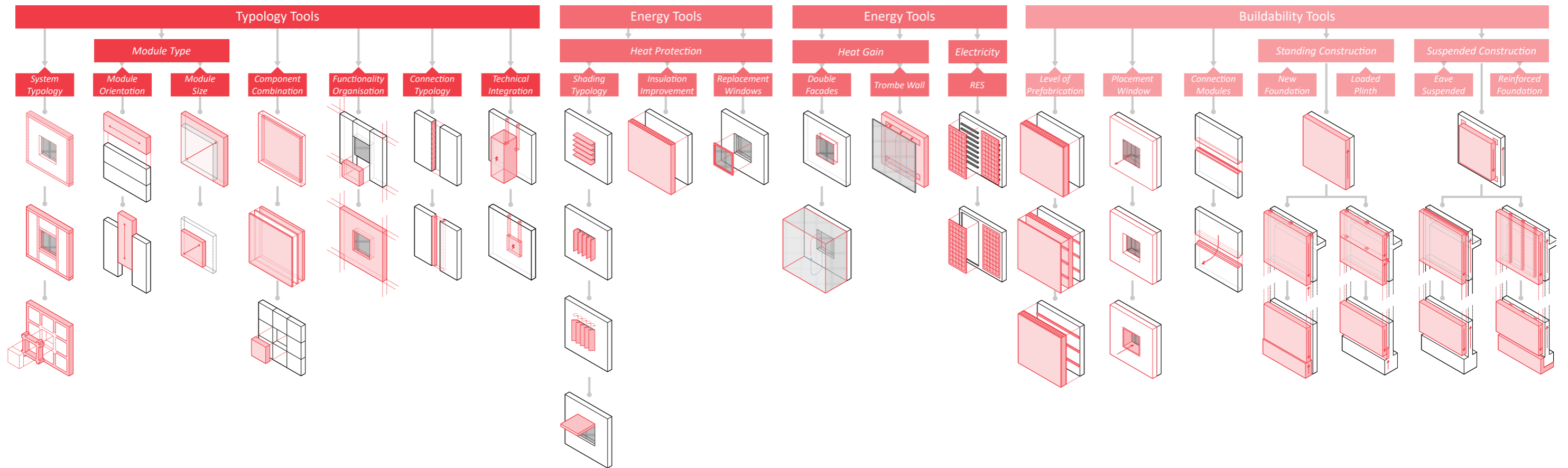


Comparison Assessment

Aspect	Grade Endis	Grade TES	Grade MeeFS	Average
Customisation	●●●●●	●●●●○	●●●●○	●●●●○
Level of Prefabrication	●●●○	●●●●○	●●○○○	●●●○○
Integration	●●○○○	●●●●○	●●●●○	●●●●○
Sustainable Materials	●●●○○	●●●○○	●●○○○	●●●○○
Structural Adjustments	●●○○○	●●●●●	●●●●●	●●●●○
Adaptability	●○○○○	●●●○○	●●●○○	●●●○○
Disturbance	●●●○○	●●●●○	●●●●●	●●●●○
Construction Time	●●●○○	●○○○○	●●○○○	●●○○○
Upgradability	●○○○○	●○○○○	●●●○○	●○○○○
Maintenance	●●●●○	●●○○○	●●○○○	●●○○○

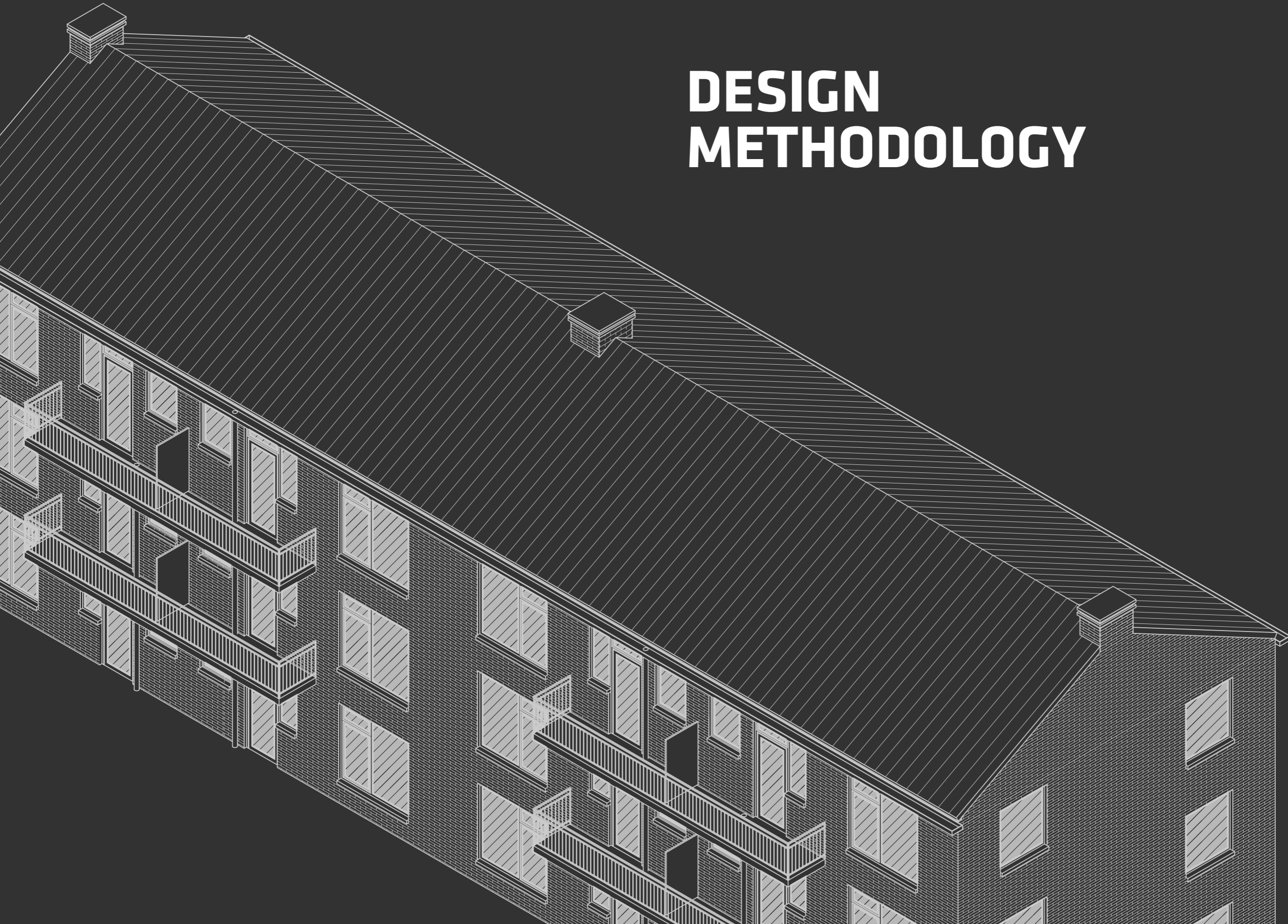


Design Tools





DESIGN METHODOLOGY





Marathonweg

Floreslaan

Madoerastraat

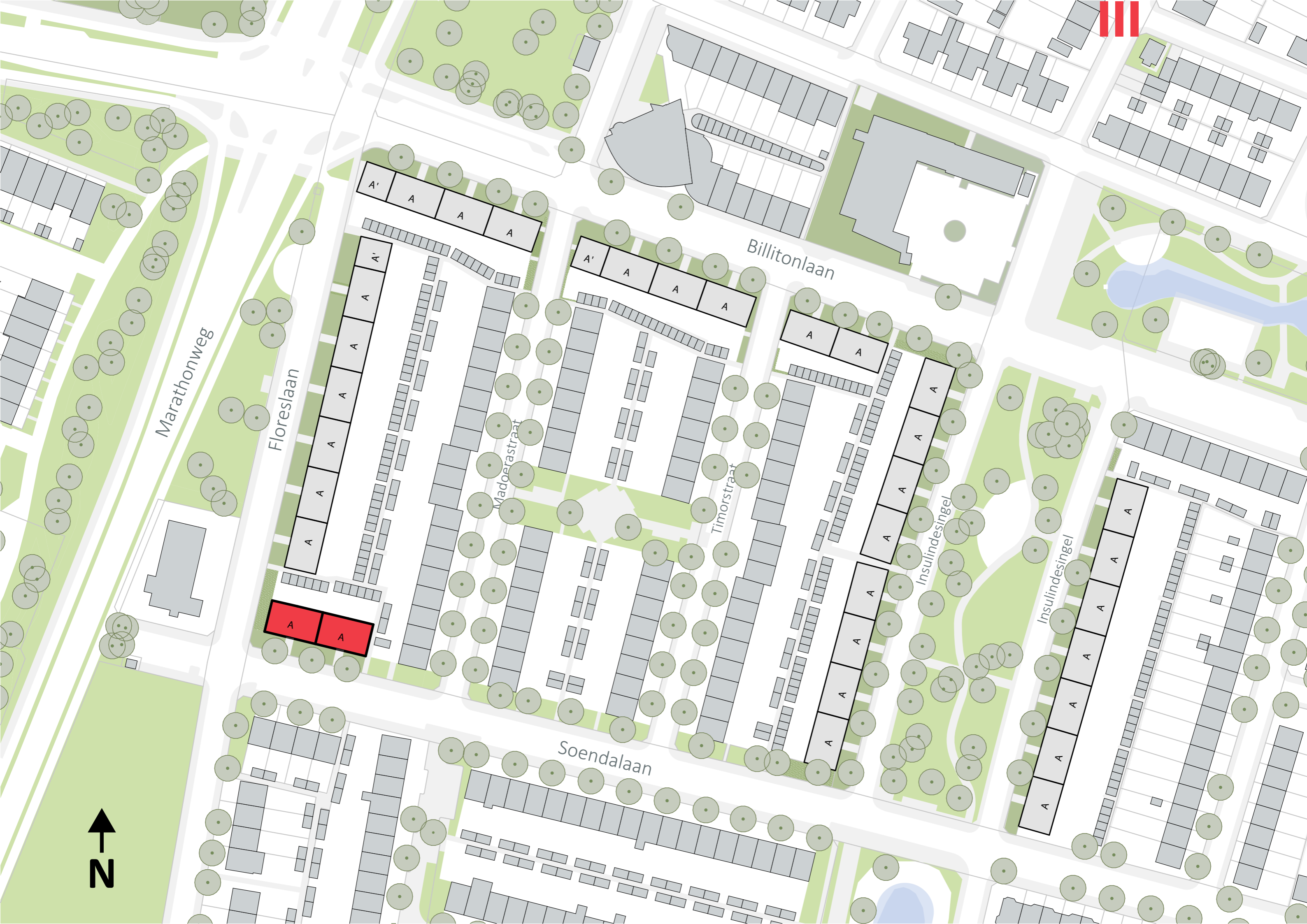
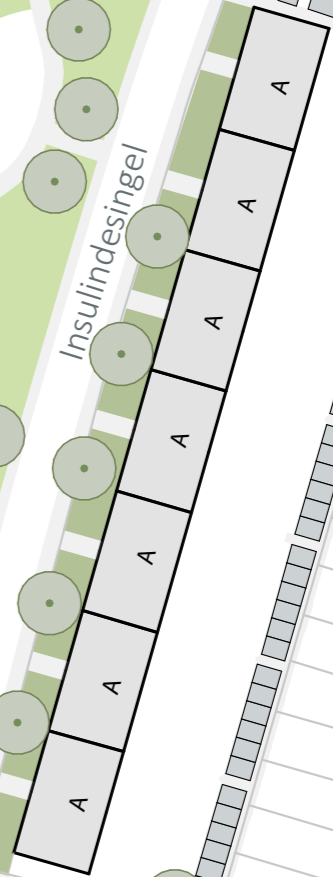
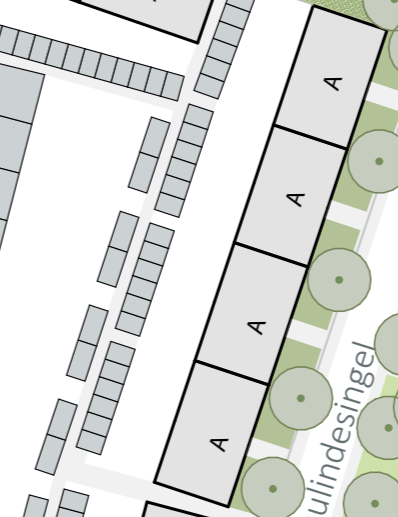
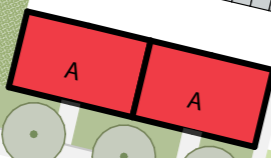
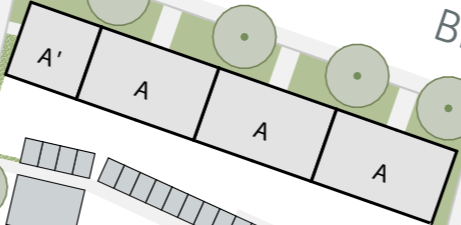
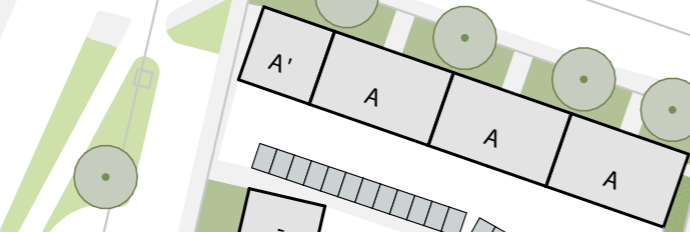
Timorstraat

