Energy Reduction Façade Renovation System

for different building typologies and climates.

P5 presentation

Iason Vovos

Student number: 5149134

Mentors: Thaleia Konstantinou, Eric van den Ham

Part 1 Current situation

Part 2 Research

Part 3 Design approach

Part 4 Design Application

PART 1

- European Union energy neutral by 2050
- Green Deal
- Paris Agreement

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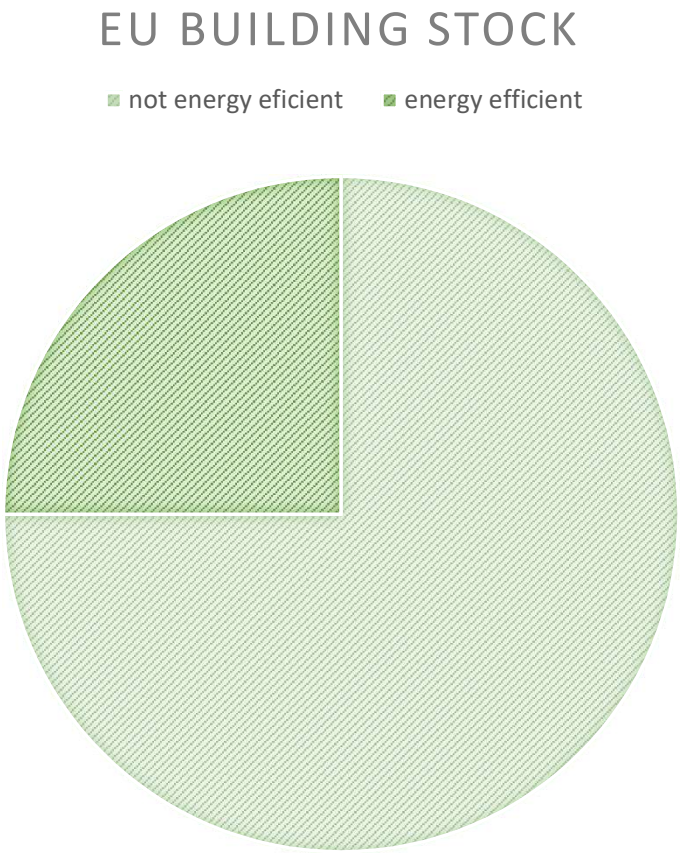
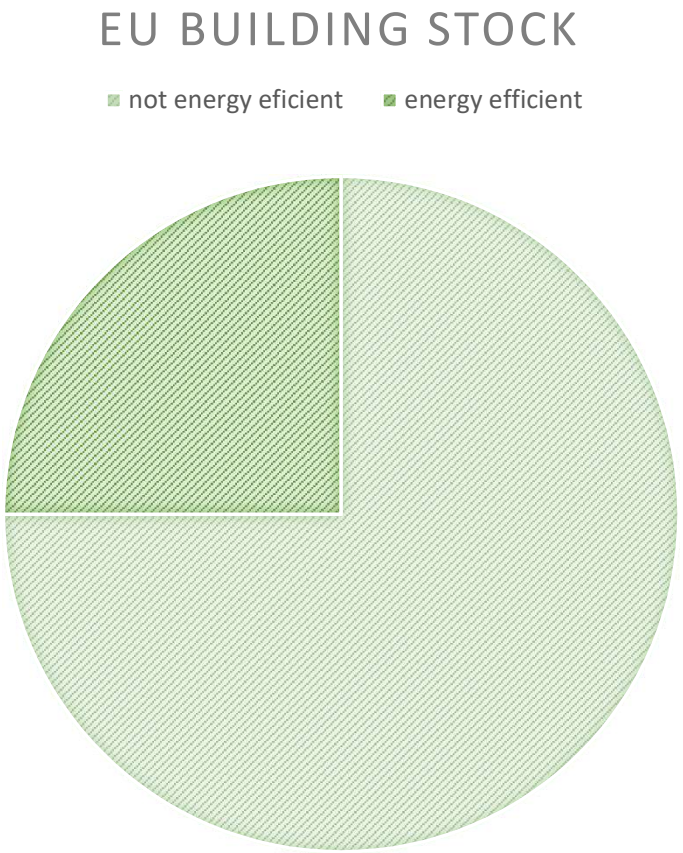
- Green Deal
- Paris Agreement



- European Union energy neutral by 2050
- Green Deal
- Paris Agreement



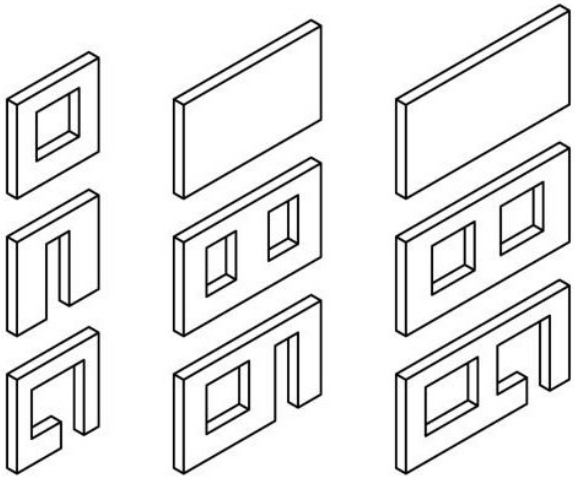
Replacement rate of existing buildings by the new-build is only 1-3 %

Renovation

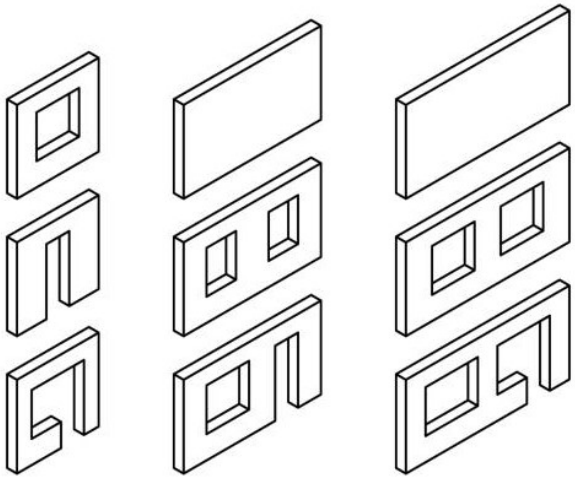
Reduction

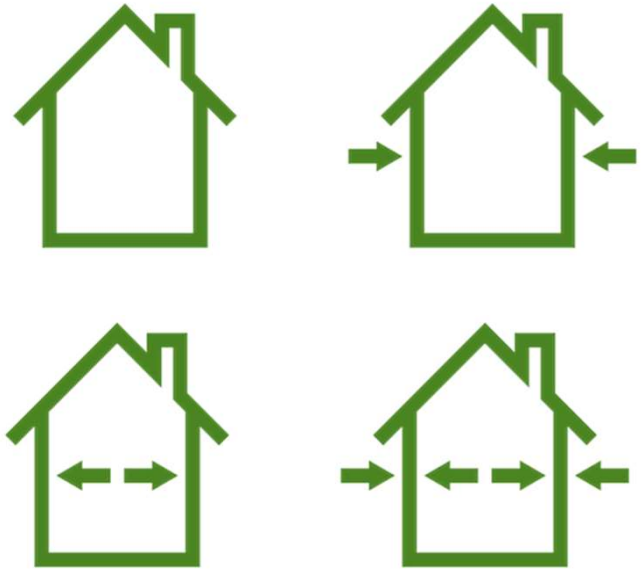
Traditional renovation methods

Prefabrication of retrofitting components



Building envelope





Scientific problem

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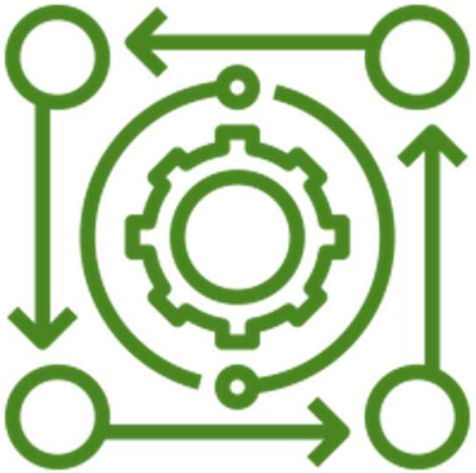


Research question

“How a prefabricated facade system for energy reduction renovation of residential buildings can be designed to be adjustable in different building typologies and climates?”

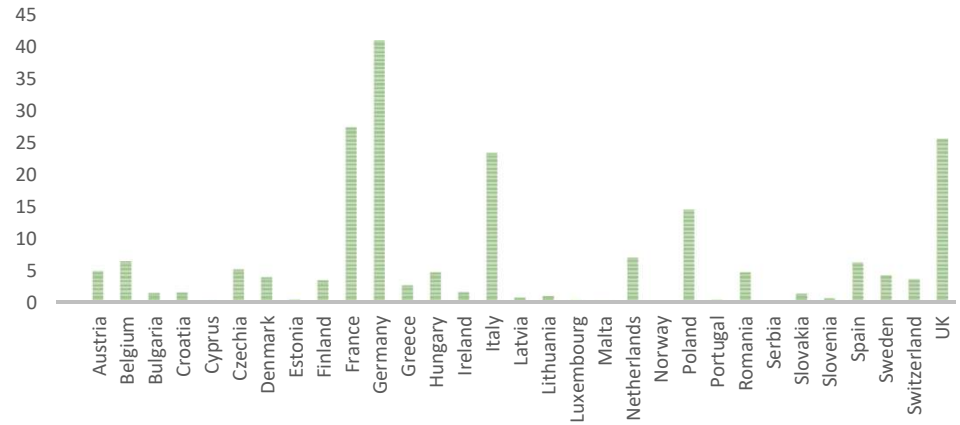
PART 2

Climate analysis

Part 2, segment 1

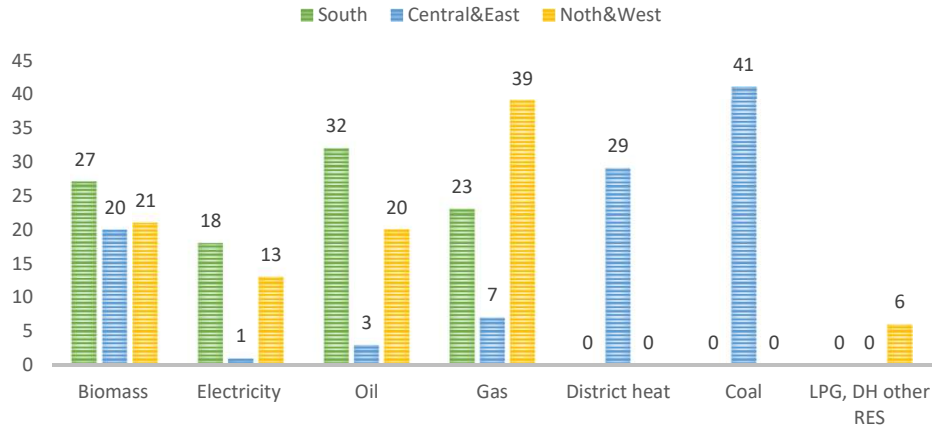
Energy consumption and climate

CONSUMPTION OF RESIDENTIAL BUILDINGS FOR SPACE HEATING IN (MTOE) FOT THE YEAR 2018



ENERGY CONSUMPTION BY SECTOR EU-27,2018

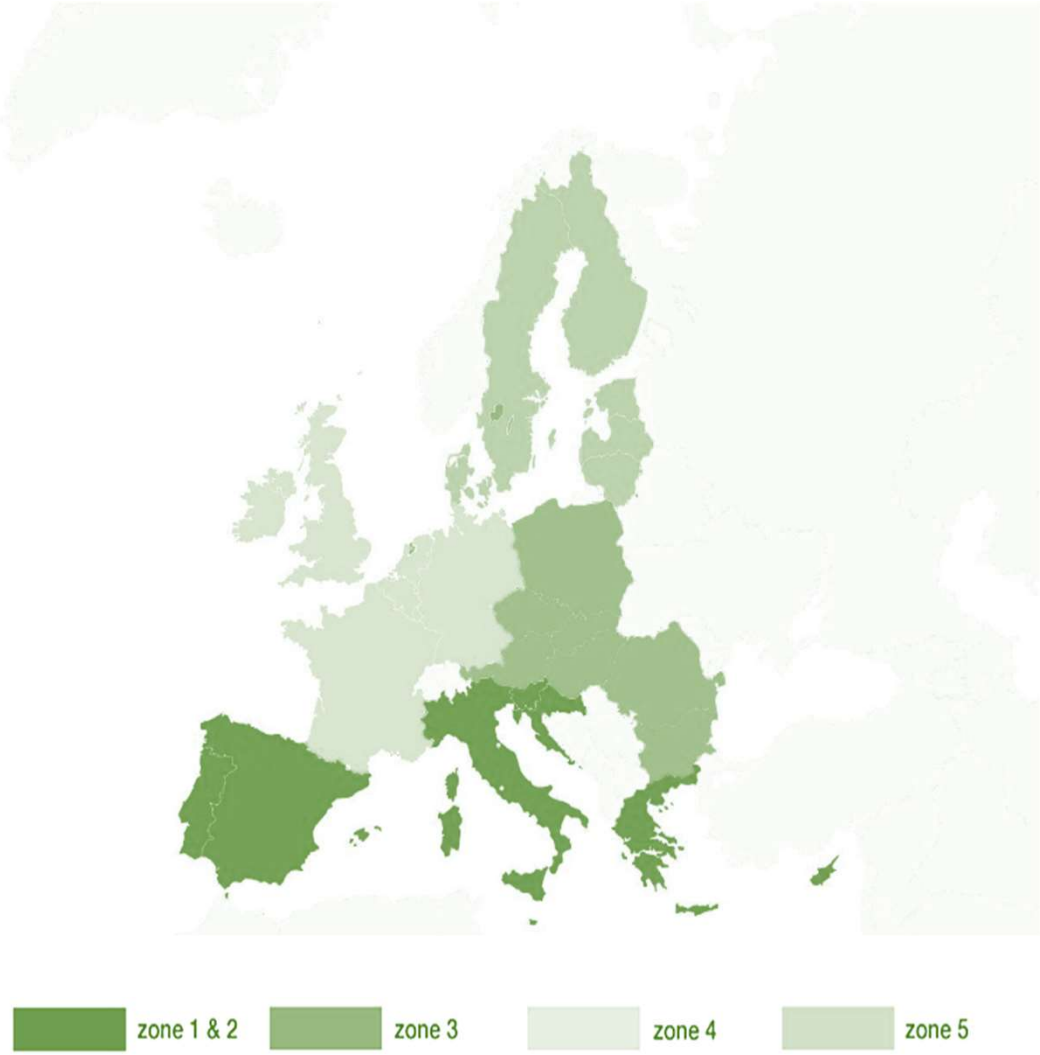
ENERGY IN RESIDENTIAL BUILDINGS BY REGION



Part 2, segment 1

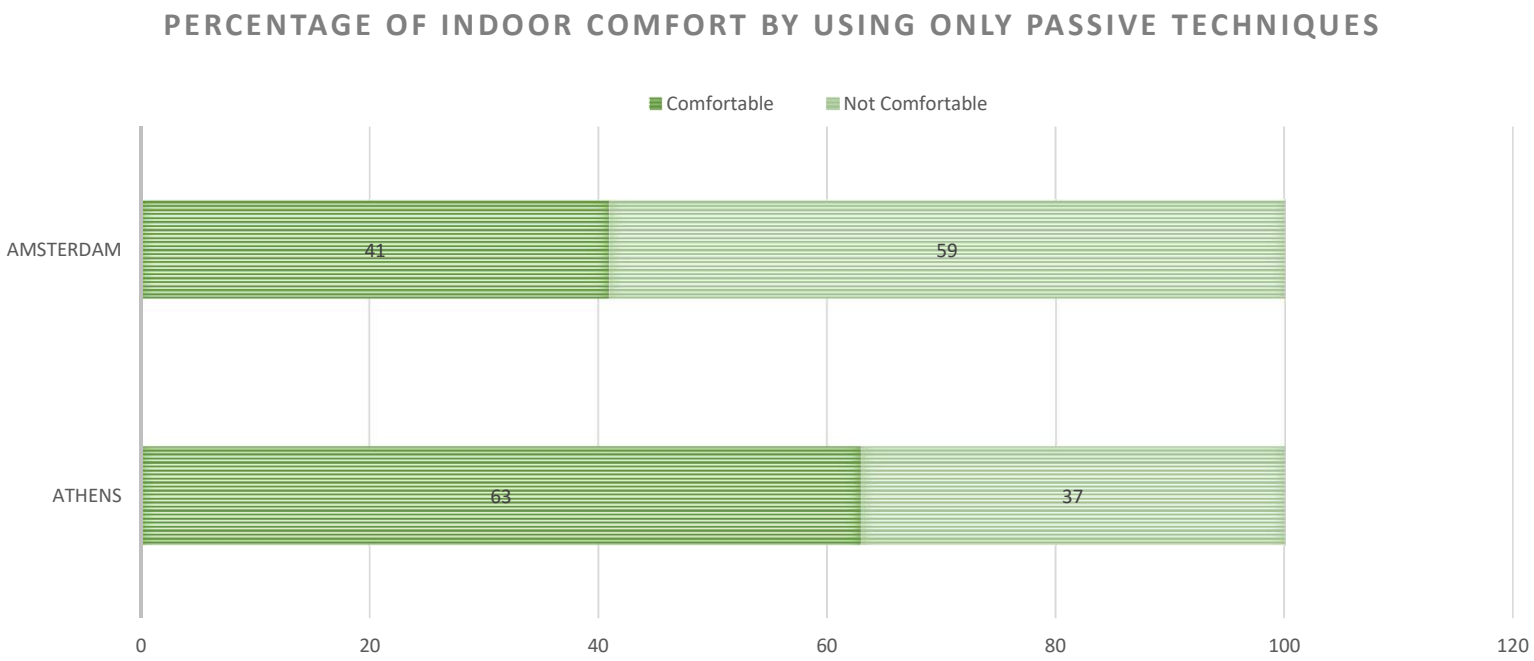
nZEB in EU

Building strategies in different climates		
KOPPEN	ECOFYS	nZEB typology
Csa - Hot and dry climate	Zone 1&2 - Temperate with dry, hot summer. (Mediterranean climate)	Well-insulated building envelope with limited fenestration area; glazing with very low SHGC and shading from direct sunlight in summer; reflective or cool colors exterior envelope surfaces essential (colors with low heat absorption to reduce the solar load during the summer period) ; solar powered AC equipment can provide day-time cooling; thermal mass and lower night-time temperatures provide comfortable indoor conditions after sunset (nocturnal ventilation)
Dfb - Warm and humid climate	Zone 3 - Temperate continental climate/humid continental climate without dry season and with warm summer;	Moderately insulated building envelope with limited fenestration area having low SHGC and effective shading devices; green (vegetated) roofs and/or reflective exterior envelope surfaces are beneficial; since the removal of latent heat (water vapor) matches the energy required for sensible cooling, investing in sophisticated ventilation is essential to provide healthy and comfortable indoor air conditions without wasting energy.
Cfb - Temperate climate	Zone 4 - Temperate without dry season and warm summer	Well-insulated building envelope with energy efficient fenestration (very low to low U-value, moderate to high SHGC- depends on glazing area); operable shading systems required to prevent summer over-heating; thermal mass and balanced ventilation with heat recovery is beneficial. Nocturnal ventilation
Dfc - Cold climate	Zone 5 - Cold, without dry season and with cold summer.	Compact building design with very well- insulated building envelope components; total fenestration area should be limited with very low U-value and high SHGC (solar heat gain coefficient); thermal mass and balanced ventilation with heat recovery is essential.



Amsterdam

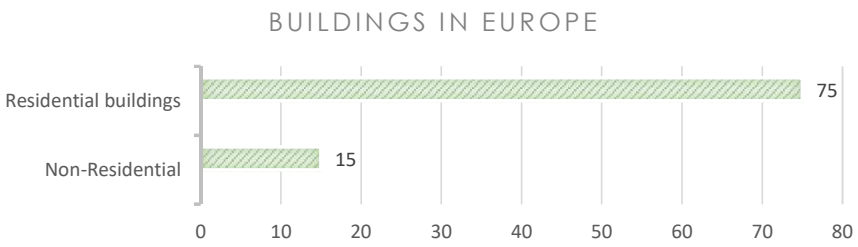
Athens

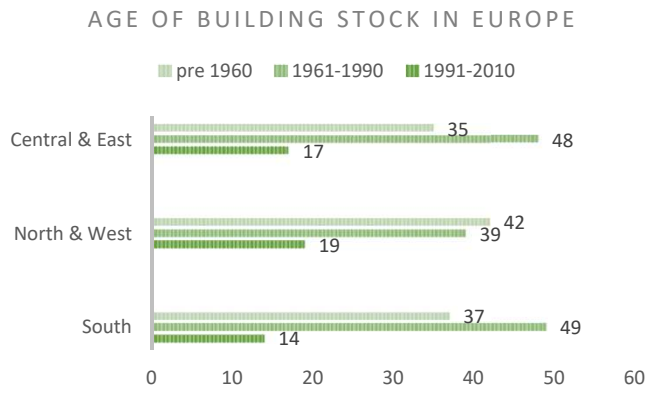


	Athens (warm climate)	Amsterdam (cold climate)
1	Well insulated buildings to keep the heat gain from people, lights and equipment inside.	Glazing should minimize conductive loss and gain (minimize U-factor). Solar radiation has less impact in this climate.
2	For passive solar heating face most of the glass area south to maximize winter sun and add overhangs for shading in the summer.	For passive solar heating face most of the glass area south to maximize winter sun and add overhangs for shading in the summer.
3	Operable wallls and shaded outdoors.	Well insulated buildings to keep the heat gain from people, lights and equipment inside.
4	Double pane high performance glazing with Low-E on west, north and east but clear in south for passive solar gain.	Sunny wind protected outdoor spaces can extend living areas in cool months.
5	Good natural ventilation can eliminate air conditioning.	Low mass, well insulated, tightly sealed construction to provide rapid heat buildup in the morning.
6	Shading to prevent overheating during summer, use passive solar gain in winter.	High performance furnace
7	Low pitched roofs and wide overhangs	Steep pitched roof with vented attic over a well-insulated ceiling
8	Window overhangs or operable sunshades can eliminate AC	Extra insulation increases occupants comfort by keeping indoor temperature more uniform.
9	Sunny wind protected outdoor spaces can extend living areas in cool months.	Exterior wind shields can protect from cold winter winds.
10	Use high mass interior surfaces to store winter passive heat and summer night coolth.	Use high mass interior surfaces to store winter passive heat and summer night coolth.
11	Screened porches provide passive comfort cooling through ventilation in warm weather.	Vestibule entries to eliminate drafts in windy sites.
12	Light colored building materials to minimize conducted heat gain.	Heat recovery ventilator to ensure indoor air quality for super tight buildings.

