GRADUATIONSTUDIO

2018-2019

Sustainable Facade Refurbishment of Existing Tall Buildings in UAE using Plug & Play approach

P5 PRESENTATION

PREMITH SATISH // 4742346

intervention
methodology
framework
background

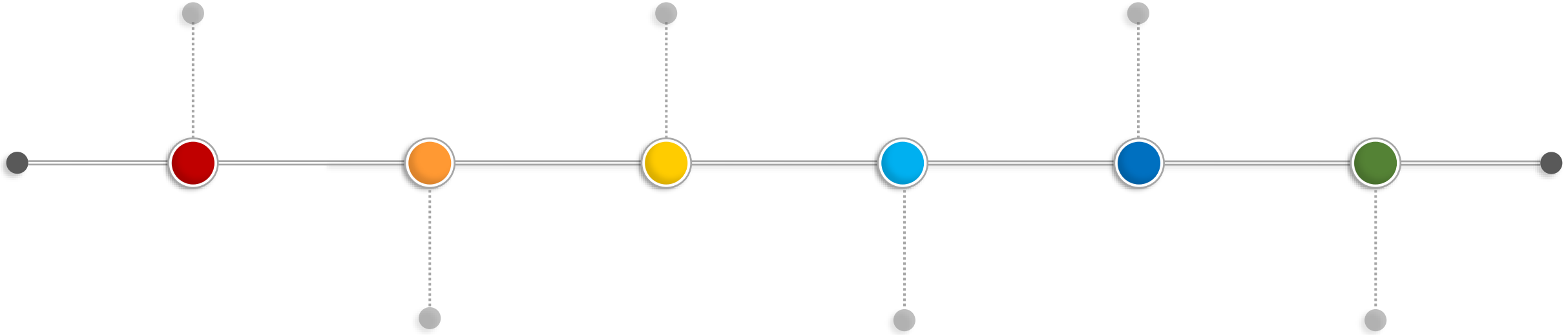
introduction

life cycle assessment
economic assessment
energy performance assessment
concept design

design development

evaluation

sustainability evaluation



framework

sustainable façade refurbishment
mppf
literature summary

design

design proposal
technical drawings
assembly and maintenance

conclusion

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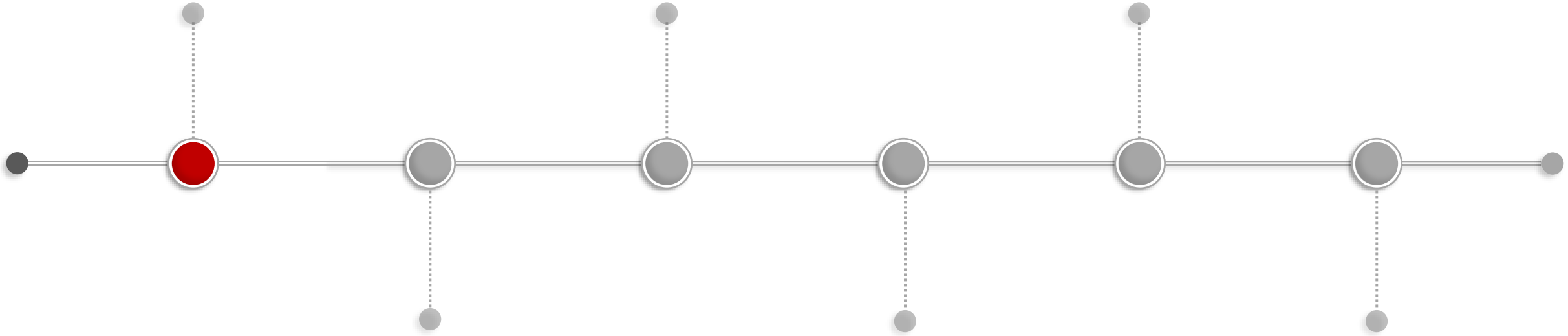