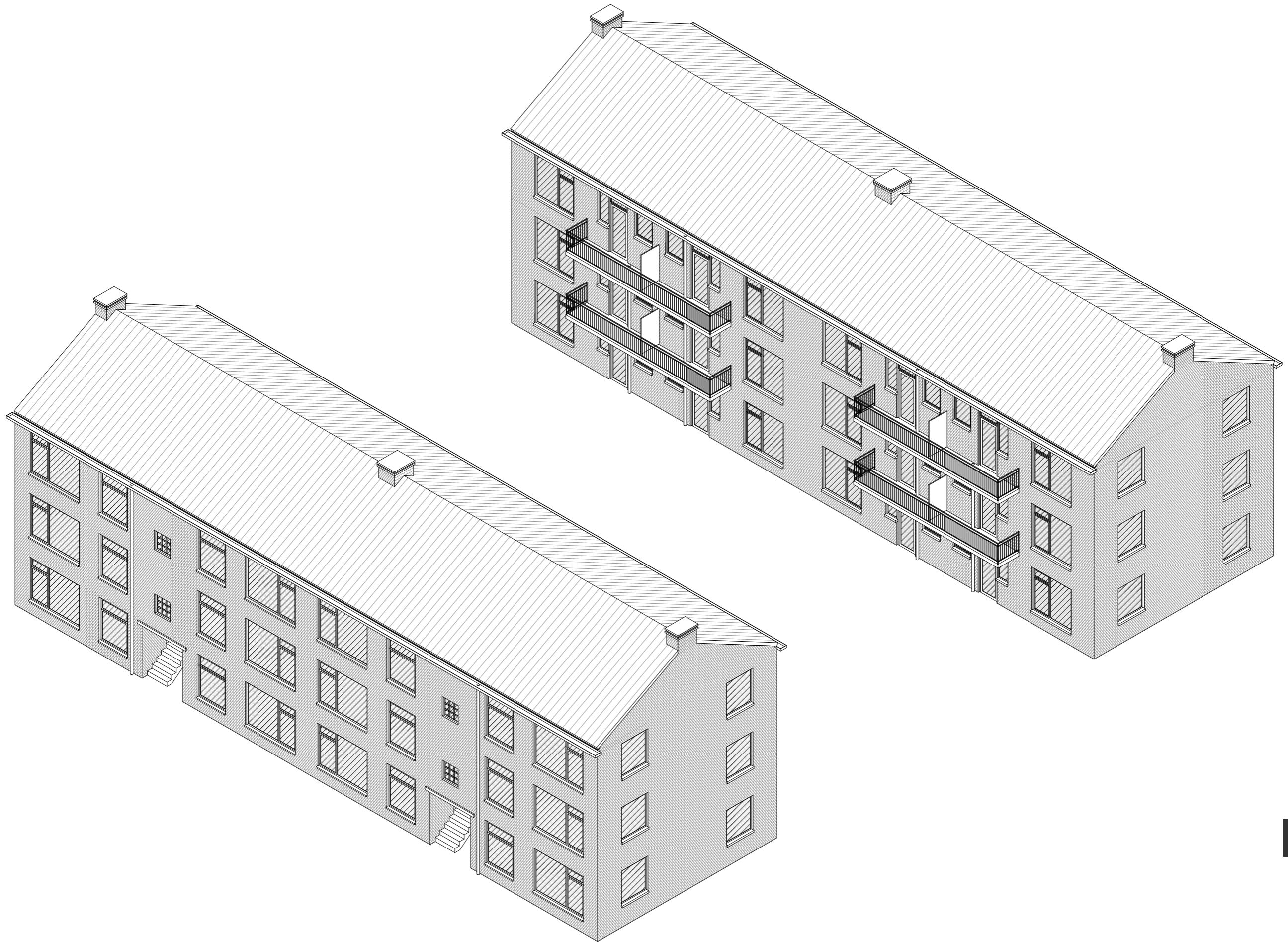
Billitonlaan

Soendalaan

Insulindingel

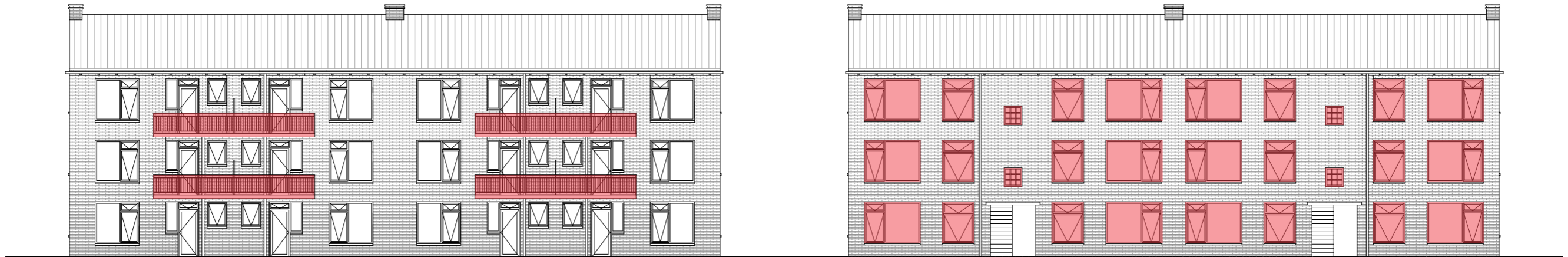
Insulindingel







Parameters



Balconies

Windows

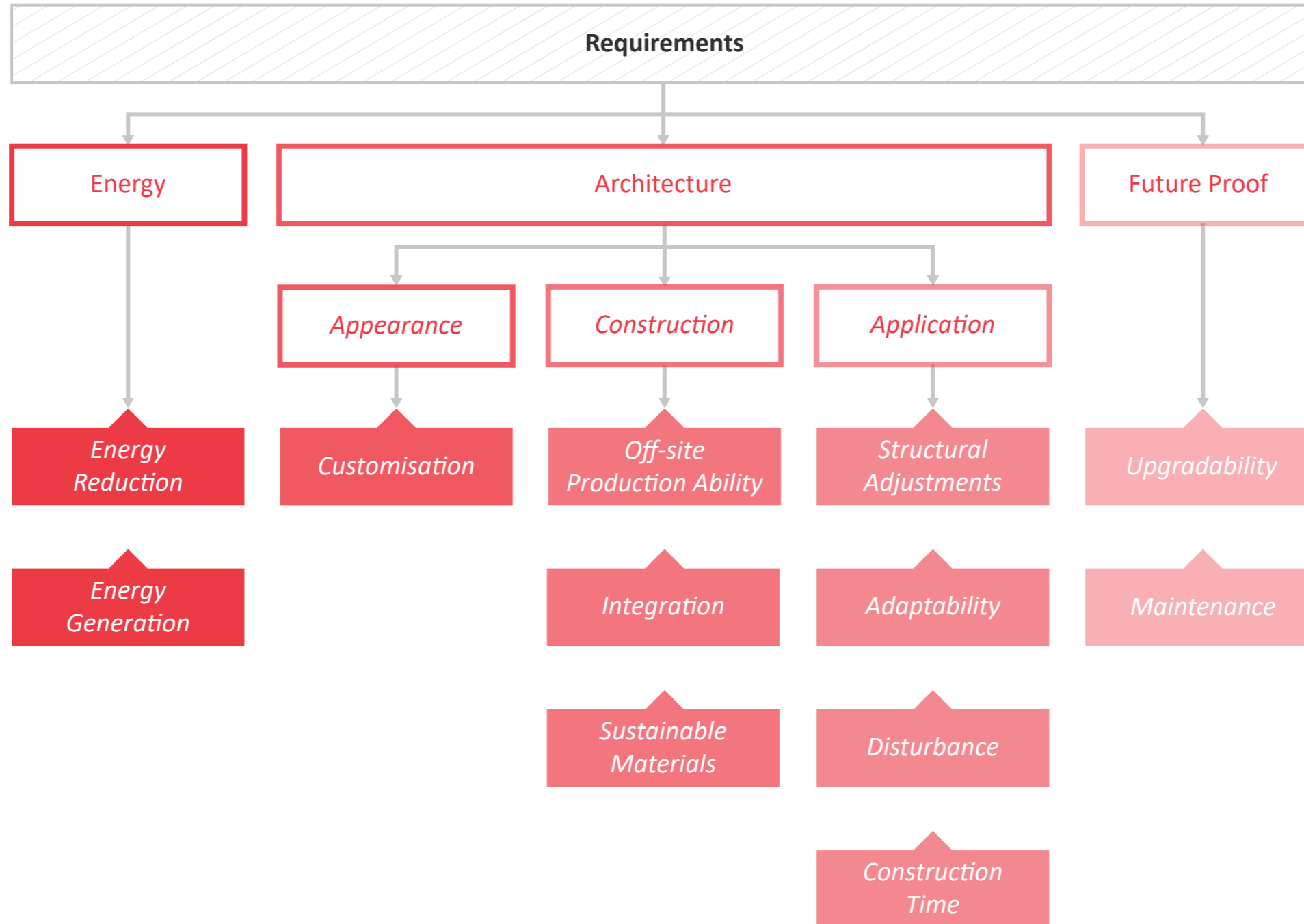


Chimneys & Rainpipes

Entrances

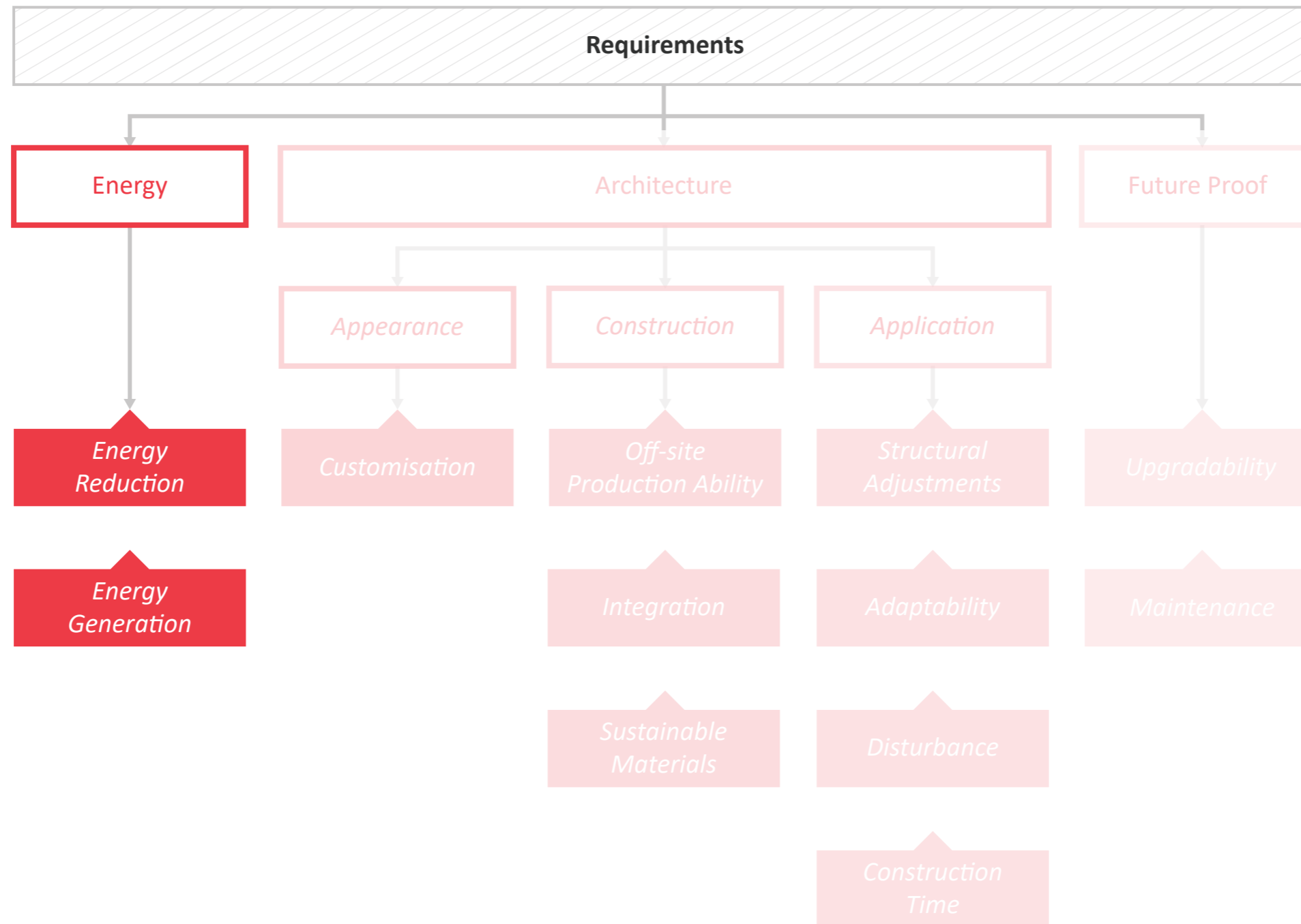


Criteria



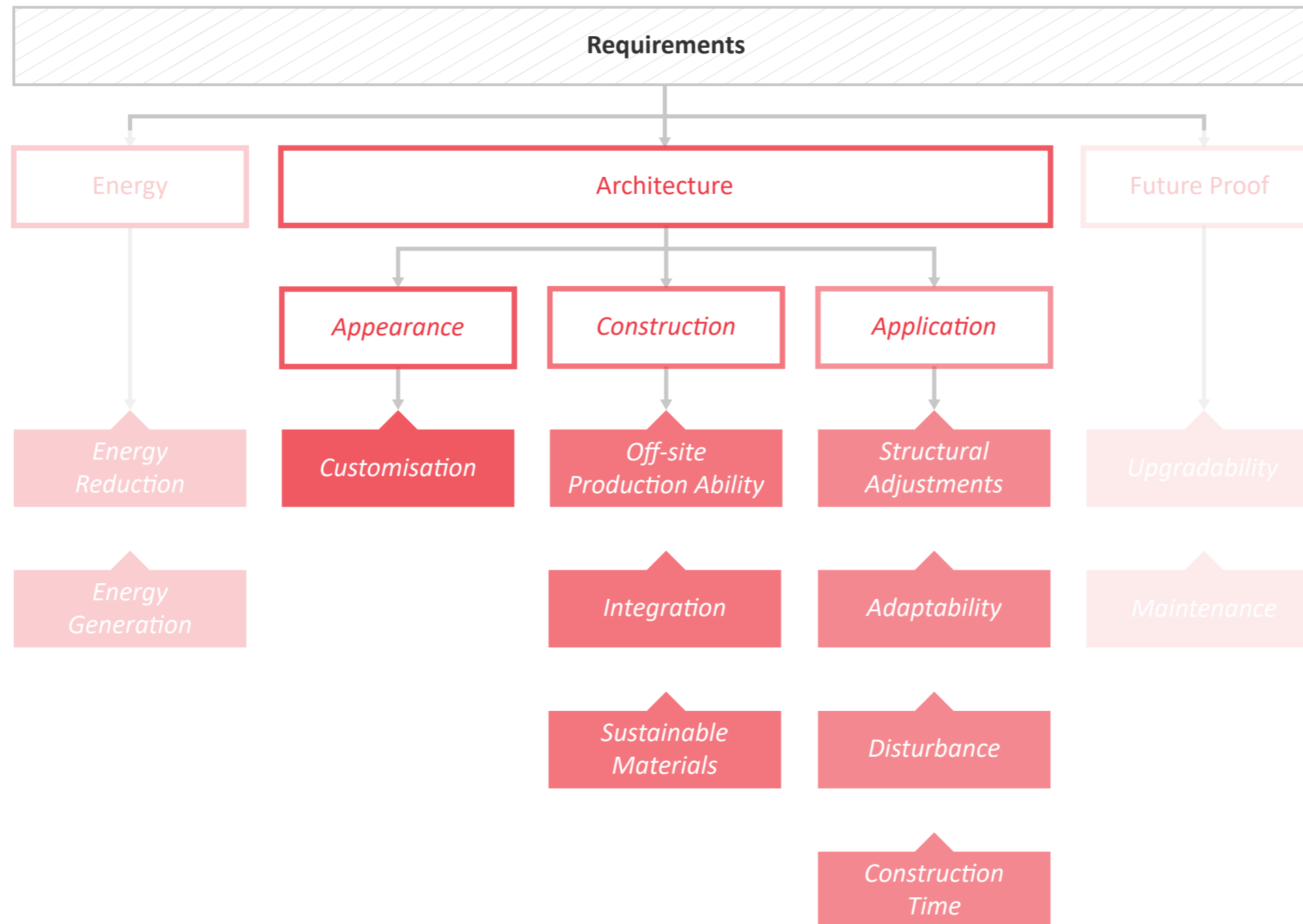


Energy



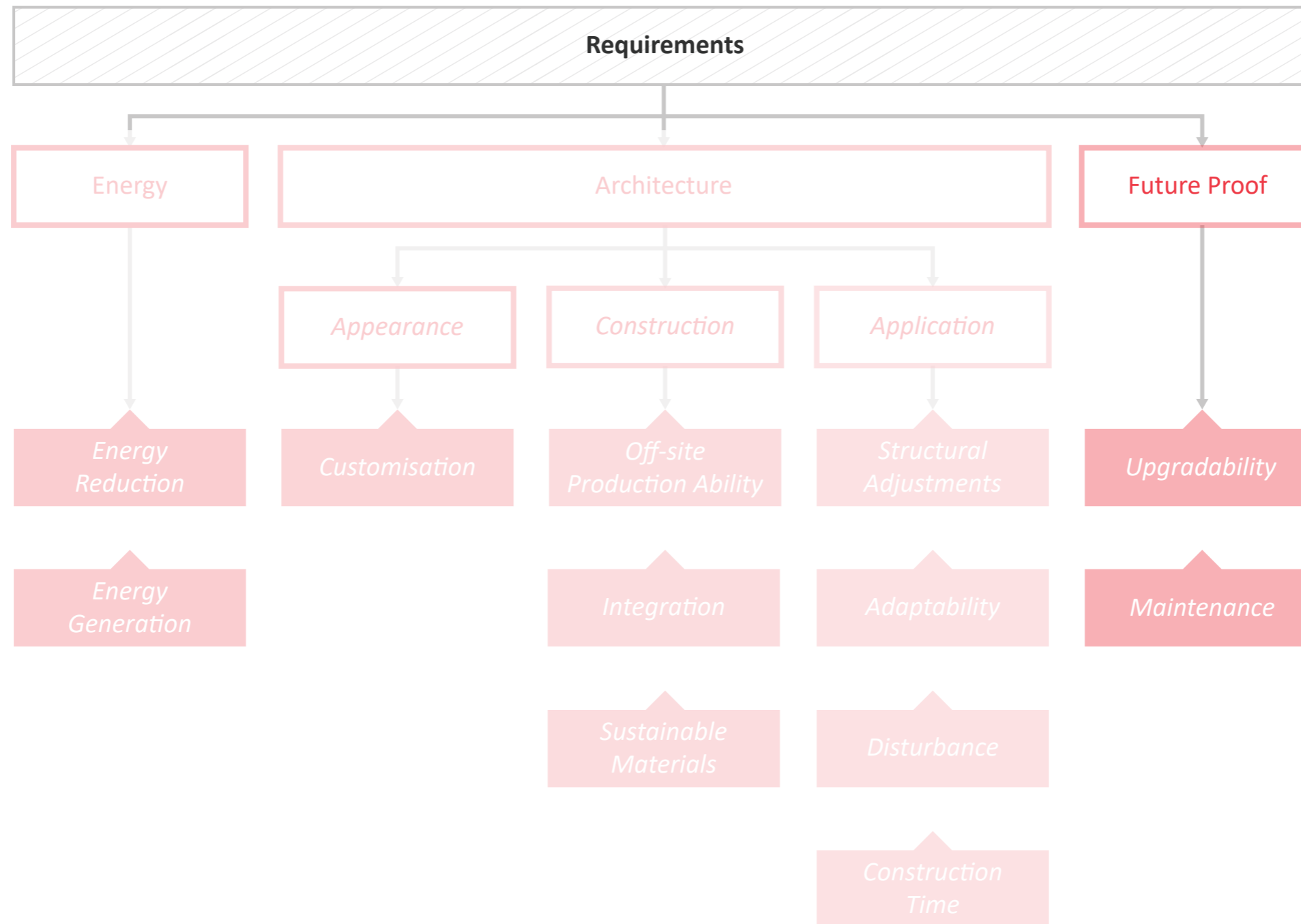


Architecture

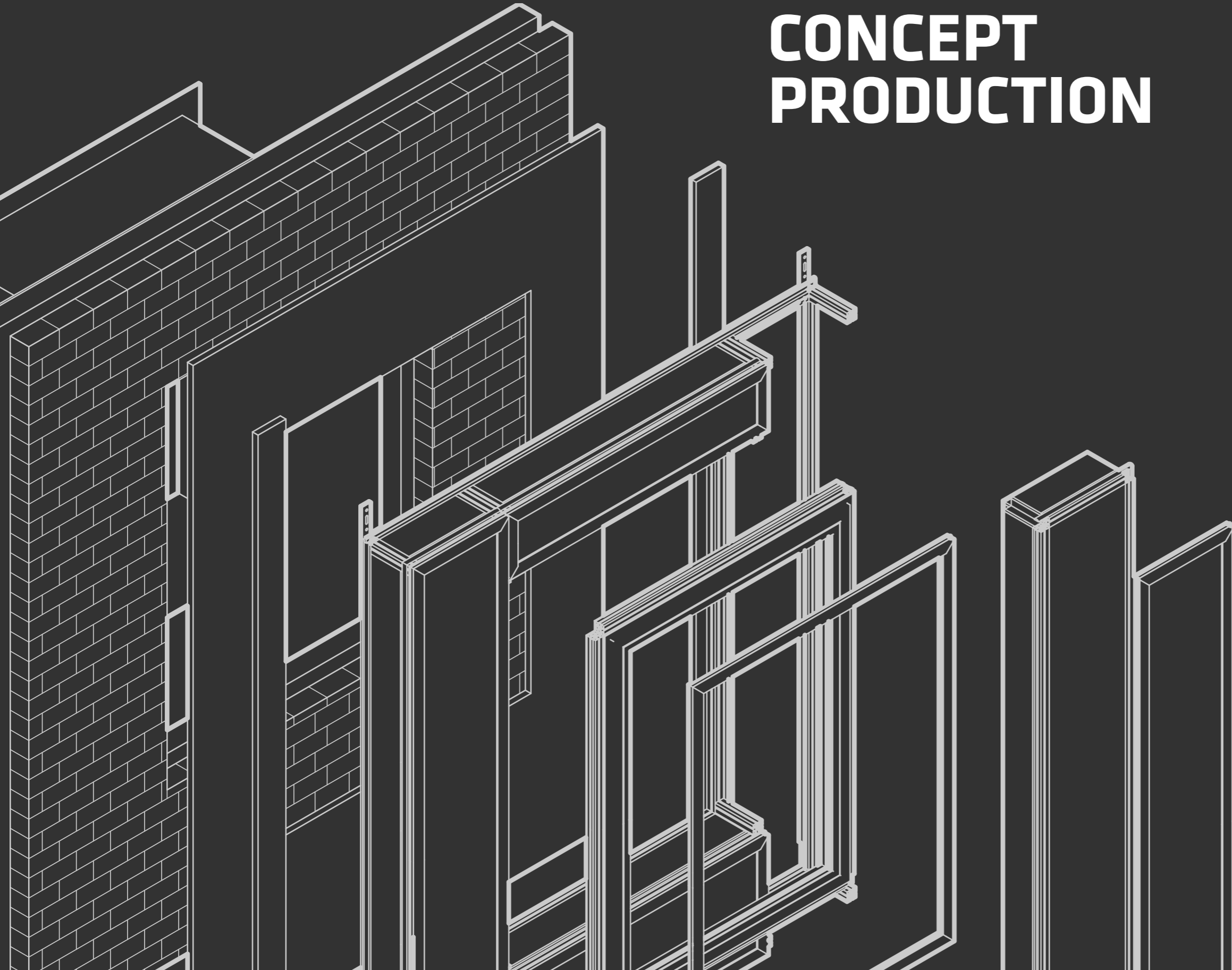




Future Proof



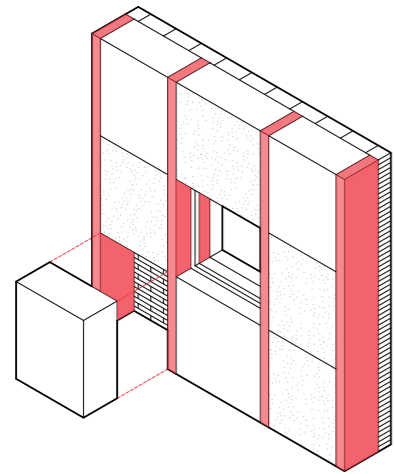
CONCEPT PRODUCTION



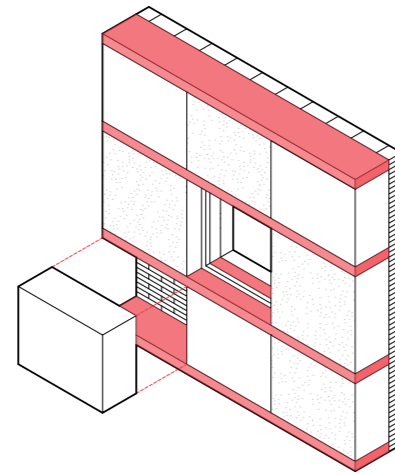
Future Components Changes

Components	Functionality	Reason For Upgradability/ Flexibility	New Component		
Cladding	Appearance	Fashion Damage Exceeded Service Life	New Cladding, potentially different substructure.		
Water Barriers	Water & Airtightness	Technology Upgrade Stricter Regulations Damage Exceeded Service Life	Different form of water barrier, either thinner or thicker.		
Insulation	Thermal Insulation Sound Insulation	Technology Upgrade Stricter Regulations Enhanced Awareness Environmental Change Damage Exceeded Service Life	Thinner insulation in different form.	Same insulation with added layer.	
Windows	Appearance Thermal Insulation Sound Insulation Daylight	Fashion Technology Upgrade Stricter Regulations Enhanced Awareness Different User Different Use Damage Exceeded Service Life	Thinner or thicker frame, potentially manufactured from a different material.	Demountable window that allows for replacement of individual glazing layers.	Bigger windows
Shading	Appearance Daylight	Fashion Different User Different Use Damage Exceeded Service Life	Shading out of different material or shape.	Different functioning shading, from static to movable or vice versa.	Adding additional shading elements
Building Installations	Heating/Cooling Ventilation	Technology Upgrade Different User Different Use Damage Exceeded Service Life	More efficient installation requiring less space/	Additional components integrated in the facade.	Additional components mounted on the exterior of the facade.
Piping	Heating/Cooling Ventilation	Technology Upgrade Different User Different Use Damage Exceeded Service Life	Different size or material piping.	Additional pipes.	Removing pipes.

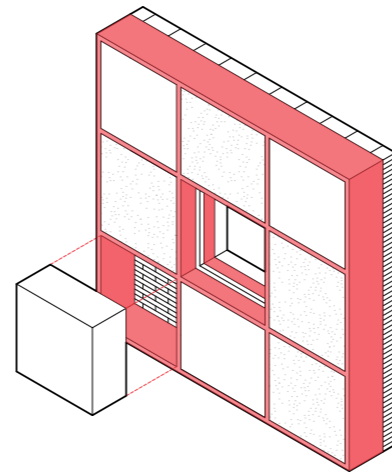
Concept Production



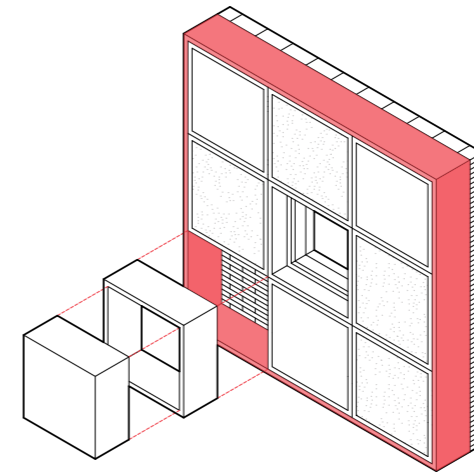
Vertical Frame



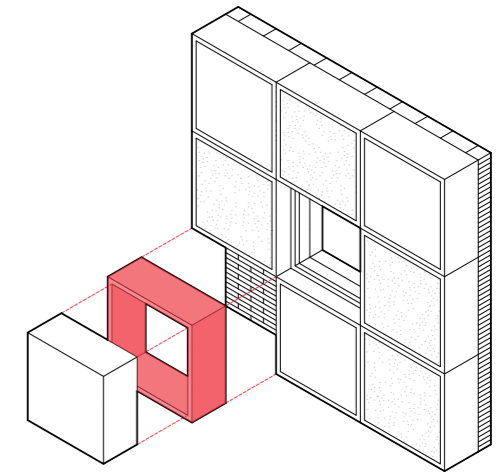
Horizontal Frame



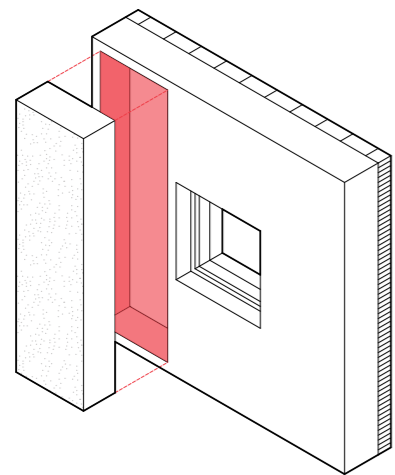
Drawer Frame



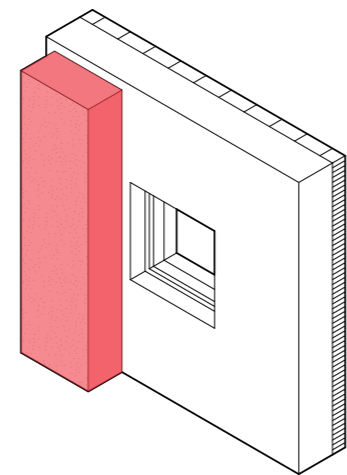
Surrounding Frame



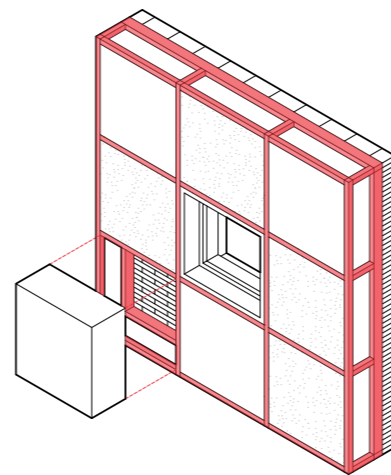
Self-Sup. Frame



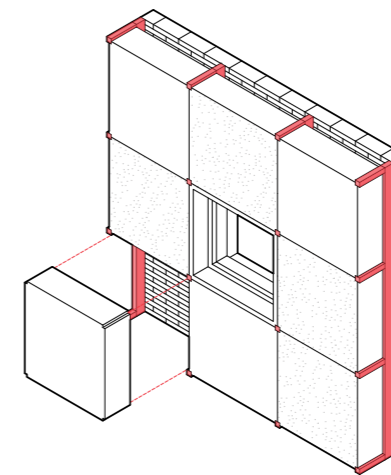
Slot System



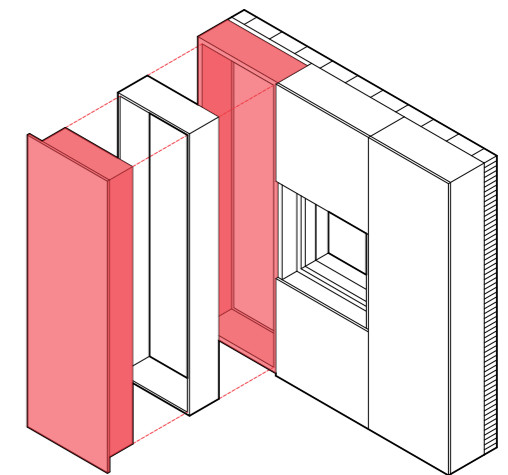
Add-in System



Open Frame

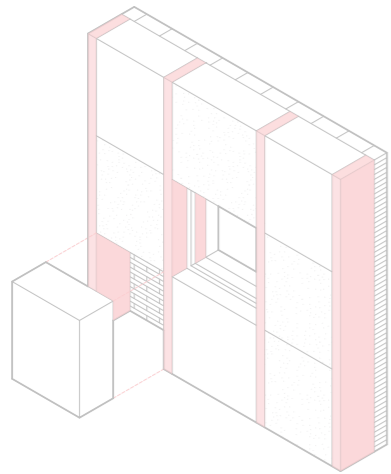


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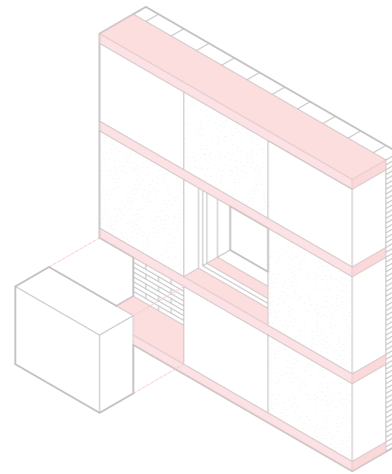


Closed Modules

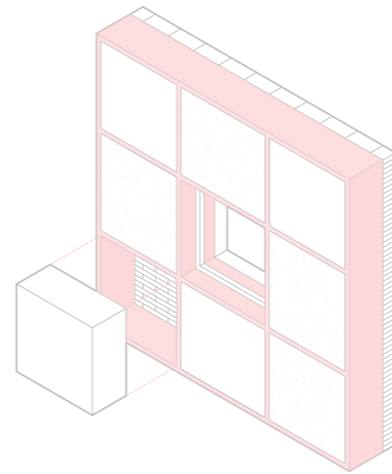
Chosen Concept



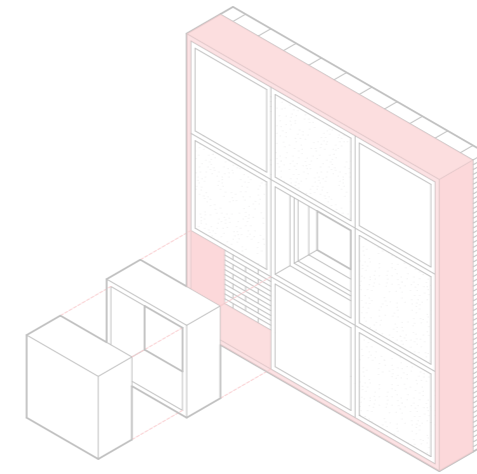
Vertical Frame



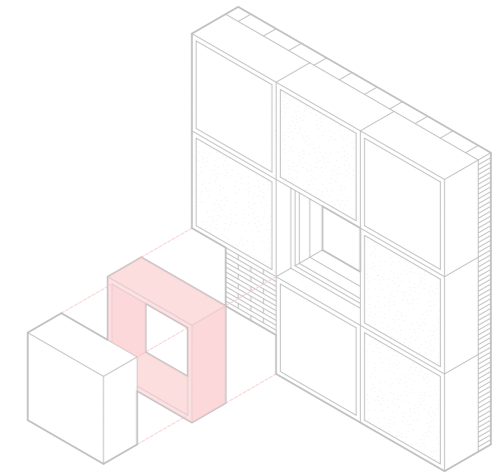
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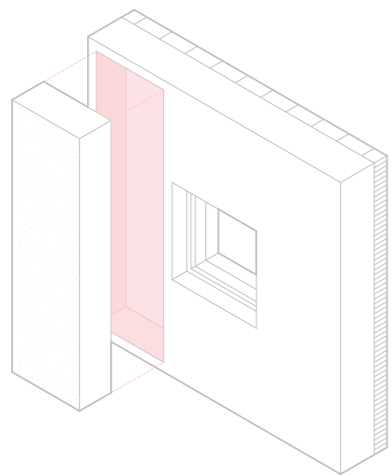
Drawer Frame



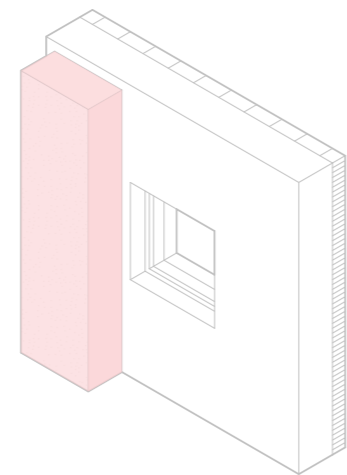
Surrounding Frame



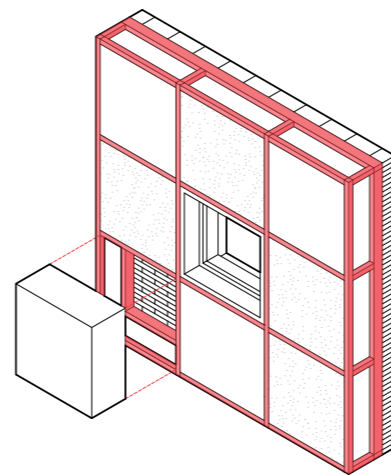
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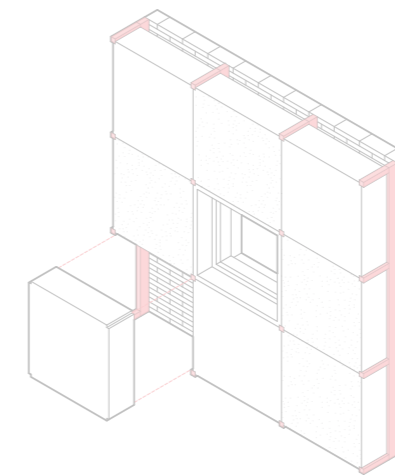
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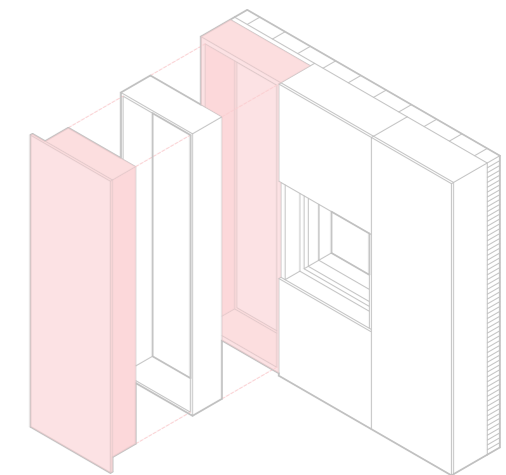
Add-in System



Open Frame

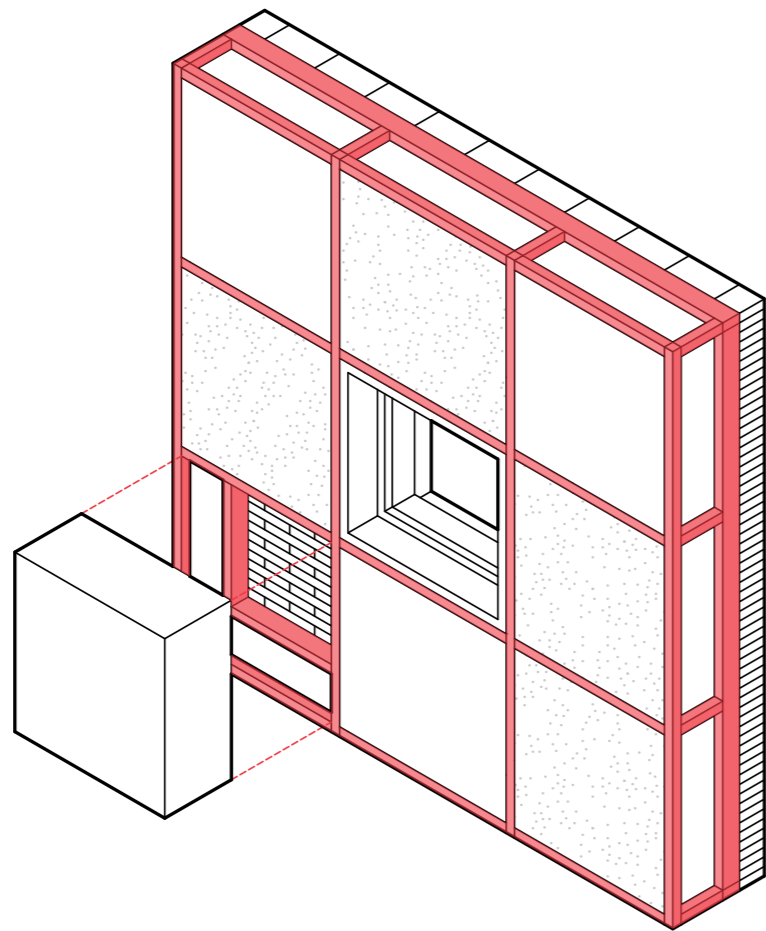


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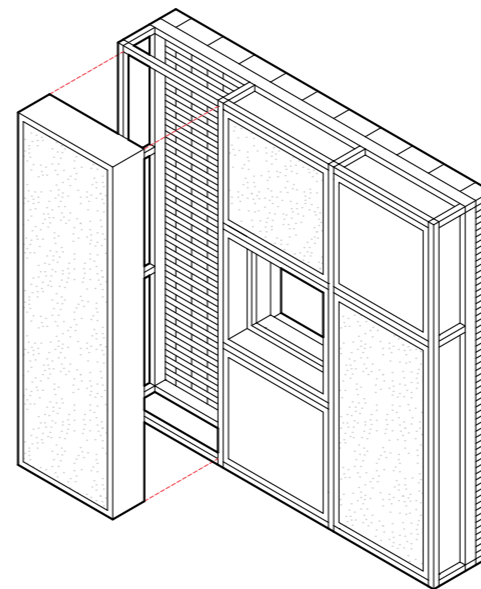


Closed Modules

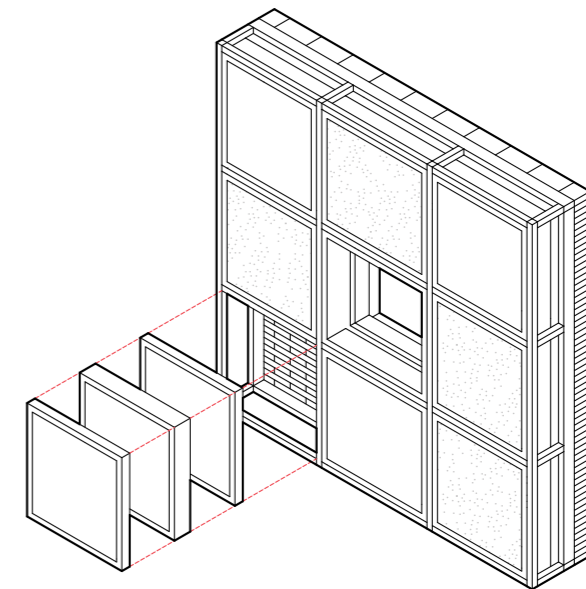
Concept Variants



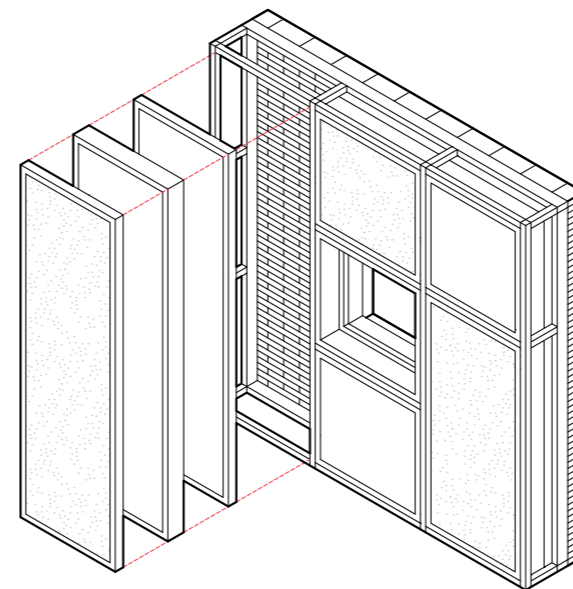
Standardised Size |
Unlayered



Adjustable Size |
Unlayered

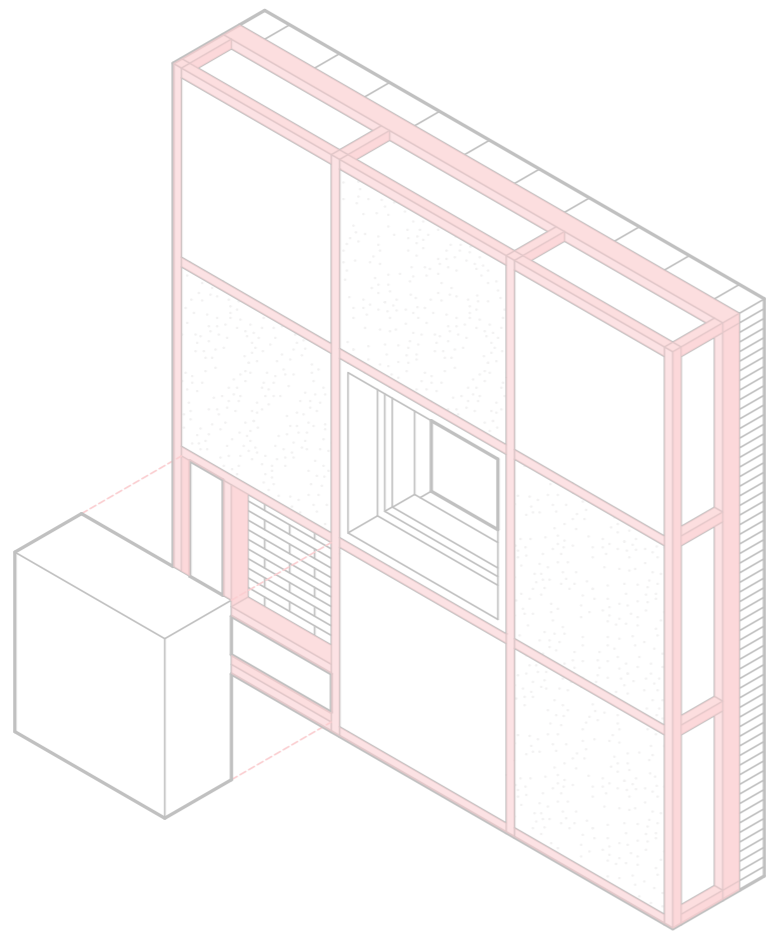


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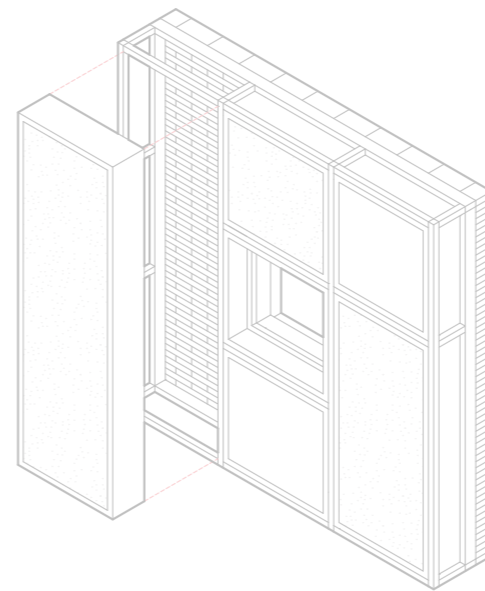