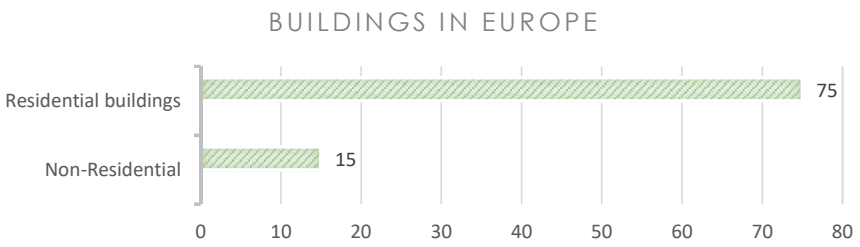
Warm Climate	Cold Climate
Operable and movable surfaces for shading (overhangs, awnings, louvers)	Wind shields
Perforated surfaces for shading and vantilation.	Heat recovery ventilator to ensure indoor air quality for super tight buildings.
Insulation	Insulation
Glazing with low-E	Glazing with very low U-value
Surfaces with high thermal capacity.	Surfaces with high thermal capacity.

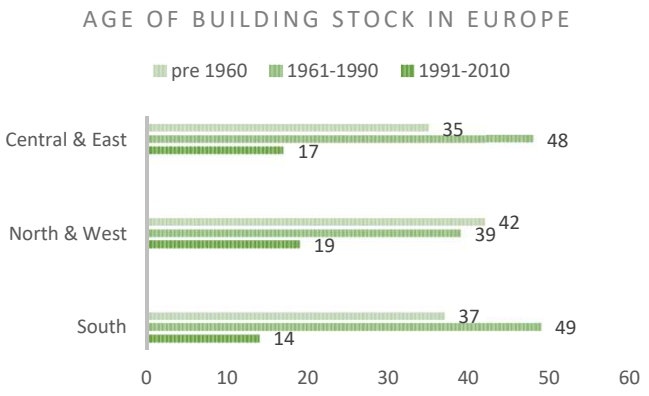
Passive functions	Active functions
Operable and movable surfaces for shading (overhangs, awnings, louvers).	Room for ventilation ducts of the heat recovery ventilator.
Perforated surfaces for shading and vantilation.	Room for other electrical instalations (PV etc.)
Insulation	
Glazing with low-E and low U-value.	
Surfaces with high thermal capacity.	
Wind shields	

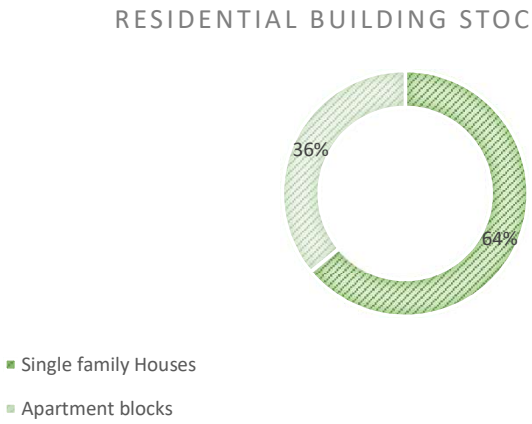


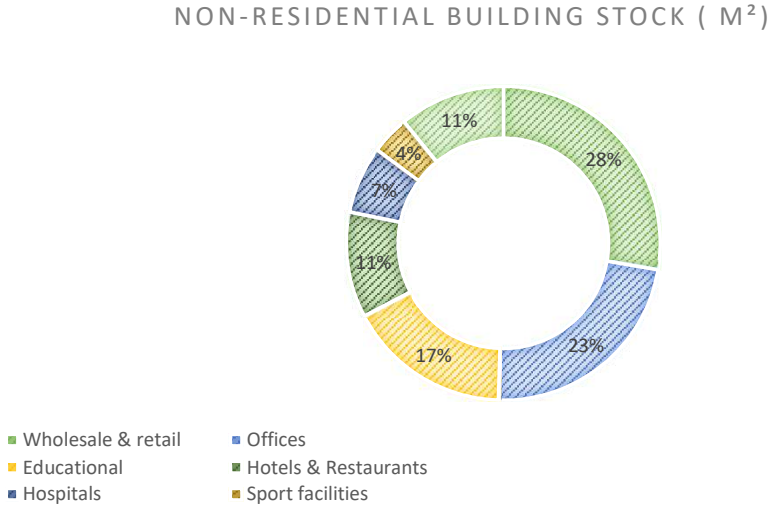


Part 2, segment 2









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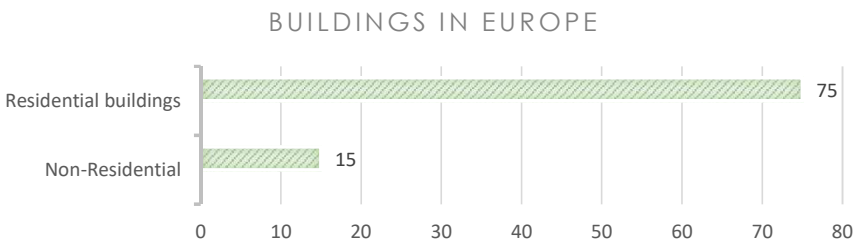
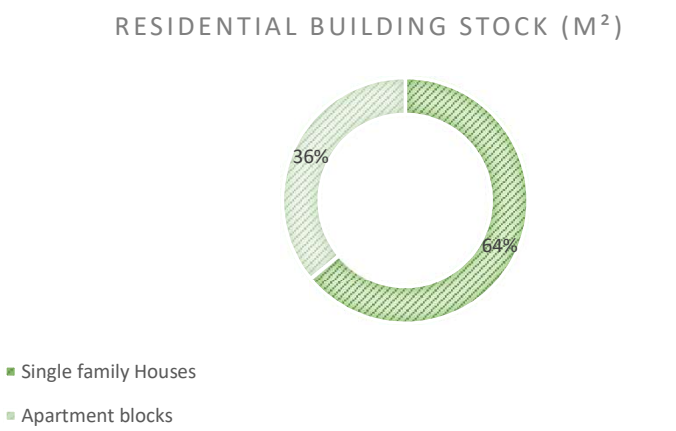
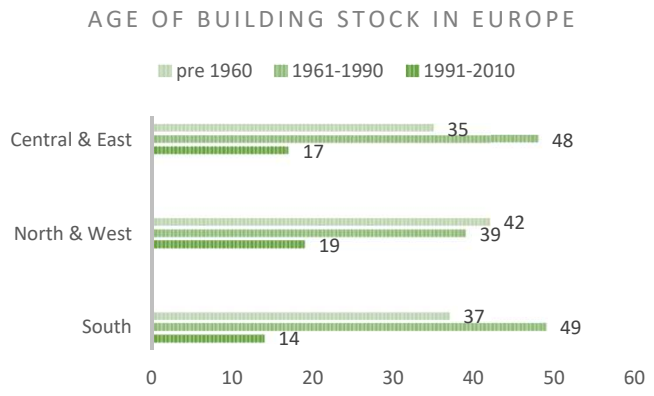
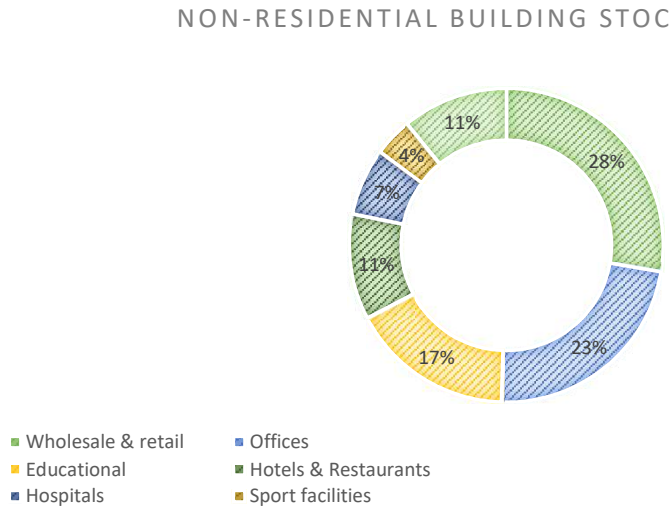


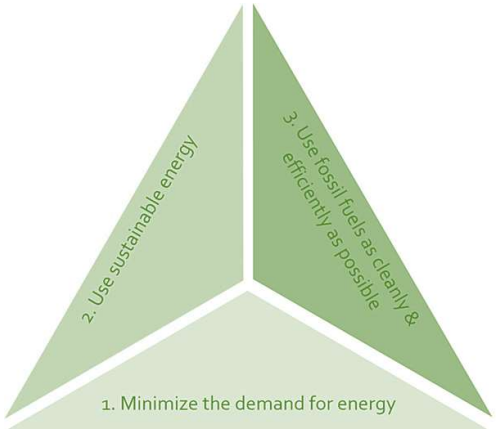




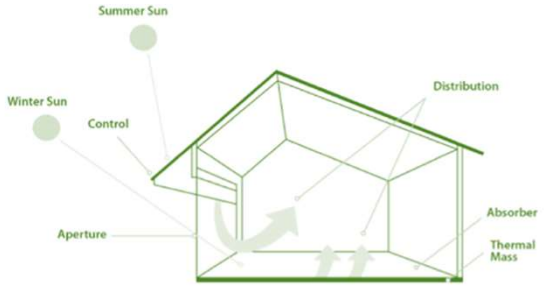


- Poor energy performance
- Low to middle-rise
- As flat a facade as possible
- Load-bearing structure in good condition
- Repetitive façade elements with similar floors and openings
- Built, based on industrialized construction methods

Part 2, segment 2

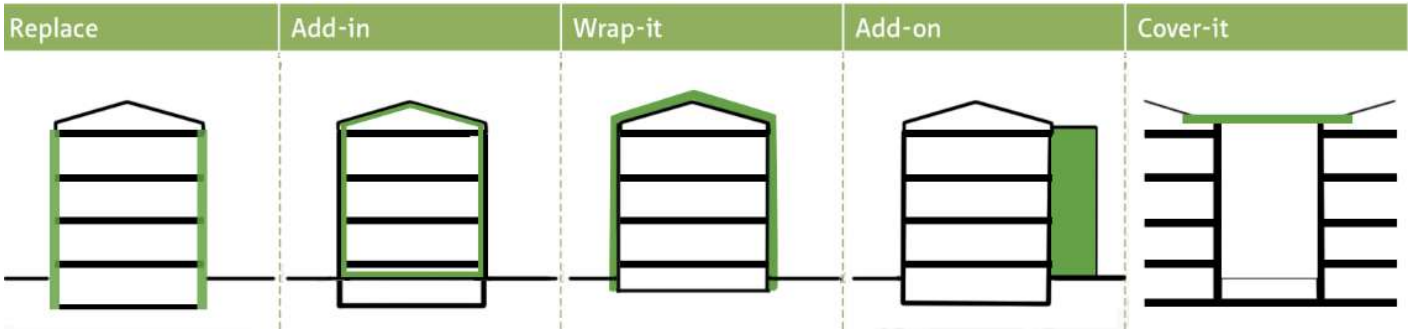


Principles of renovation



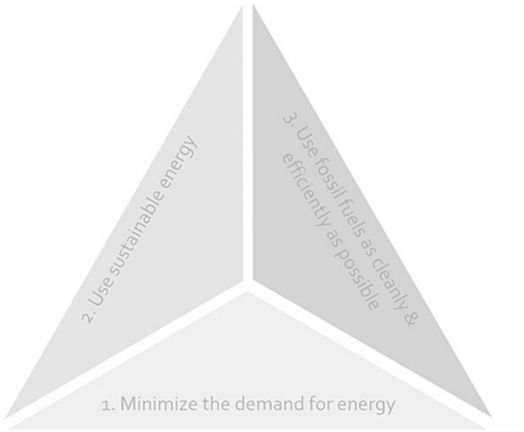
Passive

Active

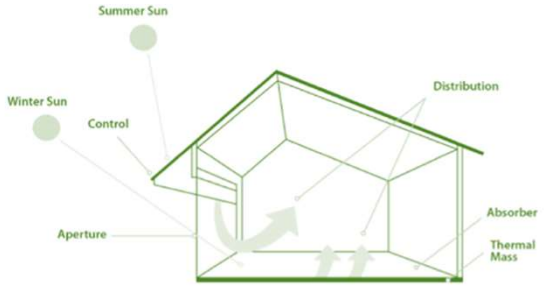


Renovation approaches

Part 2, segment 3

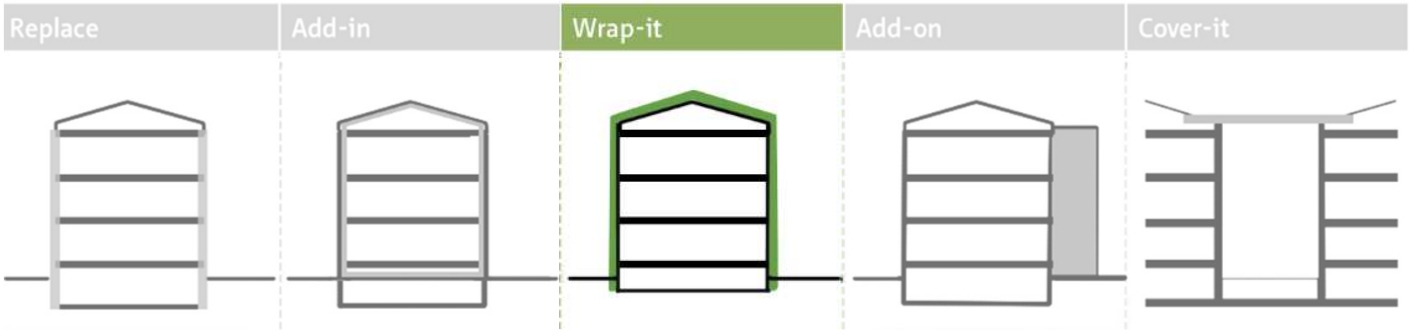


Principles of renovation



Passive

Active



Renovation approaches

Part 2, segment 3

State-of-the-Art renovation systems

MORE-CONNECT

BRESAER

2nd Skin Project

Part 2, segment 3

Evaluation of the renovation systems

MORE-CONNECT	Main characteristics	key points	limitations
Building type selection	Buildings with basic architecture characteristic and repetitive floors with as few differences as possible.	Easy to apply the same techniques in more than one building with small adjustments.	Limited choice of building type as it can be applied only to buildings with simple architectural structure.
Renovation Strategy	Wrap-it, Replace, Add on	Intervention from the exterior of the building, leads to less inconvenience for the occupants. (not for the replace)	Difficult to apply the prefab modules in the connections due to the unbalanced weight. Very precise measuring of the existing envelope.
Energy Reduction Measures	Mostly passive with the use of insulation. When actives measures are applied are heat pumps and PV panels	Eefficient in cold climates because of the insulation and the windows replacement.	Inefficient in warm climates due to the lack of sun protection methods.
System structure	Wooden prefab façade modules, produced off-site based on techniques that are applied also in new builds.	Sustainable material due the low embodied energy. Easy to handle without special tools.	Wood is a heavy material and large cross sections are needed to support built-in windows, ducts, etc.

BRESAER	Main characteristics	key points	limitations
Building type selection	Can be used in different diverse building types.	Application in most of the building types means a greater impact on the existing building stock	Not enough evidence to prove the applicability of the system (not real application)
Renovation Strategy	Wrap-it, Add on	Intervention only from the exterior of the building, leads to less disturbance for the occupants.	On-site installation of the system, resulting in time consuming, which increases costs.
Energy Reduction Measures	Incorporates most of the necessary techniques to reduce the energy consumption of a building. Focuses on new technologies.	Effective in all climates, as it has components for every weather case.	The ability to integrate multiple techniques makes system management difficult and requires additional management tools for monitoring.
System structure	Lightweight standardized system which is configurable, easy to assemble and able to support all the different envelope components.	Easy installation maintenance and replacement of the system due to standardization.	Limited literature to access as the project is still in progress,

2ND SKIN	Main characteristics	key points	limitations
Building type selection	mid-rise buildings with typical features (based on the current application example)	Has the potential to use these techniques in more buildings, with some adjustments.	Flatten the façade surface by demolishing protruding balconies
Renovation Strategy	Wrap-it, Replace	Intervention only from the exterior of the building, leads to less disturbance for the occupants.	Encounter the renovation of the building as a project, making it more difficult to apply the same approach to other buildings.
Energy Reduction Measures	Incorporates the most common techniques for a cold climate. (insulation, heat recovery ventilation, PV panels	Efficient in cold climates as it is focused on the Dutch climate.	Inefficient in warm climates due to the lack of sun protection methods.
System structure	Prefabricated, floor height, sandwich panels, featuring new windows and integrated services pipes, are attached to a substructure that consists of wooden posts connected to external existing façade.	The installment of all the ventilation pipes in one sandwich panel with insulation helps to minimize the connections between the pipes on site.	Each element has its own support system, the approach is closer to standard renovations.

Climate and Energy analysis
+
Building Stock of Europe
+
Renovation strategies
+
State-of-the-Art renovation techniques

Part 2, segment 3

PART 3

Structural

Generic design principles

Generic design principles

Structural

Climate

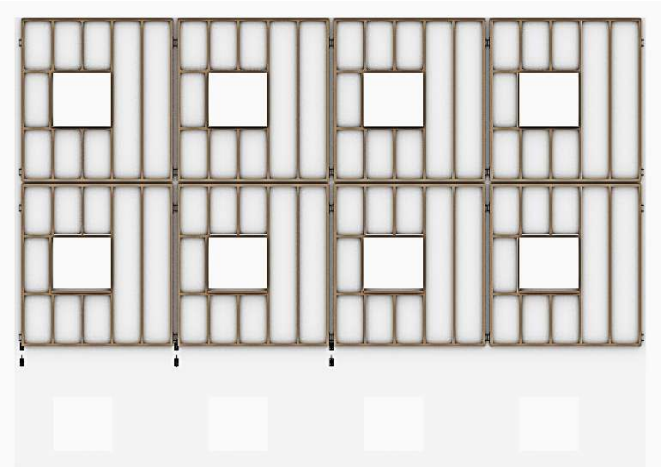
Generic design principles

Structural

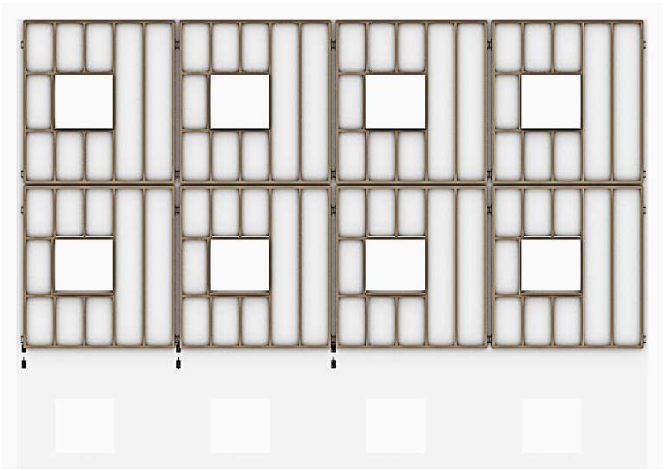
Climate

Attachment

STRUCTURAL FRAME PRINCIPLES



STRUCTURAL FRAME PRINCIPLES



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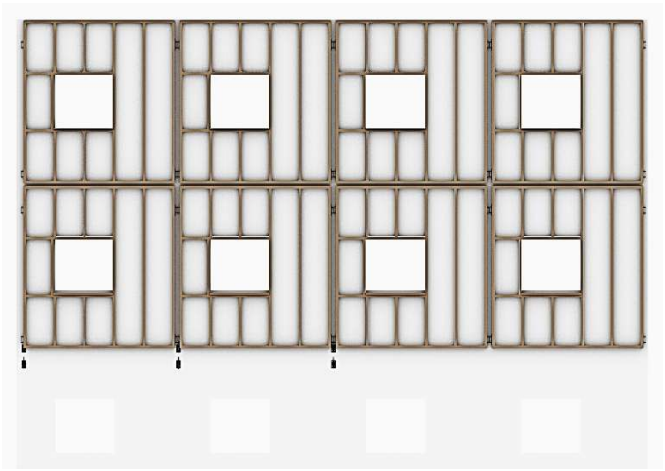


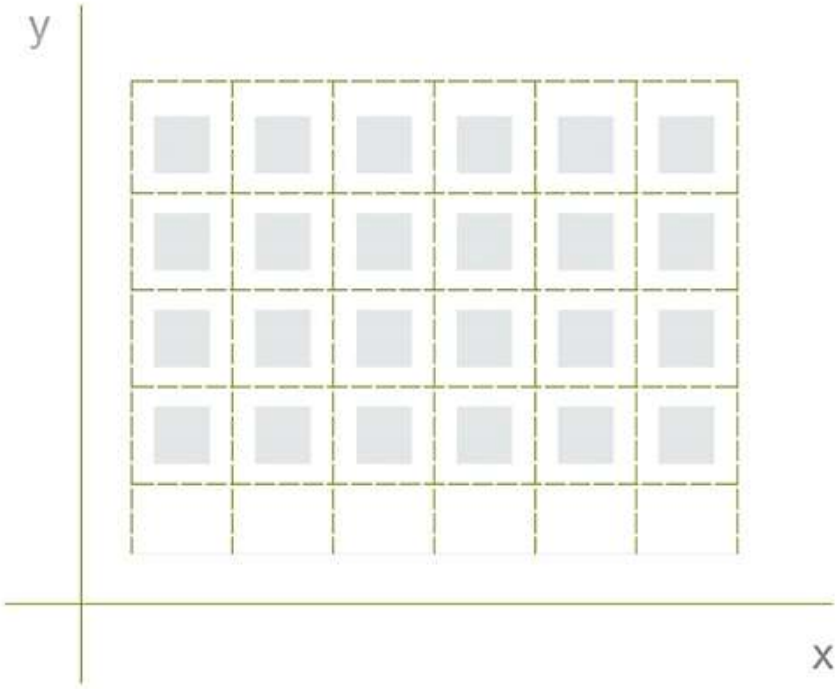
STRUCTURAL FRAME PRINCIPLES

opaque  transparent

STRUCTURAL FRAME PRINCIPLES

opaque

transparent



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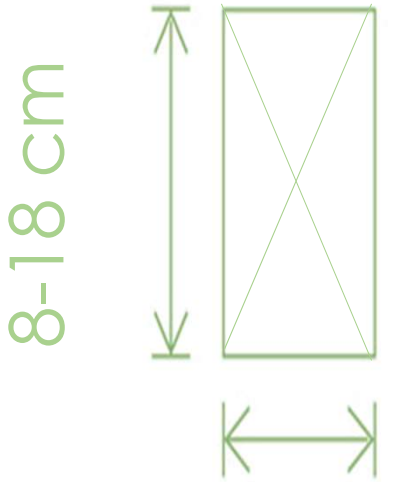

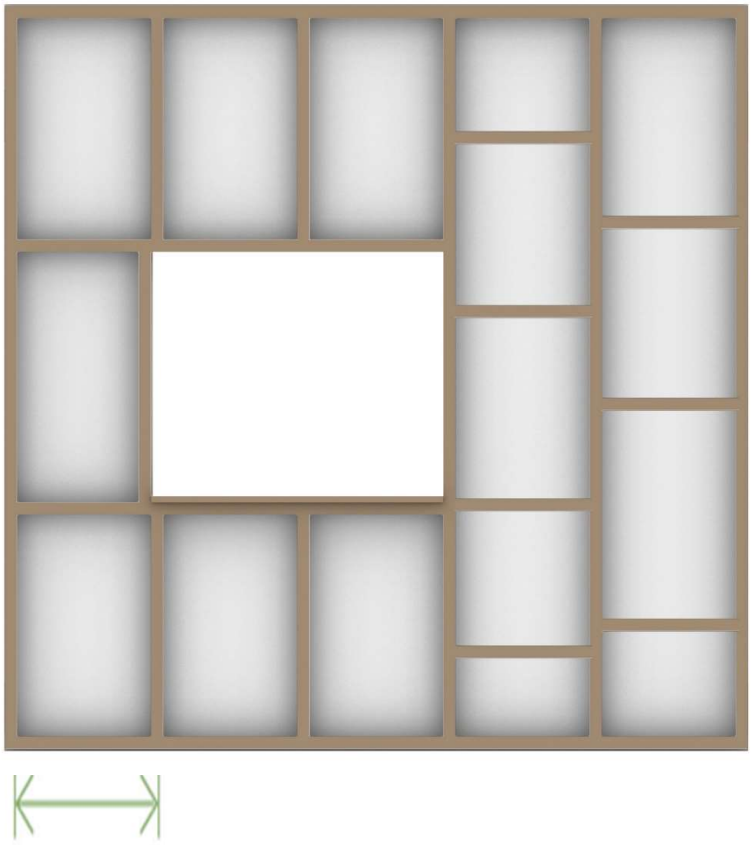

ENERGY REDUCTION ELEMENTS

	Description	Specifications	Dimensions	product	Link
Insulation Mineral wool	Is a rigid mineral wool insulation sheathing board that is non-combustible, water-repellent, fire-resistant and sound absorbent. Is an exterior non-structural insulation sheathing that provides a continuous layer of insulation around the commercial or residential building envelope.	Thermal conductivity: λ=0,040 (W/mK) U-value=0,3 for 13 cm thickness Non flammable Water and moisture-proof produced in sheets relatively low embodied energy 16,8 MJ/kg	(610 mm x 1219 mm) (914 mm x 1219 mm) (1219 mm x 1829 mm) (1219 mm x 2438 mm) Thicknesses (31.8 mm), (38.1 mm), (50.8 mm), (76.2 mm)	ROCKWOOL COMFORTBOARD ™ 80	www.rockwool.com/north-america/product-and-applications/product-groups/comfortboard-80/?selectedComfortboard%E2%84%A2%20Downloads%20specifications&Size
Plasterboard with water proof	Cement Board Outdoor is a solid, engineered wall and ceiling lining made from inorganic aggregated cement embedded in both front and back surfaces with coated glass fibre mesh. PERMAROCK® Cement Board Outdoor has all the properties required for external wall and ceiling linings that must withstand harsh weather conditions.	Thermal Conductivity λ=0.19W/mK R value= 0.035 m2 K/W	thickness 13 mm Width 1,20 m Length 3 m Weight 16 kg/m2	PERMAROCK® Cement Board	https://knauf.se/sites/default/files/2019-02/Knauf-Tech-Data-Permarock-Board-Outdoor-Oct-2014.pdf
windows (mild climate)	Aluminum window frames with thermal insulation. The Tilt & Turn system combines outstanding thermal insulation performances along with high construction flexibility combined with different glazing thermal properties according to the needs.	Double glazing 20 kg/m2 Double glazing 4-6-4 emissivity ε=0,89 U-value=3,3 (W/m2 K) OR Double glazing 20 kg/m2 with low E 4-6-4 emissivity ε=<0,05 U-value=2,5 (W/m2 K)	Adjusted in different dimensions according to the needs	Hinged insulated system SMARTIA S67	https://www.alumill.com/international/specifiens/products/windows-doors/hinged-insulated-system-smartia-s67
windows (cold climate)	Aluminum window frames with thermal insulation. The Tilt & Turn system combines outstanding thermal insulation performances along with high construction flexibility combined with different glazing thermal properties according to the needs.	Double glazing 20 kg/m2 with low E 4-6-4 emissivity ε=<0,05 U-value=2,5 (W/m2 K) OR Double glazing 20 kg/m2 with low E+ argon gas 4-12-4 emissivity = <0,05 U-value= 1,3 (W/m2K)	Adjusted in different dimensions according to the needs	Hinged insulated system SMARTIA S67	https://www.alumill.com/international/specifiens/products/windows-doors/hinged-insulated-system-smartia-s67
windows (extreme cold climate)	Aluminum window frames with thermal insulation. The Tilt & Turn system combines outstanding thermal insulation performances along with high construction flexibility combined with different glazing thermal properties according to the needs.	triple glazing with 2 low E 4-6-4-6-4 emissivity = <0,05 U-value= 1,6 (W/m2K) OR triple glazing with 2 low E+ argon gas 4-6-4-6-4 emissivity = <0,05 U-value= 1,2 (W/m2K)	Adjusted in different dimensions according to the needs	Hinged insulated system SMARTIA S67	https://www.alumill.com/international/specifiens/products/windows-doors/hinged-insulated-system-smartia-s67
Blinds for Sunshade	Quick and easy installation due to lightweight blinds. Sun shading is supplied pre-assembled, ready for installation and already rolled up on the drive shaft. Automatic setting of the top end position. An integrated sliding guide in the curtain helps to eliminate the need of mount piping in the guide rails. High degree of prefabrication.	Reduces solar heat gain in buildings. High level of transparency around 25 %. The user retains connected with the exterior environment.	Adjusted in different dimensions according to the area that needs to be shaded.	Schüco Sun Shading System CSB	www.schueco.com/de-en/fabricators/products/sun-shading-systems/roll-lamella-systems/cabinfrontoffw50-60#accordion-310926
Louvers as Sunshade	Louver protects windows and entrances from the sun, either as individual units or as a series of interlocking units covering the whole wall. The louver also efficiently prevents glare and distracting reflections from outside, thus improving working conditions, work safety, and enhancing overall comfort of the interior. It is very low-maintenance due to its robust structure.	Aluminium	Adjusted in different dimensions according to the area that needs to be shaded.	Alupro	https://www.alupro.com/en/facade-solutions/louvers/wing-louver/
Façade solar panel	High-performance photovoltaic modules for the building façade using concealed mounting clasps. In addition, this system offers extensive design possibilities and is in widespread use in commercial, public, and private buildings.	Rated power [W] P= 105.00 Rated voltage [V] V= 80.80	standard dimension 120x60 cm color variation	NICE CIGS modules (Copper Indium Gallium Di-Selenide)	https://nice-solarenergy.com/en/cigs-modules.html

Part 3, function2

ENERGY REDUCTION PRINCIPLES

Insulation

Windows

Plasterboard

Roller blinds

Louvers

PV panel

ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY
REDUCTION ELEMENTS

calculations

simulations

Part 3, function2

ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY
REDUCTION ELEMENTS

calculations

simulations

Heat transmission losses

Qheating=UxAxHDD x24x3600 [J]

Qcooling = Qtransmission + Qsun = UxAxCDD x 24 x 3600
+ qsun x g x Awindow x t [J]

ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY REDUCTION ELEMENTS

calculations

simulations

ubakus

Heat transmission losses

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simulations

ubakus

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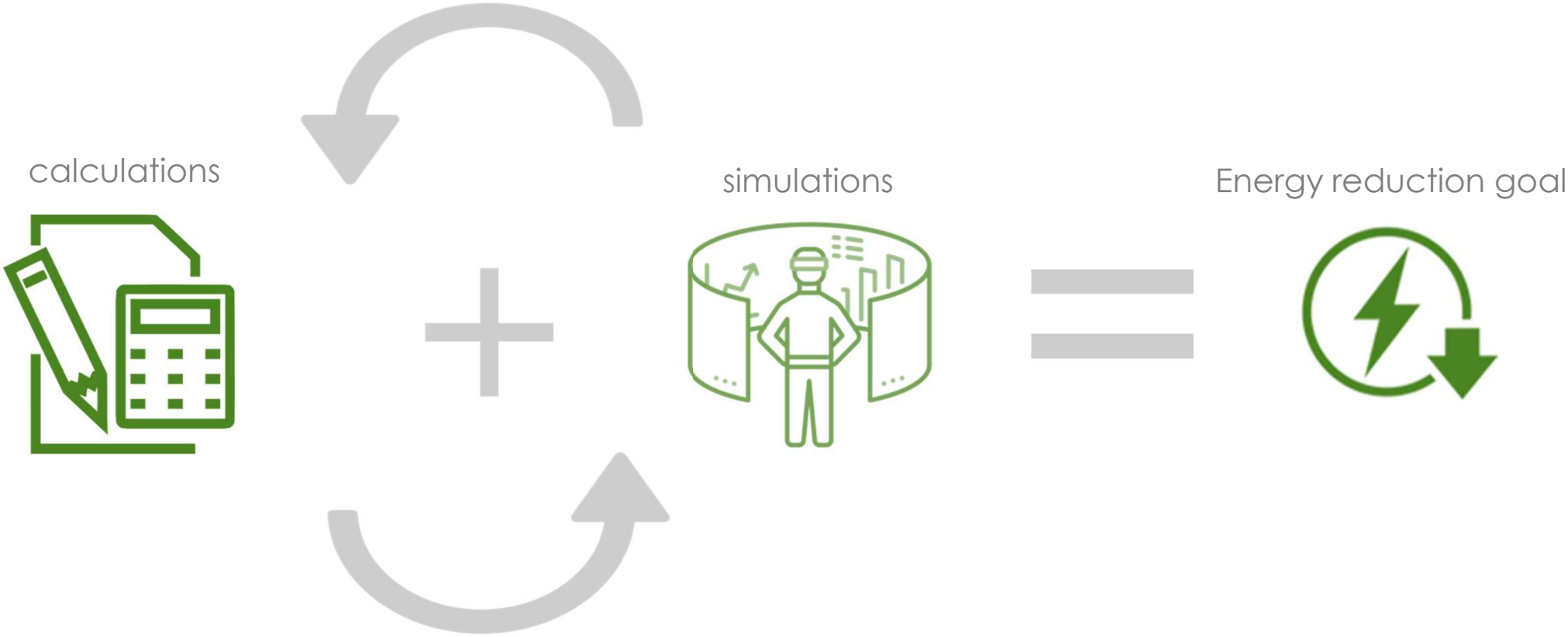
Part 3, function2

ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY
REDUCTION ELEMENTS



Part 3, function2

ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY
REDUCTION ELEMENTS

ARUP

PDA

PVGIS

calculations

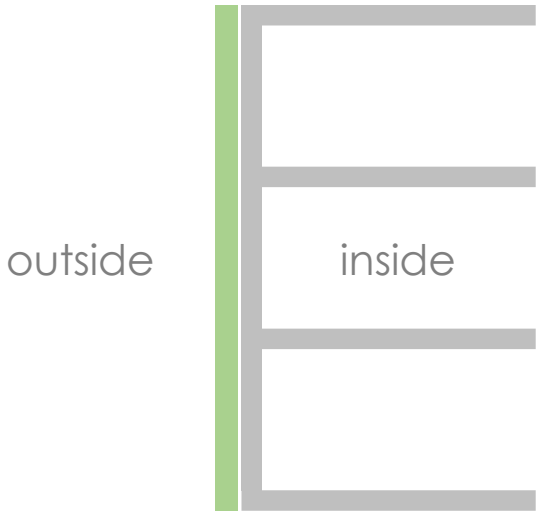
simulations

Energy reduction goal

Part 3, function2

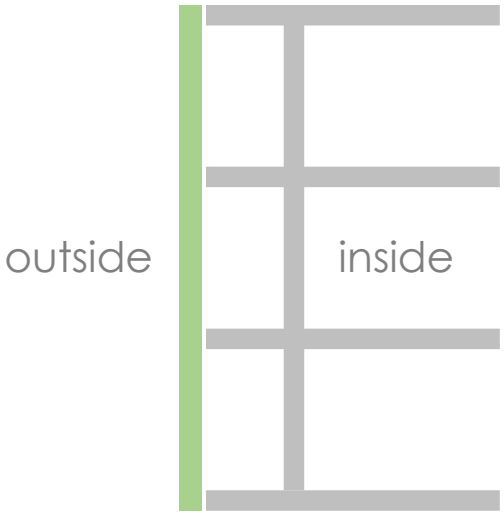
ENERGY REDUCTION PRINCIPLES

EVALUATION OF THE ENERGY
REDUCTION ELEMENTS



Flat wall Facade

$Q_{new}=Q_{system}$



Balcony

$Q_{new}=Q_{existing} \times a$

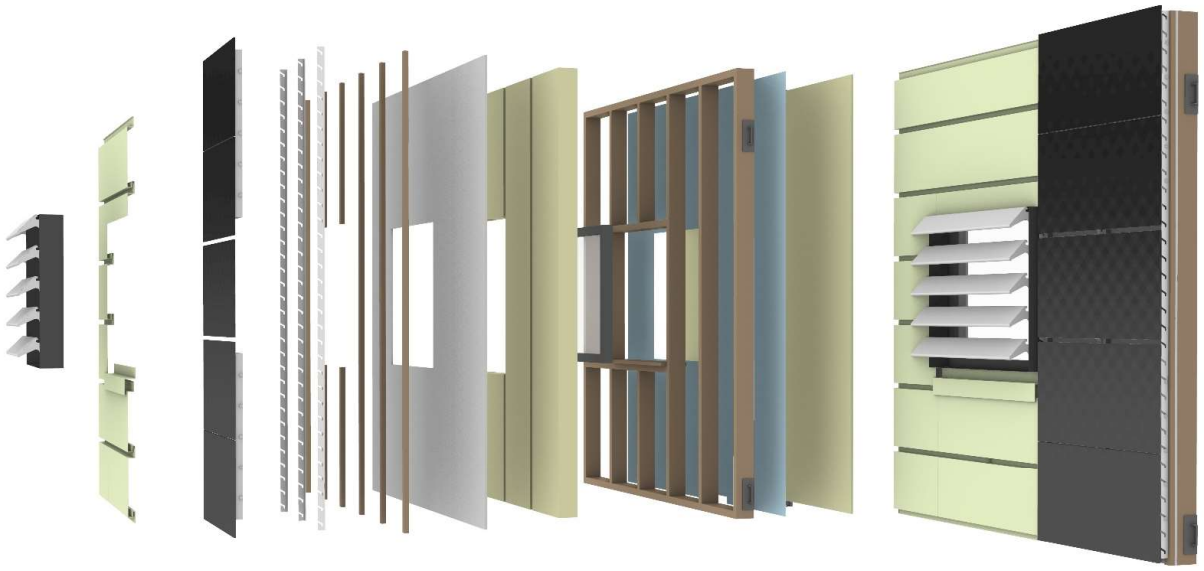
$a= Ue\ Ae/ (Ue\ Ae + Ui\ Ai)$

[100x (Current Demand-New demand)/ Current demand] %

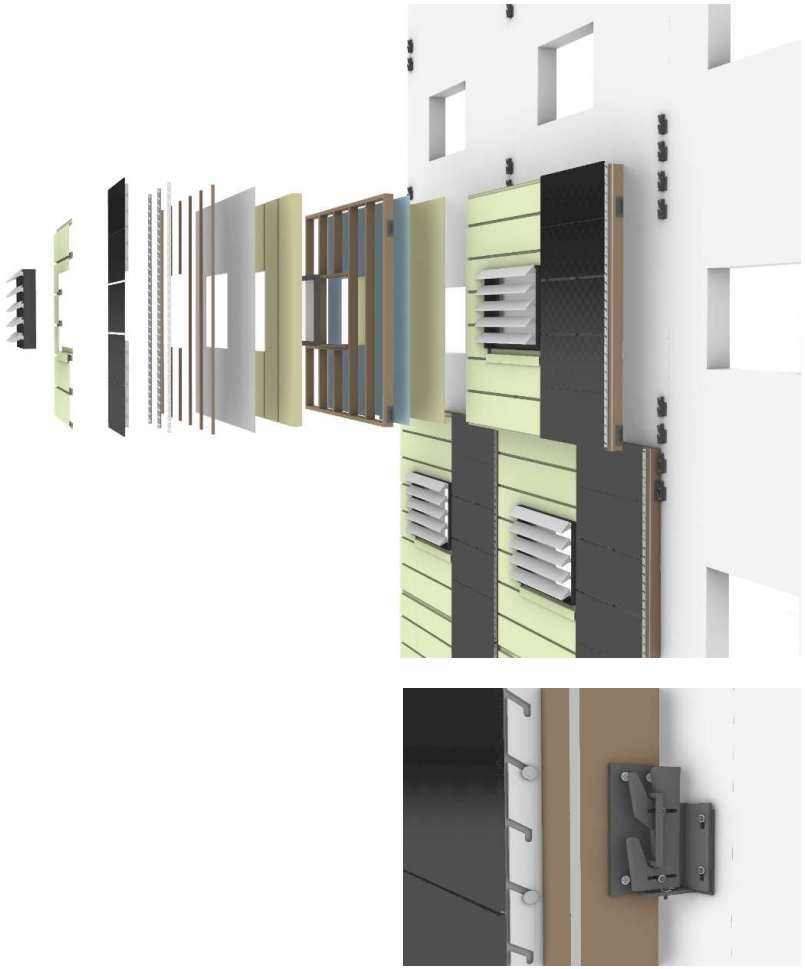
Part 3, function2

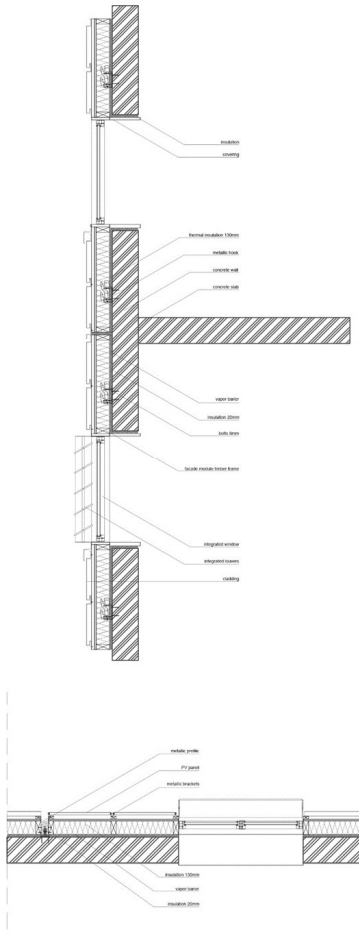
ATTACHMENT SYSTEM PRINCIPLES

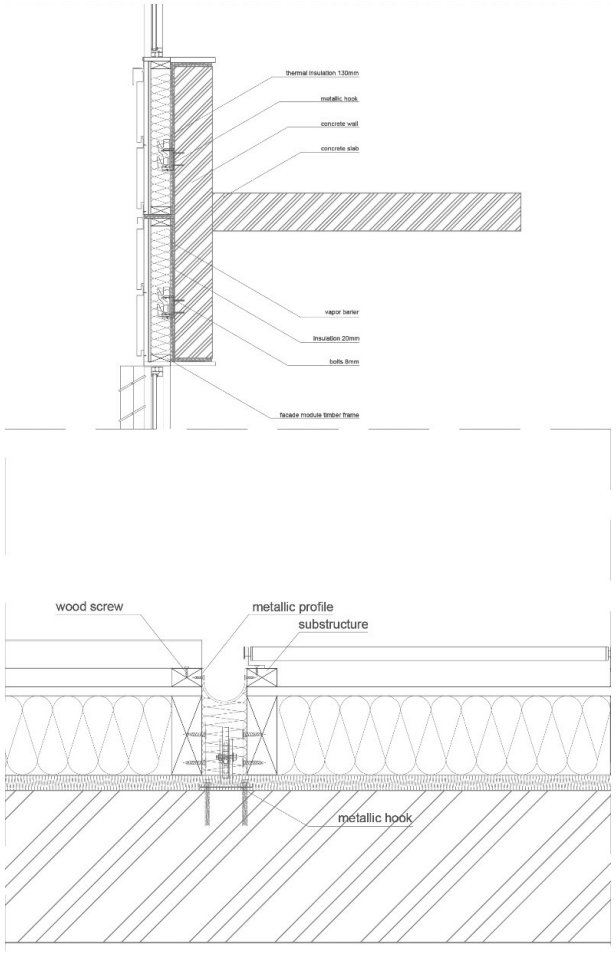
Façade Renovation System Module



Application in concrete wall

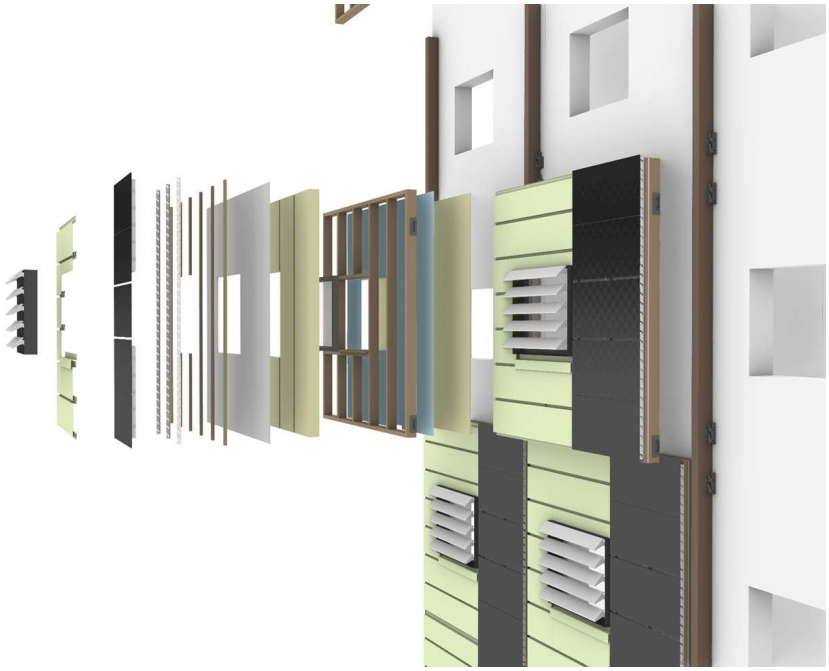


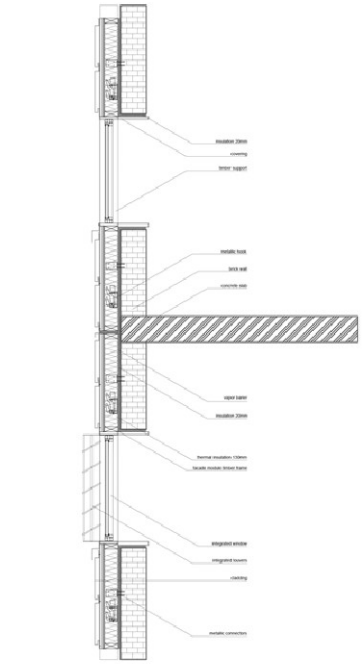


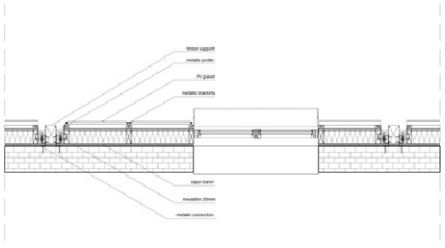


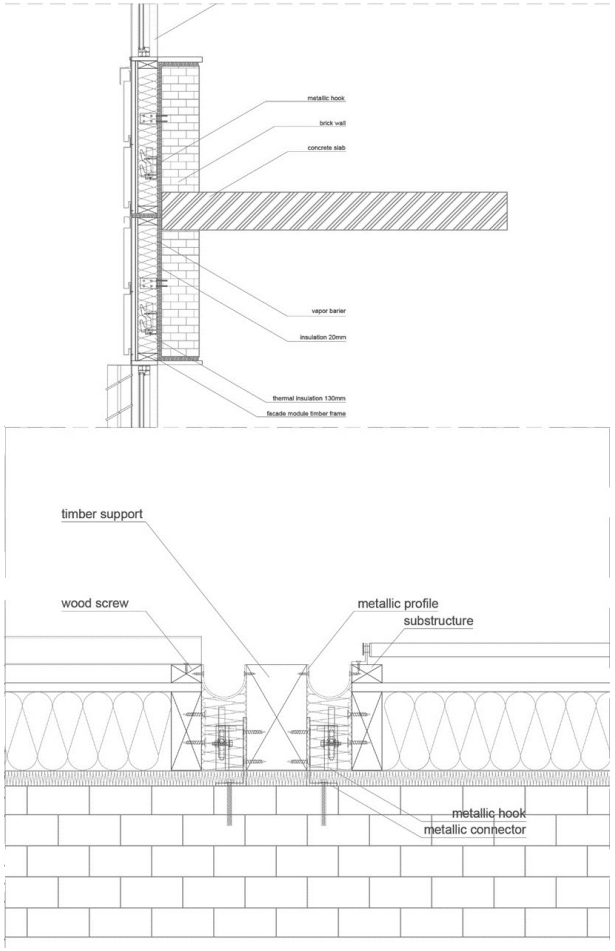
Part 3, function3

Application in brick wall

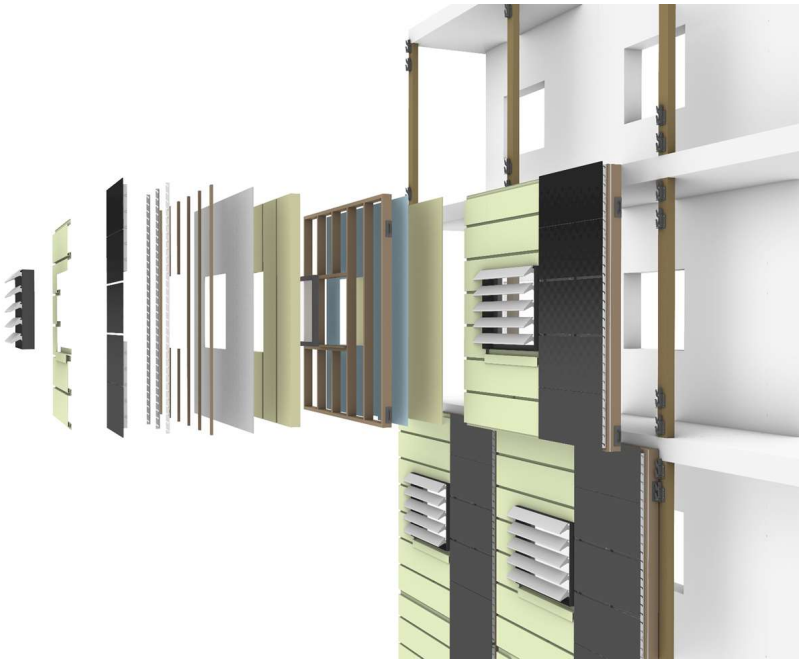


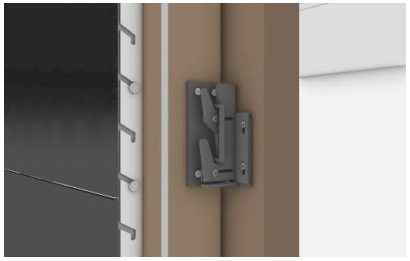


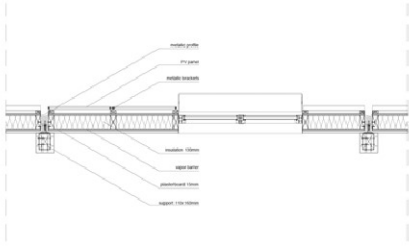


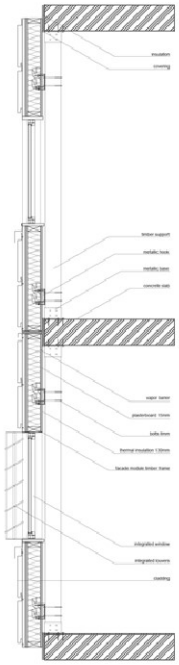


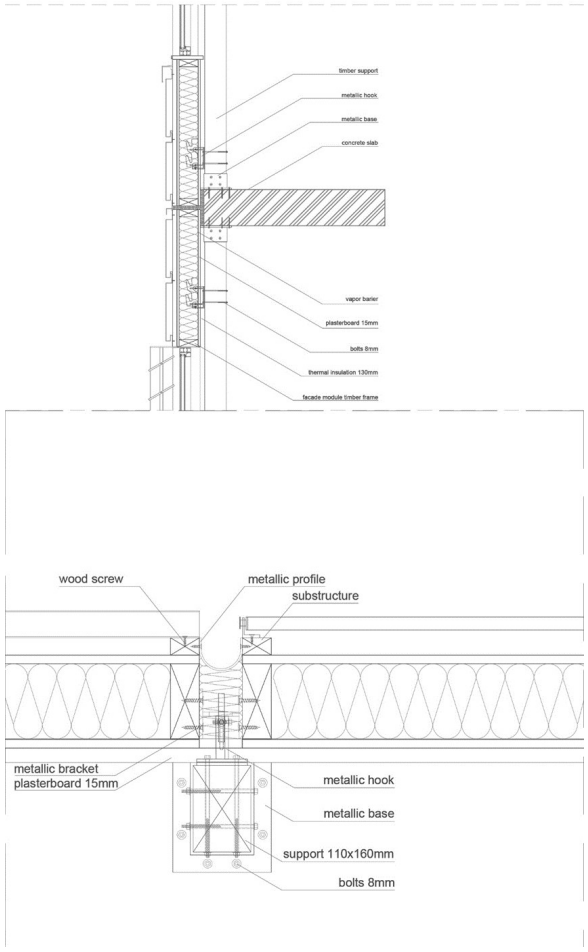
Application in balcony







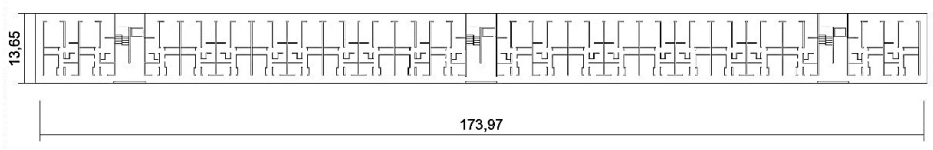




Part 3, function3

PART 4

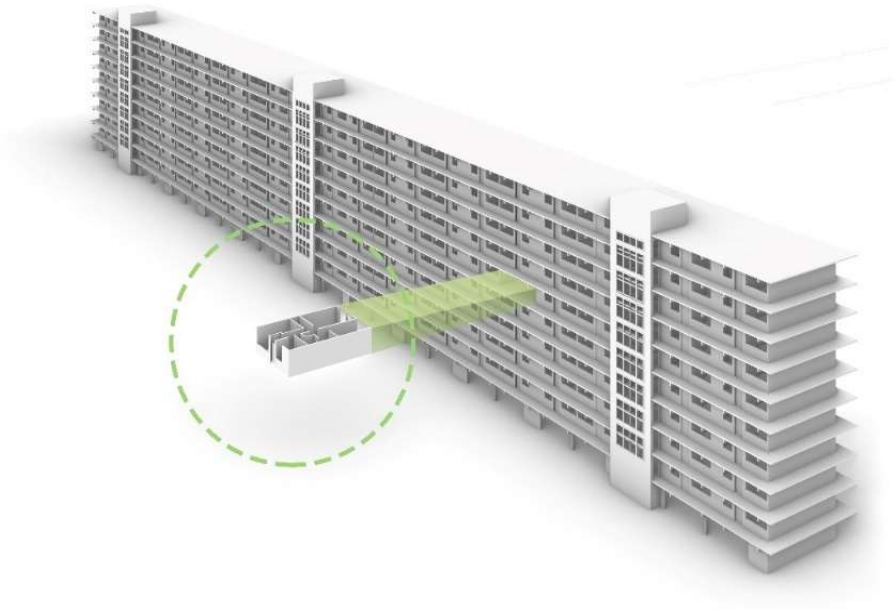
Amsterdam



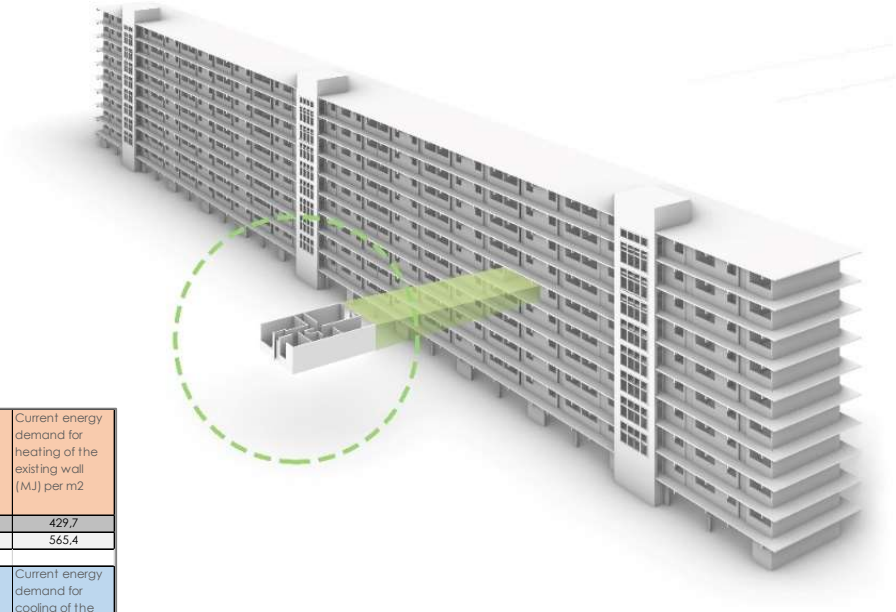
Netherlands, Amsterdam Location: Hoogoord, Year of Construction: 1968

Part 4, case study 1

Amsterdam

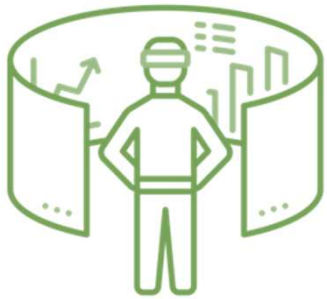


Amsterdam

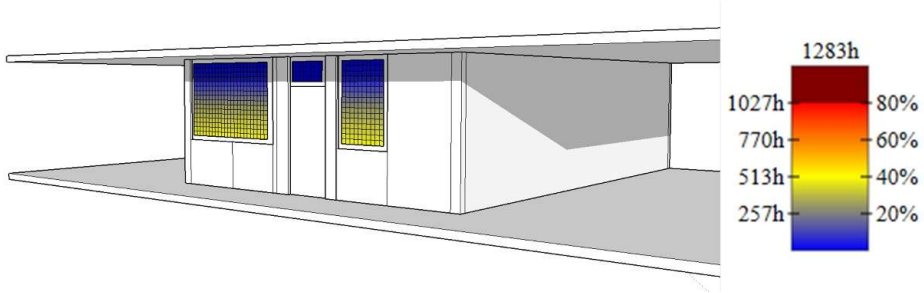


calculations

simulations



Amsterdam HDD: 2618 (base temperature 18°C)	Existing wall U-value W/(m²K)	Current energy demand for heating of the existing wall (MJ) per m2
opaque surface	1,9	429,7
transparent surface	2,5	565,4
Amsterdam CDD: 199 (base temperature 18°C)	Existing construction U-value W/(m²K)	Current energy demand for cooling of the existing wall (MJ) per m2
opaque surface	1,9	32,6
transparent surface	2,5	42,9

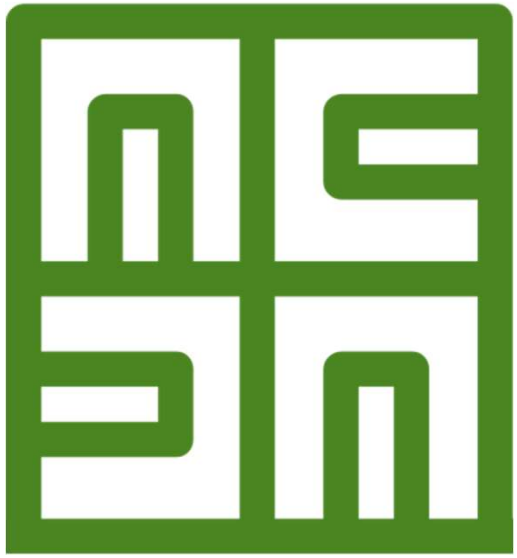


Energy performance of the existing façade for a typical apartment	total surface area of a typical apartment (m2)		Heat transmitions per square meter during the heating season. (MJ)	Heat transmitions per square meter during the cooling season. (MJ)	Current energy demand for heating of a typical apartment due to the heat ransmisions.(MJ)	Current energy demand for cooling of a typical apartment due to the heat transmitions.(MJ)	Incoming solar energy for a typical apartment that ifluenves the cooling demand.(MJ)	Average total energy demand per typical apartment (MJ)
AMSTERDAM WWR=0,54								
opaque surface	24		429,7	32,6	10.313	782,4		
transparent surface	13		565,4	42,9	7.350	557,7		10.404
total					17.663	1.340	1.806	

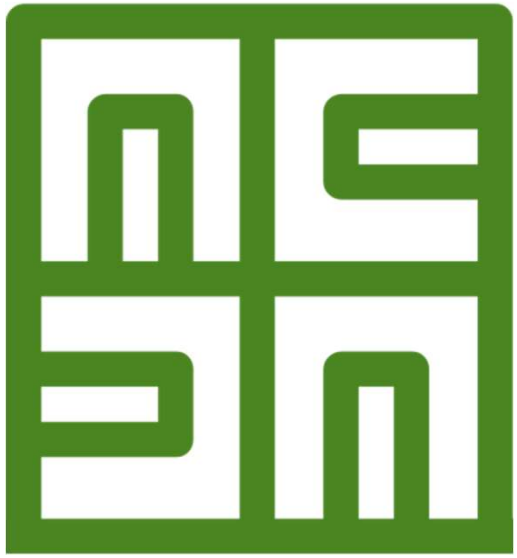
AMSTREDAM simulation inputs		Start time	6:00	Start date	1 June
		End time	20:00	End date	30 August

Part 4, case study 1

Design Approach

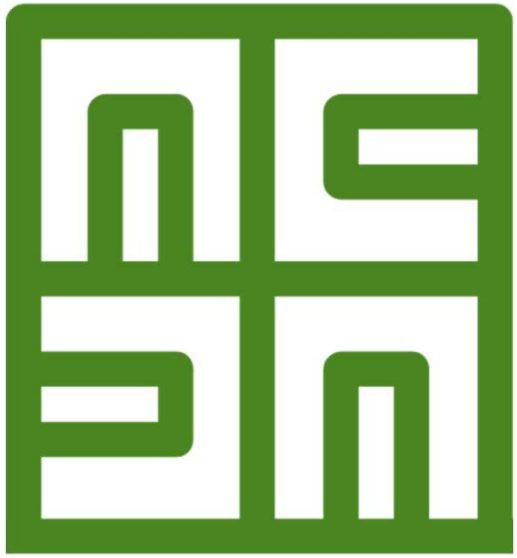


Design Approach



Function

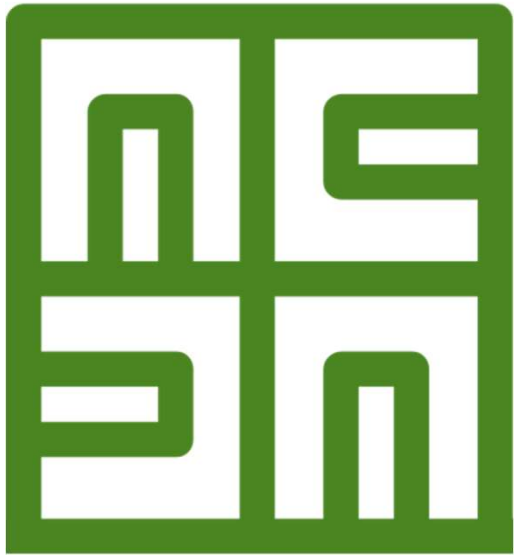
Design Approach



Function

Characteristics

Design Approach



Function

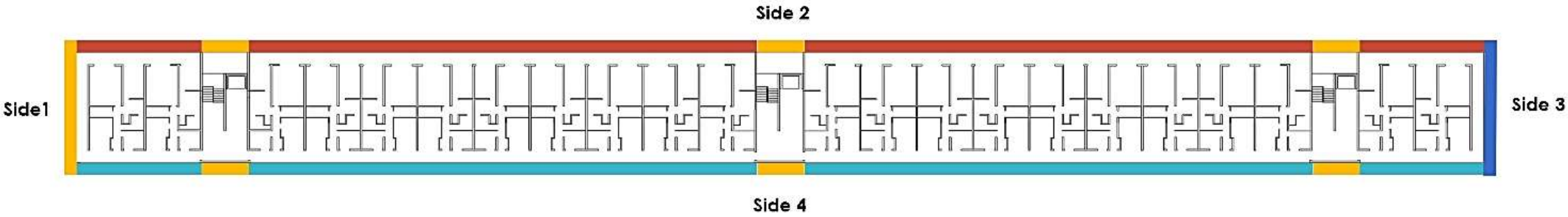
Characteristics

Orientation

Amsterdam

Functions of the building envelope

- Common external hallway on sides (1), (3), (4)
- Private balconies on side (2)
- Vertical common circulation on sides (2) and (4)