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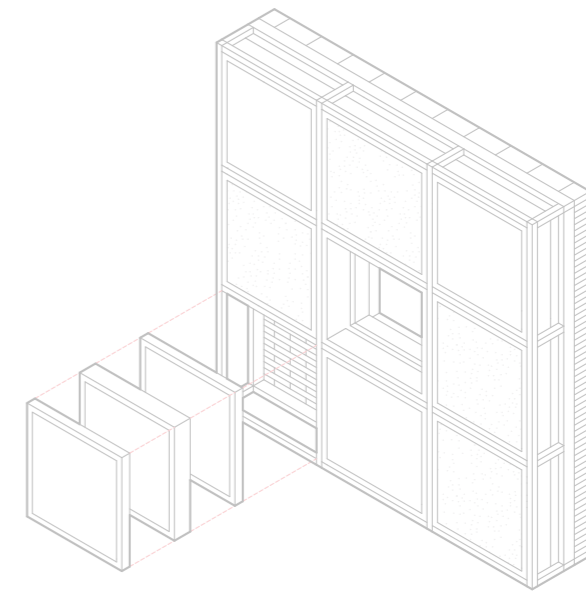
Chosen Variant



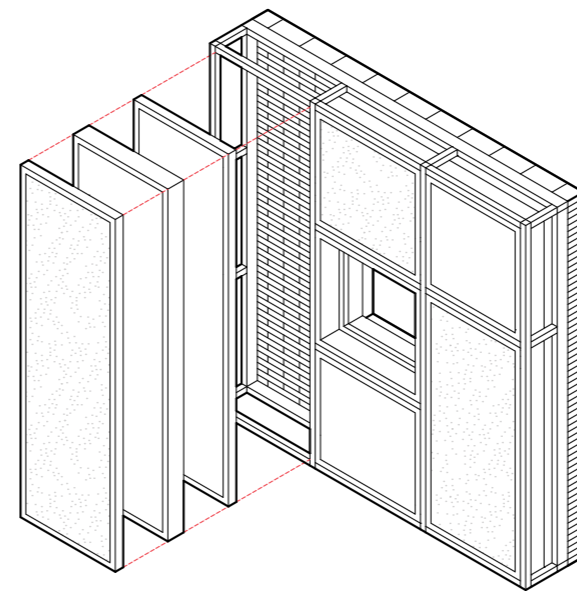
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Adjustable Size |
Unlayered

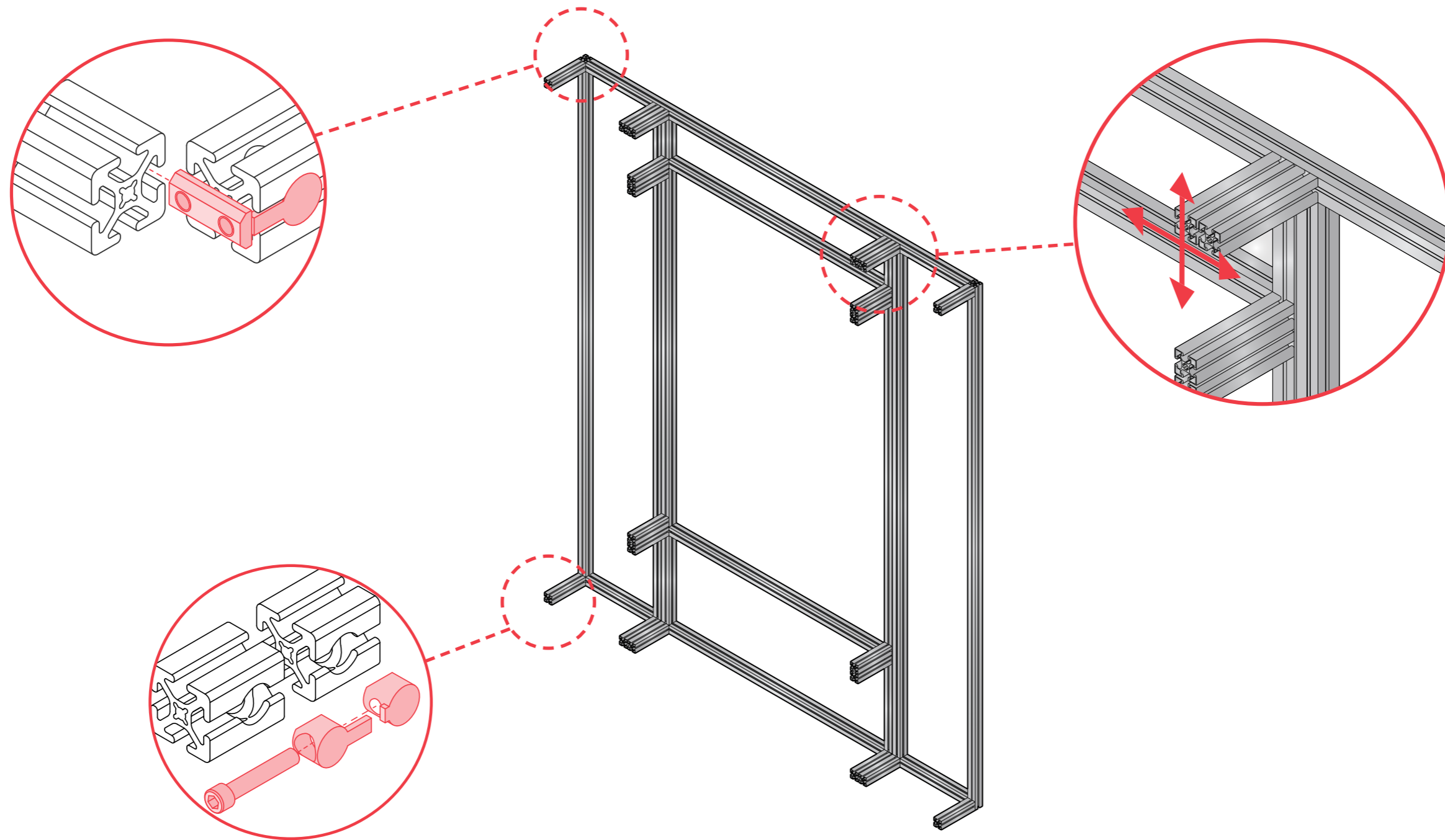


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Layered

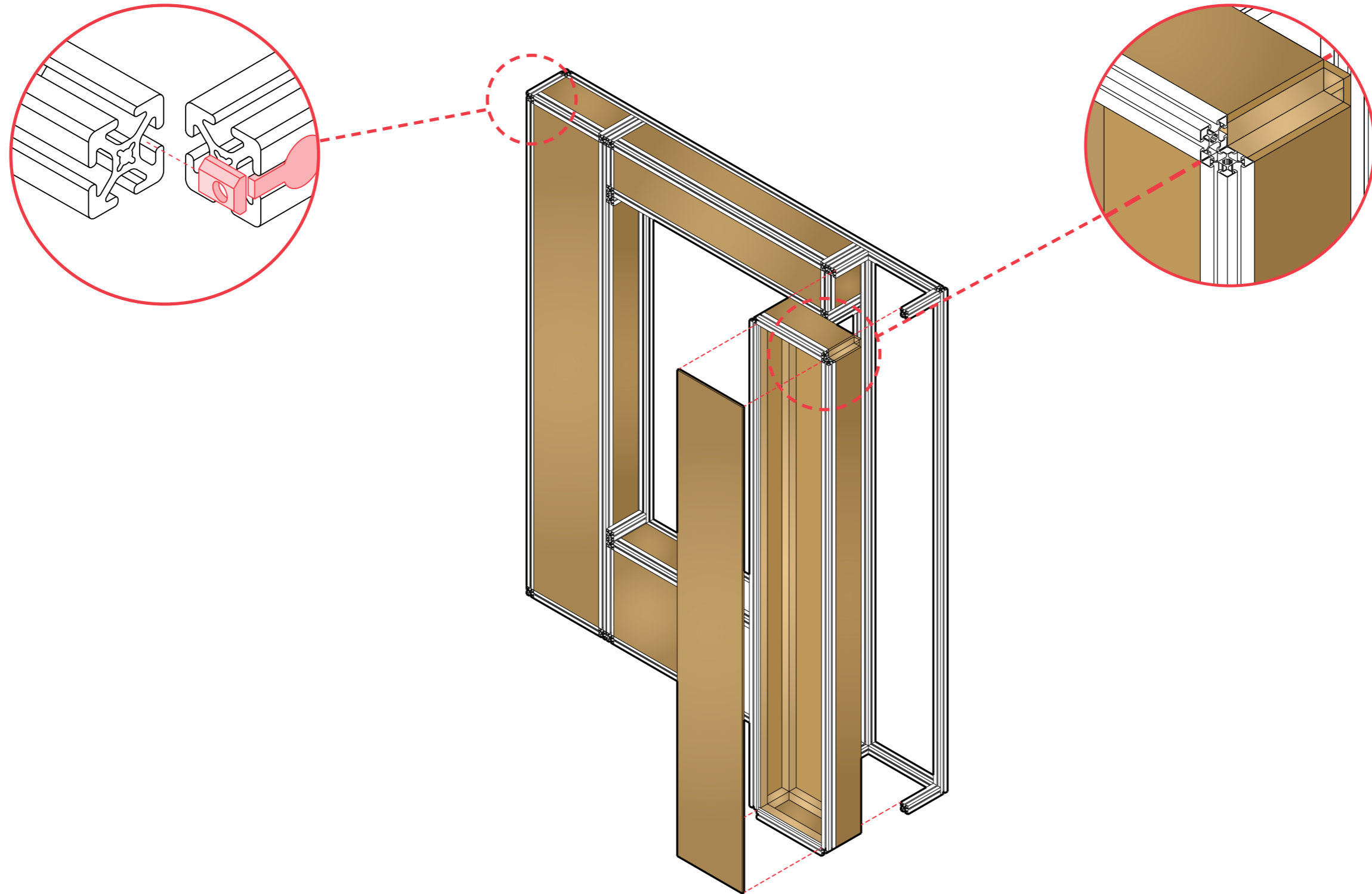


Adjustable Size |
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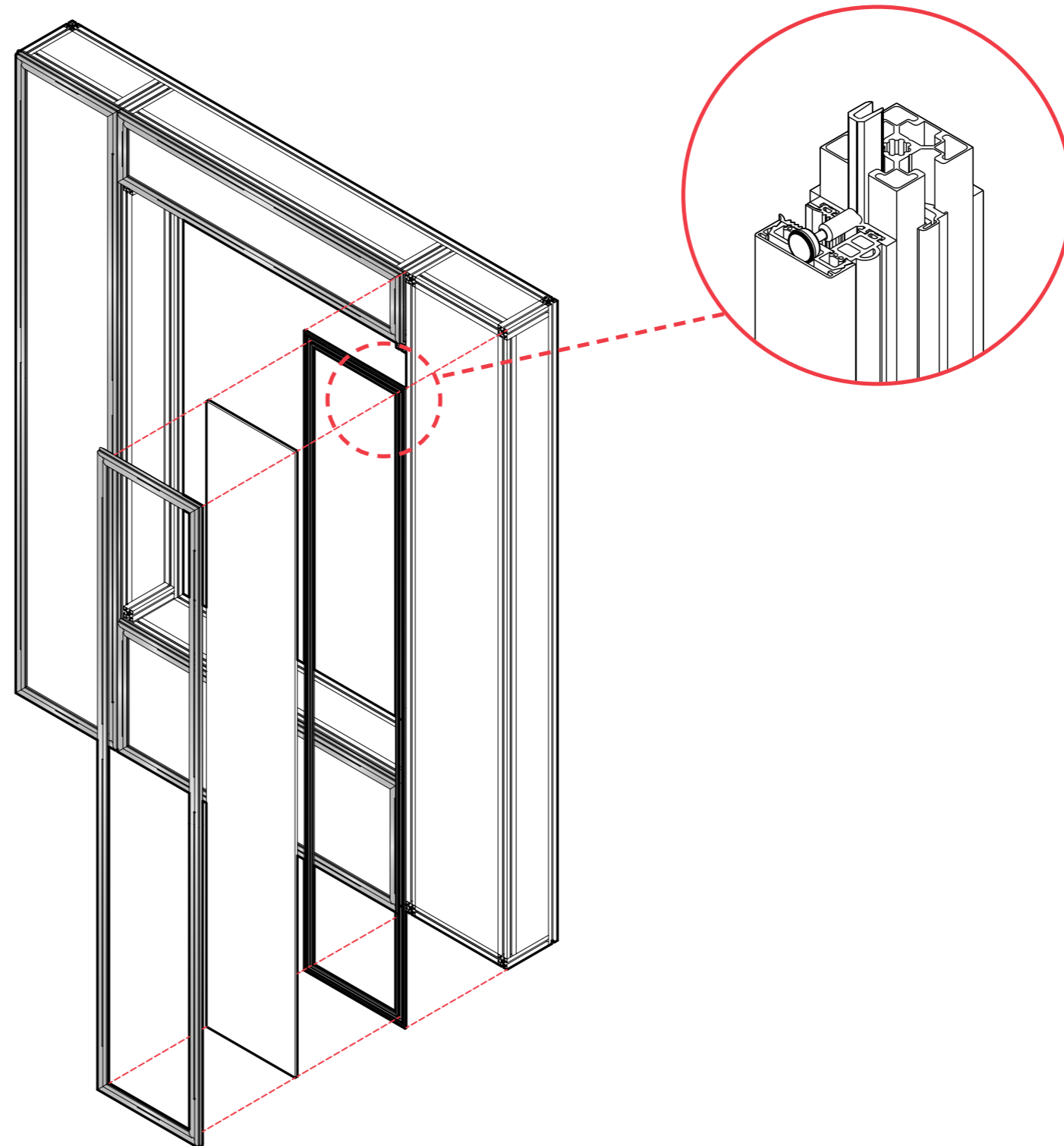
Main Frame