Amsterdam

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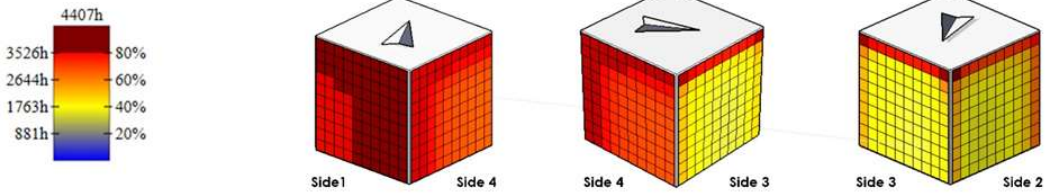

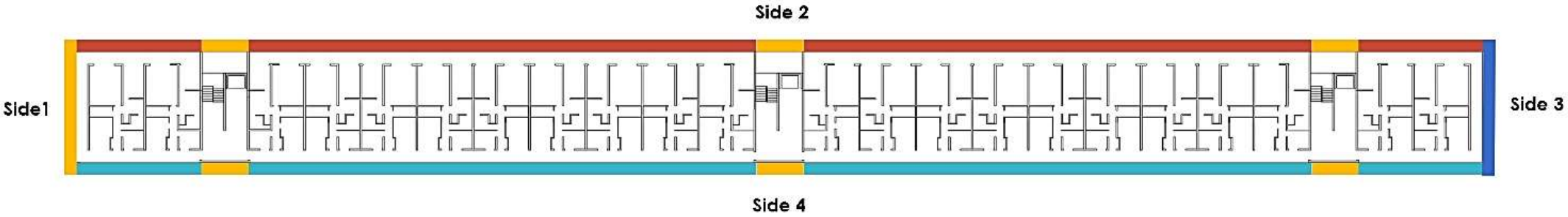

Amsterdam

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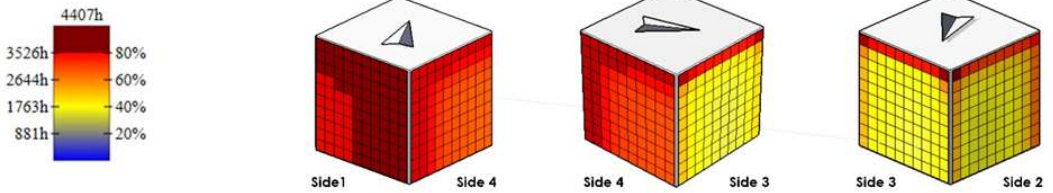
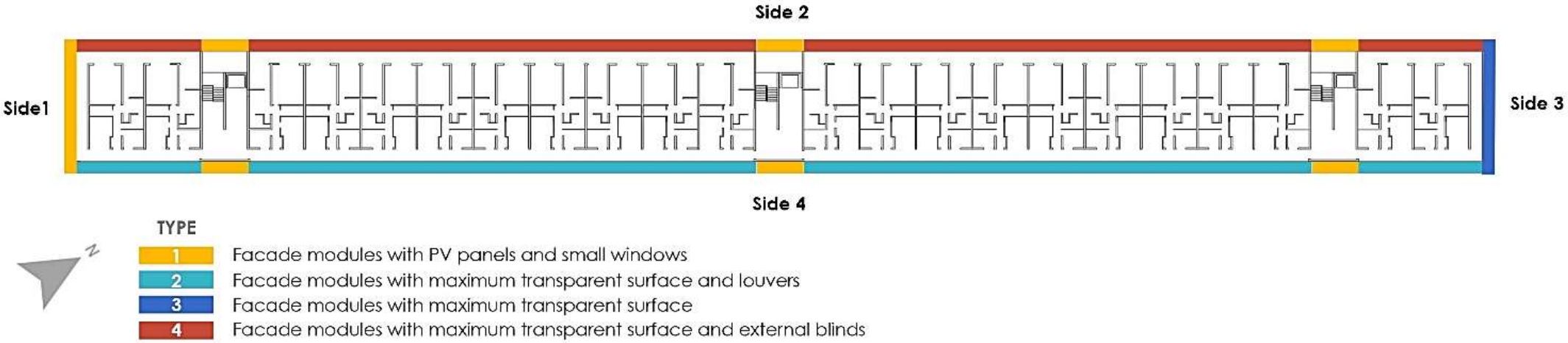
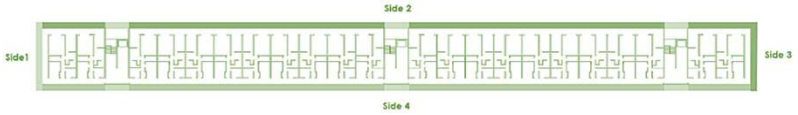




Side 1

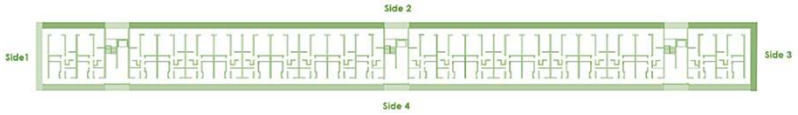


Characteristics:

Balconies without openings and flat wall façade, good orientation for energy generations from PV panels

Determination of the grid for the support system and the façade system modules on side (1).

Side 1



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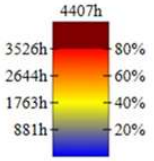
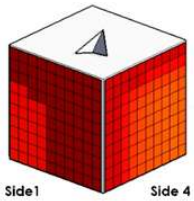
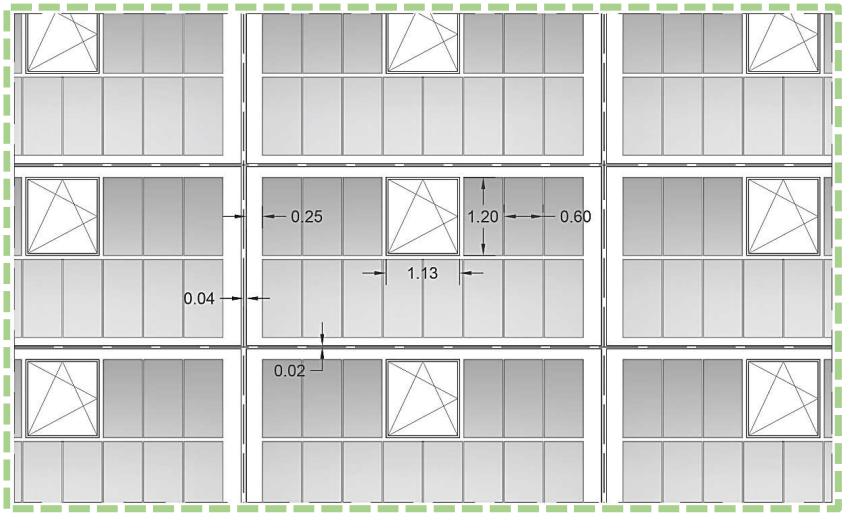


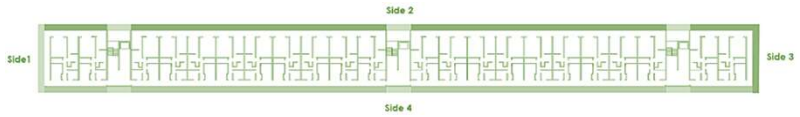


Sun-Hours analysis)



Part of the façade system on side (1), module type (1)

Side 1



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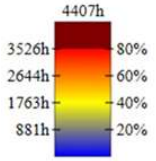
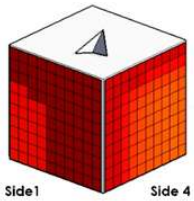
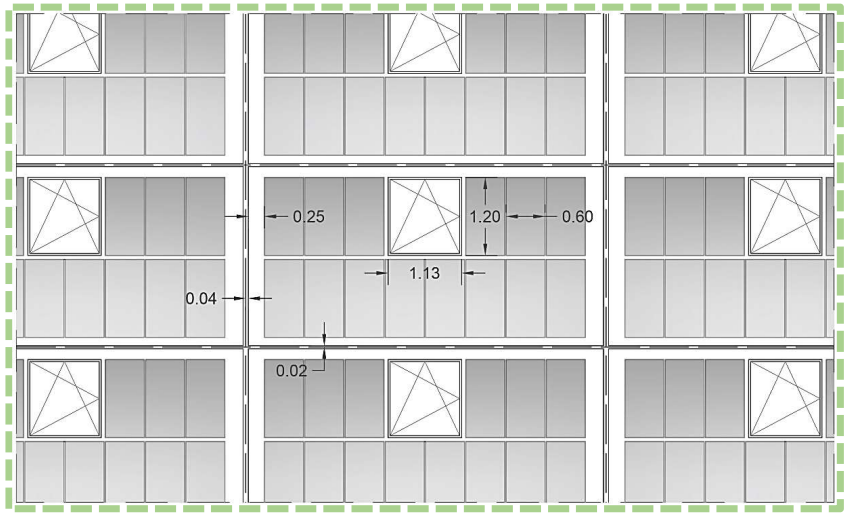




Sun-Hours analysis

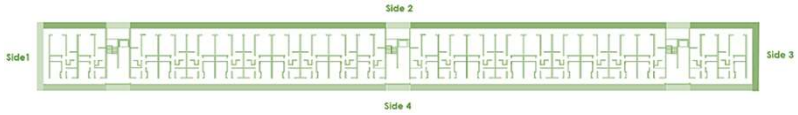


Part of the façade system on side (1), module type (1)

Month	SIDE 1 Monthly electricity production (kWh)/PV	SIDE 2 Monthly electricity production (kWh)/PV	SIDE 4 Monthly electricity production (kWh)/PV
January	3,2	0,7	4,6
February	4,2	1,1	5,4
March	8,4	2,5	9,6
April	11,2	4,4	11,9
May	11	5,8	11
June	11,3	6,8	10,1
July	11,3	6,4	10,4
August	10,4	4,9	10,5
September	8,7	2,9	9,9
October	6,3	1,5	7,8
November	3,5	0,7	5
December	2,6	0,5	4
Average	7,7	3,2	8,4

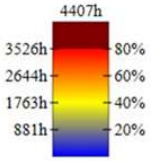
Electricity Production of a PV panel according to the building side

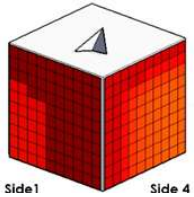
Side 2 and 4

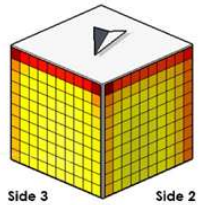


Characteristics:

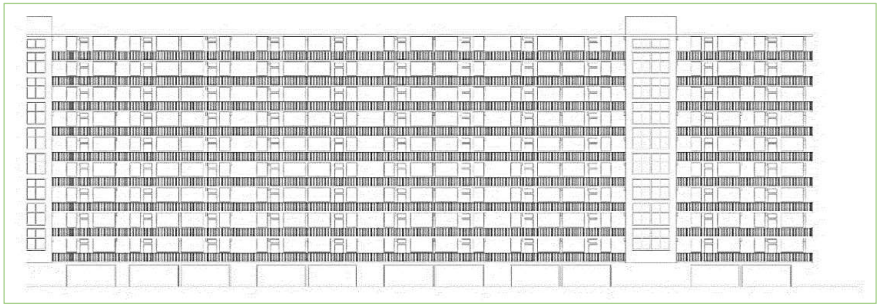
Balconies with openings and flat wall façade, good orientation for energy generations from PV panels



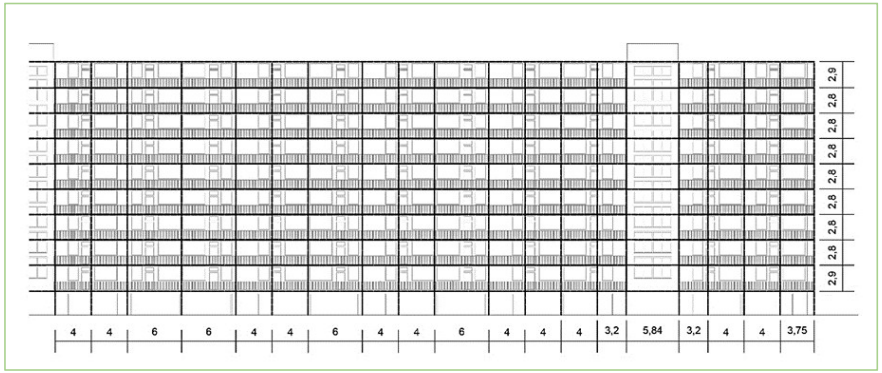




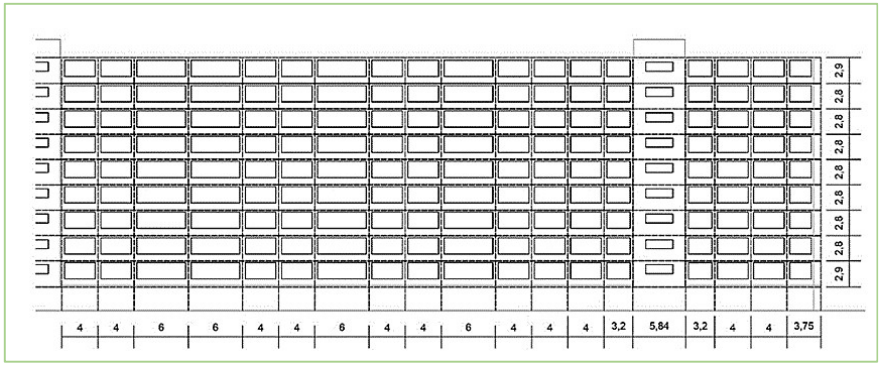
Current facade



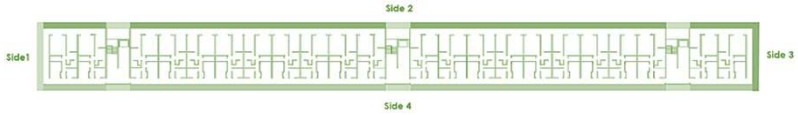
Support position



Façade modules

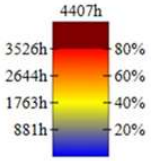


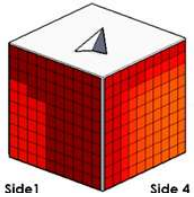
Side 2 and 4

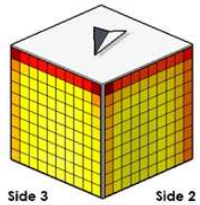


Characteristics:

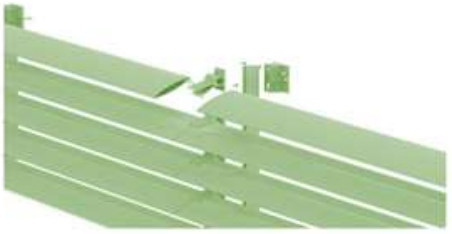
Balconies with openings and flat wall façade, good orientation for energy generations from PV panels



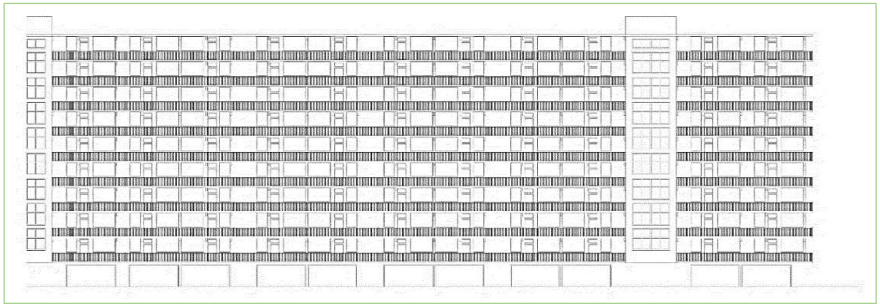


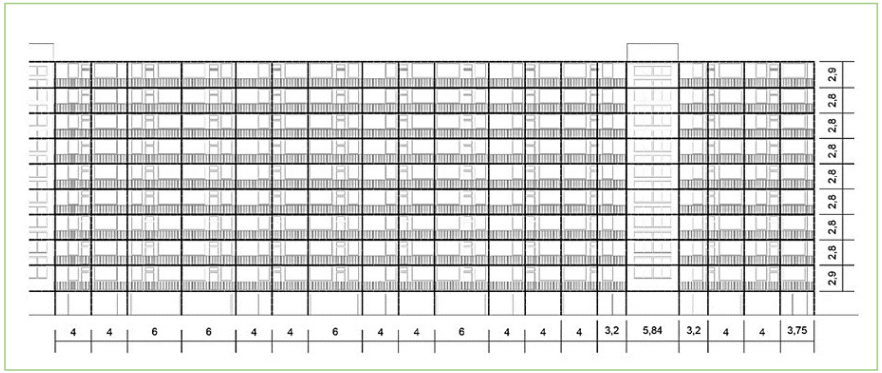


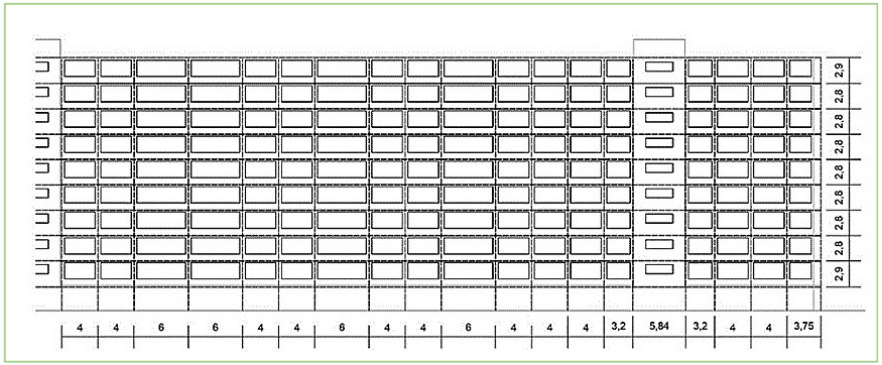
Roller blinds



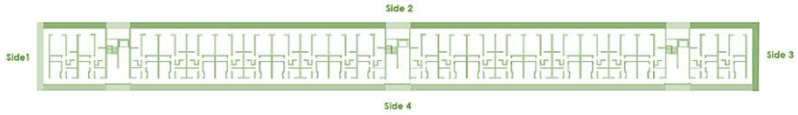
Louvers



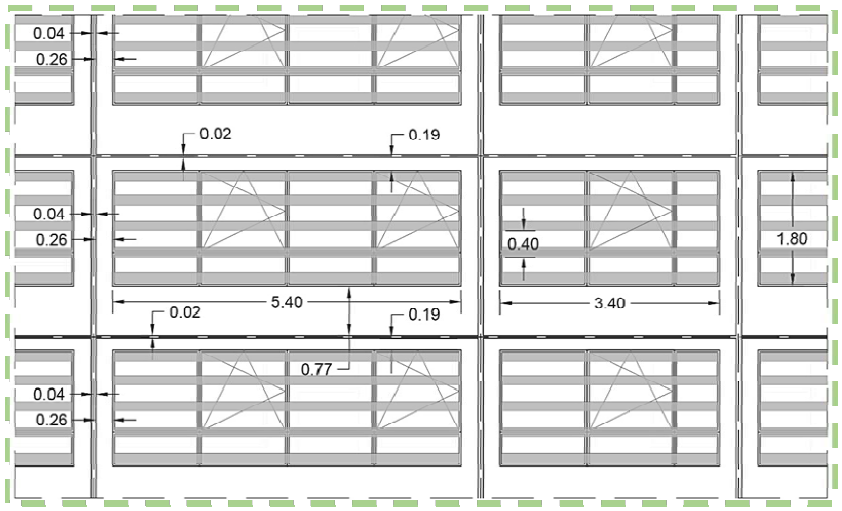




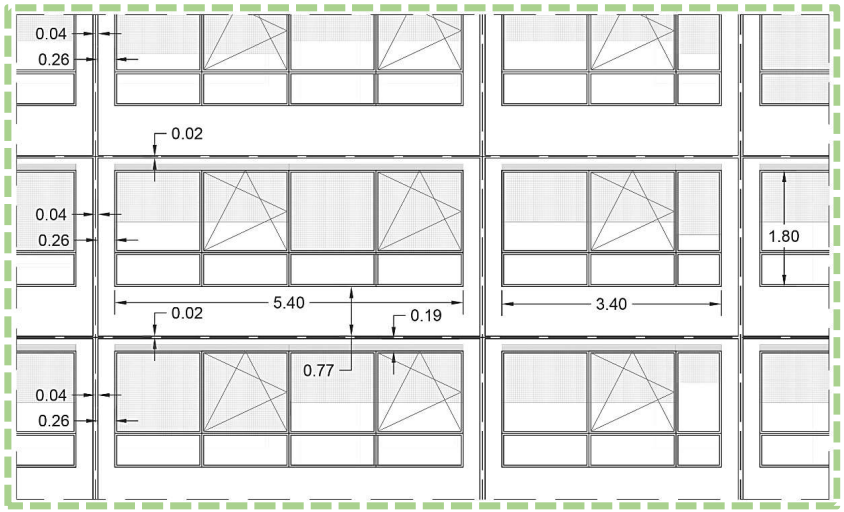
Side 2 and 4



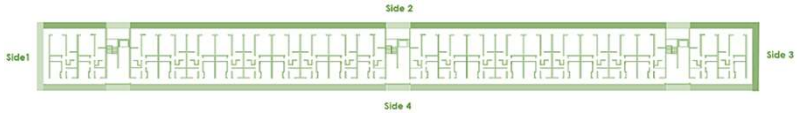
part of the façade system on side (4,) modular type (2)

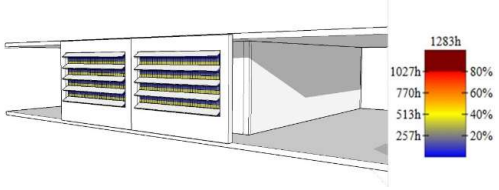


part of the façade system on side (2) modular type (4)



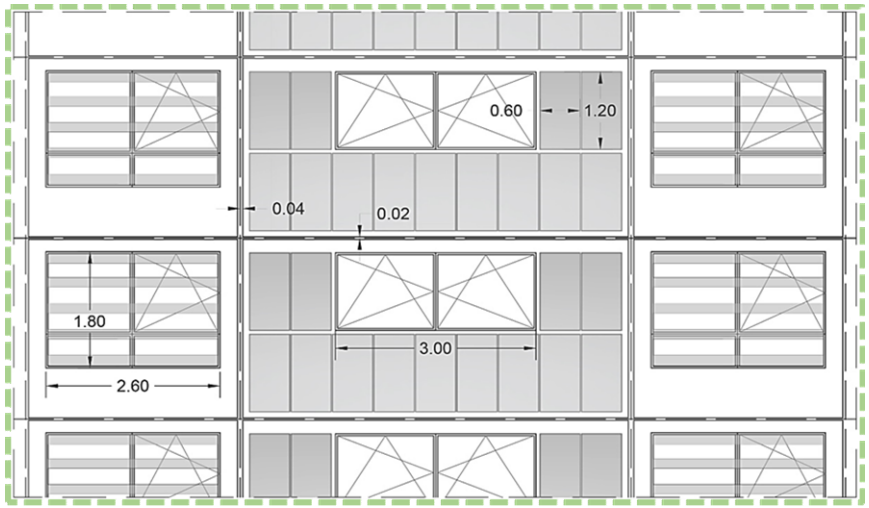
Side 2 and 4





AMSTREDAM	Start time	6:00	Start date	1 June
simulation inputs	End time	20:00	End date	30 August

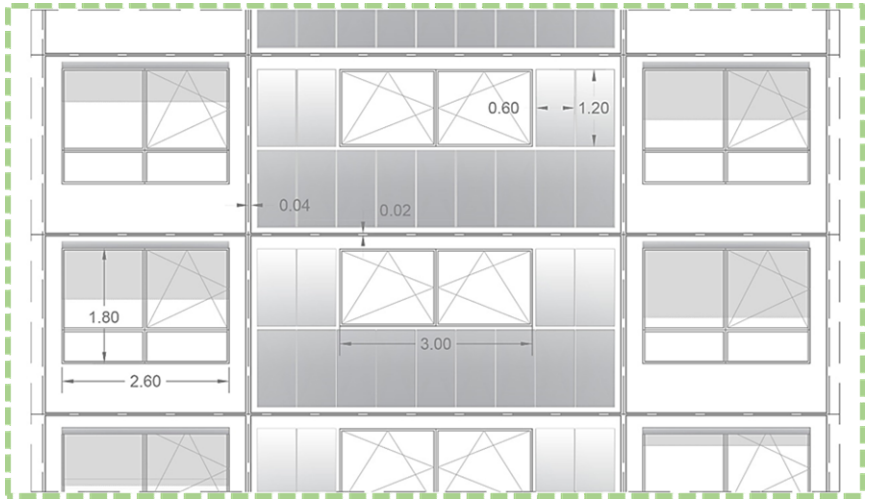
part of the façade system on side (4), modular type (1) and (2)



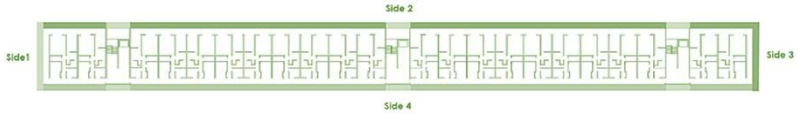
Month	SIDE 1 Monthly electricity production (kWh)/PV	SIDE 2 Monthly electricity production (kWh)/PV	SIDE 4 Monthly electricity production (kWh)/PV
January	3,2	0,7	4,6
February	4,2	1,1	5,4
March	8,4	2,5	9,6
April	11,2	4,4	11,9
May	11	5,8	11
June	11,3	6,8	10,1
July	11,3	6,4	10,4
August	10,4	4,9	10,5
September	8,7	2,9	9,9
October	6,3	1,5	7,8
November	3,5	0,7	5
December	2,6	0,5	4
Average	7,7	3,2	8,4

Electricity Production of a PV panel according to the building side

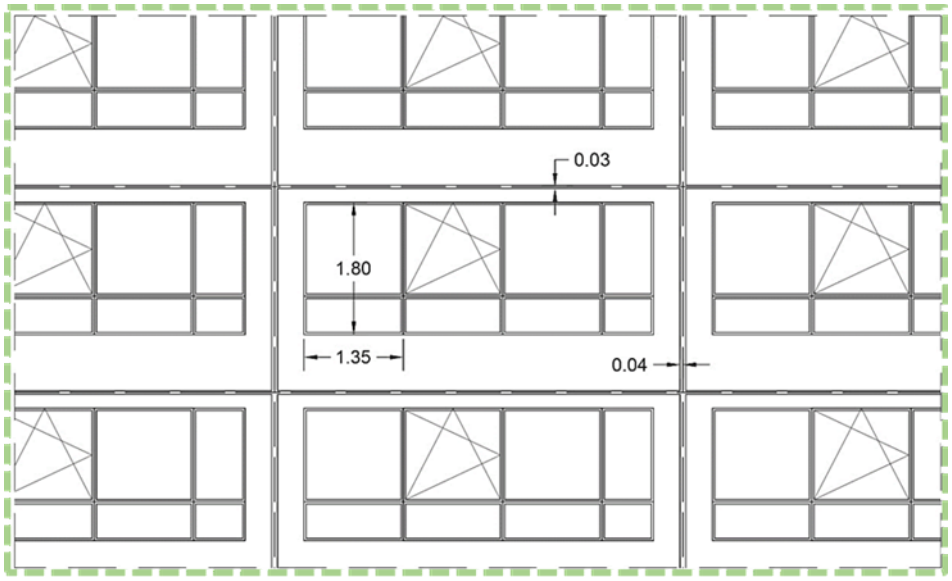
part of the façade system on side (2) modular type (1) and (4).



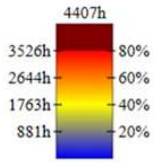
Side 3

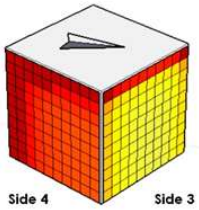


increase the percentage of the opaque part at the lower part of the modules without dramatically obstructing natural light

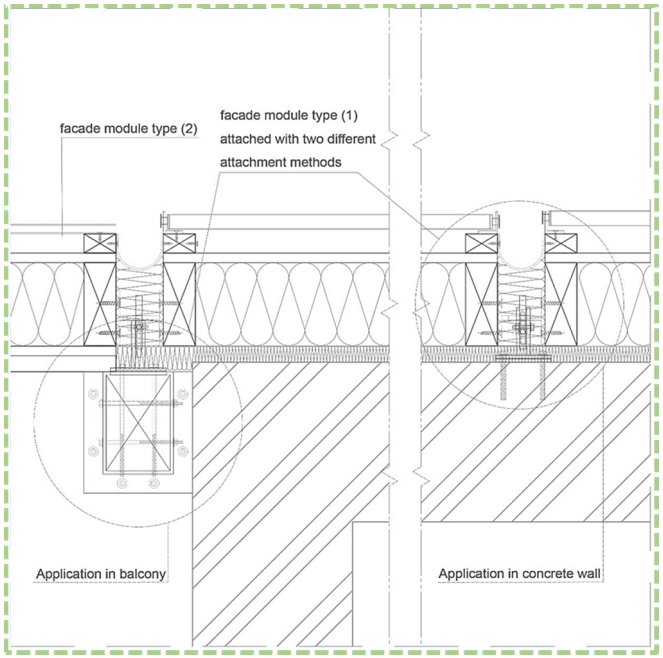


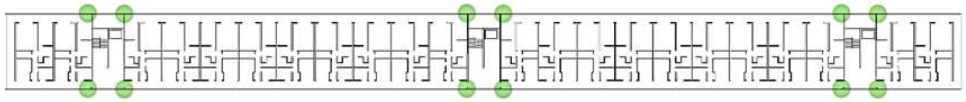
Maximum transparent surface



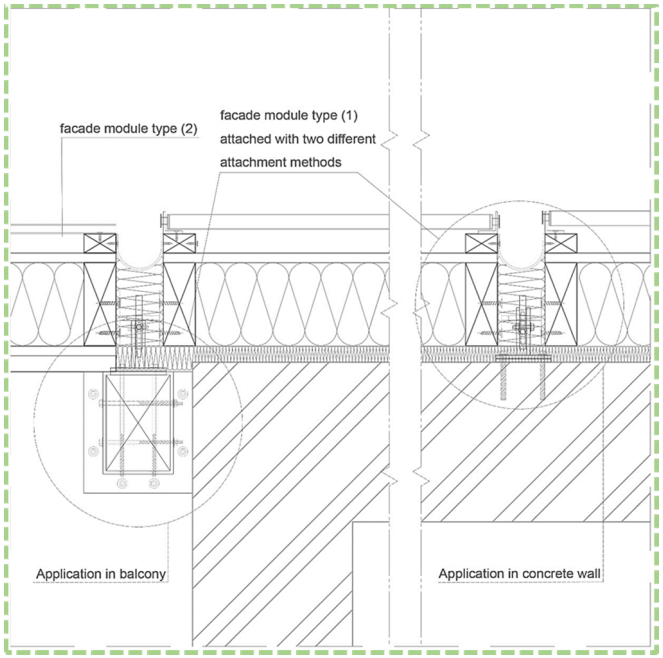


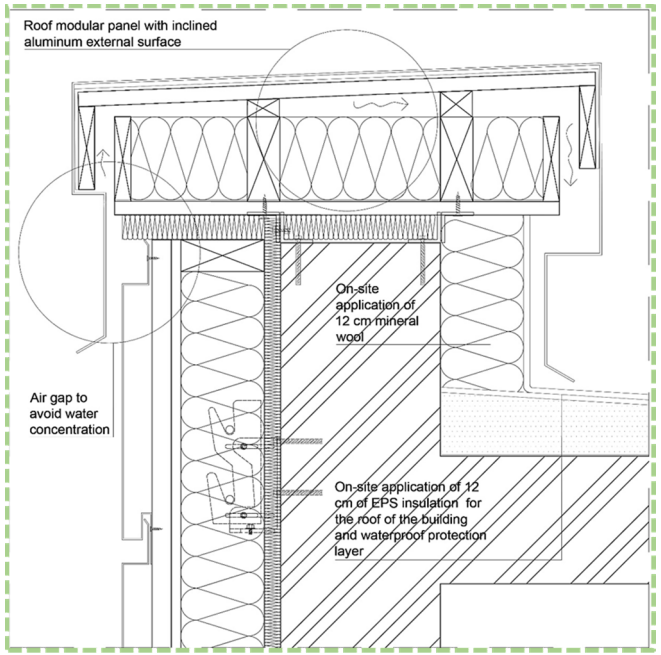
CRITICAL POINTS

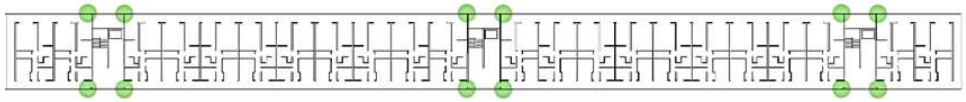




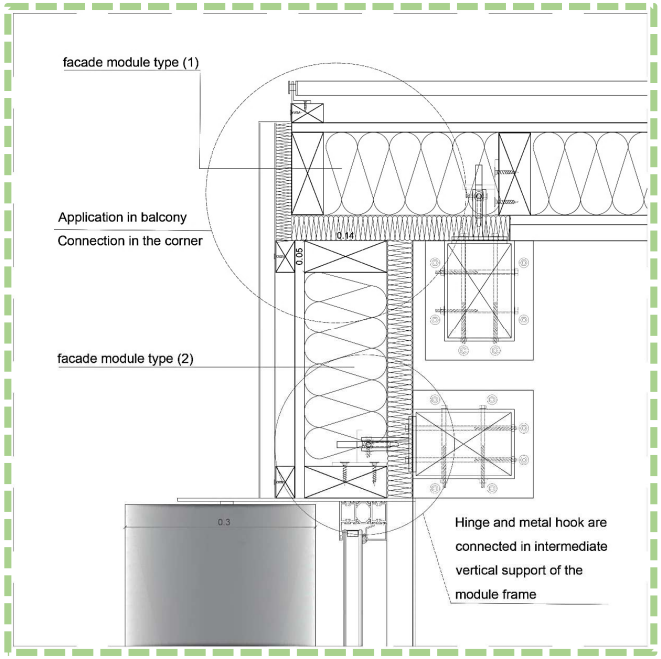
CRITICAL POINTS

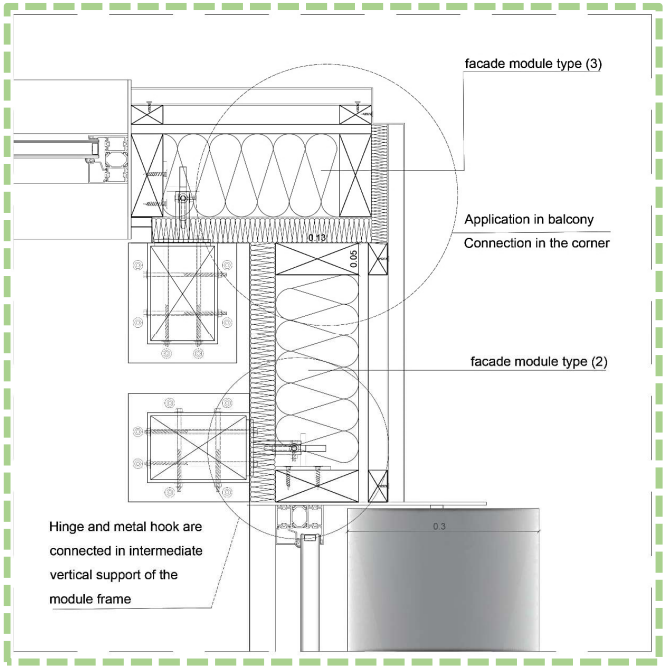


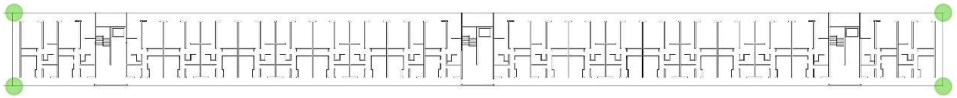


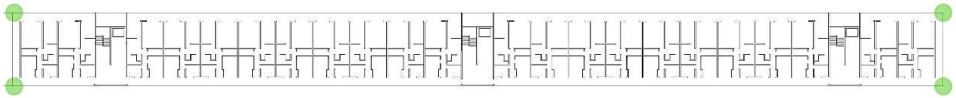


CRITICAL POINTS









ENERGY SAVINGS

		Temperature weighing factor α= Ue Ae/ (Ue Ae +Ui Ai)	New energy demand for heating of a typical apartment after the application of the façade system. (MJ)	New energy demand for cooling of a typical apartment after the application of the façade system. (MJ)	Incoming solar energy for a typical apartment that ifluenves the cooling demand.(MJ)	Average total energy demand per typical apartment after the renovation.(MJ)	Percentage of improvement after the application of the façade system ro energy reduction renovation.
AMSTERDAM NEW WWR=1,46							
opaque surface	15	0,08	825	62,5			
transparent surface	22	0,46	3381	256		3.026	70%
total			4.206	318,5	1.528		

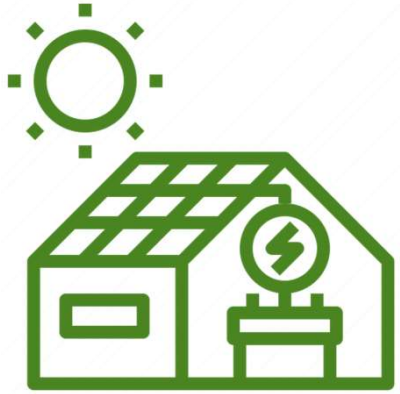
Opaque surface of the system U-value =0.27 W/(m2K)

Transparent surface of the system U = 1.3 W / (m2 K) and g-value = 0,2

Energy savings due to the Passive design techniques is 70%

ENERGY SAVINGS

		Temperature weighing factor α= Ue Ae/ (Ue Ae +Ui Ai)	New energy demand for heating of a typical apartment after the application of the façade system. (MJ)	New energy demand for cooling of a typical apartment after the application of the façade system. (MJ)	Incoming solar energy for a typical apartment that ifluenves the cooling demand.(MJ)	Average total energy demand per typical apartment after the renovation.(MJ)	Percentage of improvement after the application of the façade system ro energy reduction renovation.
AMSTERDAM NEW WWR=1,46							
opaque surface	15	0,08	825	62,5			
transparent surface	22	0,46	3381	256		3.026	70%
total			4.206	318,5	1.528		



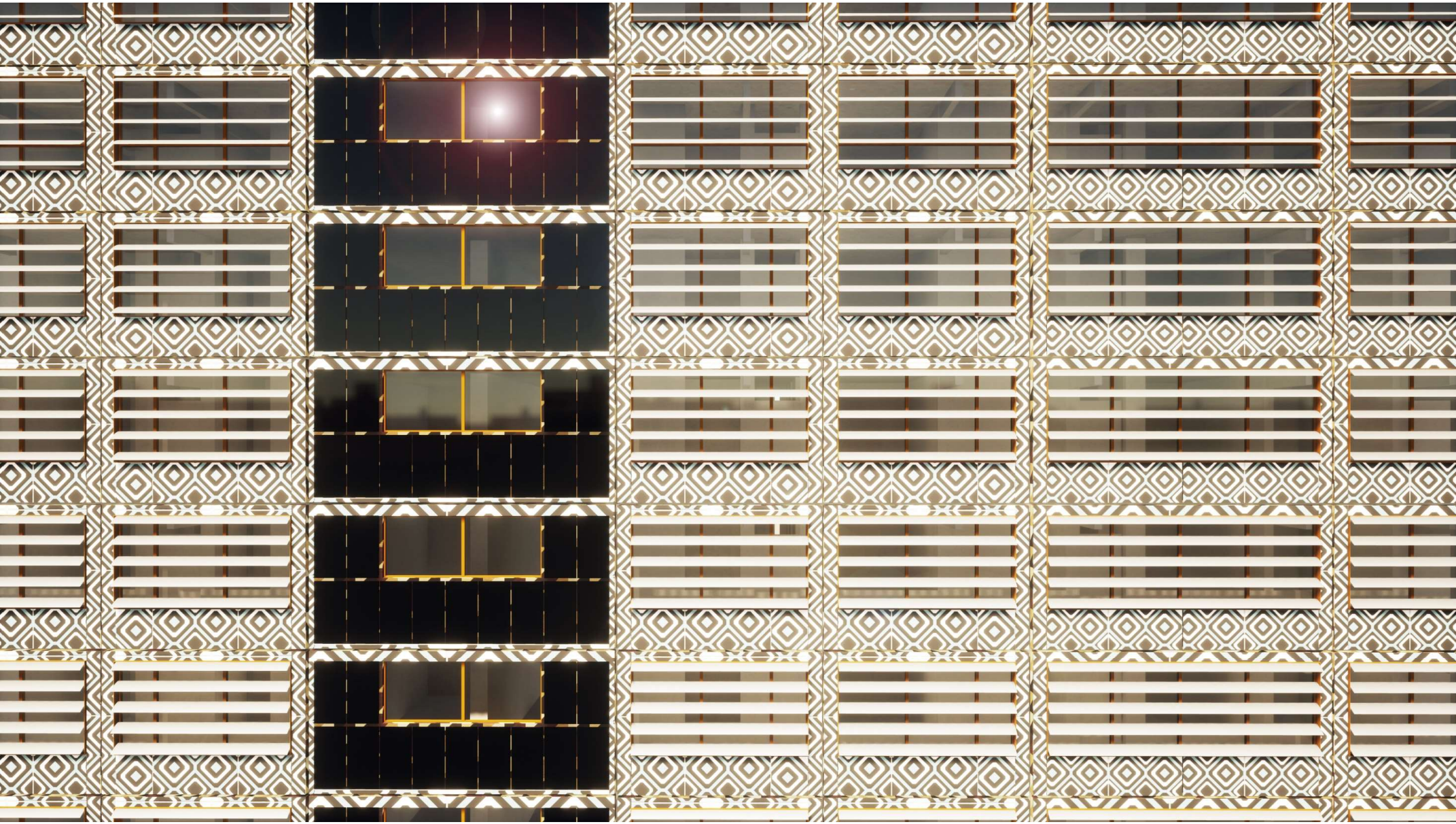
Energy produced from PV panels for every apartment is 257 kWh which is 925 MJ

Opaque surface of the system U-value =0.27 W/(m2K)