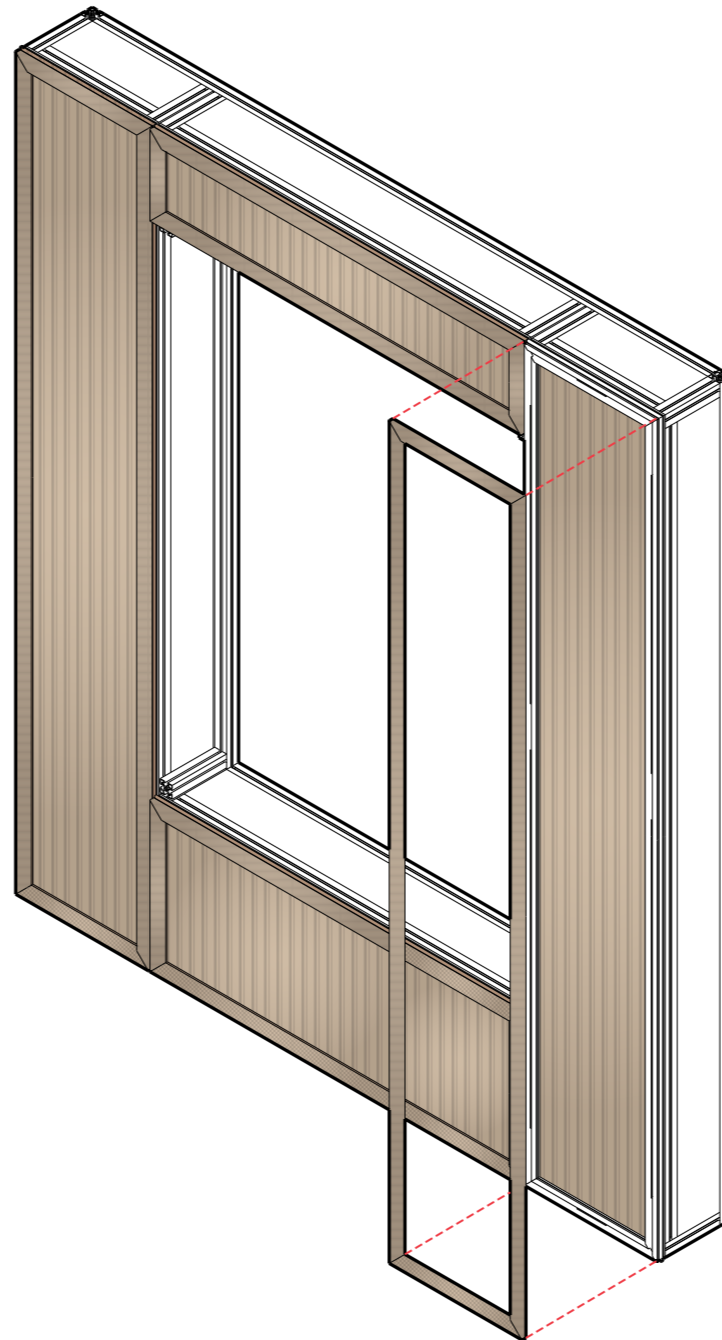
Boxes



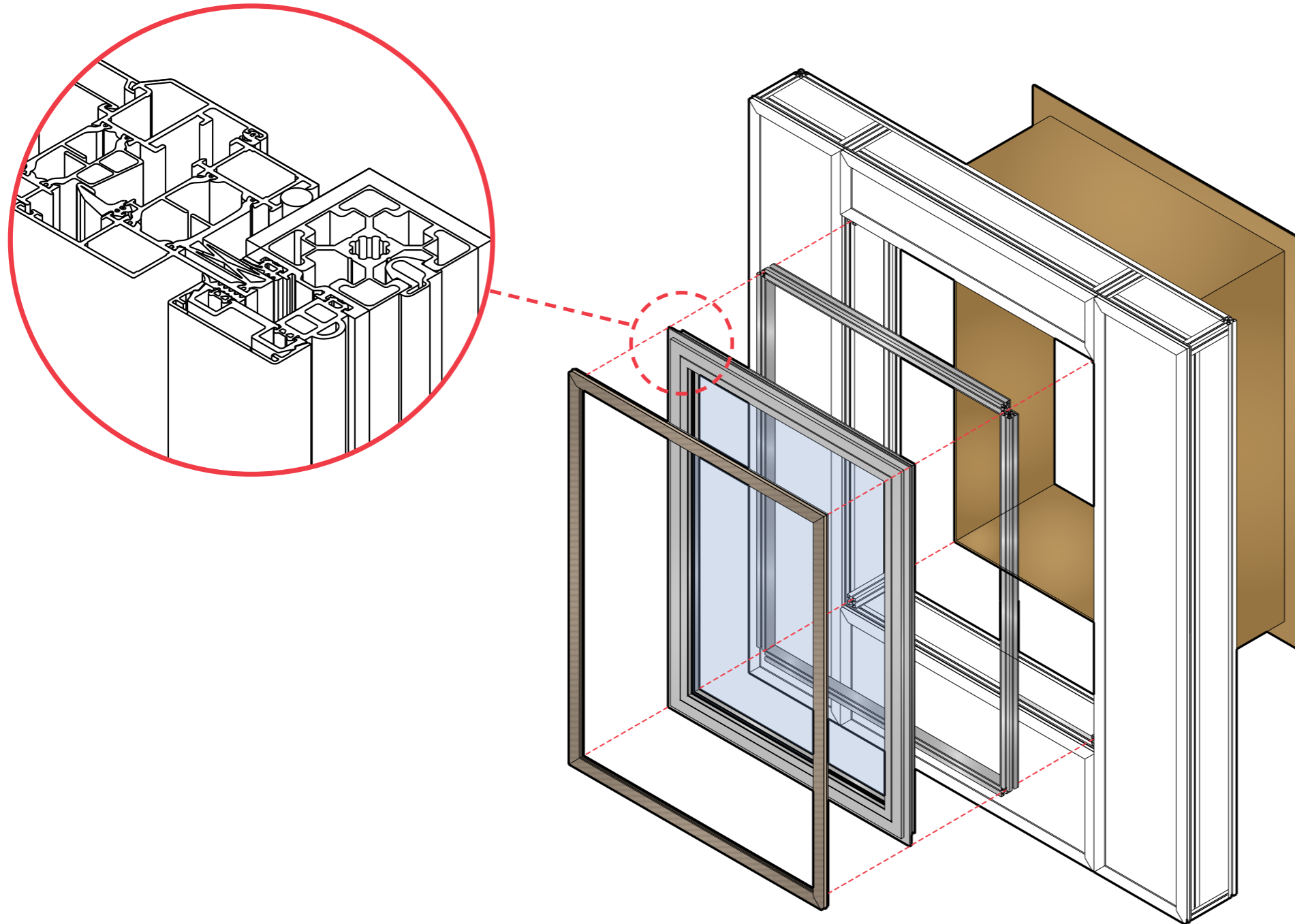
Protection Layer



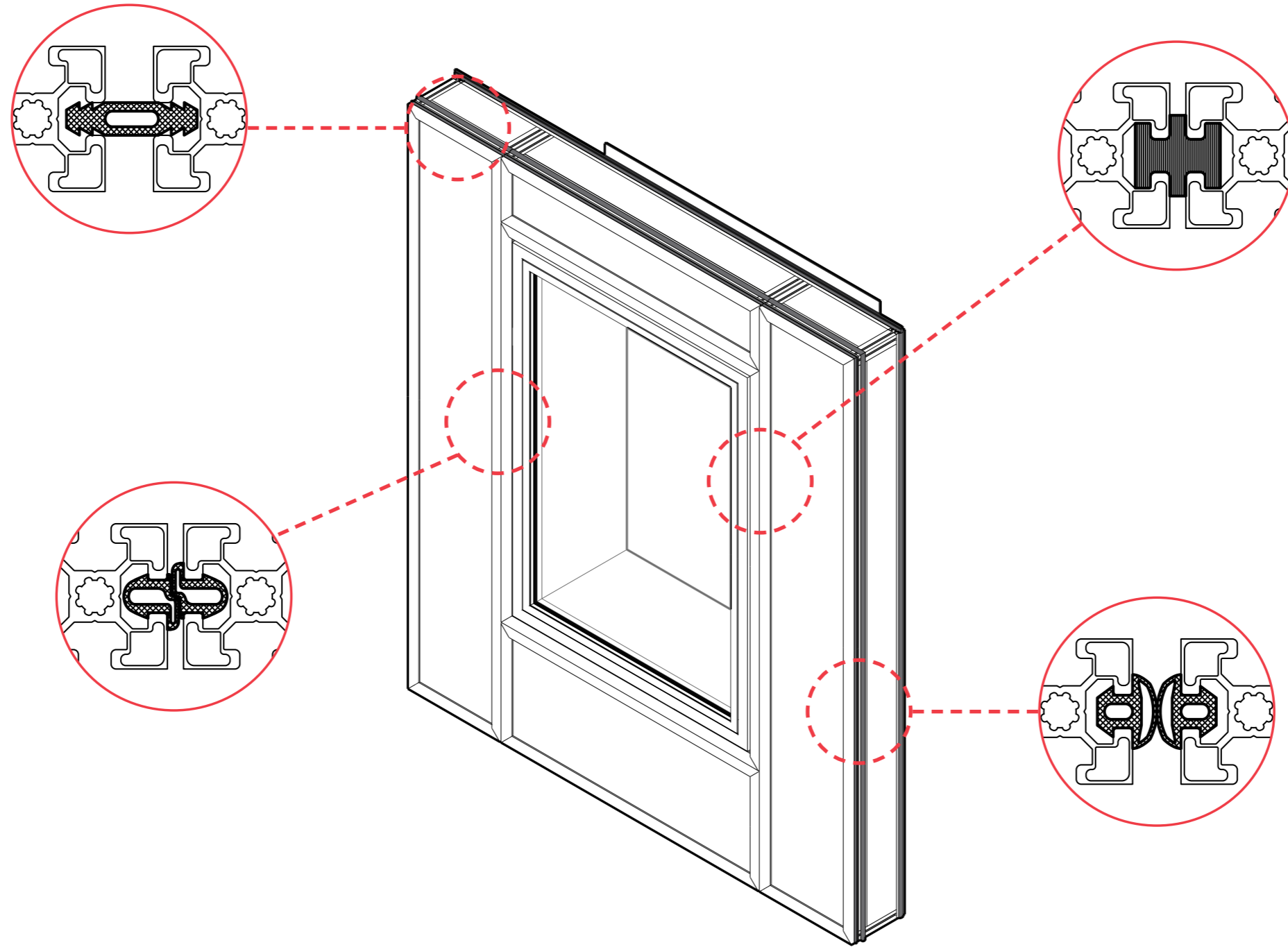
Cladding



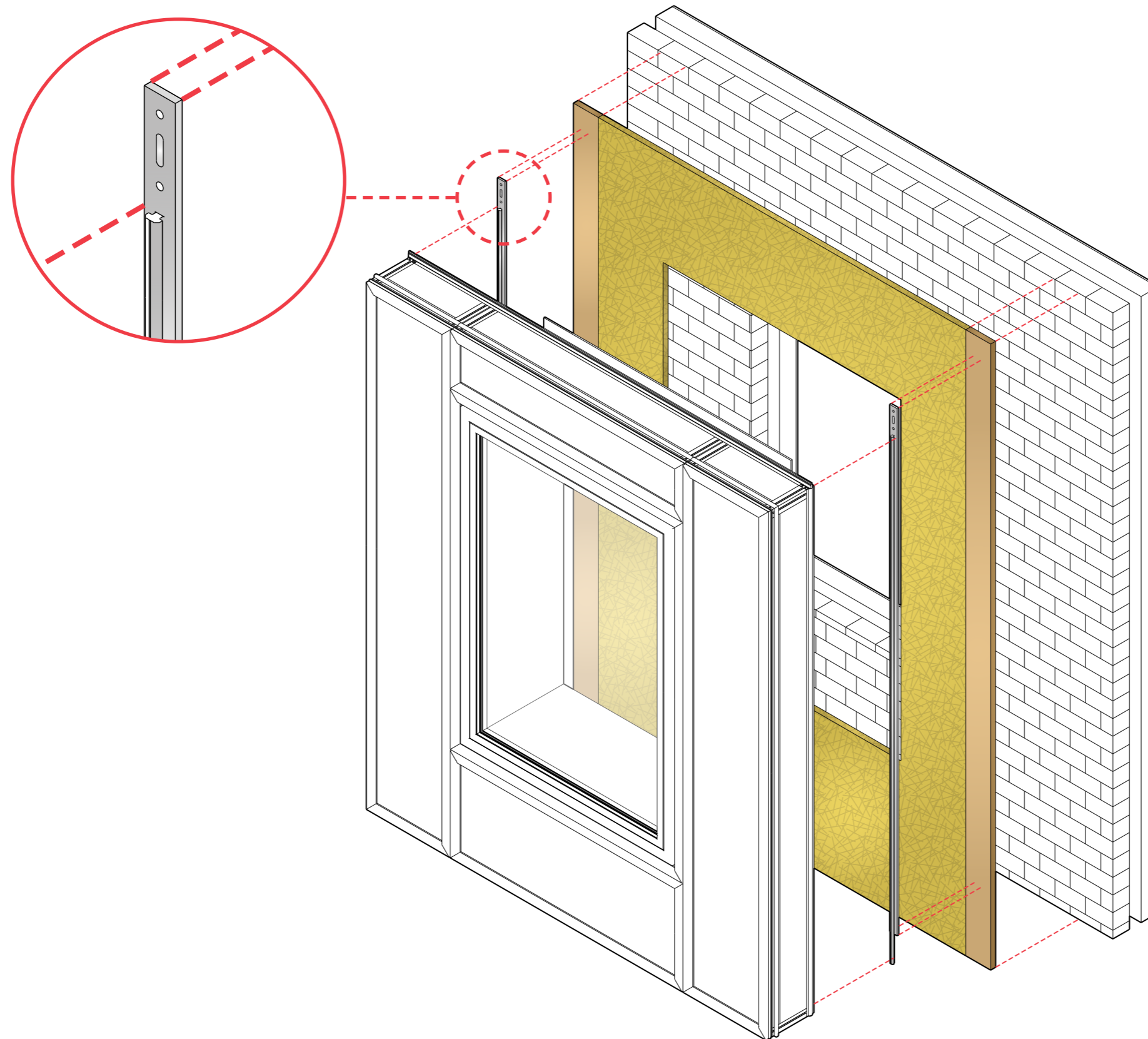
Window Integration



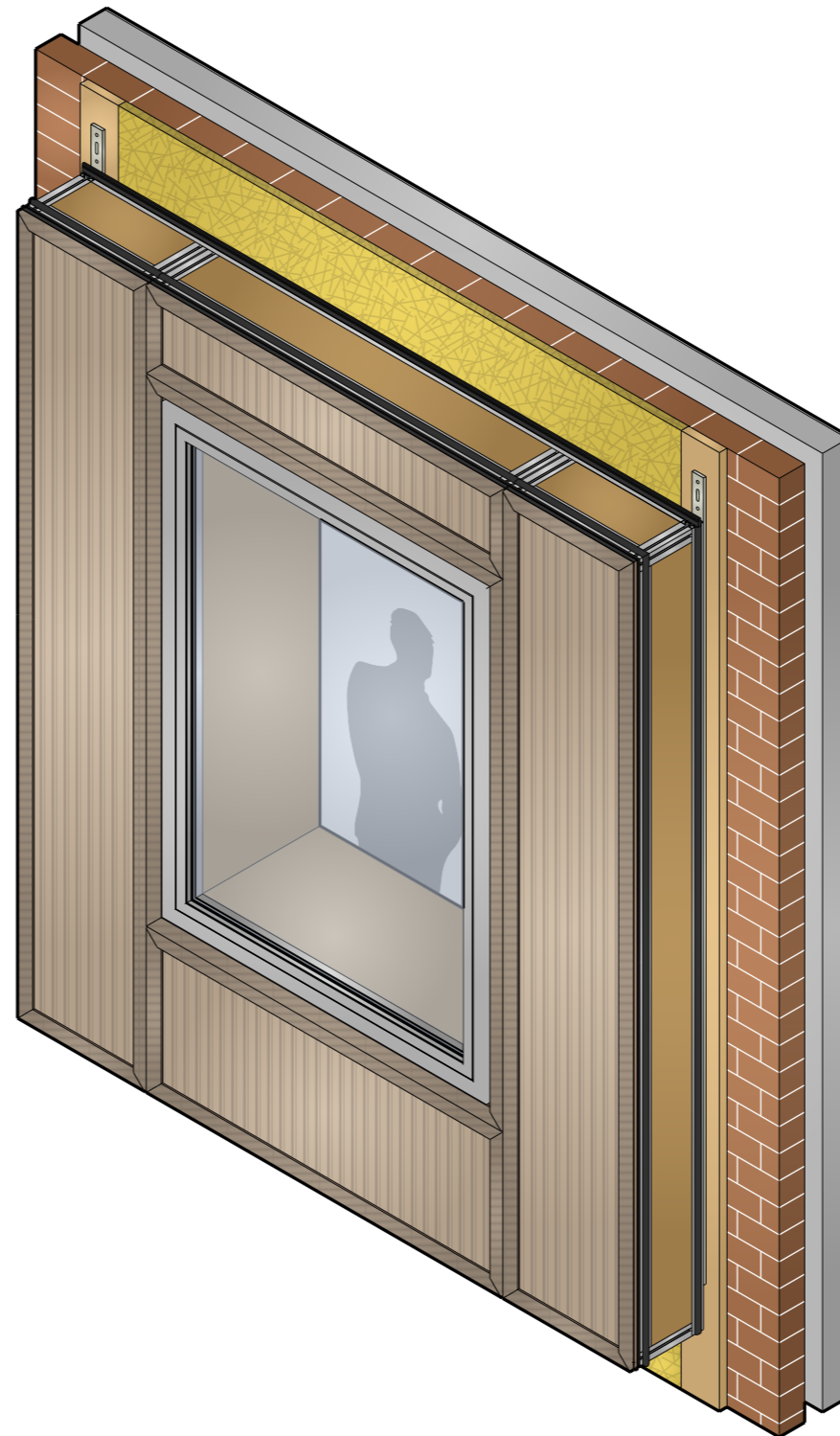
Connections

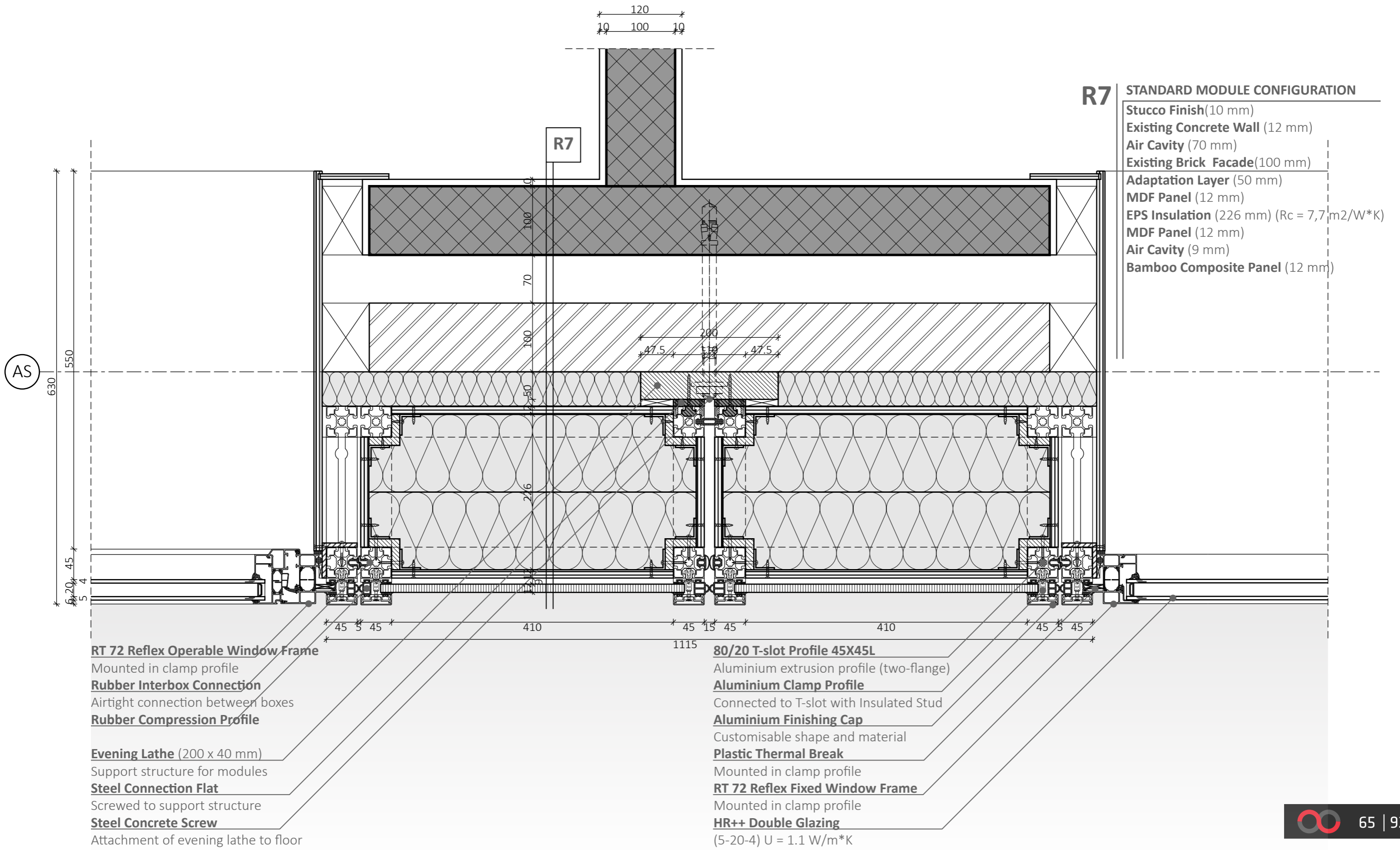


Adaptation Layer



Completed System





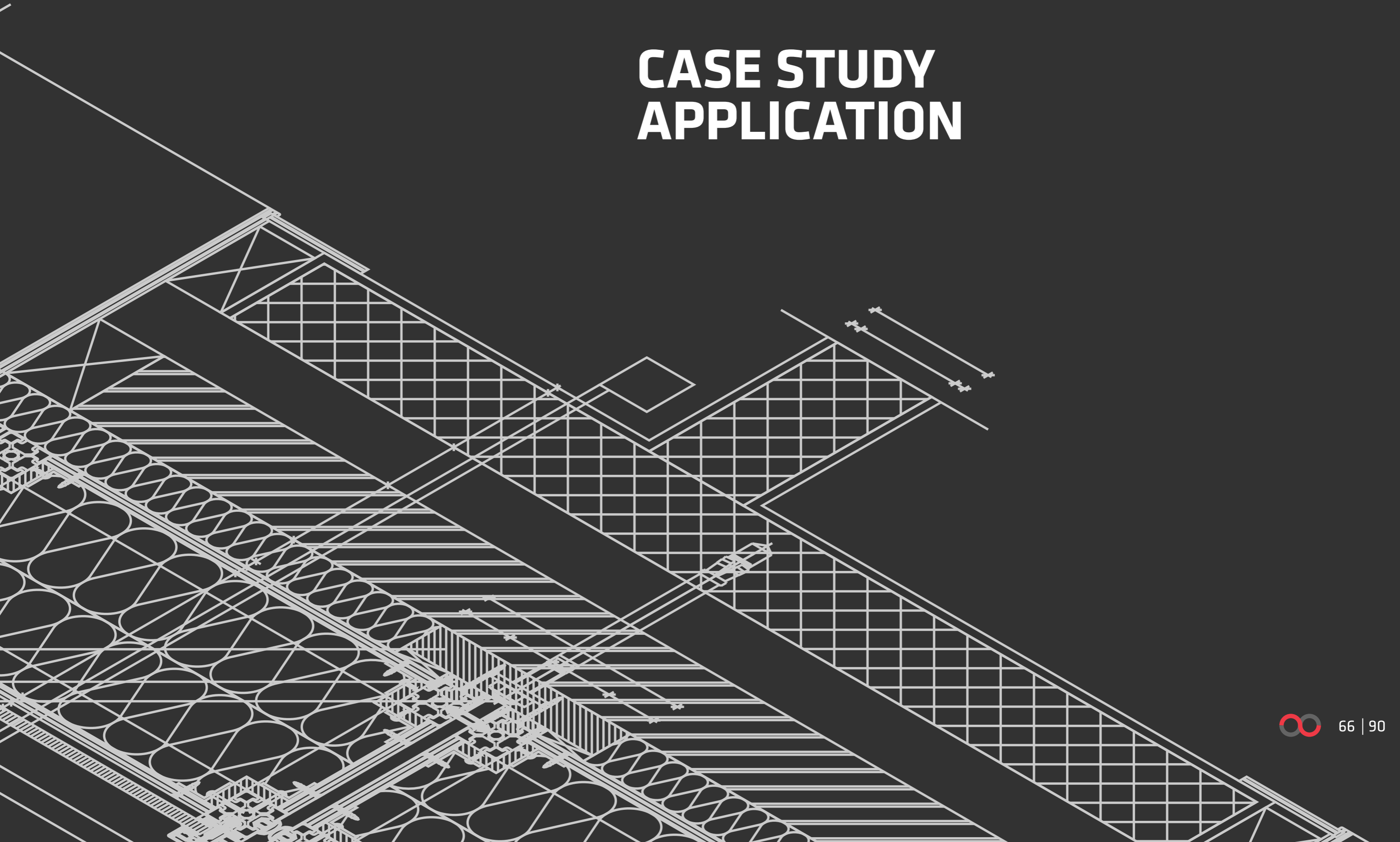
R7 STANDARD MODULE CONFIGURATION

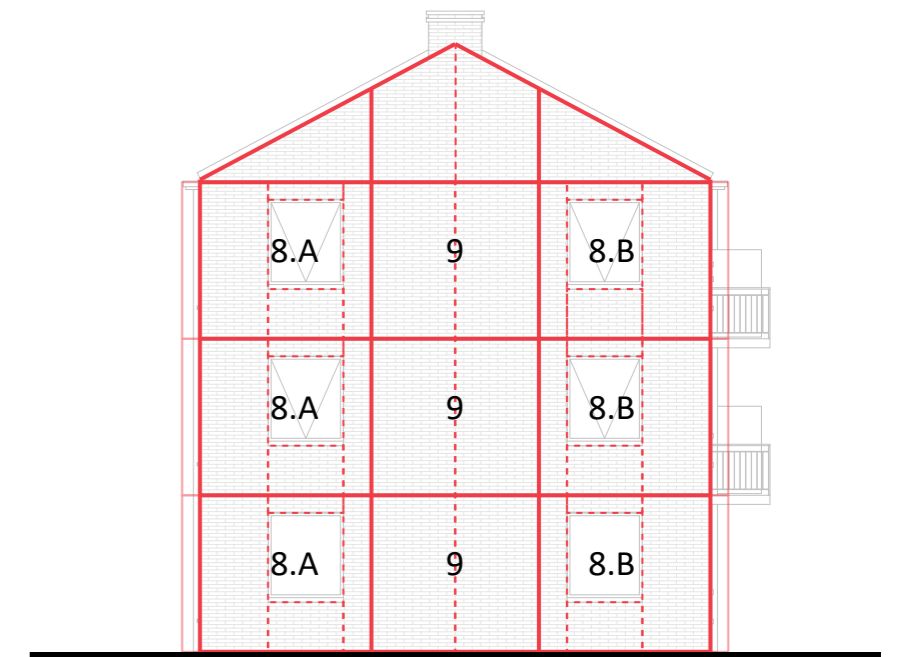
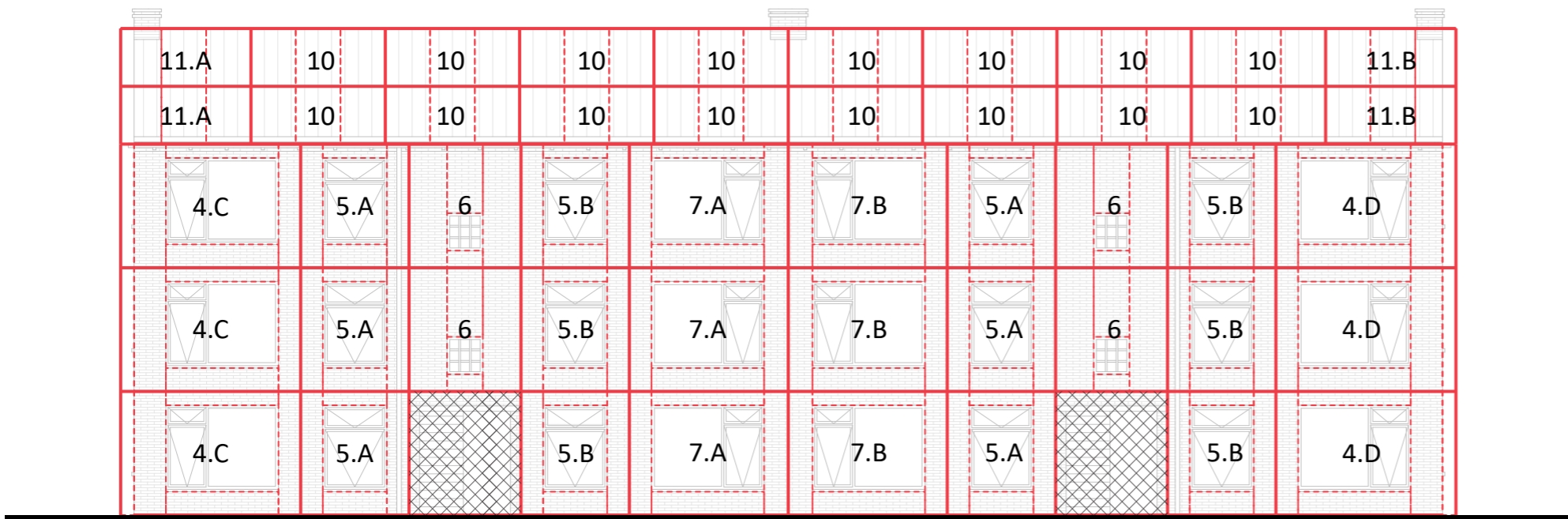
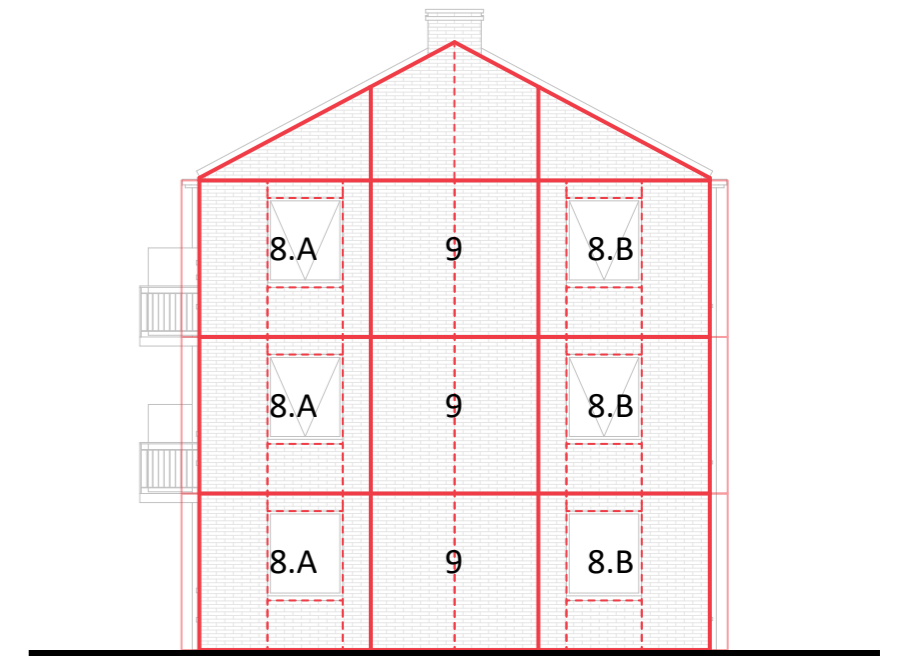
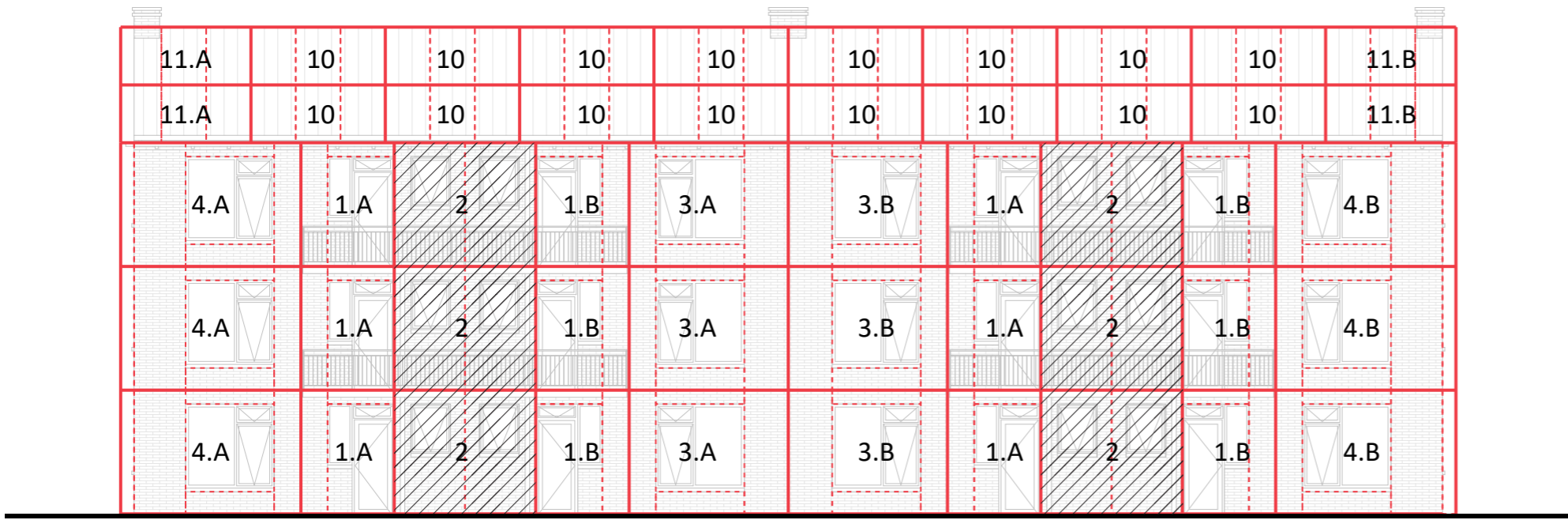
- Stucco Finish(10 mm)
- Existing Concrete Wall (12 mm)
- Air Cavity (70 mm)
- Existing Brick Facade(100 mm)
- Adaptation Layer (50 mm)
- MDF Panel (12 mm)
- EPS Insulation (226 mm) ($R_c = 7,7 \text{ m}^2/\text{W}^*\text{K}$)
- MDF Panel (12 mm)
- Air Cavity (9 mm)
- Bamboo Composite Panel (12 mm)

- RT 72 Reflex Operable Window Frame**
Mounted in clamp profile
- Rubber Interbox Connection**
Airtight connection between boxes
- Rubber Compression Profile**
- Evening Lathe (200 x 40 mm)**
Support structure for modules
- Steel Connection Flat**
Screwed to support structure
- Steel Concrete Screw**
Attachment of evening lathe to floor

- 80/20 T-slot Profile 45X45L**
Aluminium extrusion profile (two-flange)
- Aluminium Clamp Profile**
Connected to T-slot with Insulated Stud
- Aluminium Finishing Cap**
Customisable shape and material
- Plastic Thermal Break**
Mounted in clamp profile
- RT 72 Reflex Fixed Window Frame**
Mounted in clamp profile
- HR++ Double Glazing**
(5-20-4) $U = 1.1 \text{ W}/\text{m}^*\text{K}$

CASE STUDY APPLICATION

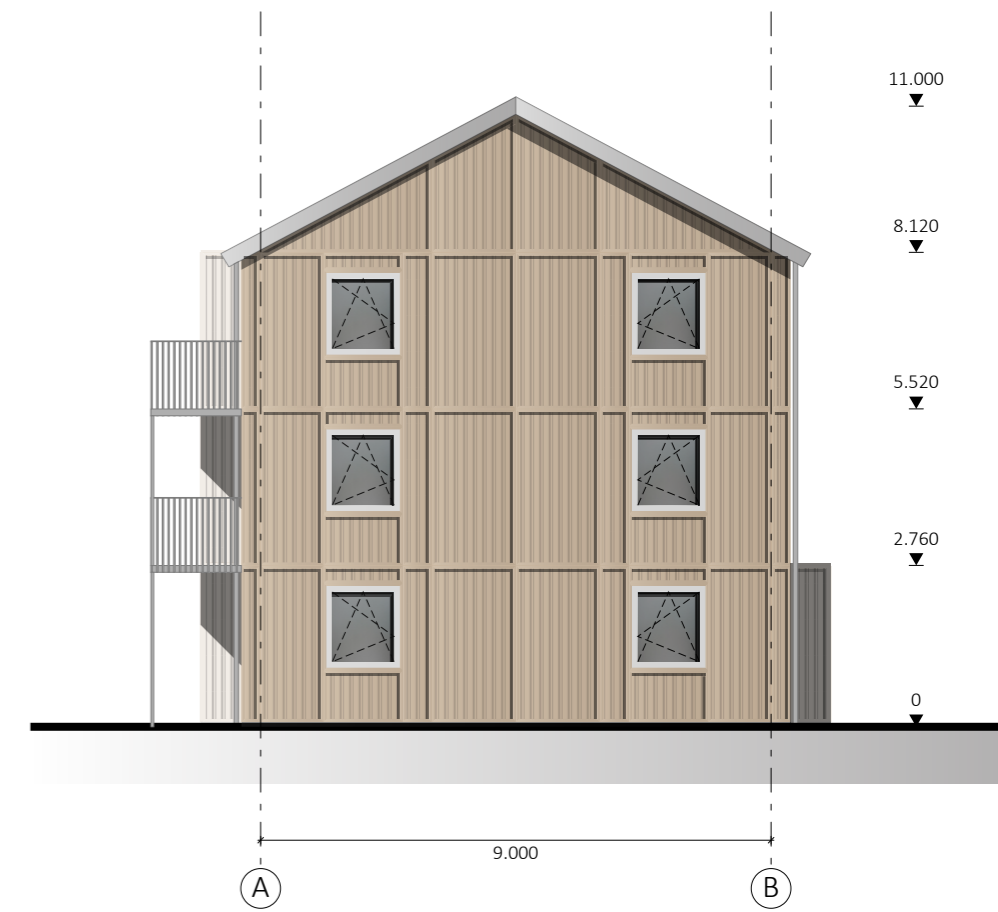




V



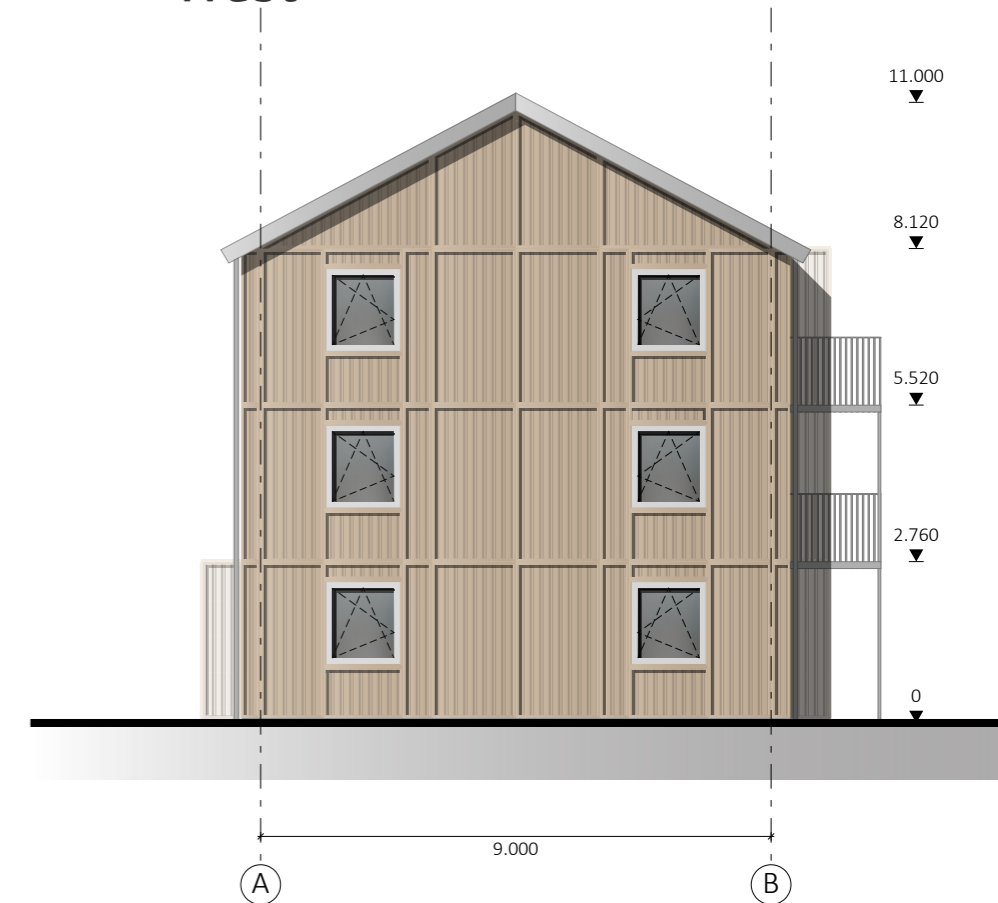
North



West

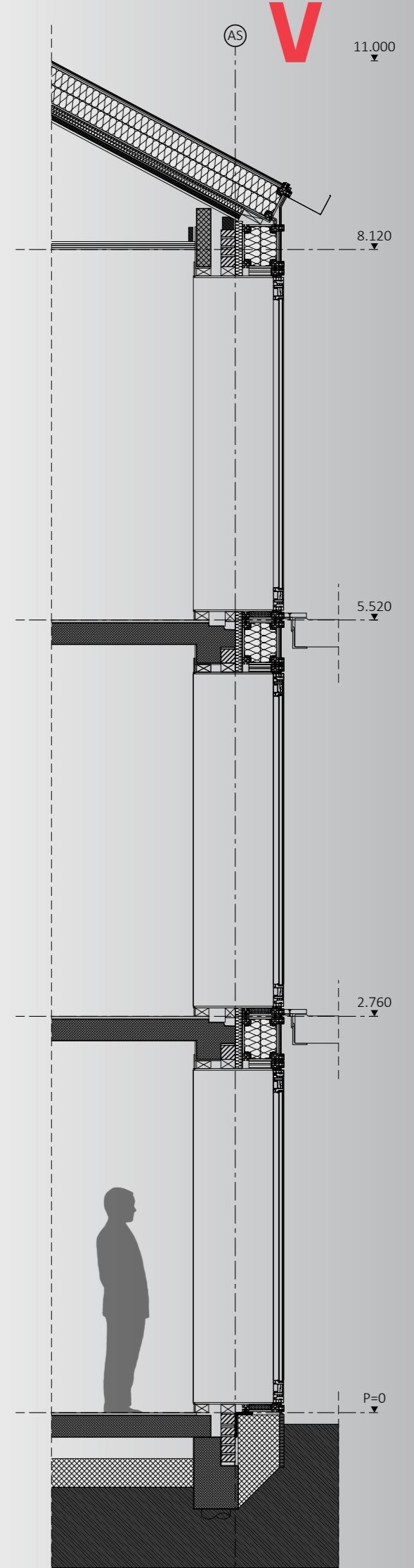
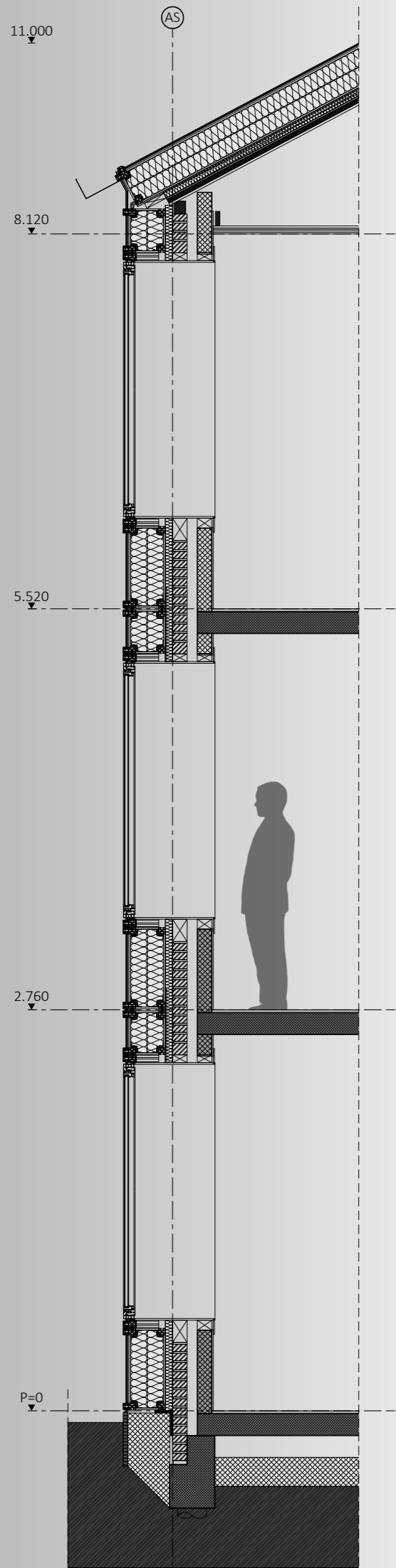