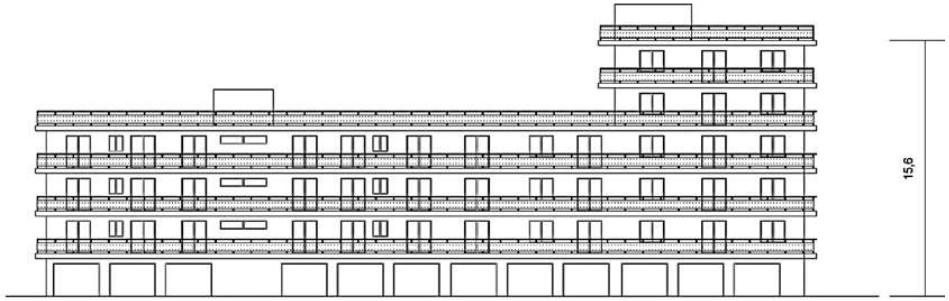
Transparent surface of the system U = 1.3 W / (m2 K) and g-value = 0,2

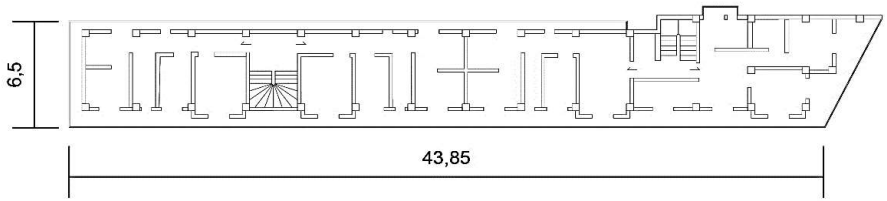
Energy savings due to the Passive design techniques is 70%

79%



ATHENS

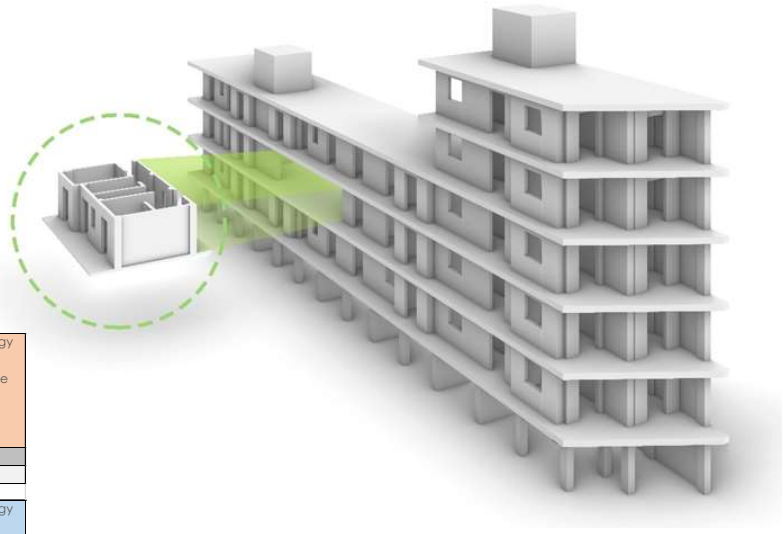




Greece, Athens, Location: Amfitheas 24-26, Construction year: 1974

Part 4, case study 2

ATHENS

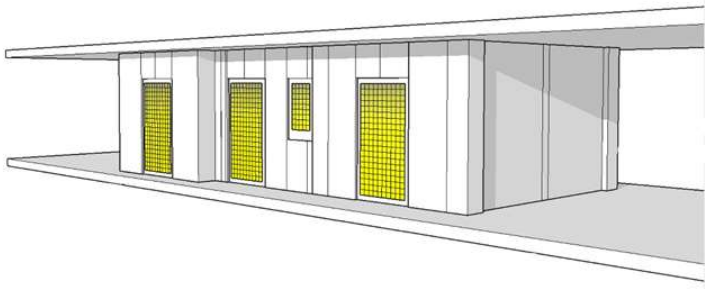


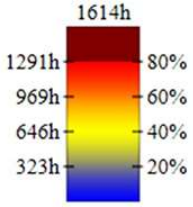
calculations

simulations

Athens HDD: 1170 (base temperature 18°C)	Existing wall U-value W/(m²K)	Current energy demand for heating of the existing wall (MJ) per m2
opaque surface	1,48	149,6
transparent surface	5,7	576,2

Athens CDD: 1168 (base temperature 18°C)	Existing construction U-value W/(m²K)	Current energy demand for cooling of the existing wall (MJ) per m2
opaque surface	1,48	149,3
transparent surface	5,7	575,2





ATHENS simulation inputs	Start time	6:00	Start date	1 June
	End time	20:00	End date	30 September

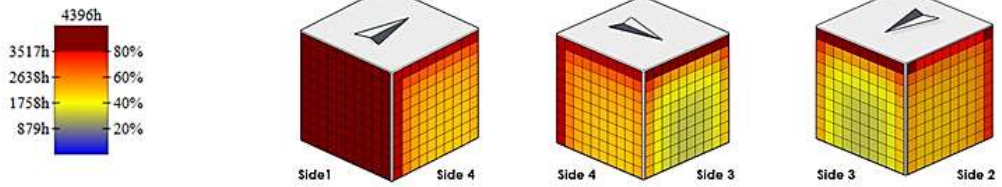
Energy performance of the existing façade for a typical apartment	total surface area of a typical apartment (m2)		Heat transmitions per square meter during the heating season. (MJ)	Heat transmitions per square meter during the cooling season. (MJ)	Current energy demand for heating of a typical apartment due to the heat ransmisions. (MJ)	Current energy demand for cooling of a typical apartment due to the heat transmitions. (MJ)	Incoming solar energy for a typical apartment that ifluenves the cooling demand. (MJ)	Average total energy demand per typical apartment (MJ)
ATHENS WWR=0,38								
opaque surface	31,7		149,6	149,3	4.742	4.732		
transparent surface	12,3		576,2	575,2	7.087	7.074		15.752
total					11.829	11.806	7.869	

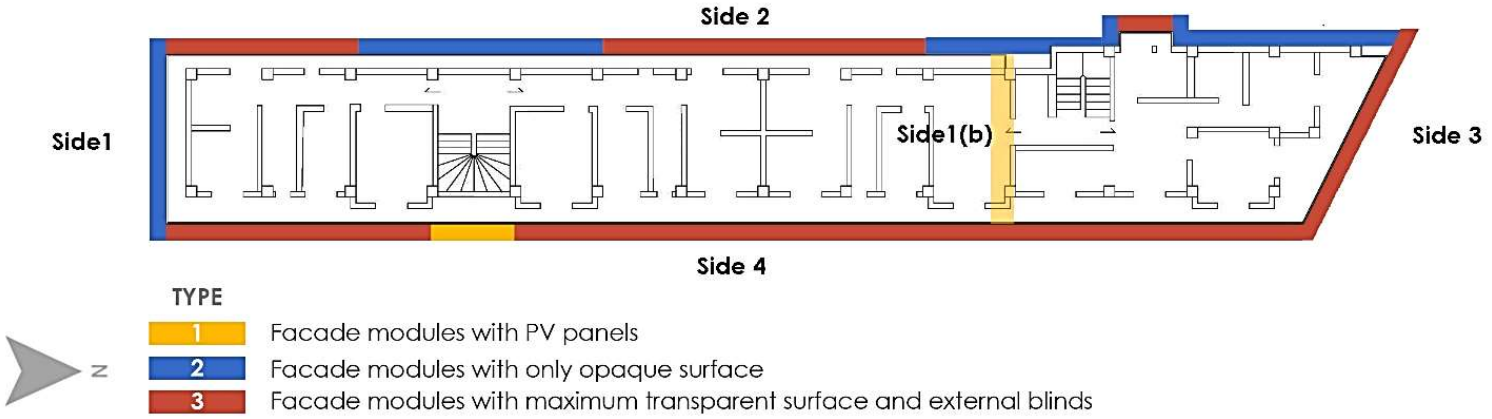
Part 4, case study 2

ATHENS

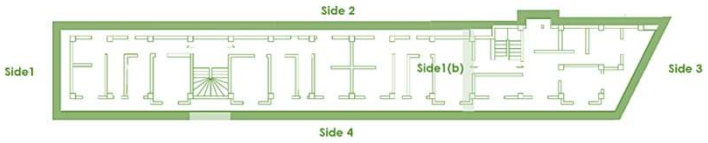
functions of the building envelop

1. Private balconies on all sides
2. Vertical common circulation on sides (2) and (4)

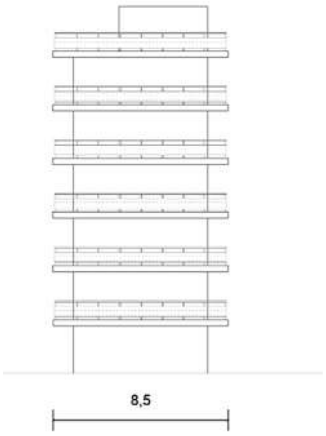


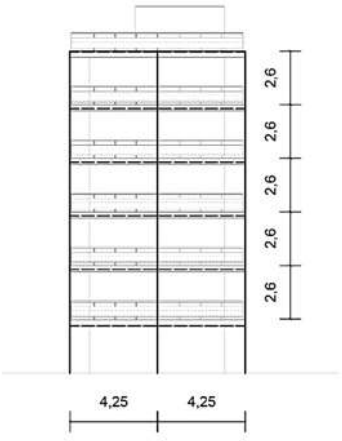


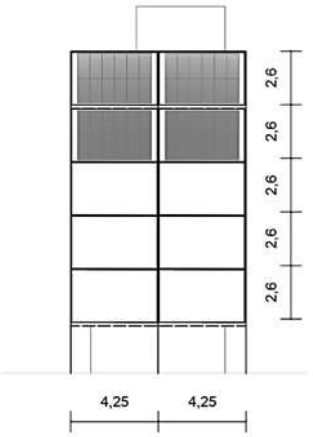
ATHENS



Side 1, 1b

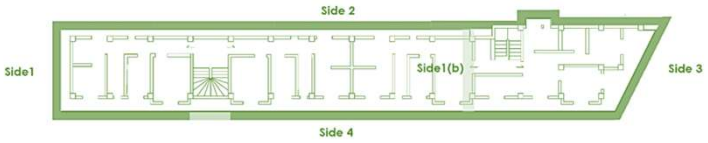




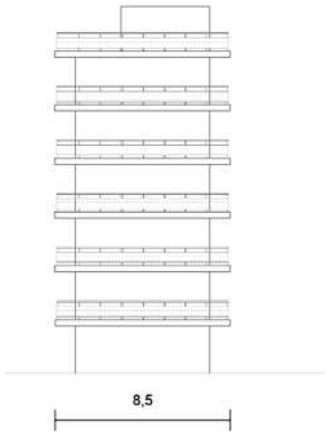


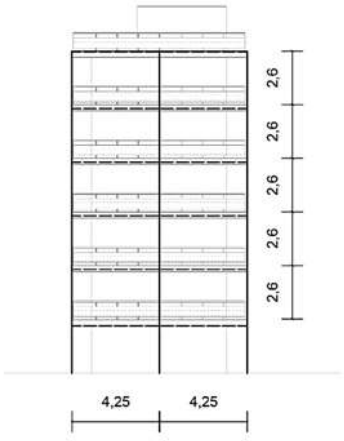
Month	**SIDE 1(b)** Monthly electricity production (kWh)/PV	**SIDE 4** Monthly electricity production (kWh)/PV
January	9,4	3,5
February	8,3	4,2
March	9,8	6,2
April	8,1	7,5
May	6,3	8,7
June	5,1	9,1
July	5,7	9,5
August	7,8	8,8
September	9,5	7,1
October	9,9	5,2
November	9,6	3,8
December	8,8	3,1
Average	8,2	6,4

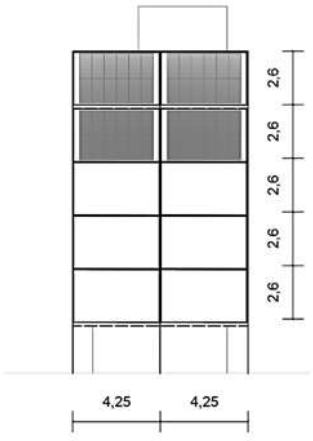
ATHENS



Side 1, 1b

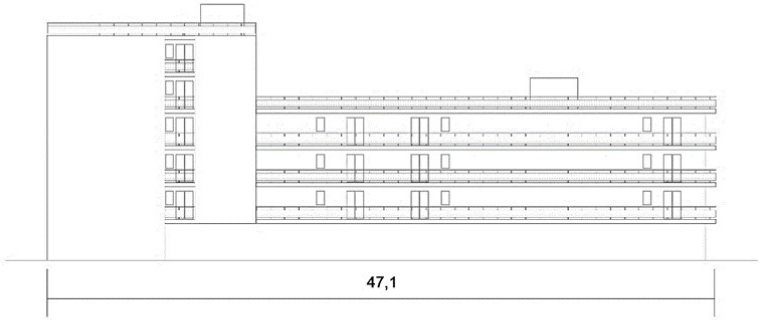


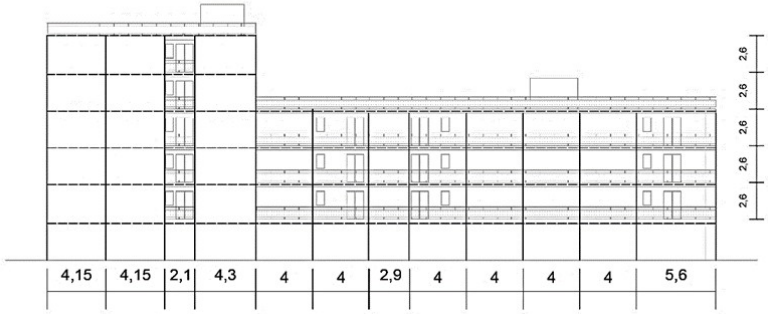


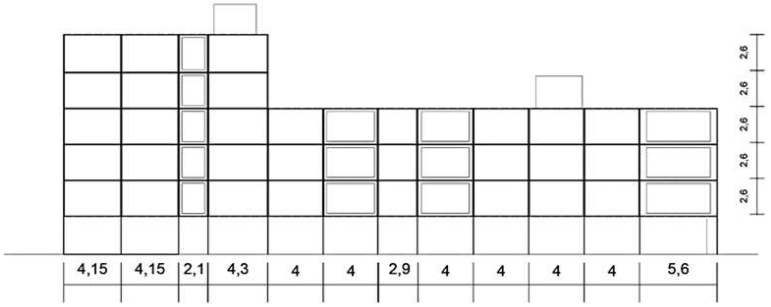


Month	SIDE 1(b) Monthly electricity production (kWh)/PV	SIDE 4 Monthly electricity production (kWh)/PV
January	9,4	3,5
February	8,3	4,2
March	9,8	6,2
April	8,1	7,5
May	6,3	8,7
June	5,1	9,1
July	5,7	9,5
August	7,8	8,8
September	9,5	7,1
October	9,9	5,2
November	9,6	3,8
December	8,8	3,1
Average	8,2	6,4

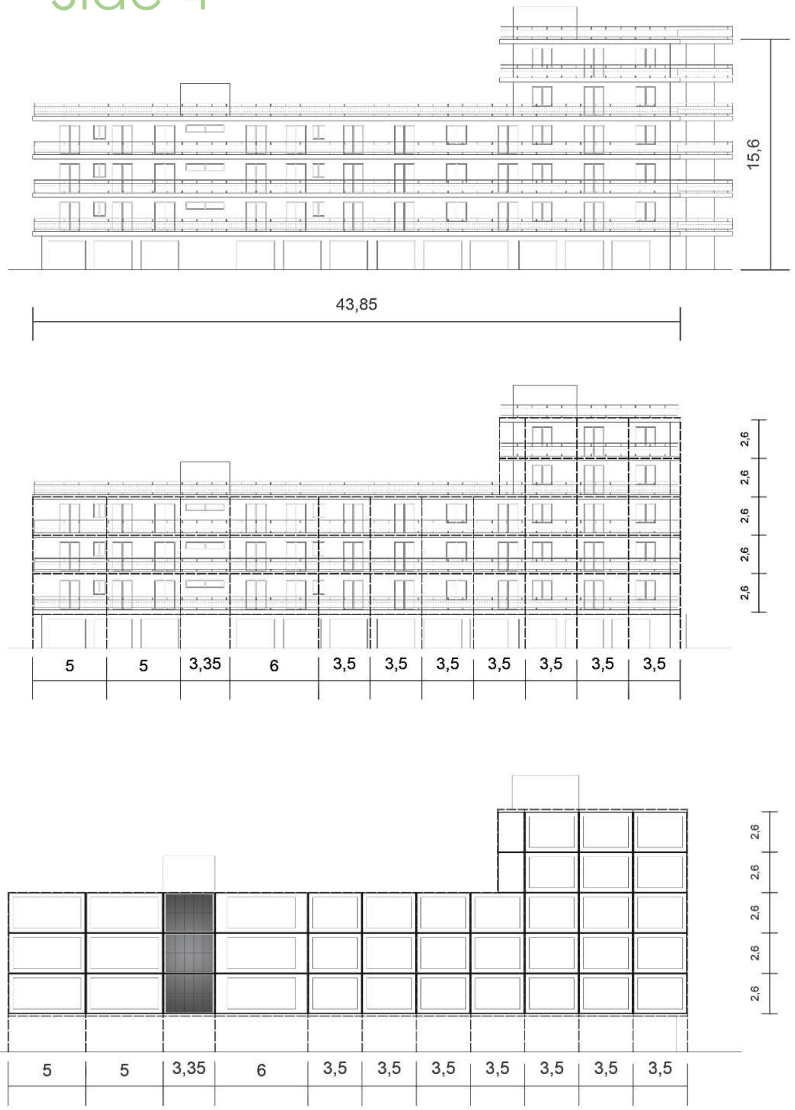
Side 2

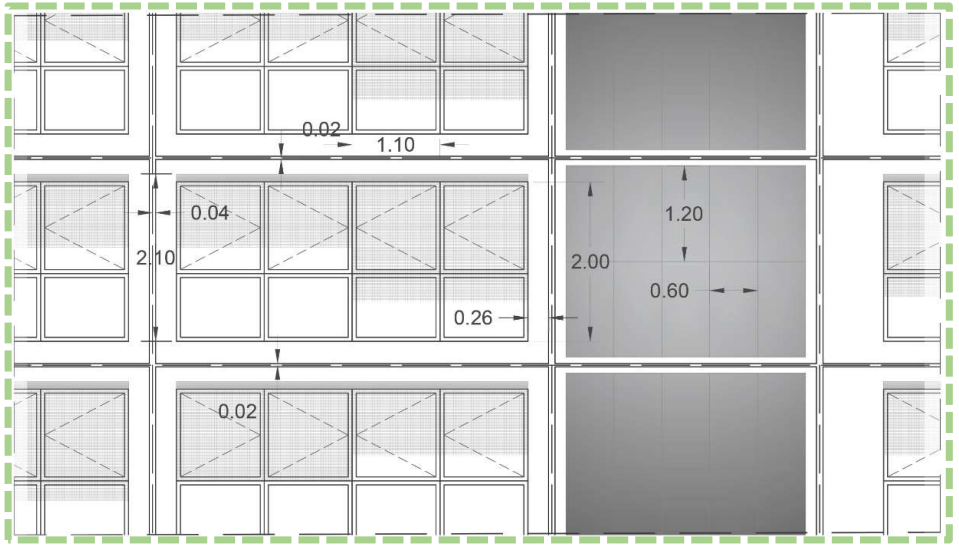






Side 4

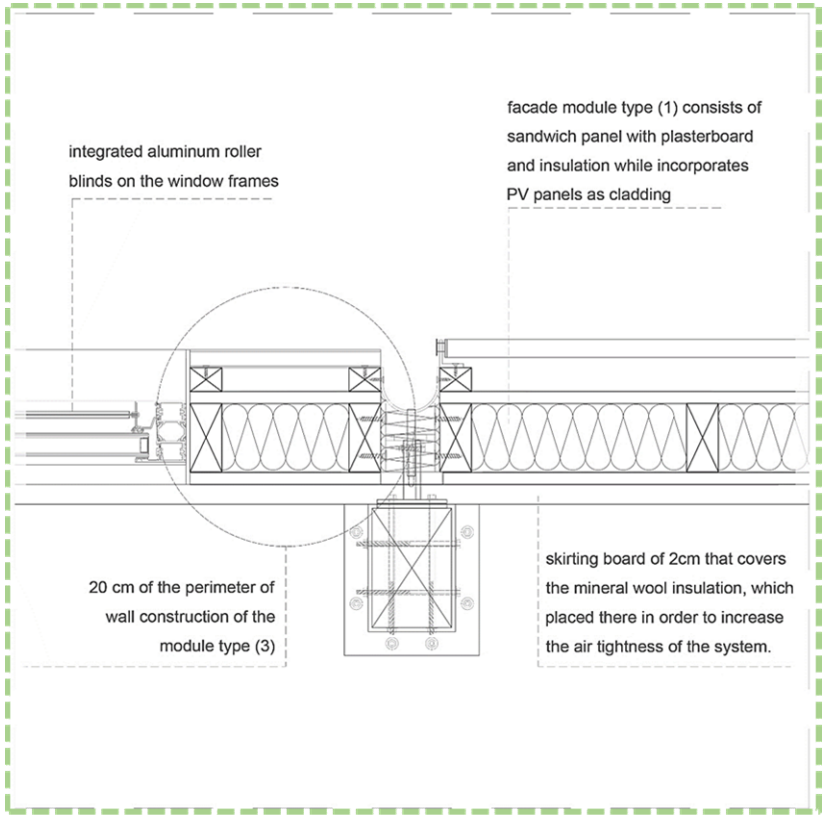


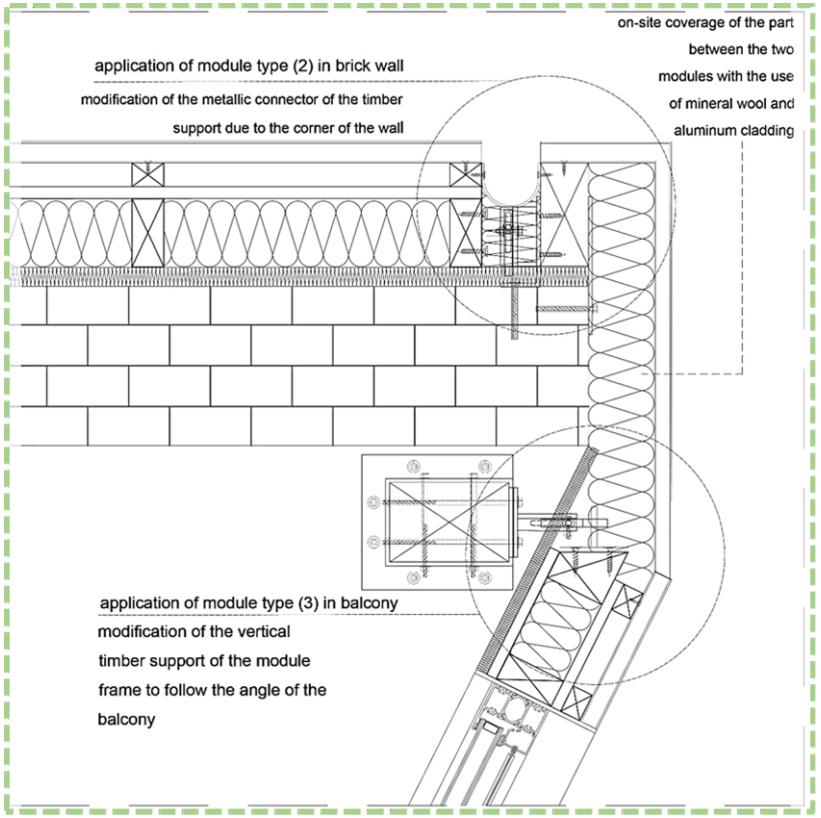


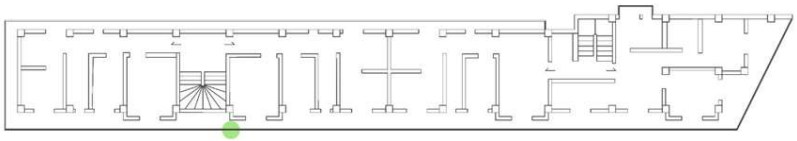
Type 3

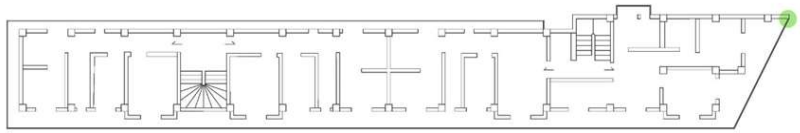
Month	SIDE 1(b) Monthly electricity production (kWh)/PV	SIDE 4 Monthly electricity production (kWh)/PV
January	9,4	3,5
February	8,3	4,2
March	9,8	6,2
April	8,1	7,5
May	6,3	8,7
June	5,1	9,1
July	5,7	9,5
August	7,8	8,8
September	9,5	7,1
October	9,9	5,2
November	9,6	3,8
December	8,8	3,1
Average	8,2	6,4