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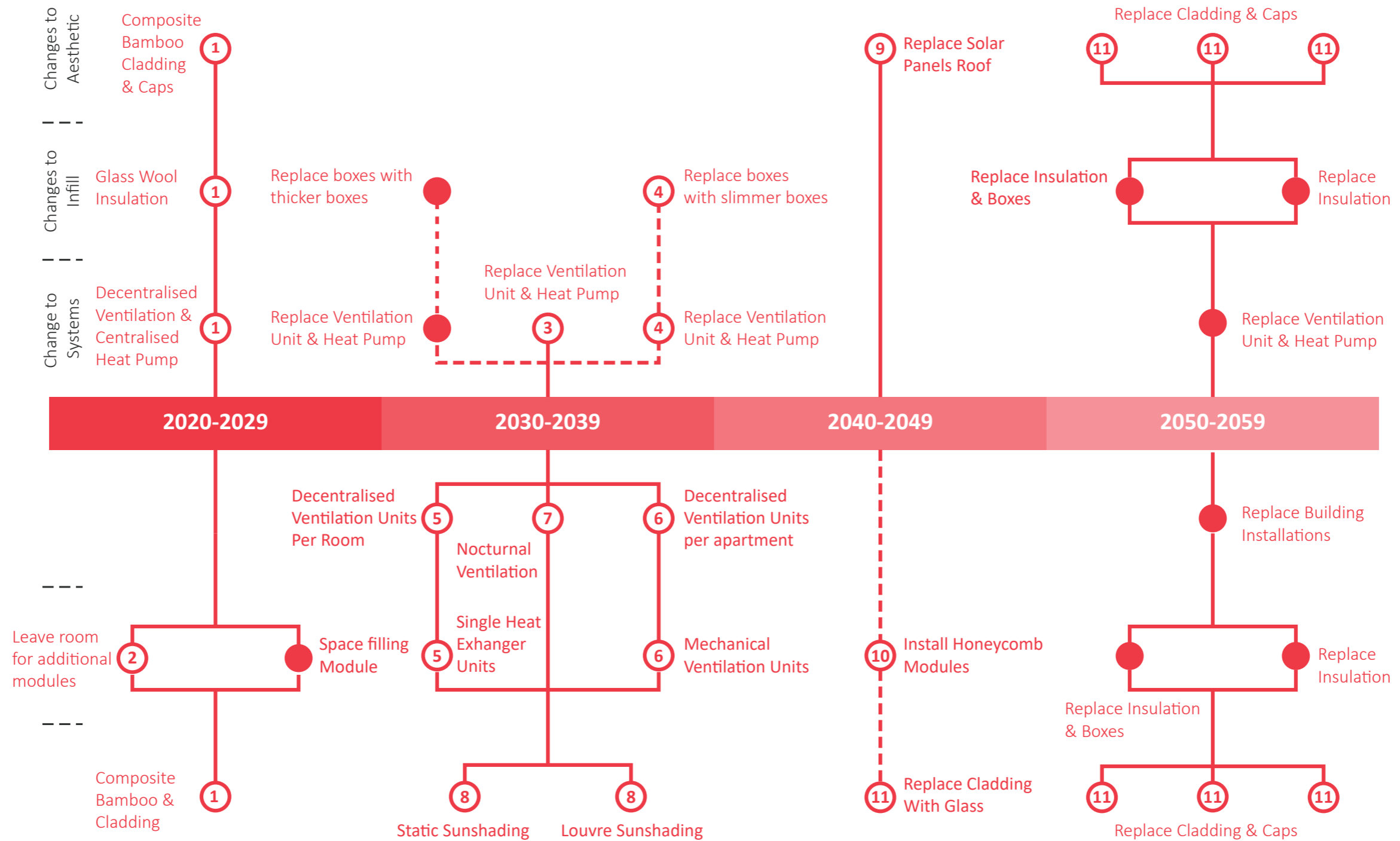


East

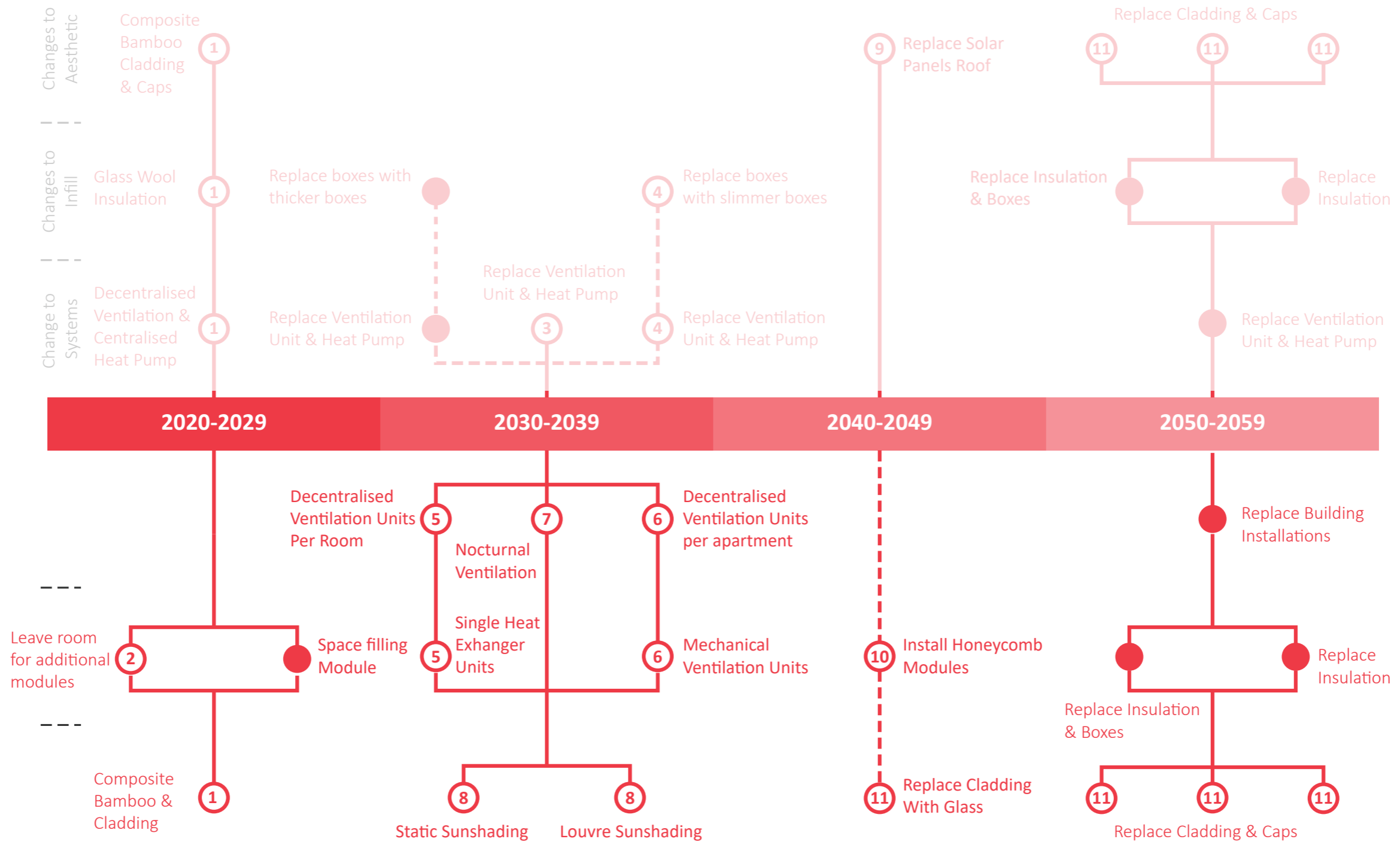




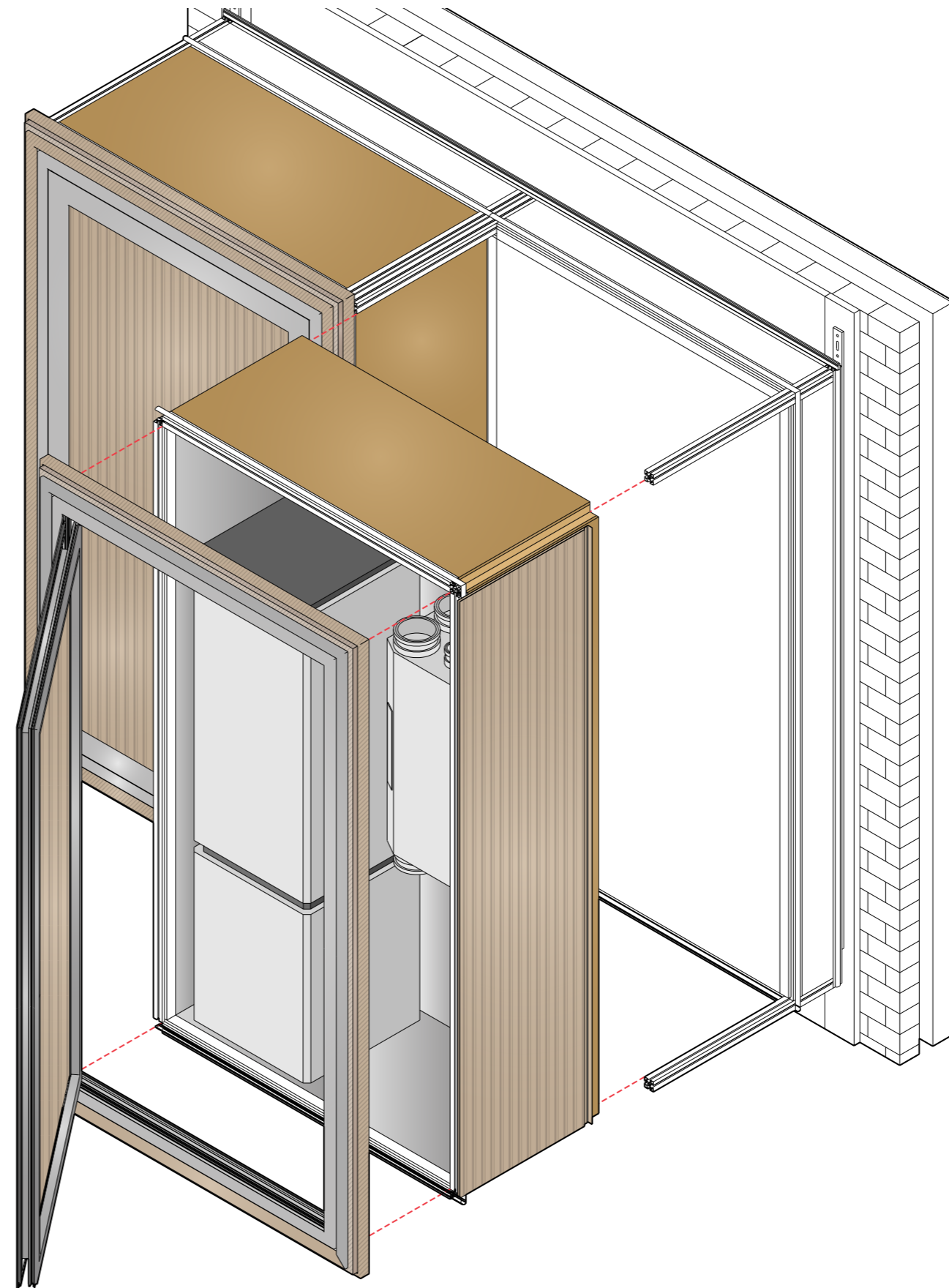
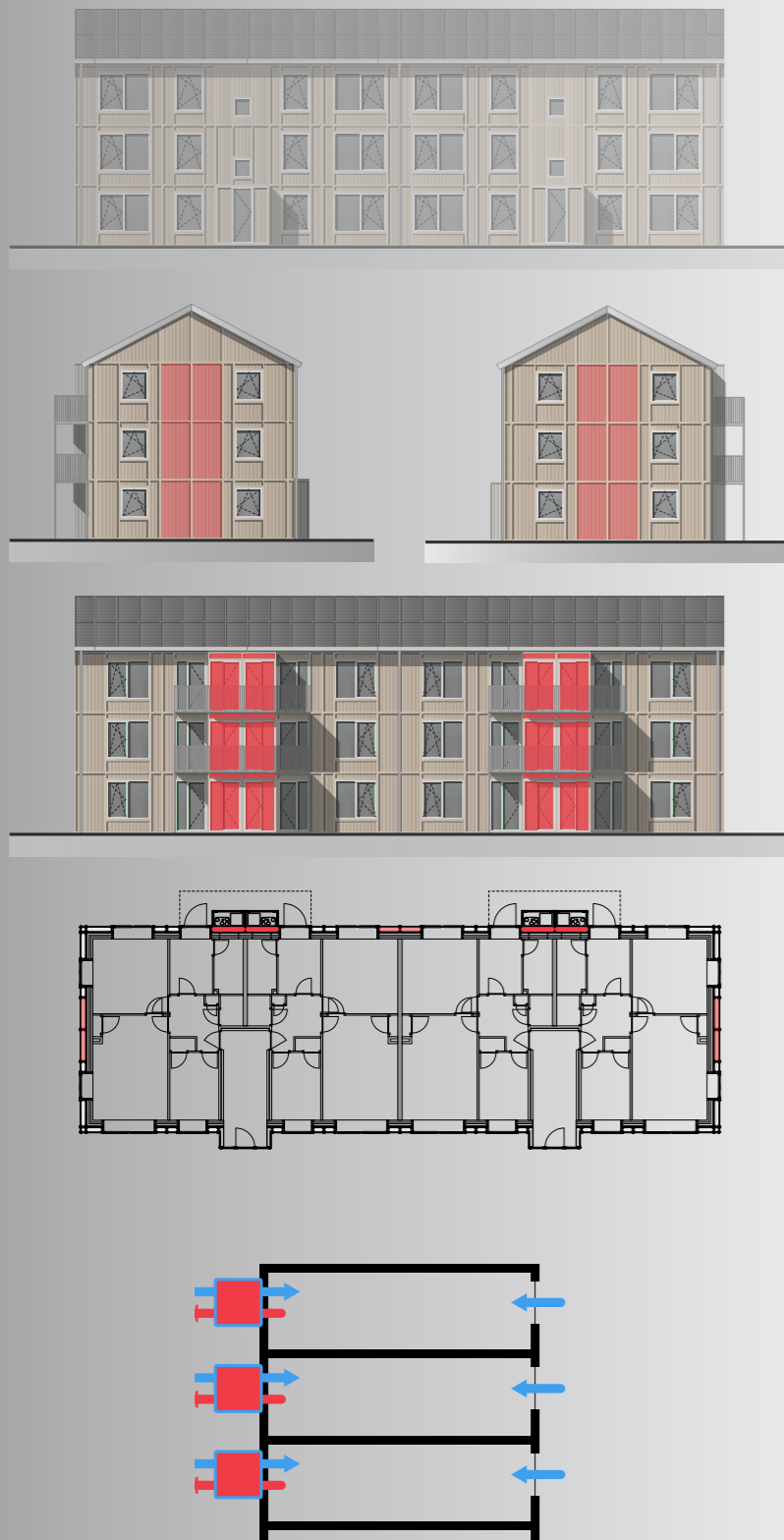
Scenario's



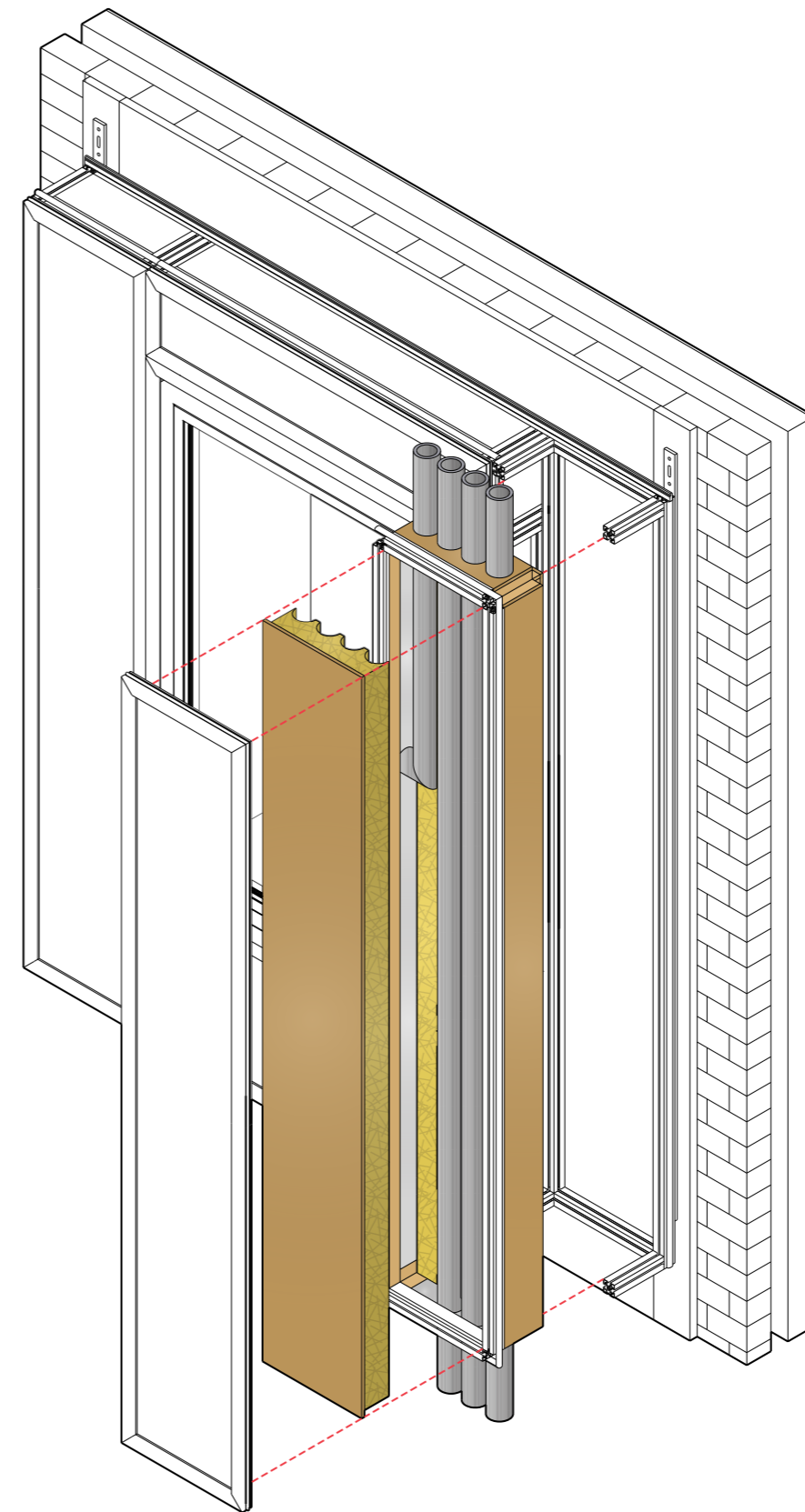
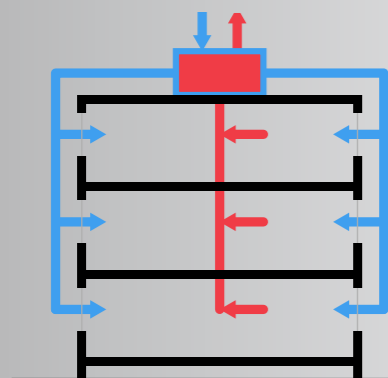
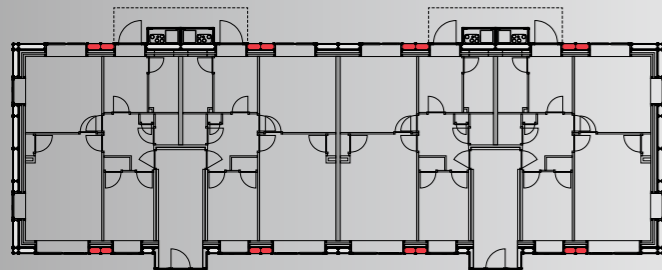
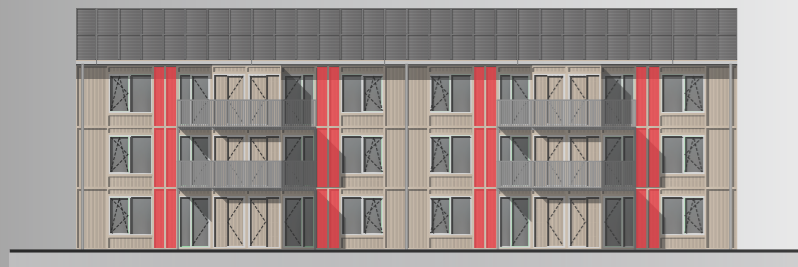
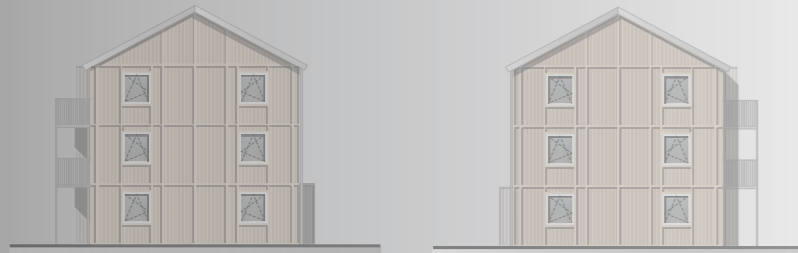
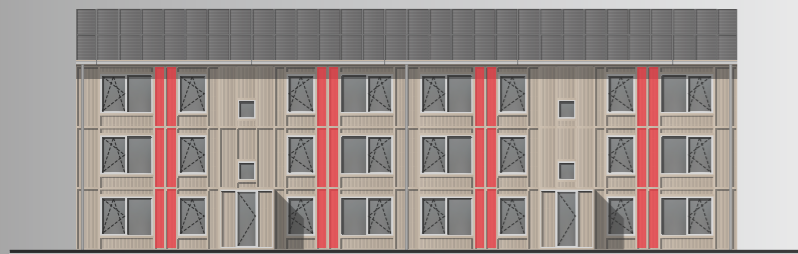
BPIE Scenario



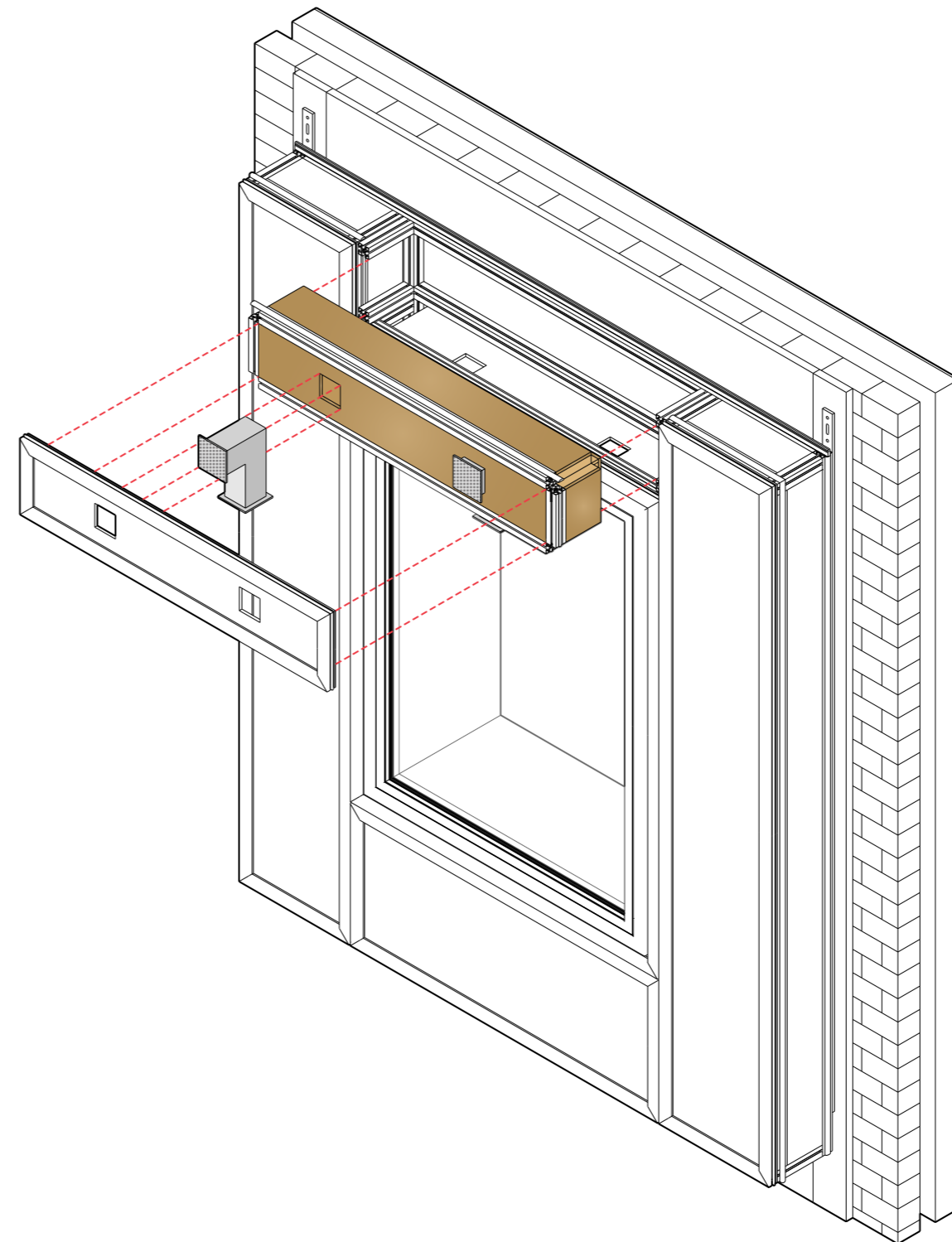
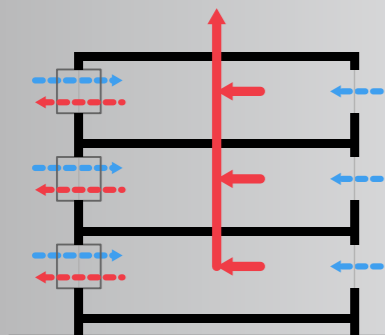
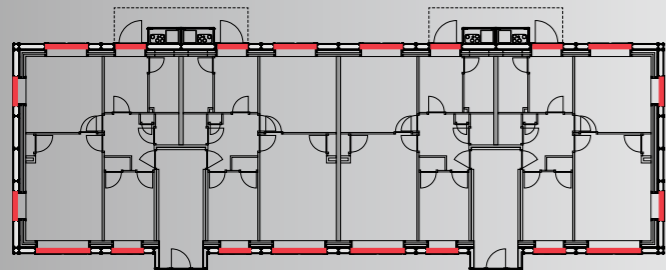
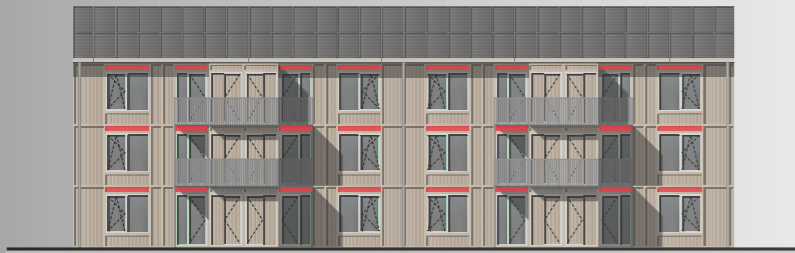
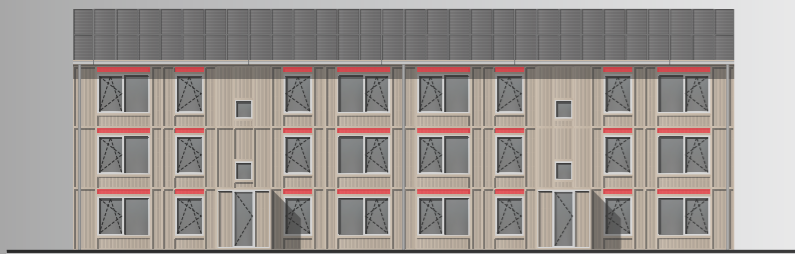
Heat Pump & Heat Exchanger



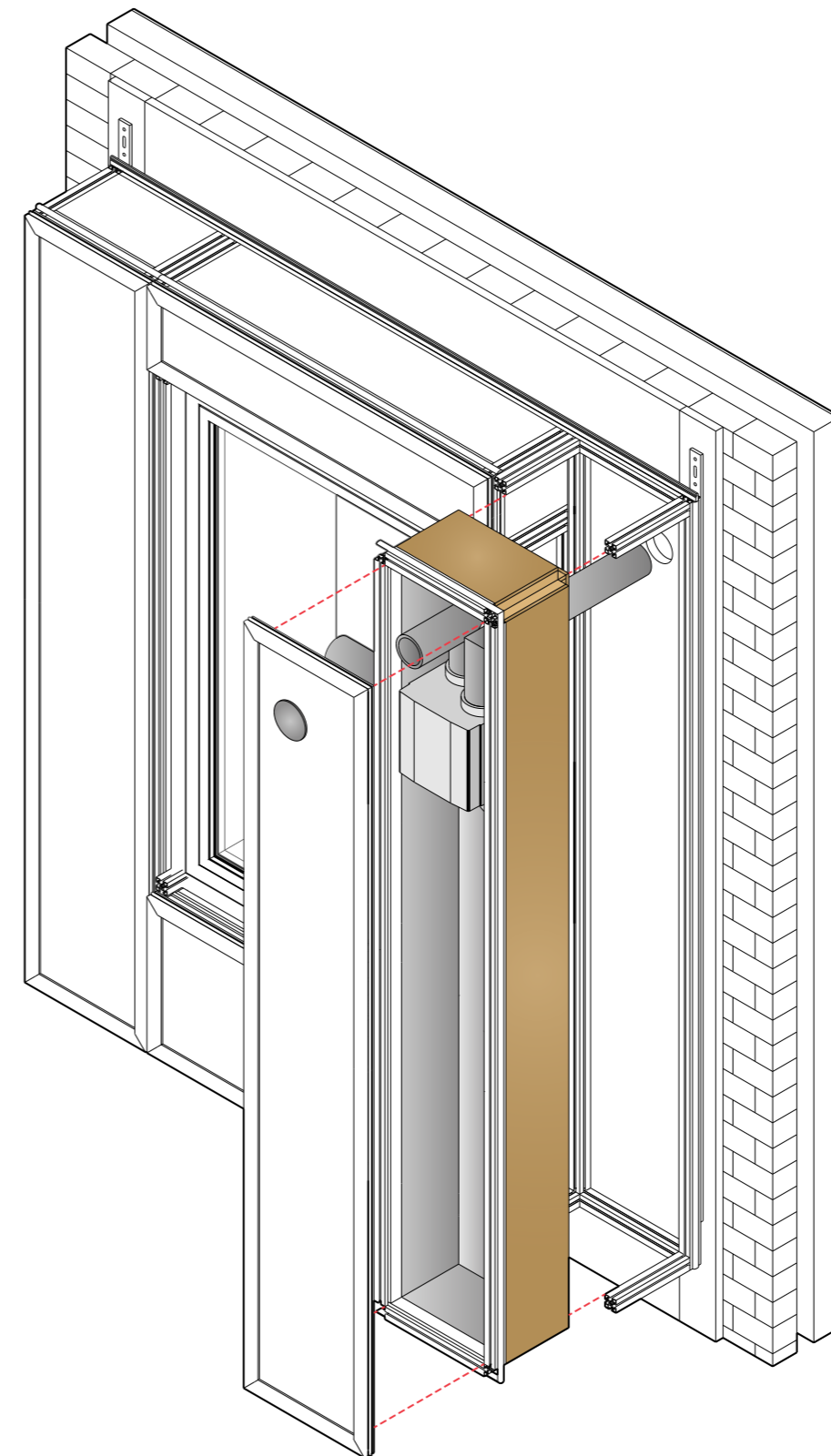
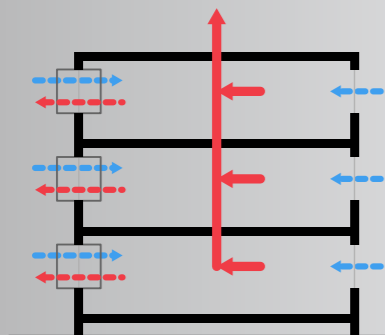
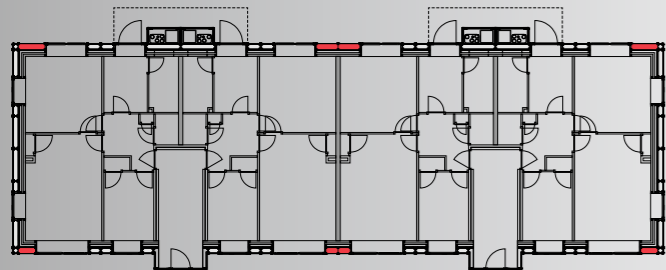
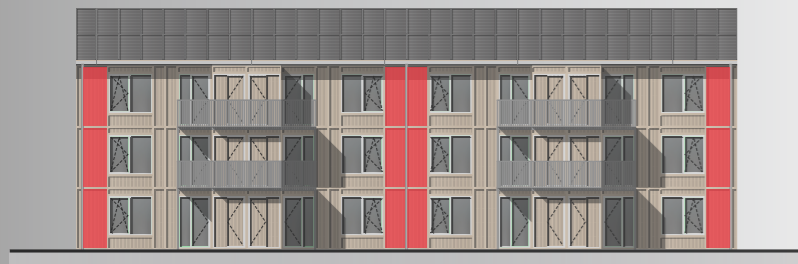
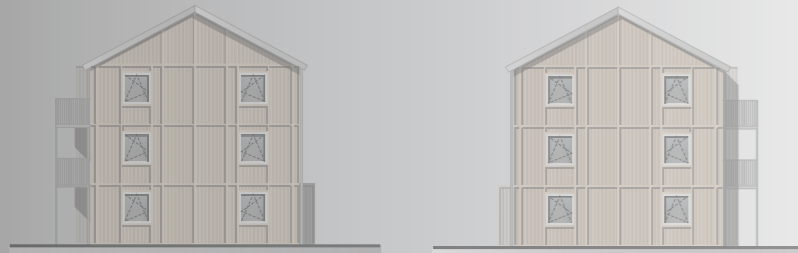
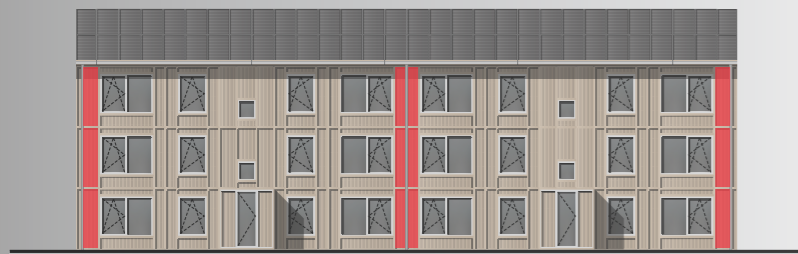
Centralised Ventilation



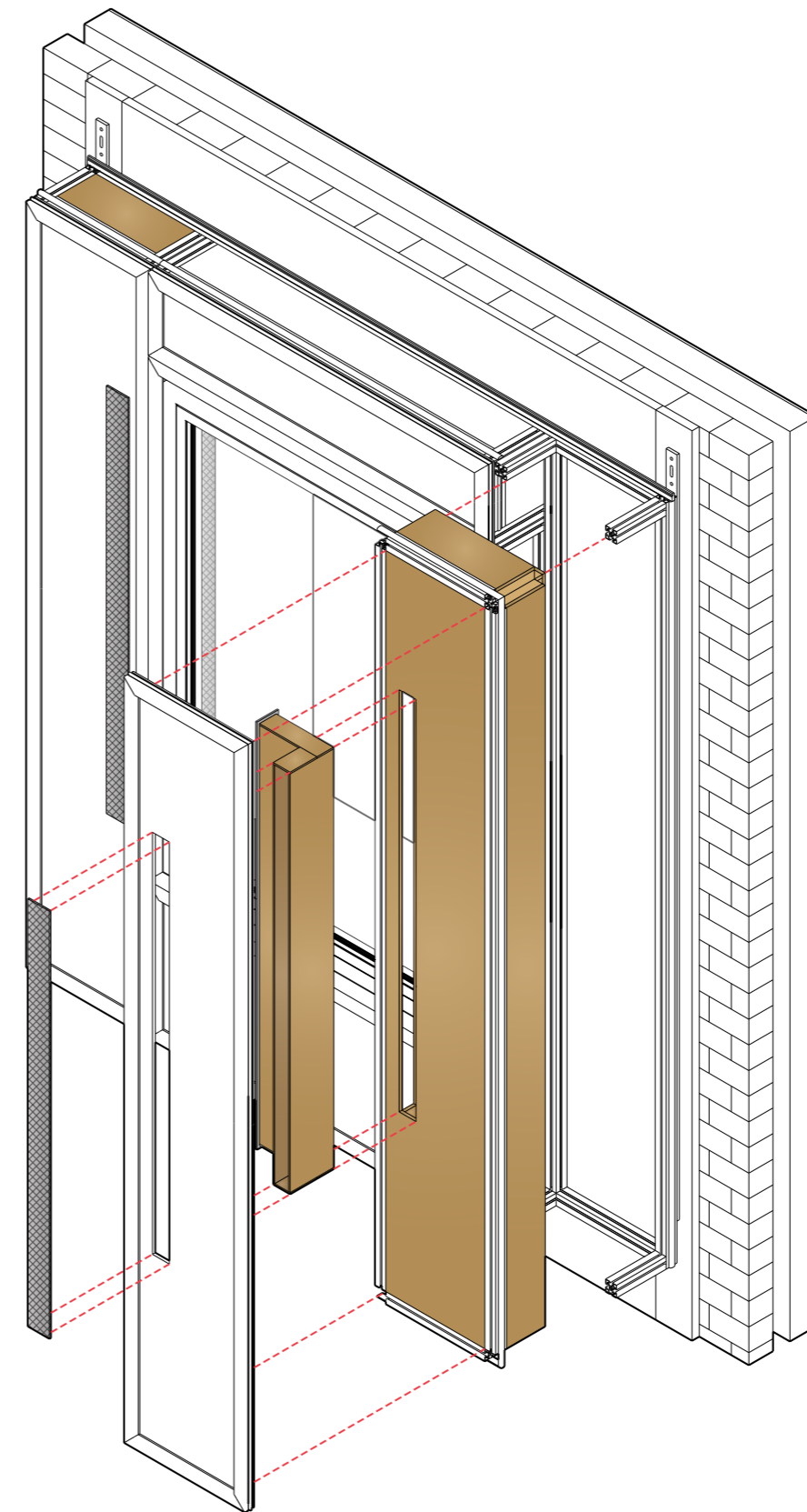
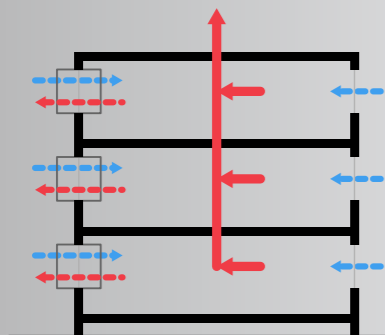
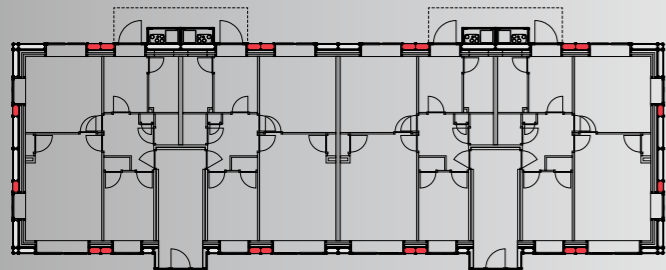
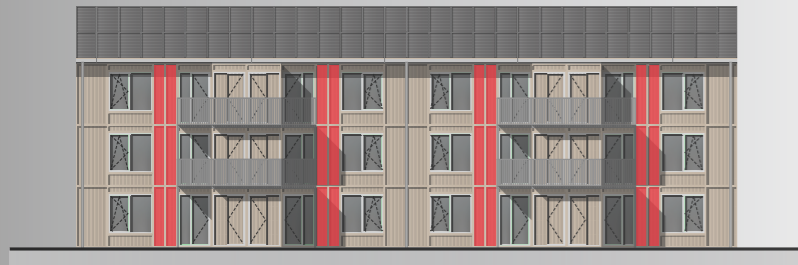
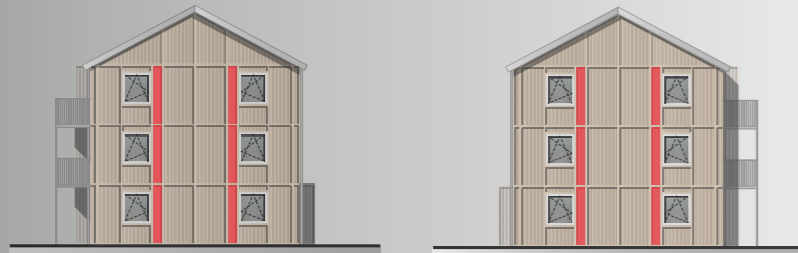
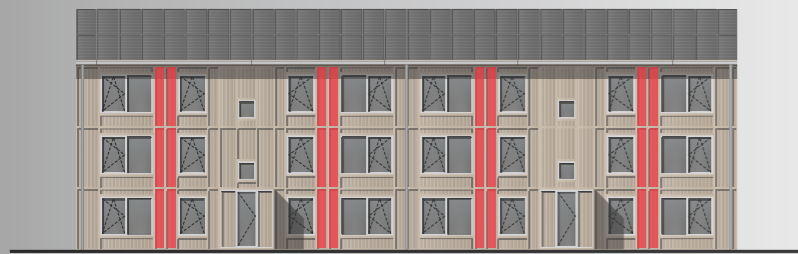
Decentralised Heat Exchanger Unit



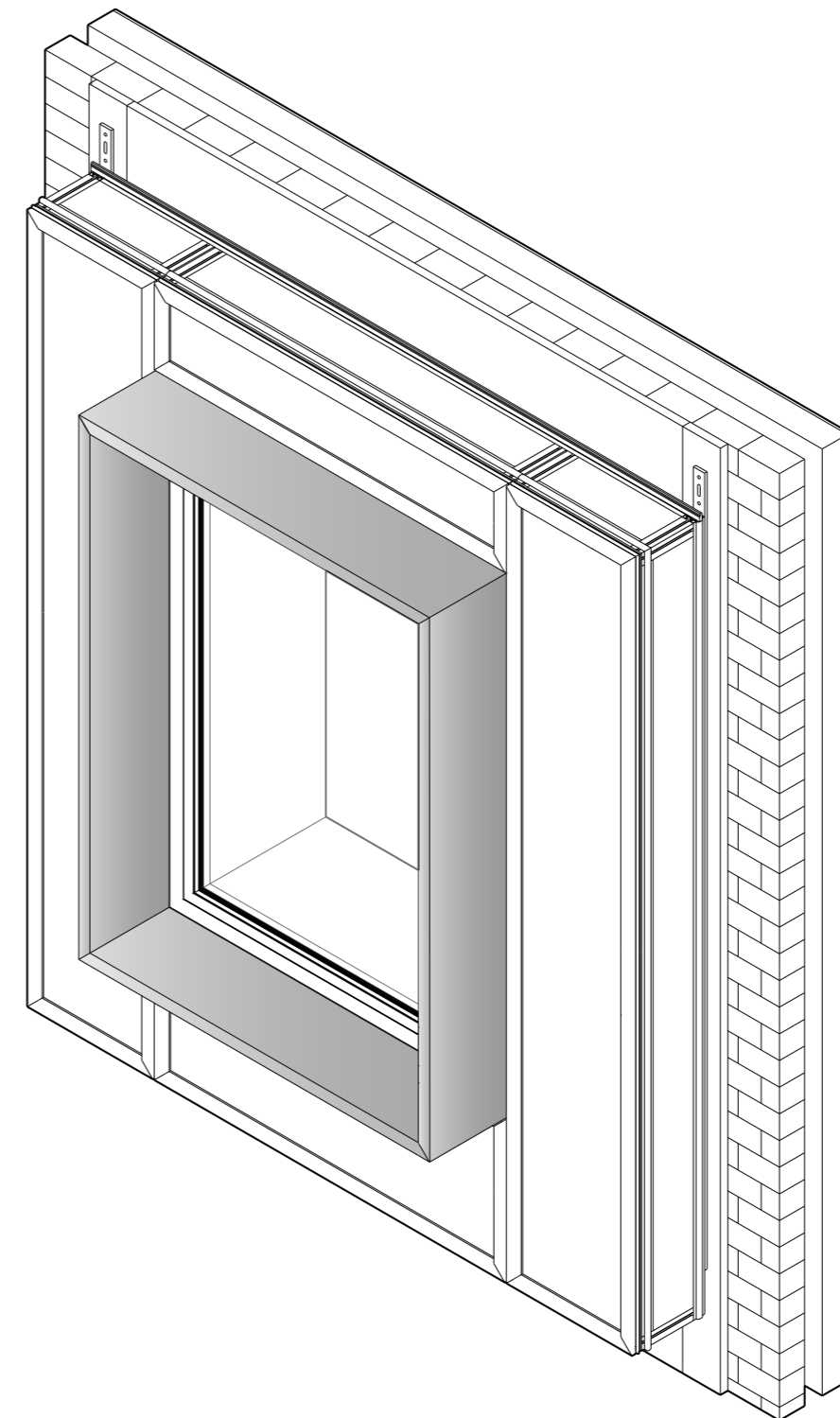
Decentralised Ventilation



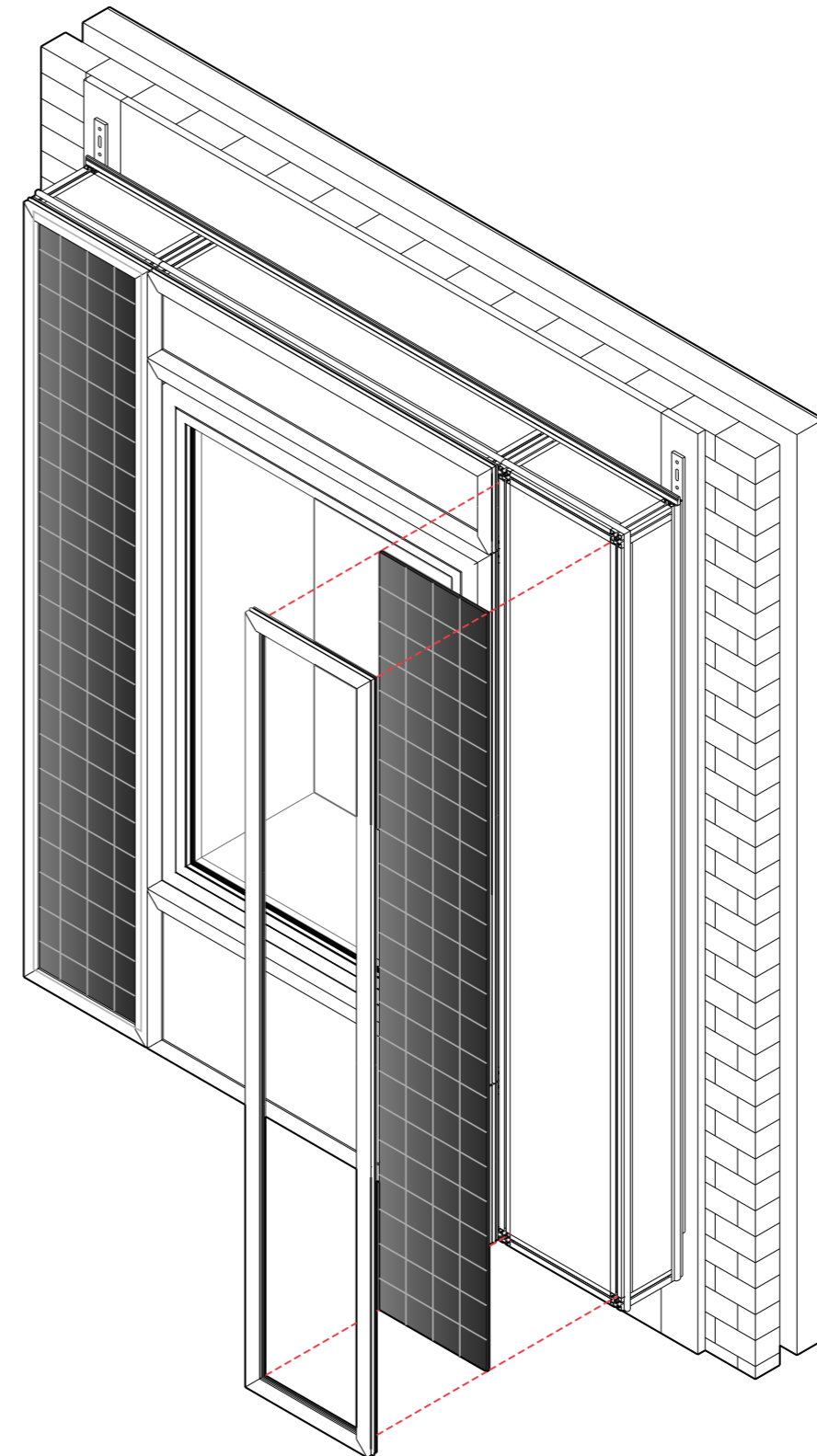
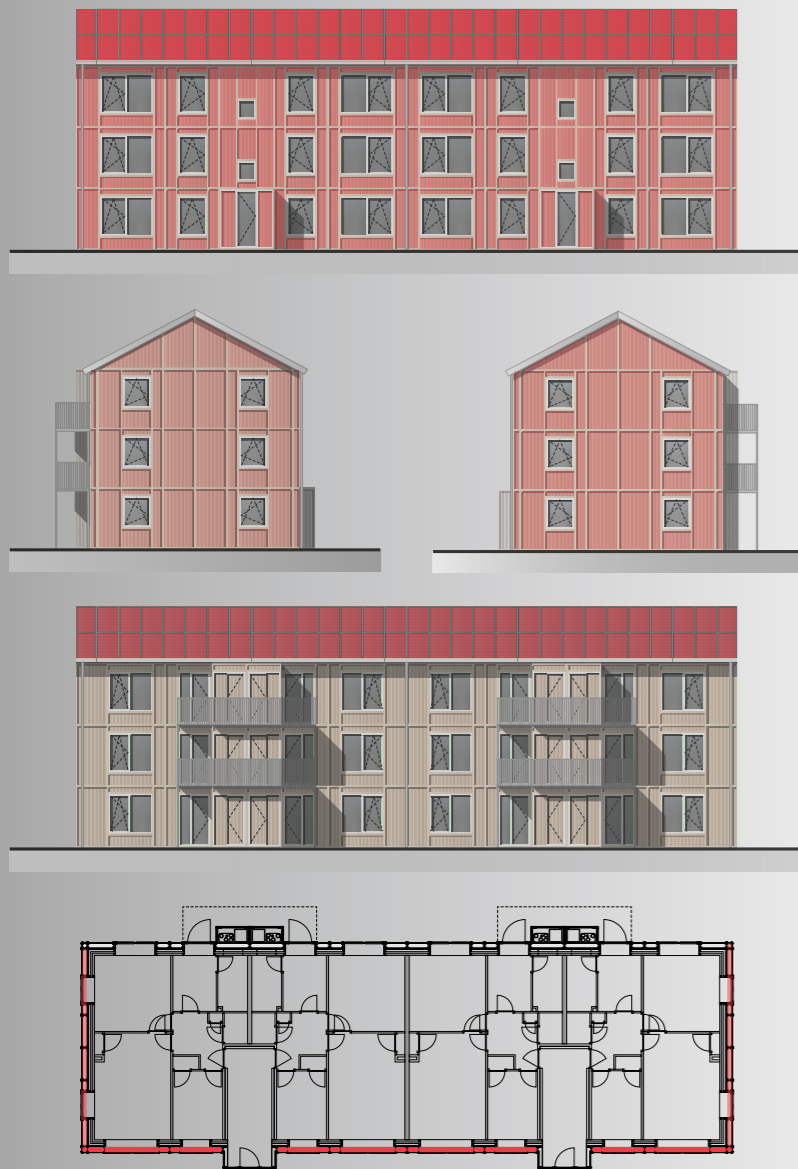
Nocturnal Ventilation