CRITICAL POINTS



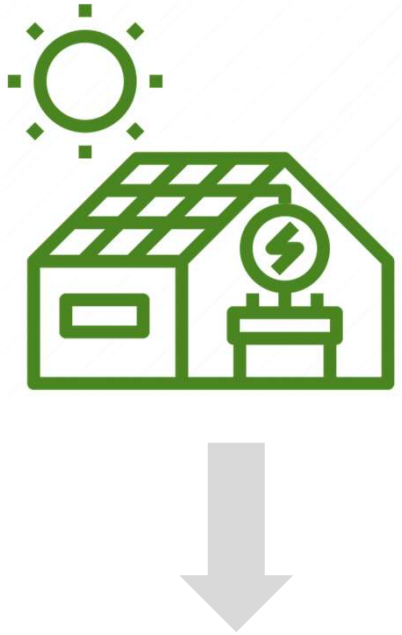






ENERGY SAVINGS

		Temperature weighing factor α= Ue Ae/ (Ue Ae +Ui Ai)	New energy demand for heating of a typical apartment after the application of the façade system. (MJ)	New energy demand for cooling of a typical apartment after the application of the façade system. (MJ)	Incoming solar energy for a typical apartment that ifluenves the cooling demand.(MJ)	Average total energy demand per typical apartment after the renovation.(M	Percentage of improvement after the application of the façade system ro energy reduction renovation.
ATHENS NEW WWR=1,58							
opaque surface	17	0,13	616	615			
transparent surface	27	0,33	2.338	2.334		4.148	73%
total			2954	2949	2.393		

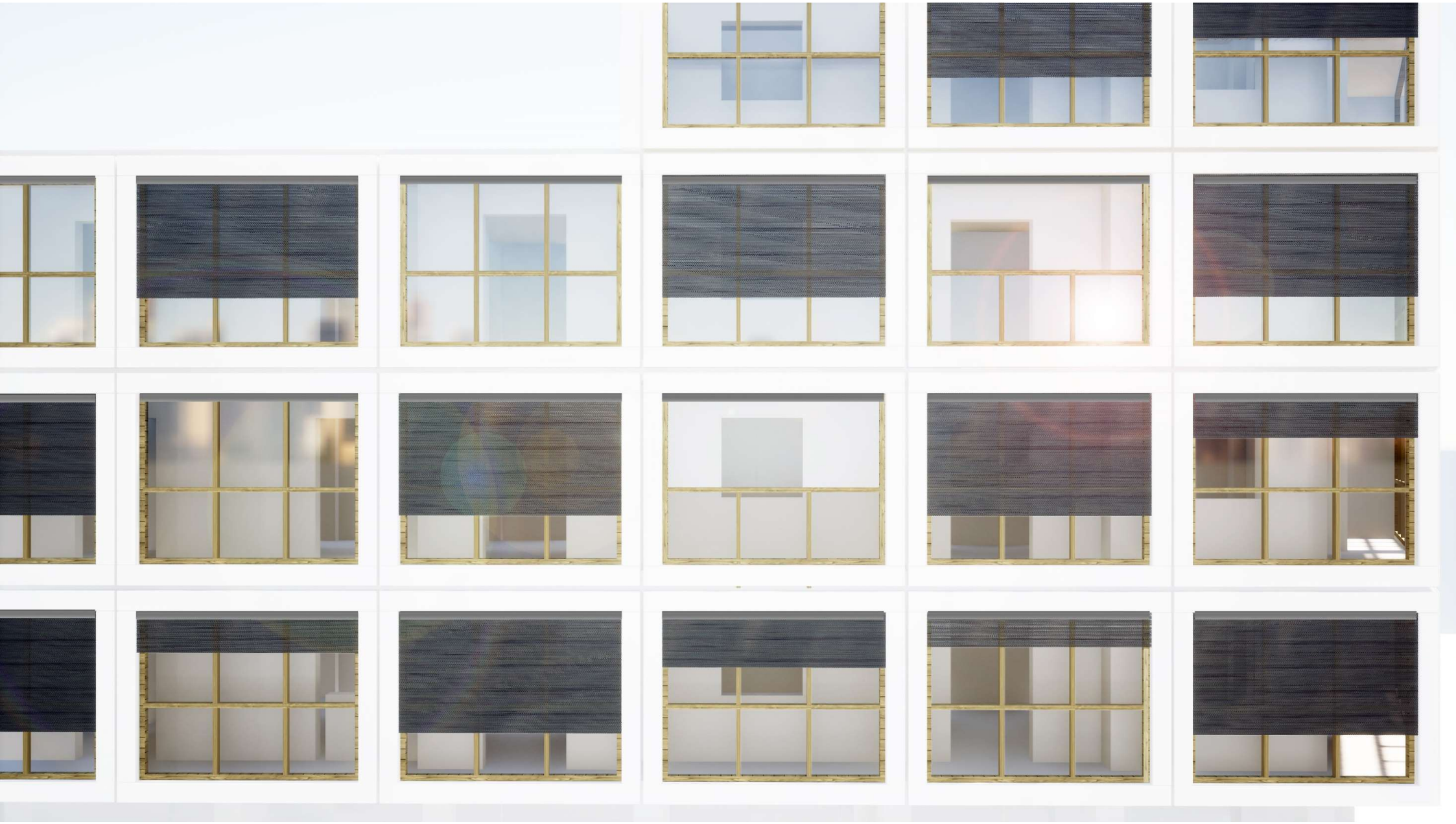


Opaque surface of the system U-value =0.43 W/(m2K))

Transparent surface of the system U = 1.3 W / (m2 K) and g-value = 0,2

Energy savings due to the Passive design techniques is 73%


Βασιλόπουλος
800 m



OVERVIEW

Information Search

OVERVIEW

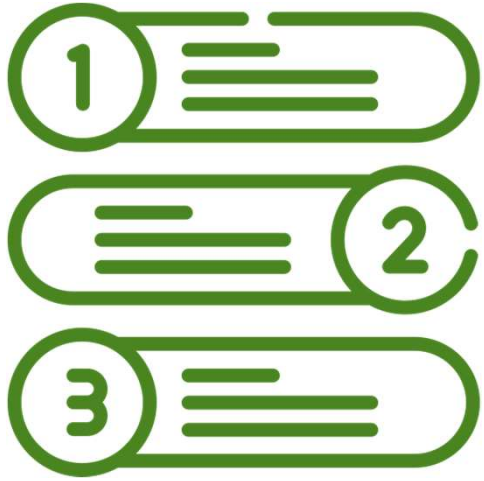
Information Search

Process

OVERVIEW

Information Search

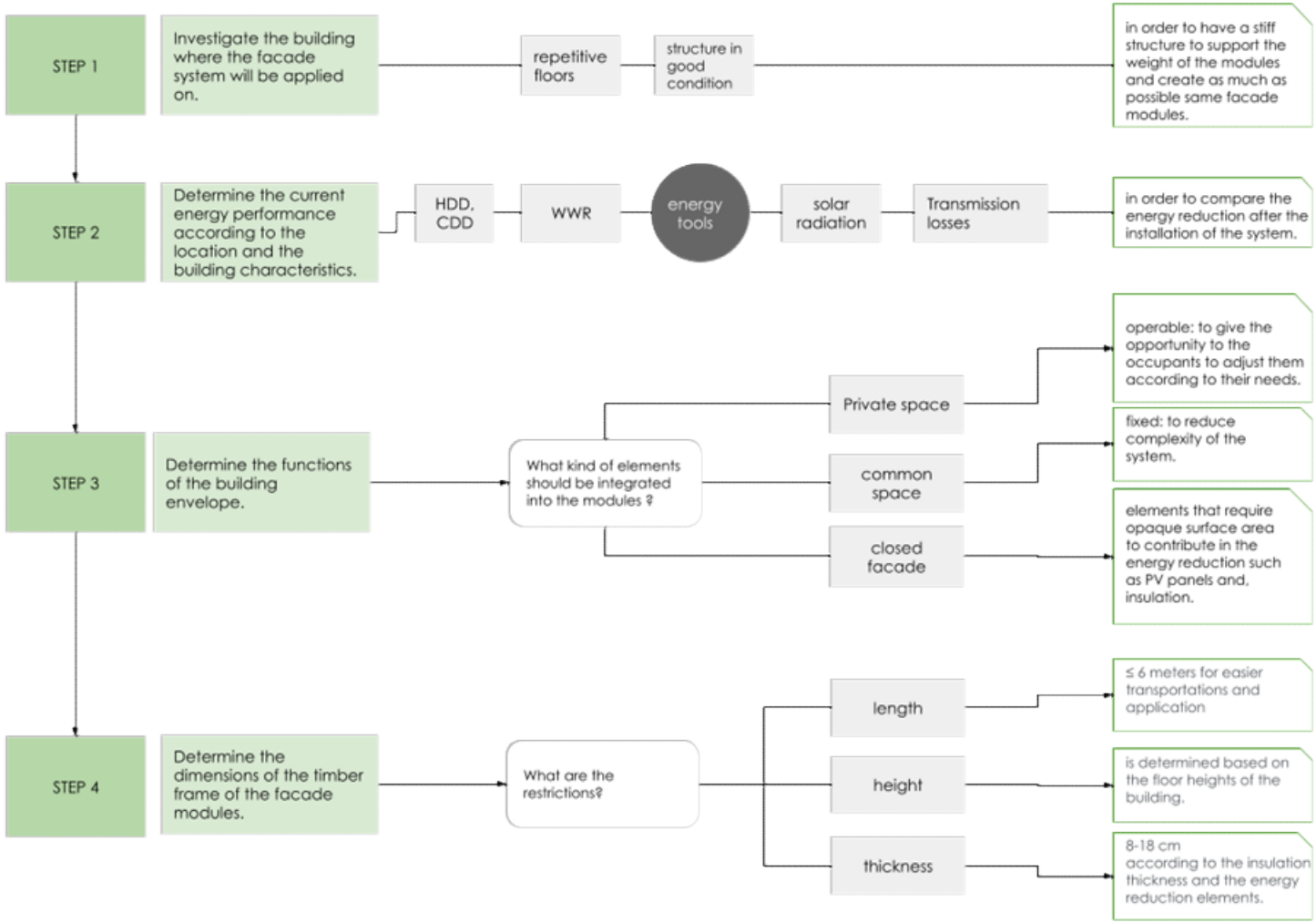
Process



Steps

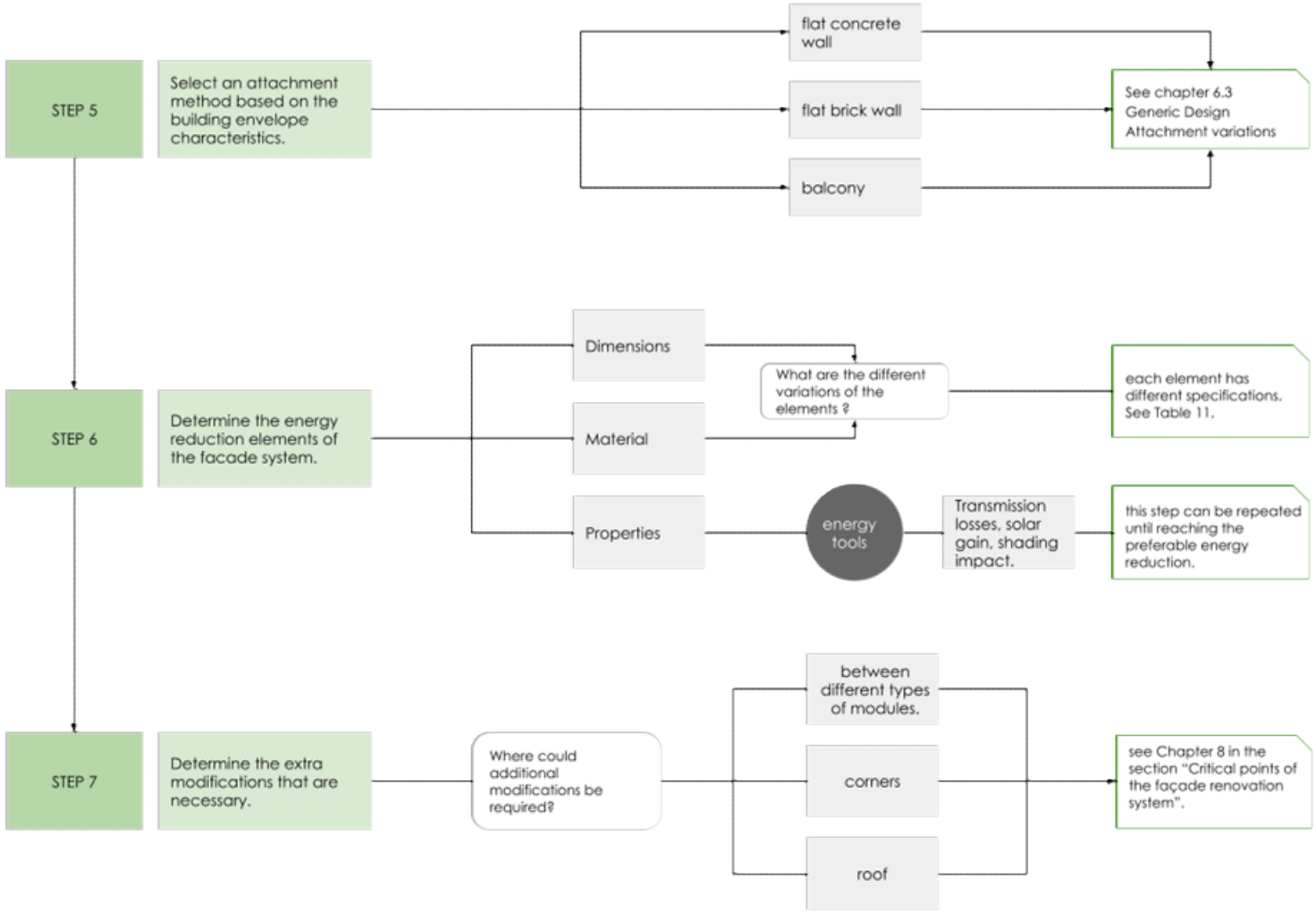
STAGE 1

Facade Module design



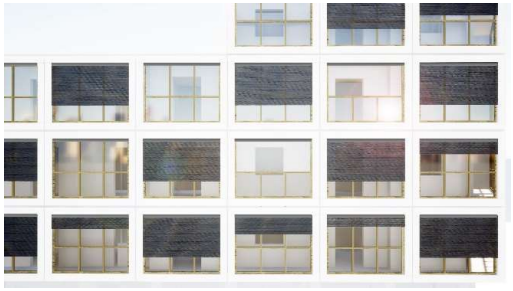
STAGE 2

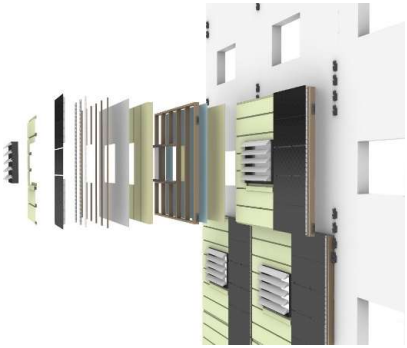
Facade Module design

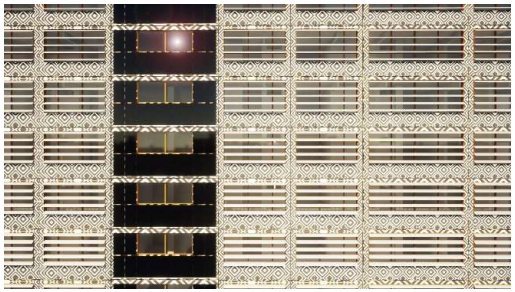


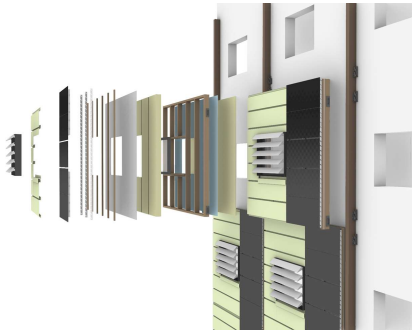
OVERVIEW

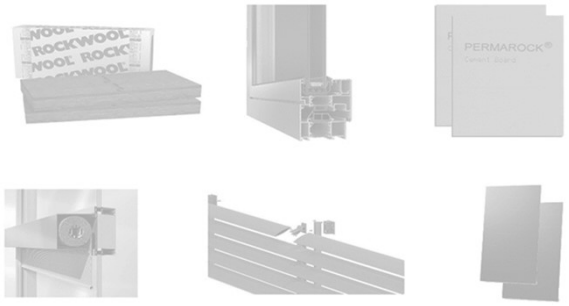
	Façade system parts.		Dimensions		Material	
			adjustable	Fixed	Standard	Vary
1	Structure		✓		✓	
2	connectors		✓		✓	
3	insulation		✓		✓	
4	Plasterboard		✓		✓	
5	cladding		✓			✓
6	windows		✓		✓	
7	PV panels			✓	✓	
8	Louvers		✓		✓	
9	Roller blinds		✓		✓	

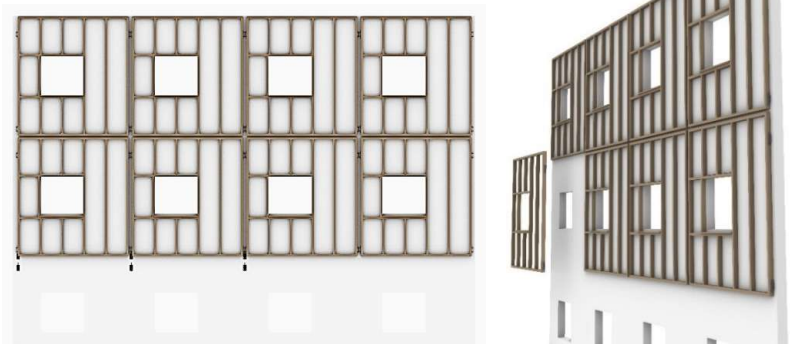


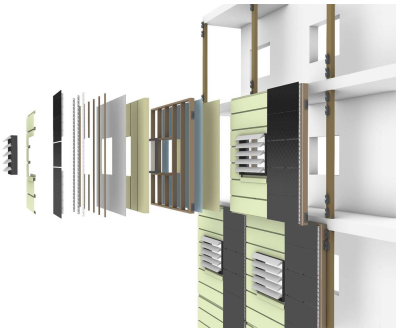












REASEARCH QUESTION

"How a prefabricated facade system for energy reduction renovation of residential buildings can be designed to be adjustable in different building typologies and climates?"

CONLUSIONS and DESIGN LIMITATIONS

- On-Site modification
- Initial cost might be expensive
- High organizational and design requirements
- Modular design might be monotonous
- More accurate simulations are needed

Thank you!