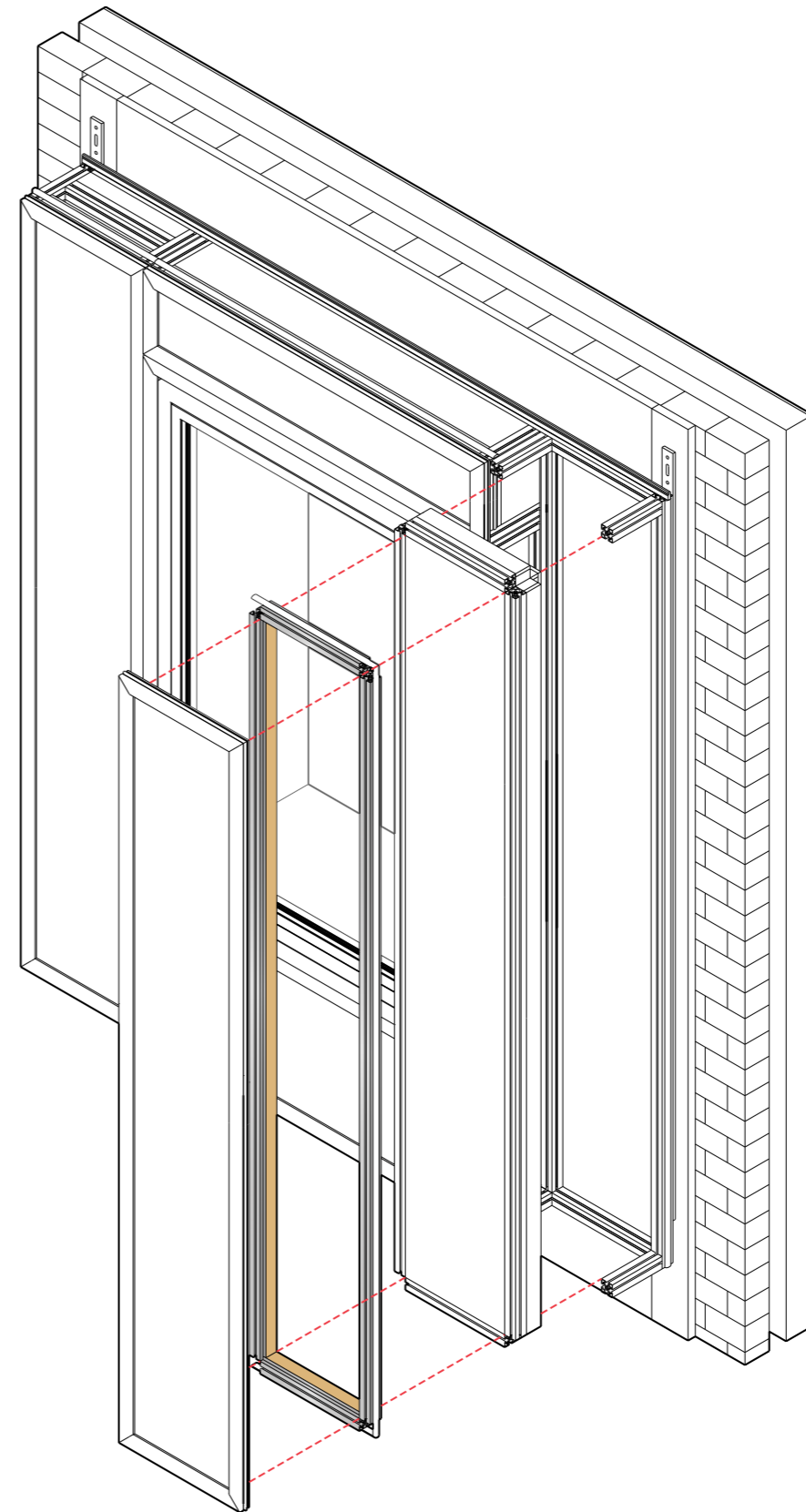
Static Solar Shading



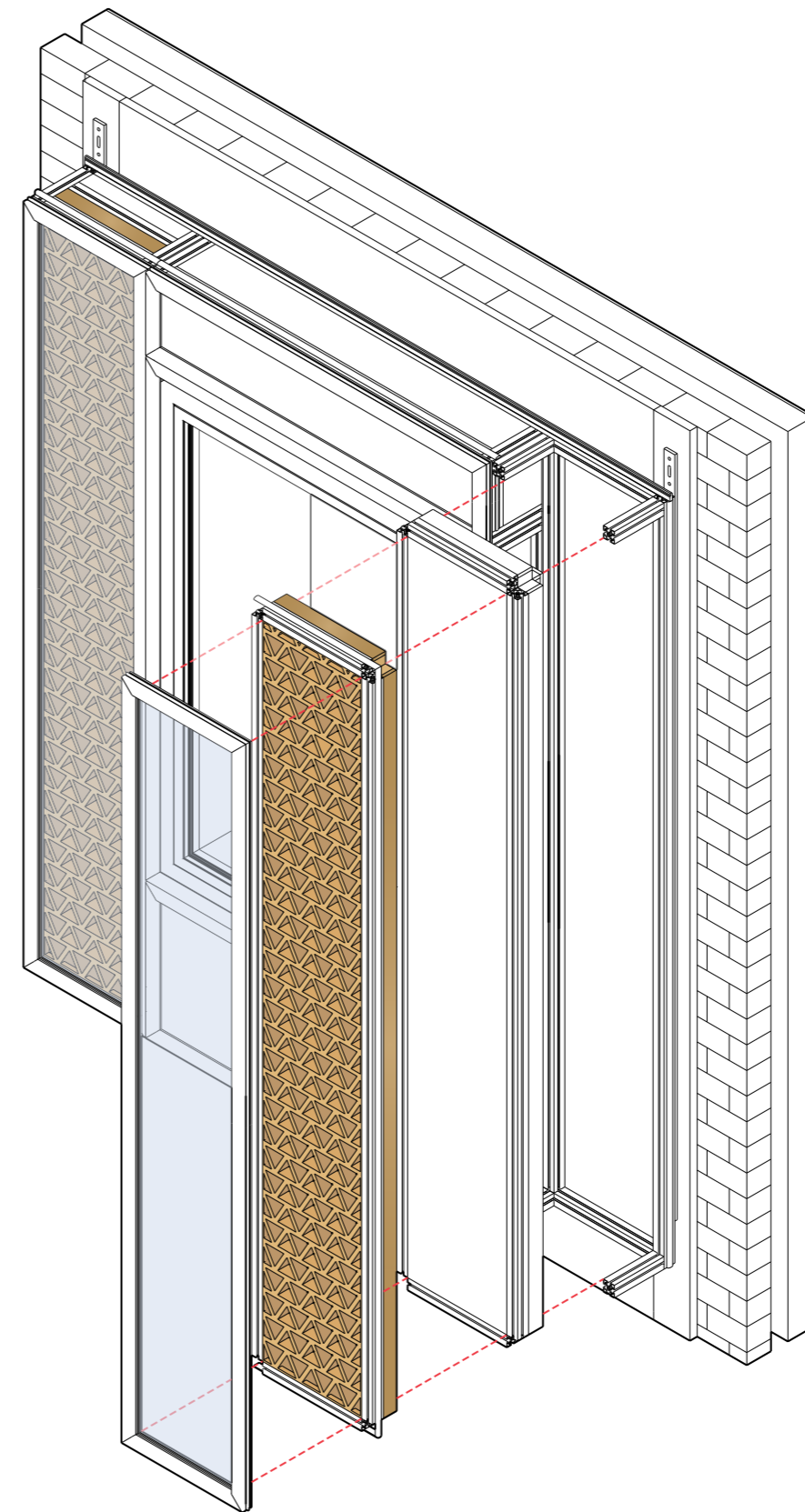
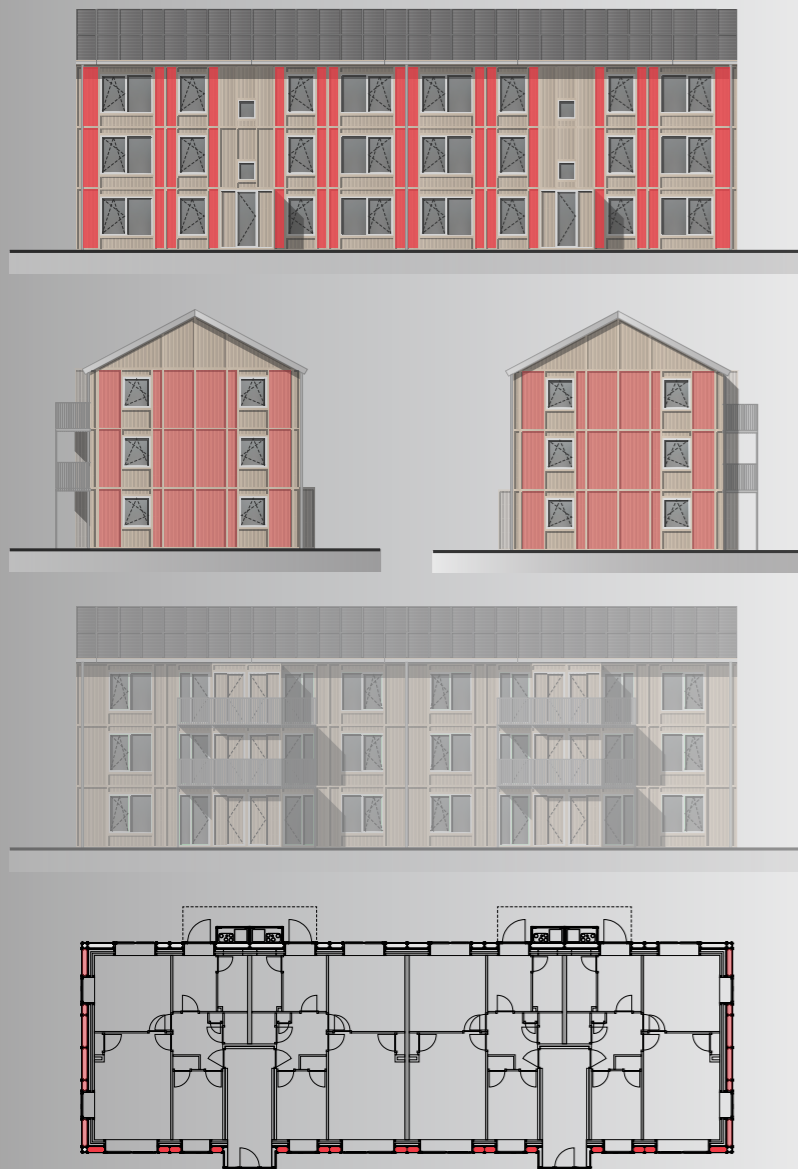
Solar Panel

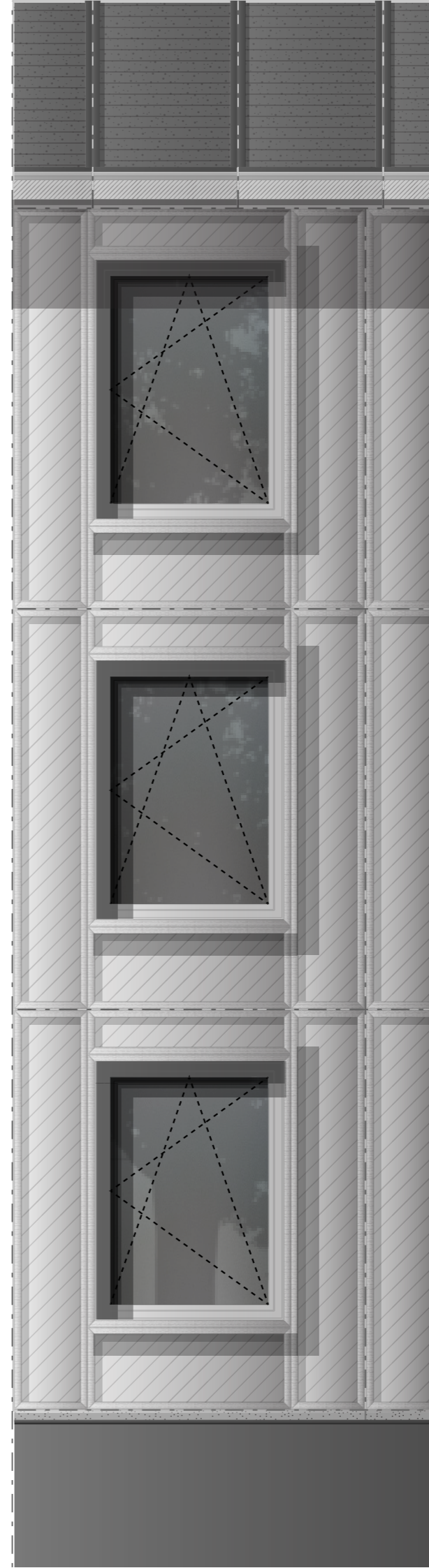
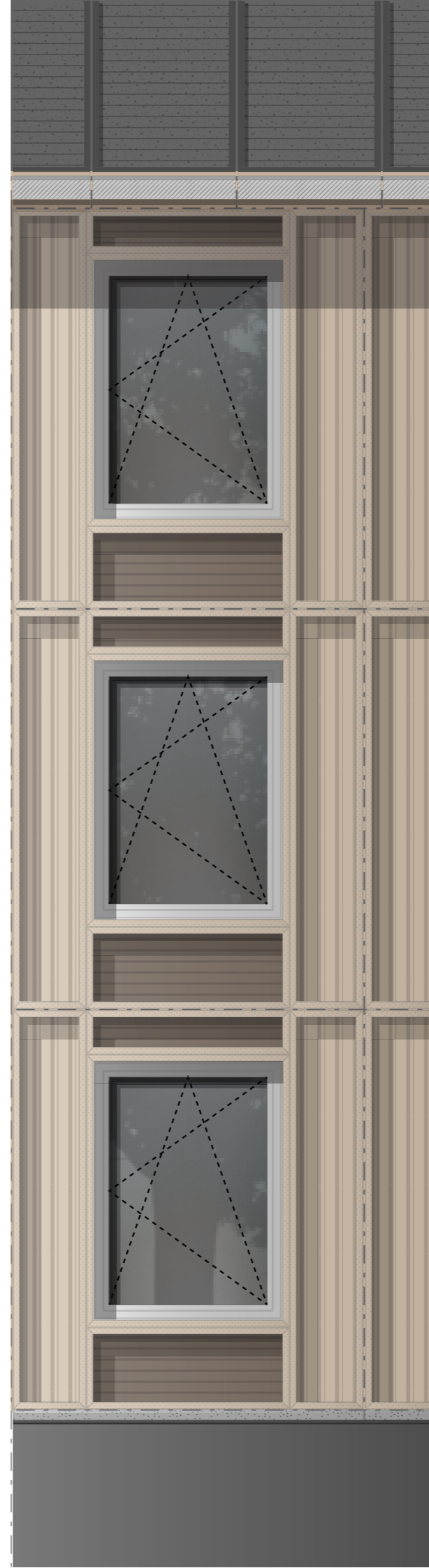
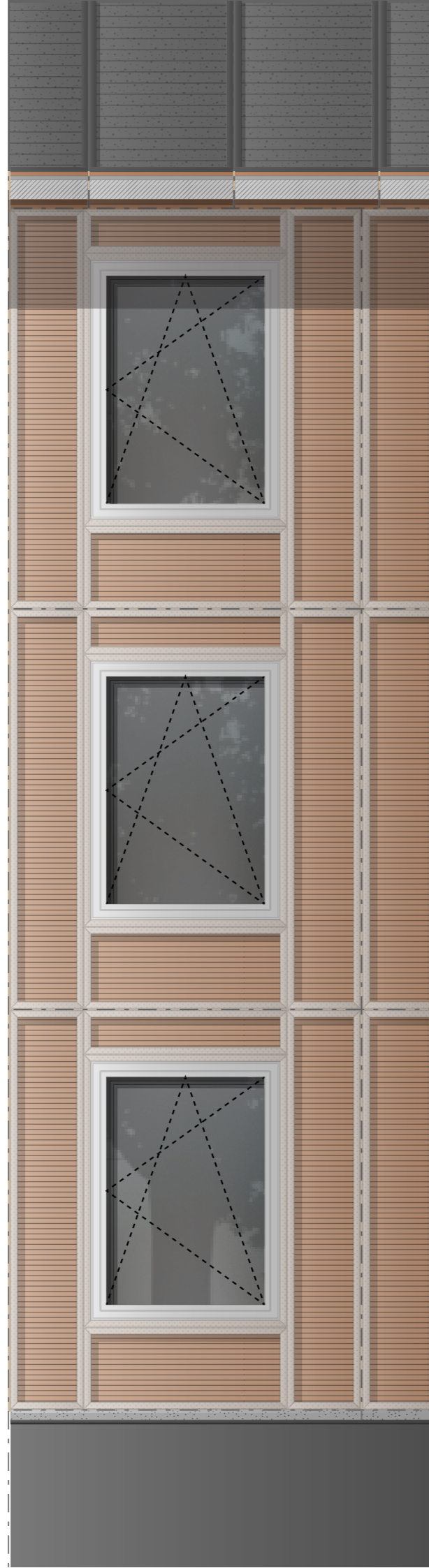
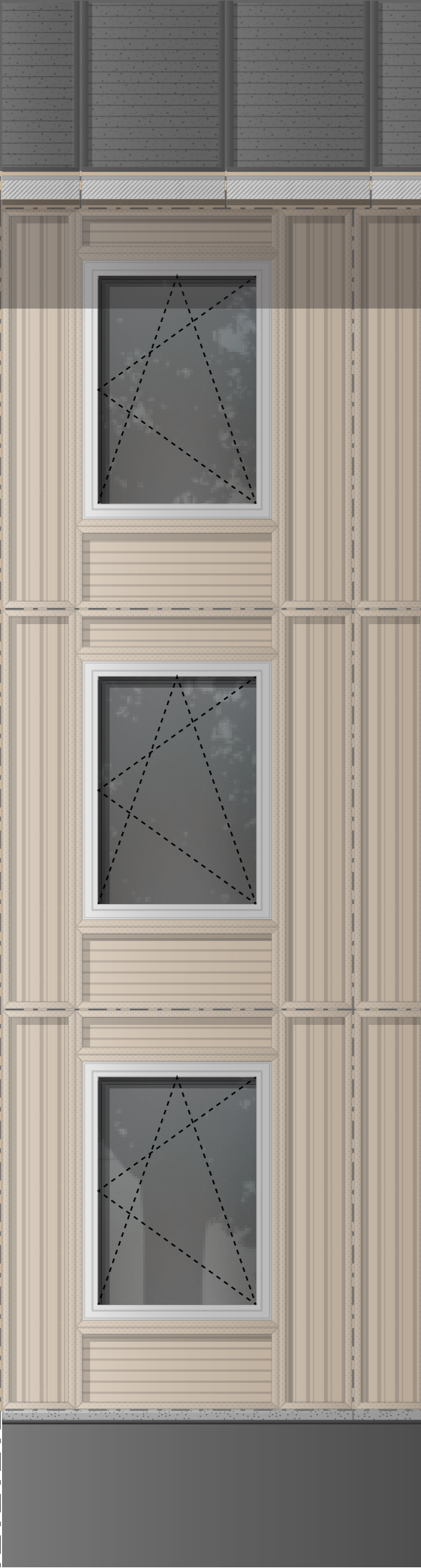


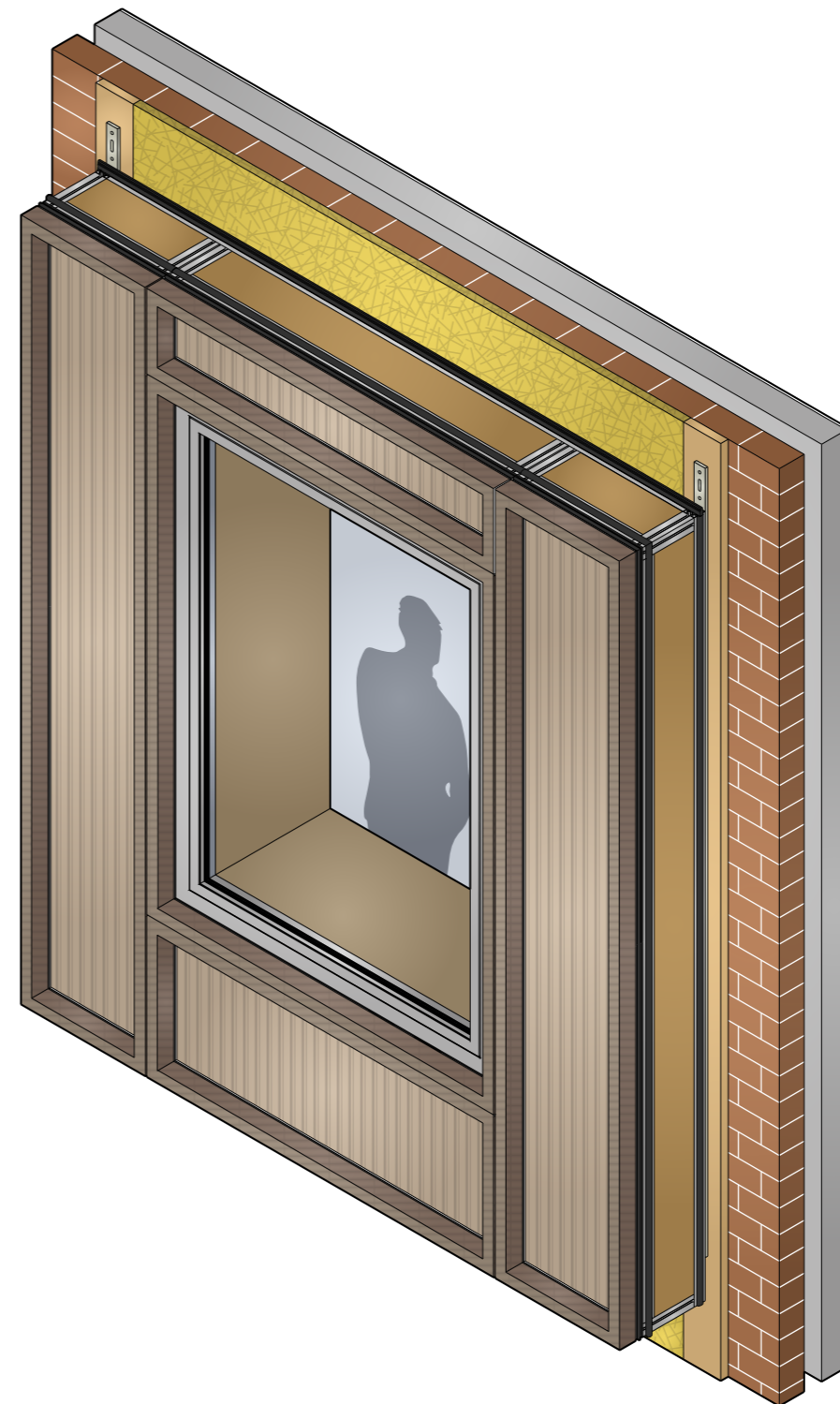
Placeholder Frame

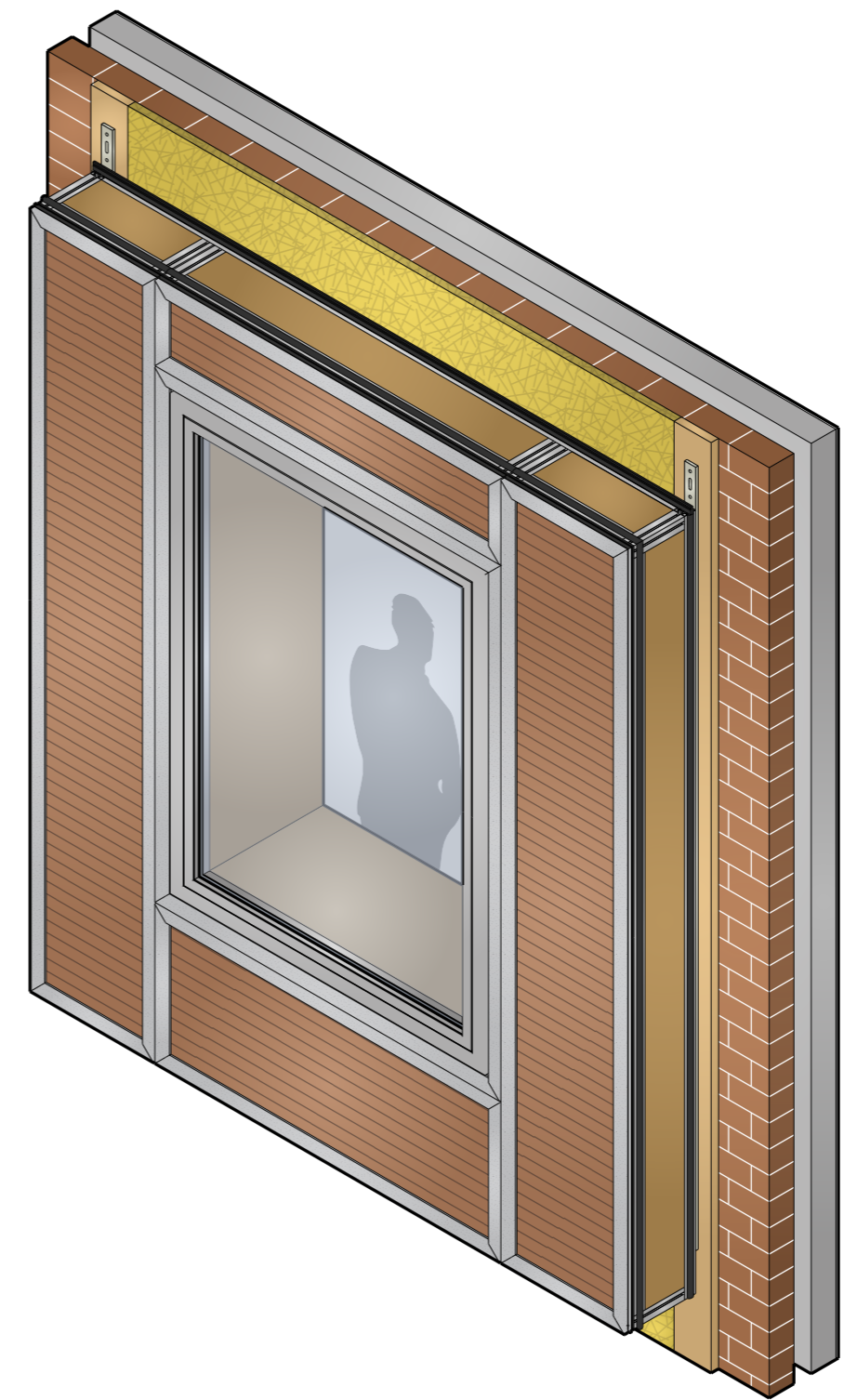


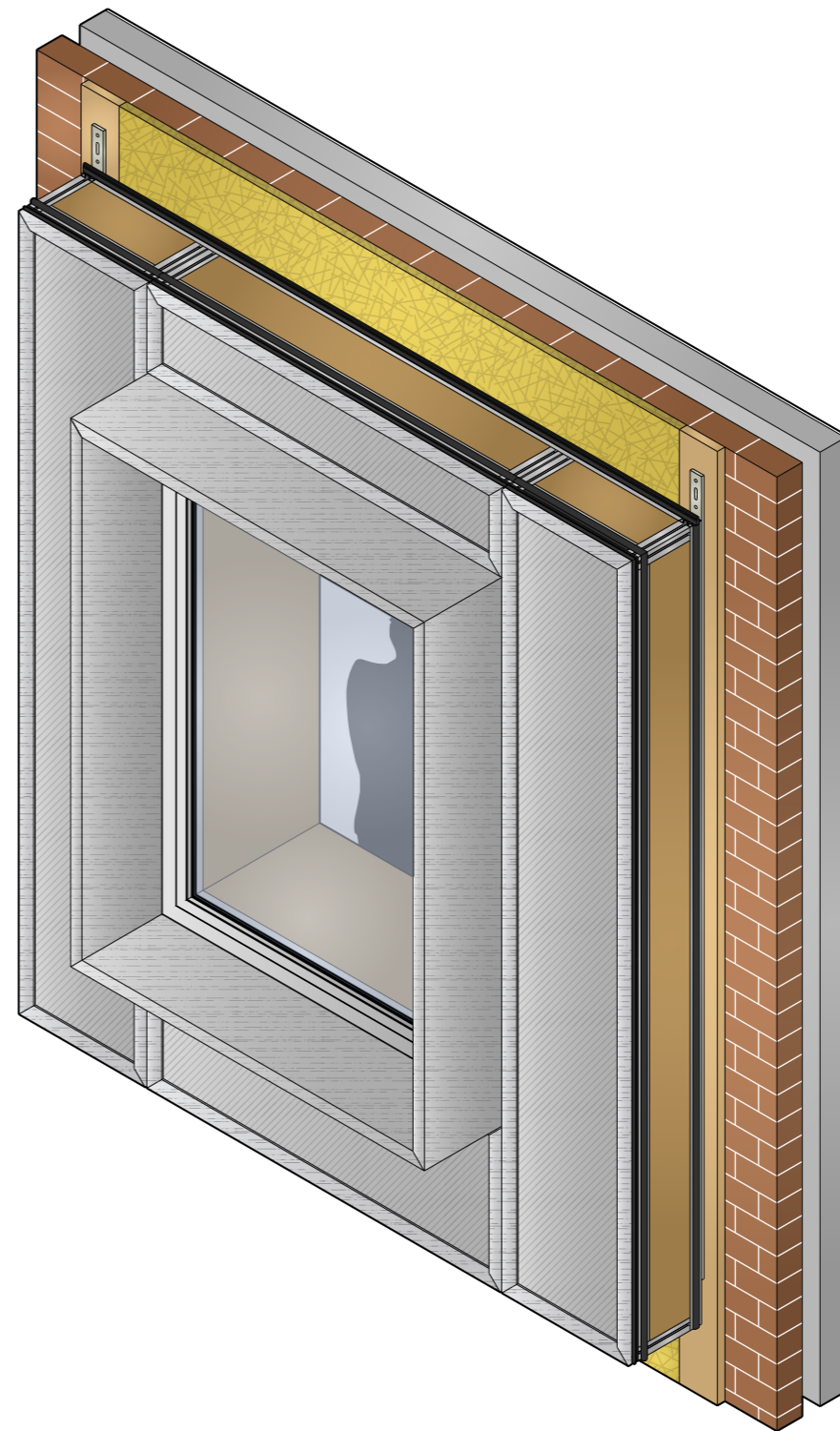
Solar Comb

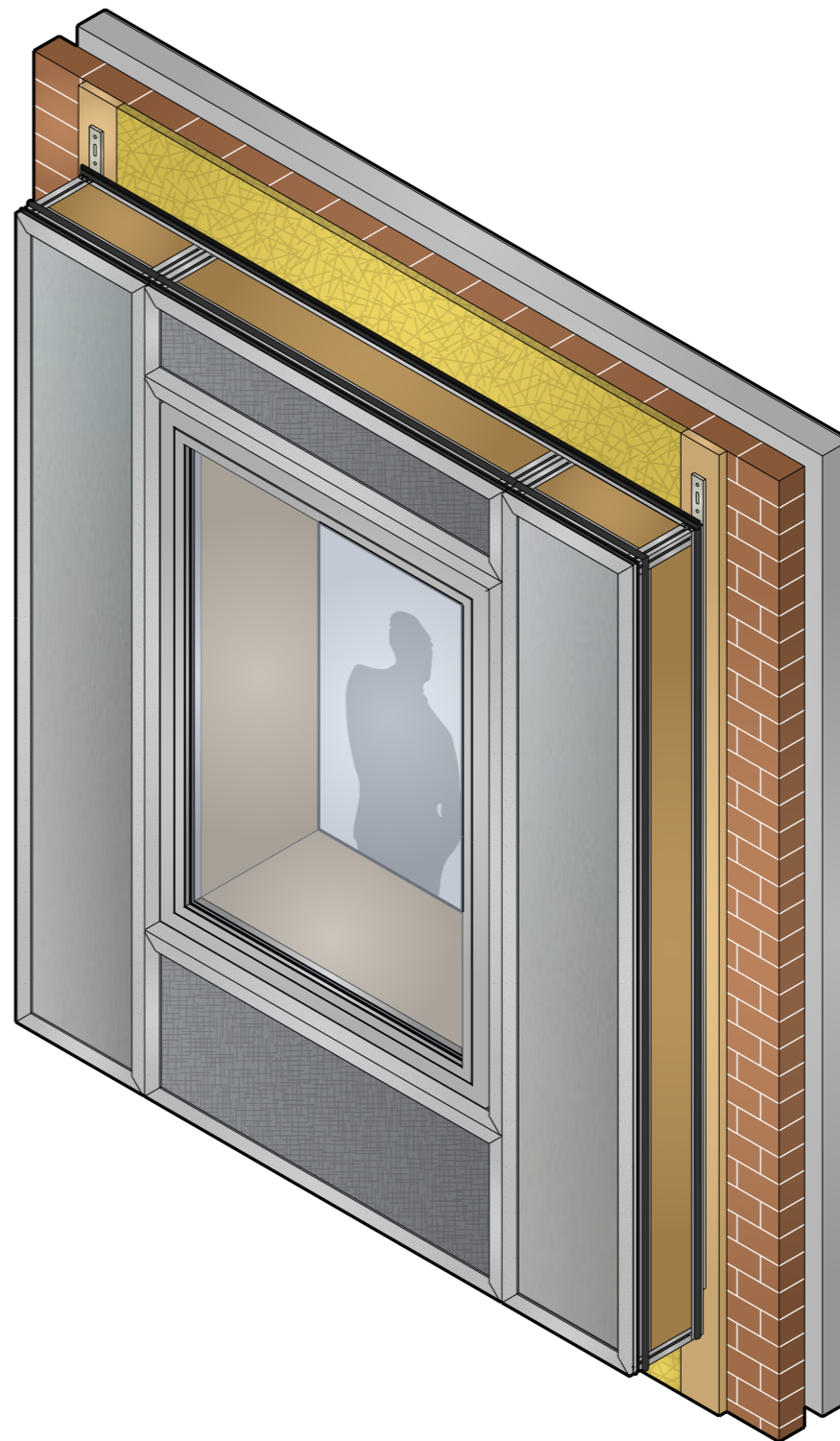




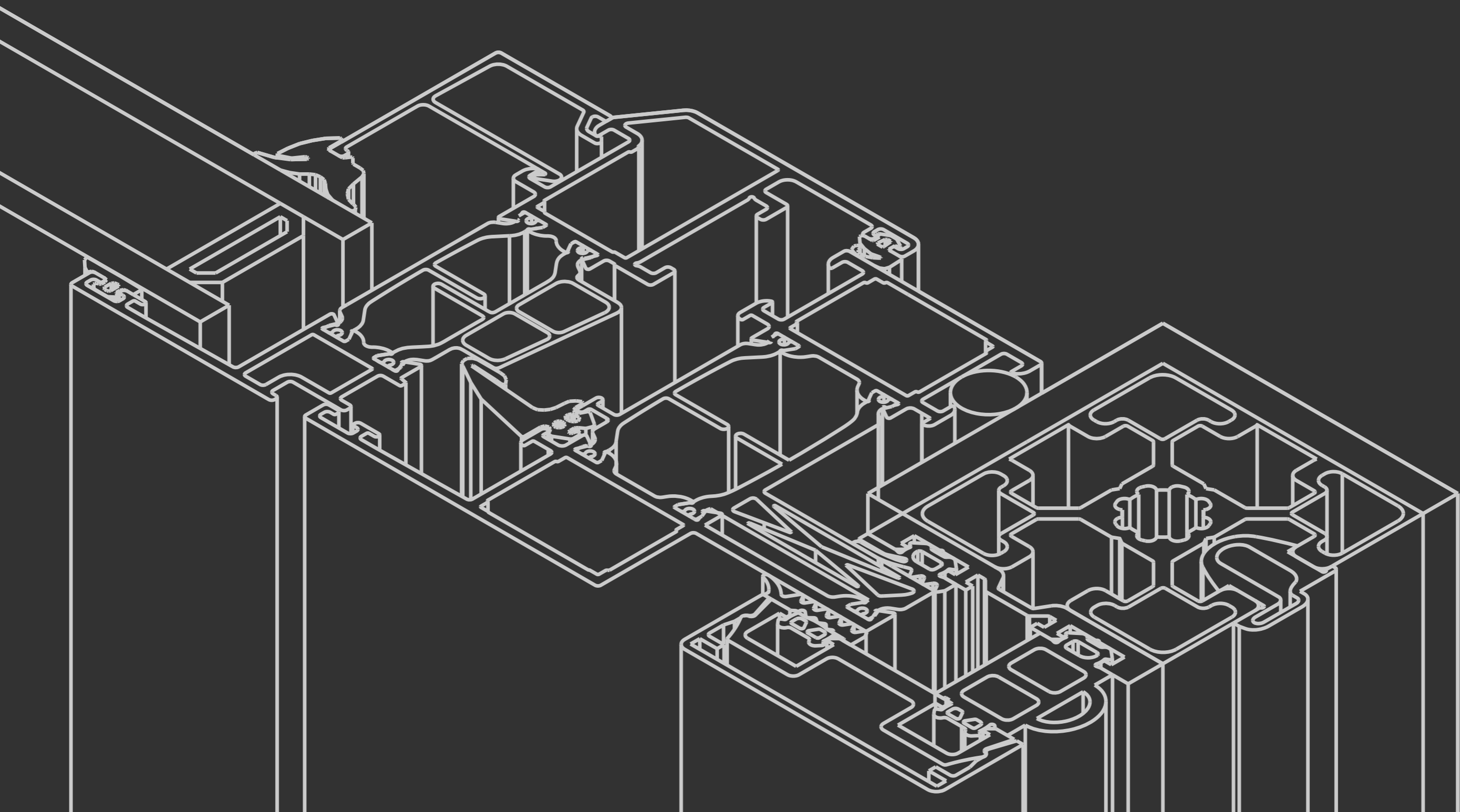








EVALUATION & CONCLUSIONS



Evaluation

Assessment Final Design			
Category	Sub-category	Criteria	Improved
Architecture	Appearance	Customisation	-
	Construction	Off-site Production Ability	=
Integration		+	
Sustainable Materials		-/+	
Application	Structural Adjustments	=	
	Adaptability	+	
	Disturbance	=	
	Construction Time	-/+	
Future Proof	Upgradability	++	
	Maintenance	++	

Limitations

- *What are the exact costs of implementing such system?
Production line, training construction workers, application, etc.*
- *“Fool proof” system?
Will the production process, as well as the application and upgradation process be “simple” enough to be an effective strategy.*
- *Will the BPIE scenario prove to be an effective strategy?*
- *Effectiveness of the system increases when the amount of buildings renovated with the system increases.*

Research Question

*“In what way can a **prefabricated** building envelope system for **energy reduction renovation** of building envelopes of **Dutch post-war apartment blocks** be designed to be **future proof** by taking into account **service life** and **changing standards**?”*

Answer

- ***Designing a system with long-term effectiveness in mind instead of short-term success.***
- *By separating functional layers, as well as functionalities.*
- *By offering the ability to adapt to changes in functionality, technology and regulations, either foreseen or unforeseen, through changing of boxes and layers, as well as layout of box areas or module sizes.*

Why?

Government:

- *A larger chance of widespread acceptance due to spreading of costs due to gradual renovation.*

Building Industry:

- *Be able to adjust to new technologies.*
- *Increase the lifespan of the complete system.*
- *Interchangeability between different apartments.*
- *Different levels of energy reduction possible, catered to individual projects needs.*

Homeowners:

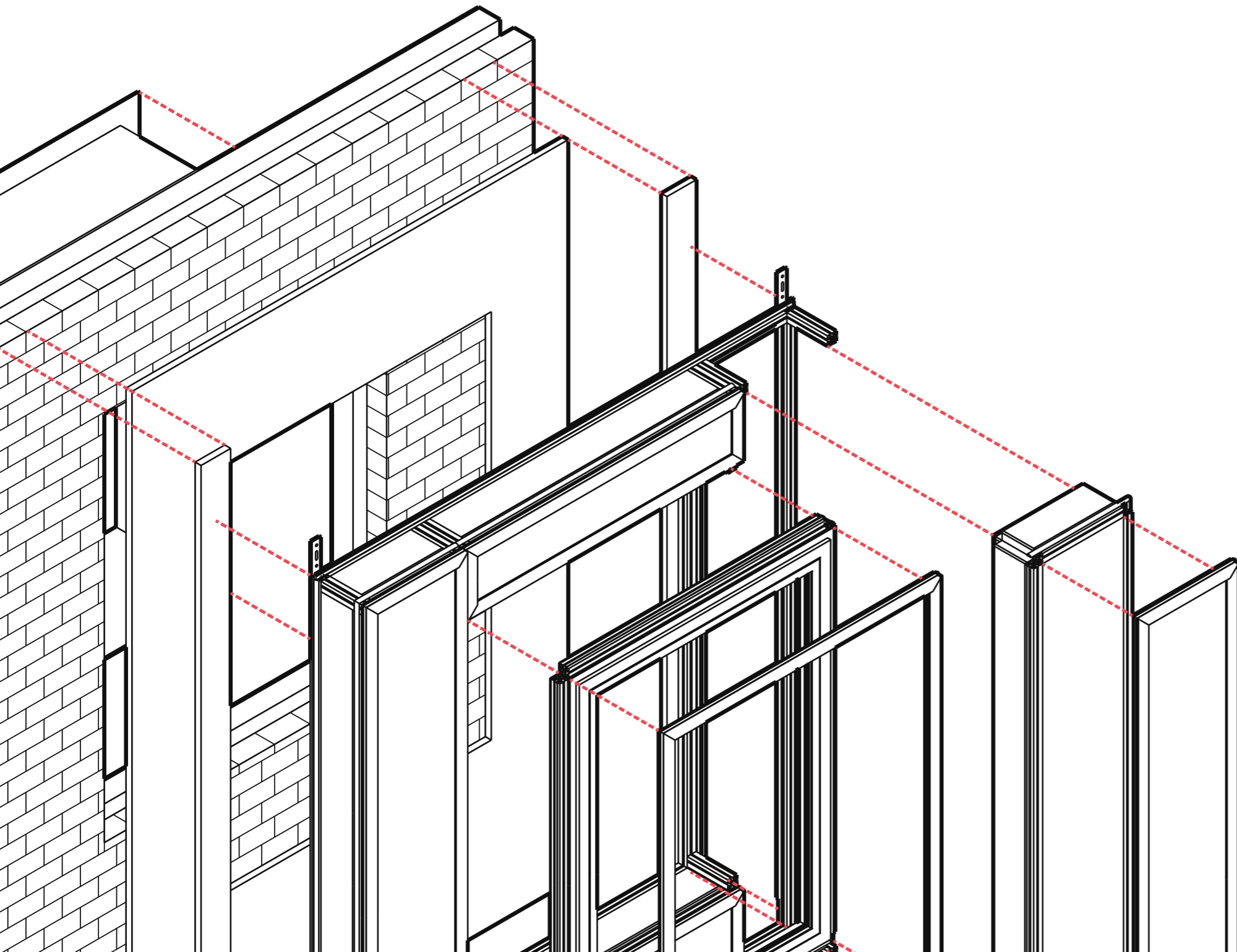
- *Variety of choice between building installations, be able to adapt if a system becomes outdated, for lowered costs.*

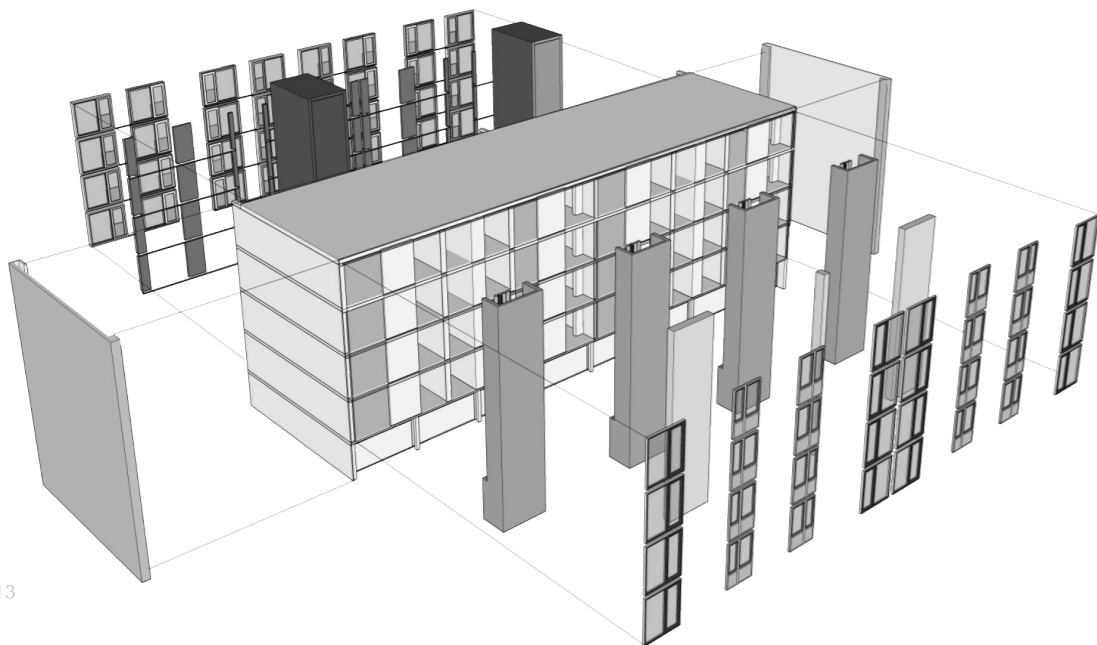
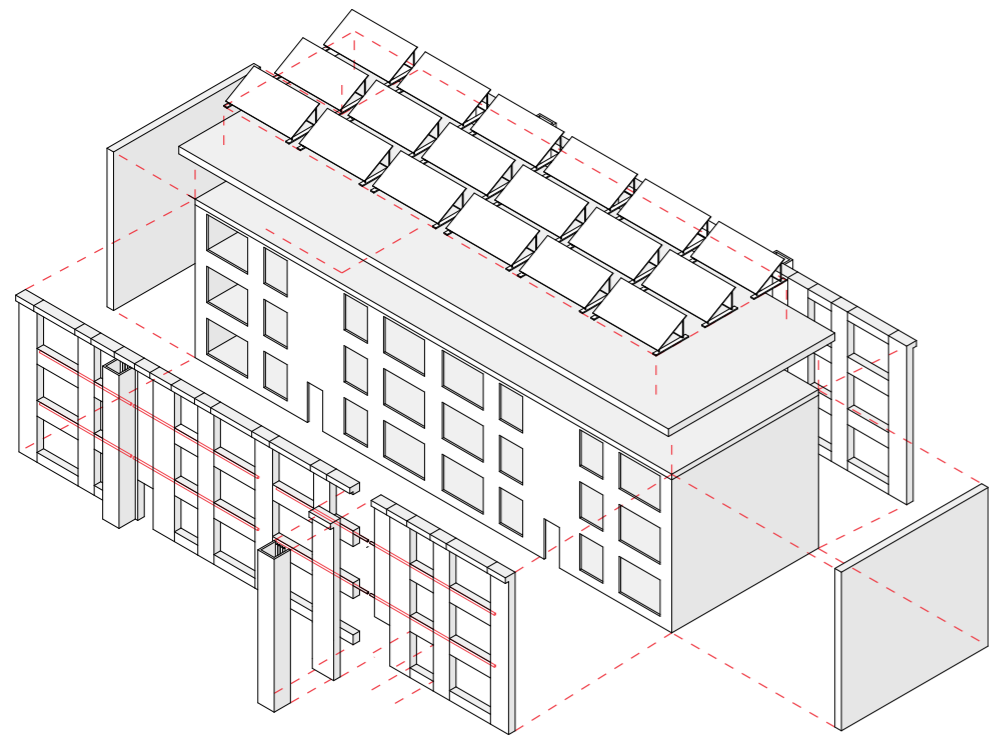
Architects:

- *Customisation options in appearance, while incorporating sustainable design.*

RE[∞]NOVATE

Thank You!

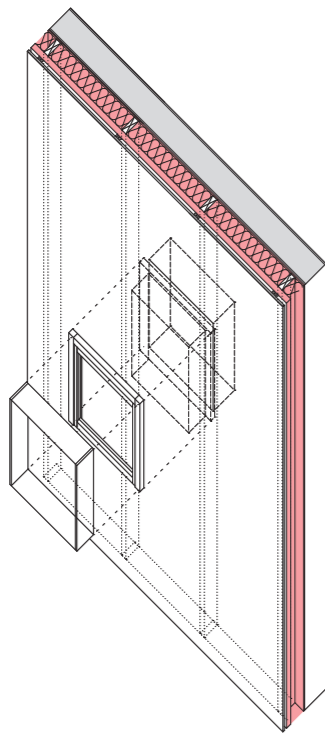
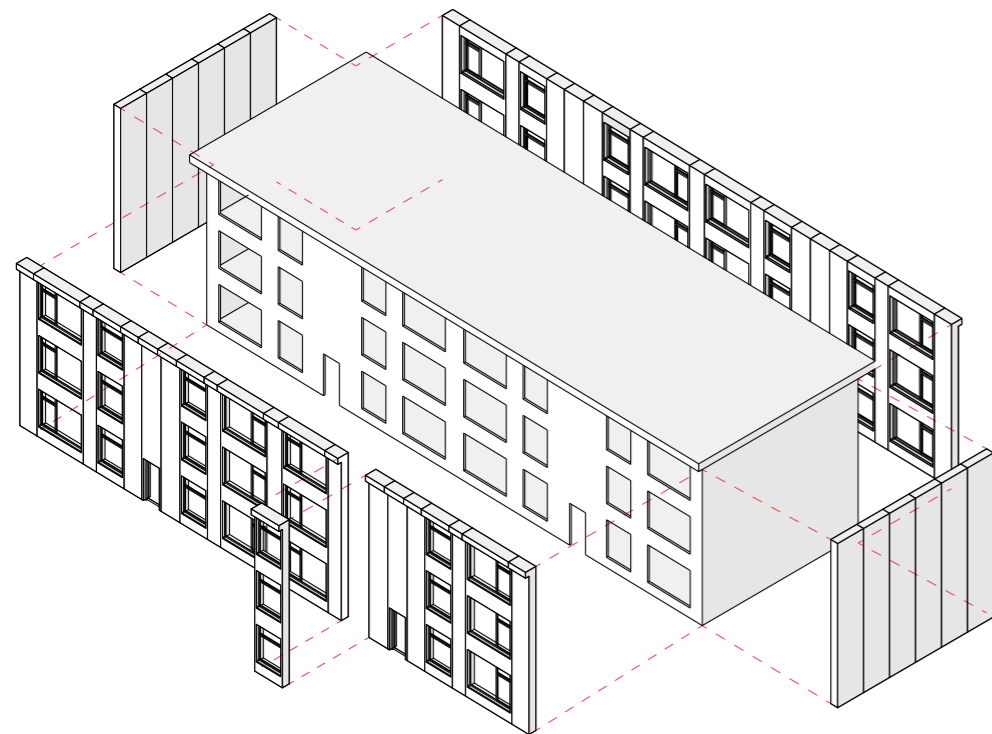




ENDIS Assessment

Architecture, Construction, Application and Long-Term Functionality

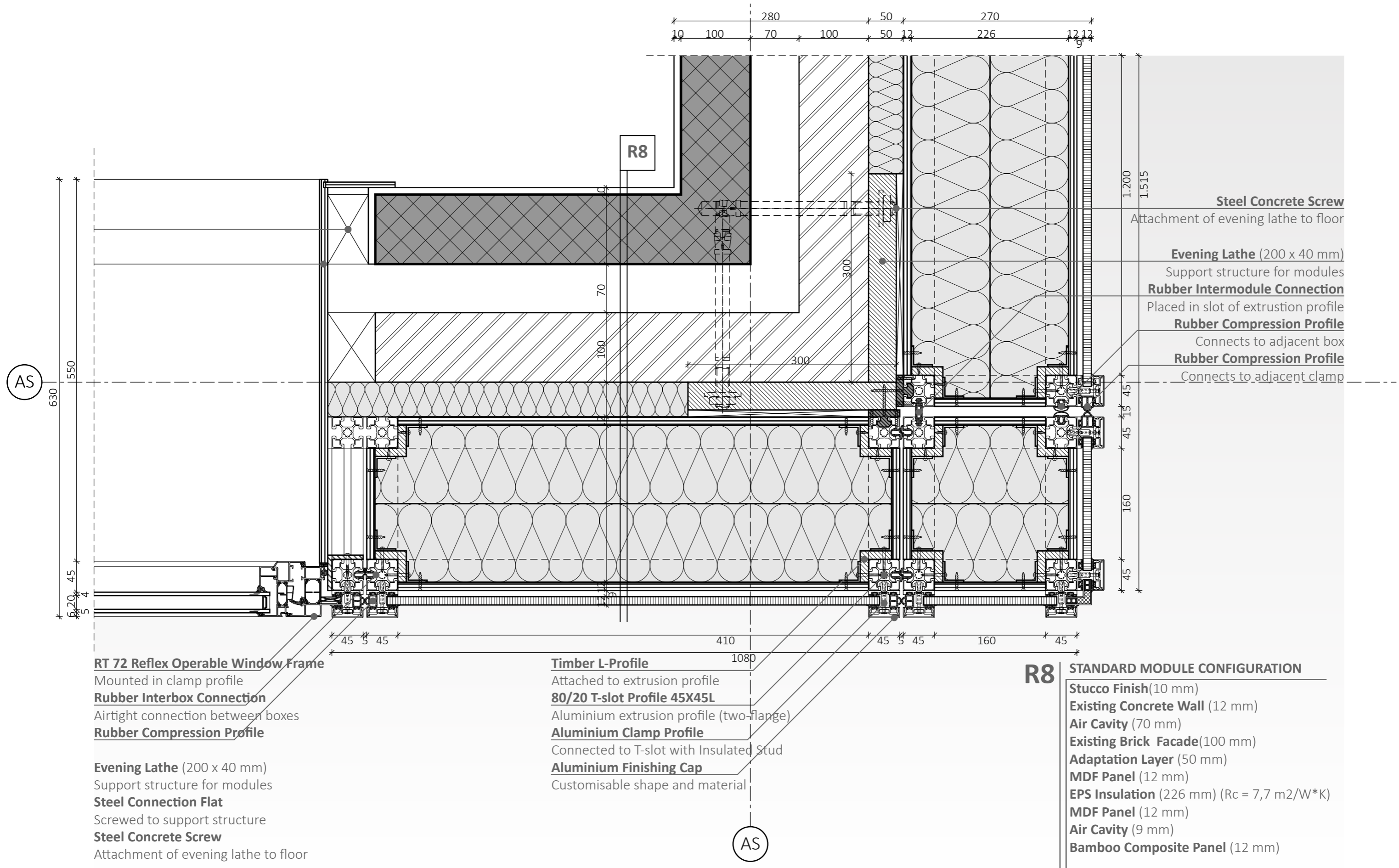
Aspect	Grade	Elaboration
Customisation	● ● ● ● ●	Due to the approach every project can be customised in all aspects.
Level of Prefabrication	● ● ● ○ ○	The semi-prefabricated. All components are manufactured in a factory, but have to be assembled on-site.
Integration	● ● ○ ○ ○	Installations are combined with the thermal renovation but are separated.
Sustainable Materials	● ● ● ○ ○	ENDIS uses steel as its main selling points, although it's highly recyclable the embodied energy is high.
Structural Adjustments	● ● ○ ○ ○	No structural adjustments are needed to the original building. The shaft needs a separate support structure
Adaptability	● ○ ○ ○ ○	The approach involves a customised approach per project. The system doesn't adapt to parameters.
Disturbance	● ● ● ○ ○	Although occupants can stay in their homes, a relatively high amount of on-site labour must be performed.
Construction Time	● ● ● ○ ○	Approximately seven weeks on average are necessary to wrap a existing building.
Upgradability	● ○ ○ ○ ○	Upgradability is not integrated in the design of the system.
Maintenance	● ● ● ● ○	Maintenance can be easily performed on the intallations without occupants present.



TES Energy Facade Assessment

Architecture, Construction, Application and Long-Term Functionality

Aspect	Grade	Elaboration
Customisation	● ● ● ● ○	<i>The TES Energy Facade can be customised on every aspect, the basis of wood construction always used.</i>
Level of Prefabrication	● ● ● ● ○	<i>The elements can be four stories high, other sizes are also possible.</i>
Integration	● ● ● ● ○	<i>Installations can be integrated into the panel, with piping and ducts tucked into the insulation layer of the panel.</i>
Sustainable Materials	● ● ● ○ ○	<i>The construction is made out of wood, which is a material with low embodied energy, the other materials are adjustable.</i>
Structural Adjustments	● ● ● ● ●	<i>No adjustments have to be made to the structure.</i>
Adaptability	● ● ● ○ ○	<i>The system comes with standard details that can be used for a large variety of typologies, the details have to be adjusted accordingly.</i>
Disturbance	● ● ● ● ○	<i>Disturbance is relatively minimised, with occupants remaining at their homes. Cranes need to be used to place the modules.</i>
Construction Time	● ○ ○ ○ ○	<i>Construction period was approximately one and a half years which is, even when considering the scale of the projects, very slow.</i>
Upgradability	● ○ ○ ○ ○	<i>The panel doesn't integrate upgradability in it's system.</i>
Maintenance	● ● ○ ○ ○	<i>Maintenance is difficult to the installation due to the closed off nature of the system.</i>



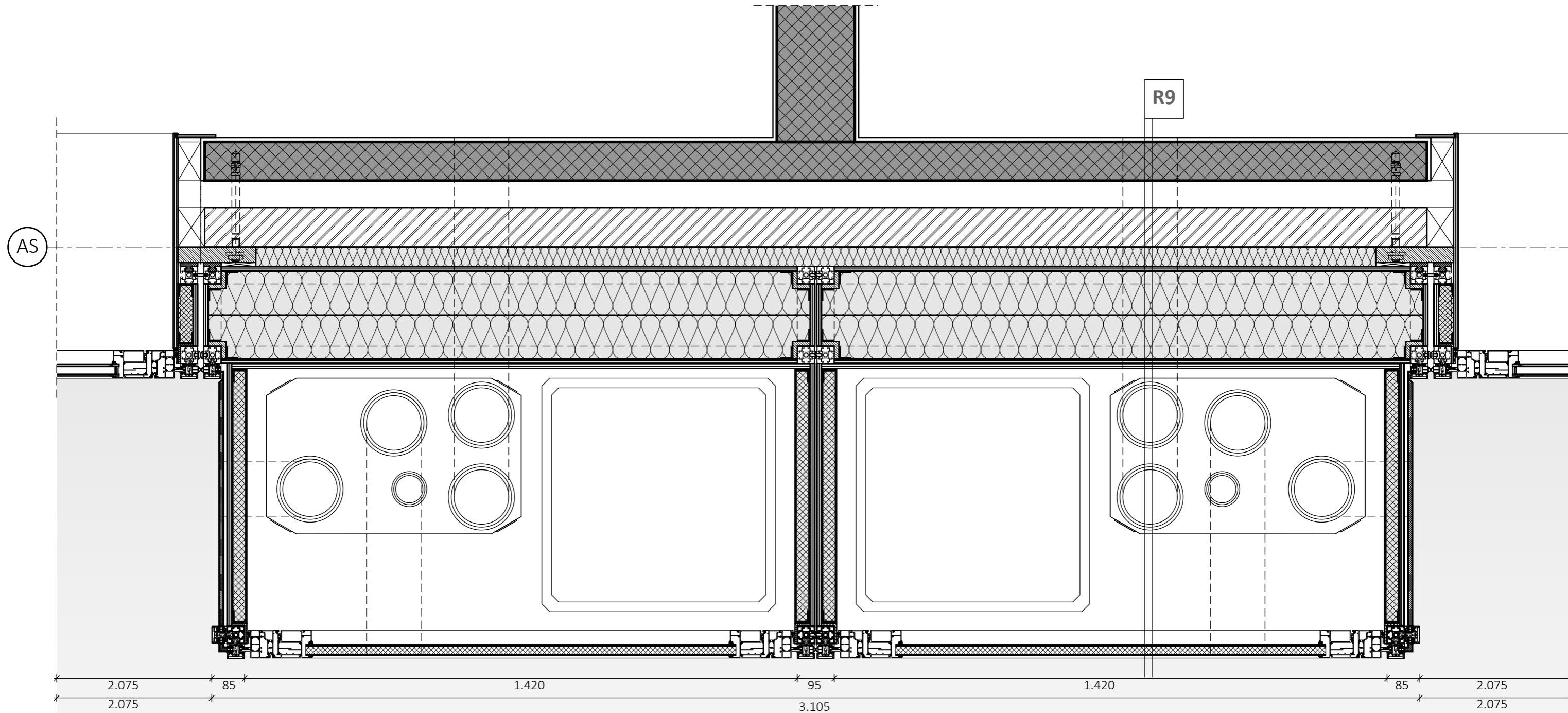
RT 72 Reflex Operable Window Frame
 Mounted in clamp profile
Rubber Interbox Connection
 Airtight connection between boxes
Rubber Compression Profile

Evening Lathe (200 x 40 mm)
 Support structure for modules
Steel Connection Flat
 Screwed to support structure
Steel Concrete Screw
 Attachment of evening lathe to floor

Timber L-Profile
 Attached to extrusion profile
80/20 T-slot Profile 45X45L
 Aluminium extrusion profile (two-flange)
Aluminium Clamp Profile
 Connected to T-slot with Insulated Stud
Aluminium Finishing Cap
 Customisable shape and material

R8 STANDARD MODULE CONFIGURATION

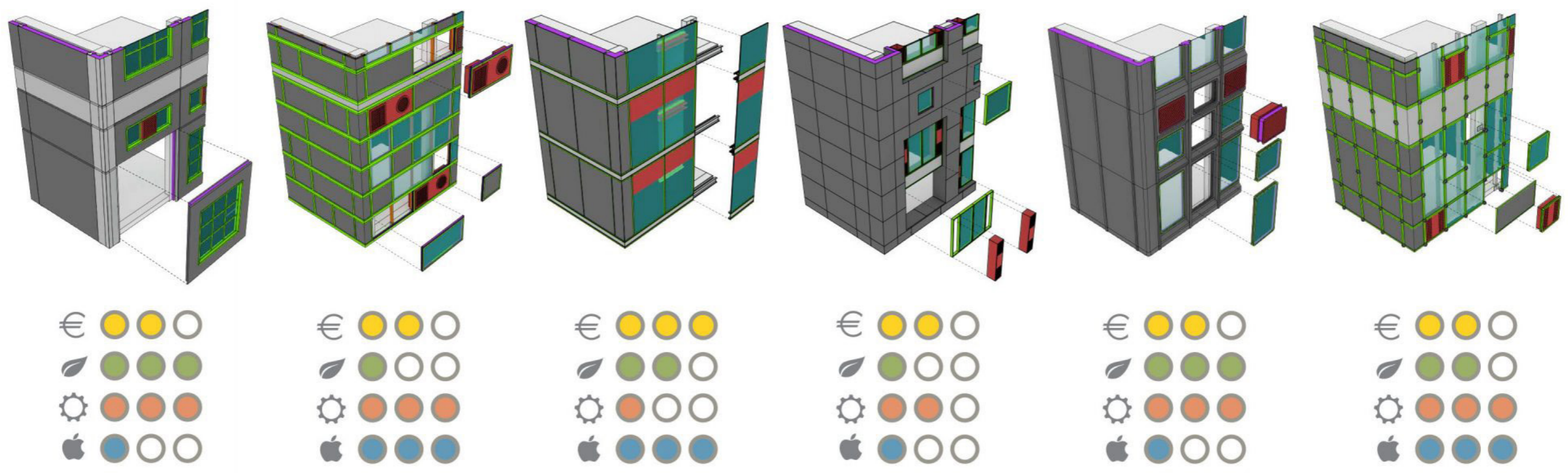
- Stucco Finish (10 mm)
- Existing Concrete Wall (12 mm)
- Air Cavity (70 mm)
- Existing Brick Facade (100 mm)
- Adaptation Layer (50 mm)
- MDF Panel (12 mm)
- EPS Insulation (226 mm) ($R_c = 7,7 \text{ m}^2/\text{W} \cdot \text{K}$)
- MDF Panel (12 mm)
- Air Cavity (9 mm)
- Bamboo Composite Panel (12 mm)



R9 INSTALLATIONS MODULE CONFIGURATION

- Stucco Finish(10 mm)
- Existing Concrete Wall (12 mm)
- Air Cavity (70 mm)
- Existing Brick Facade(100 mm)
- Adaptation Layer (50 mm)
- MDF Panel (12 mm)
- EPS Insulation (226 mm) ($R_c = 7,7 \text{ m}^2/\text{W}^*\text{K}$)
- MDF Panel (12 mm)
- MDF Panel (12 mm)
- Installation Space (710 mm)
- Integrated RT 72 Reflex Door (29 mm)

Lease your facade?



(Source: Ir. Juan Azcarate-Aguerre)

Lease your 2ndSkin Renovation?