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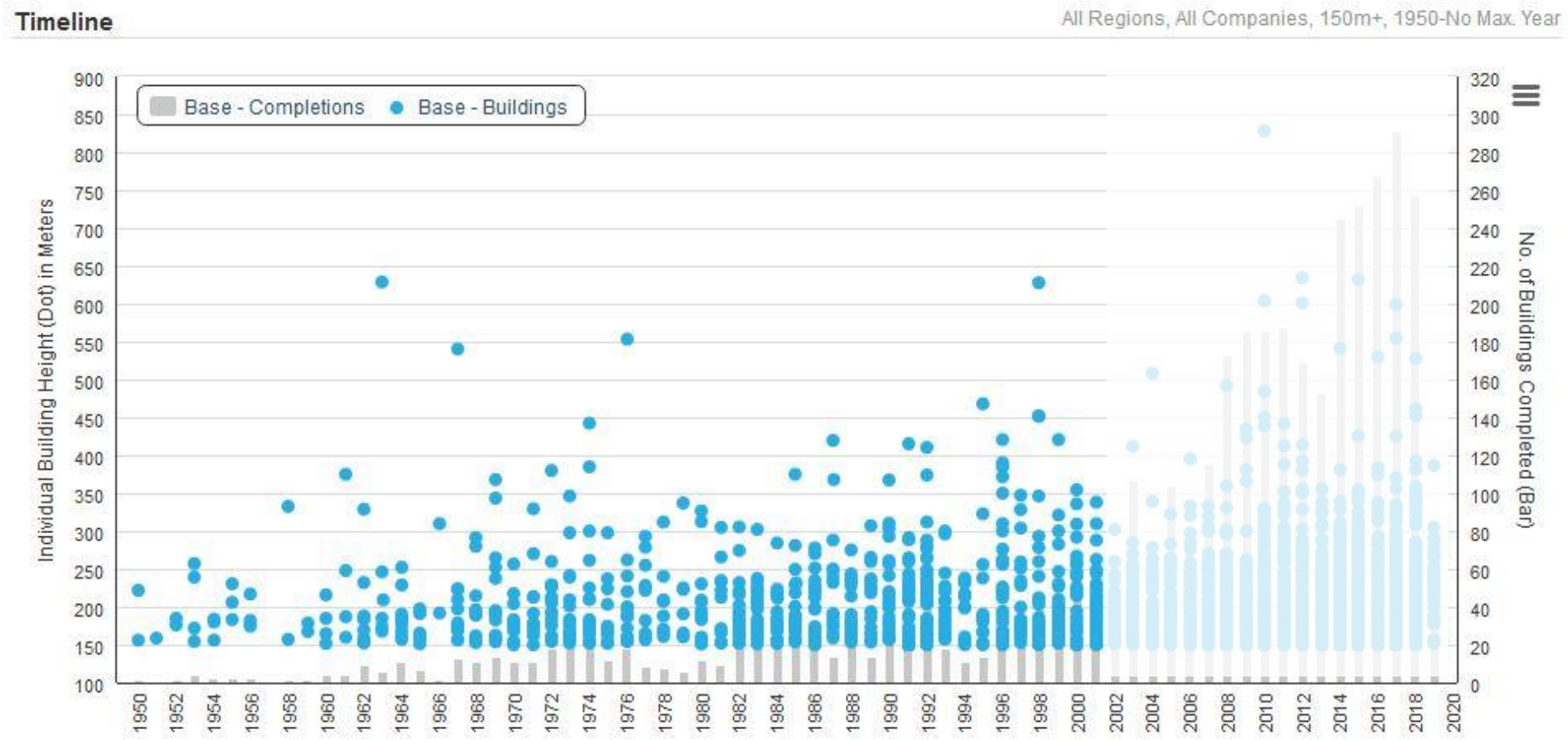


RECORD OF EXISTING TALL BUILDINGS

Sources: http://www.skyscrapercenter.com/compare-data/

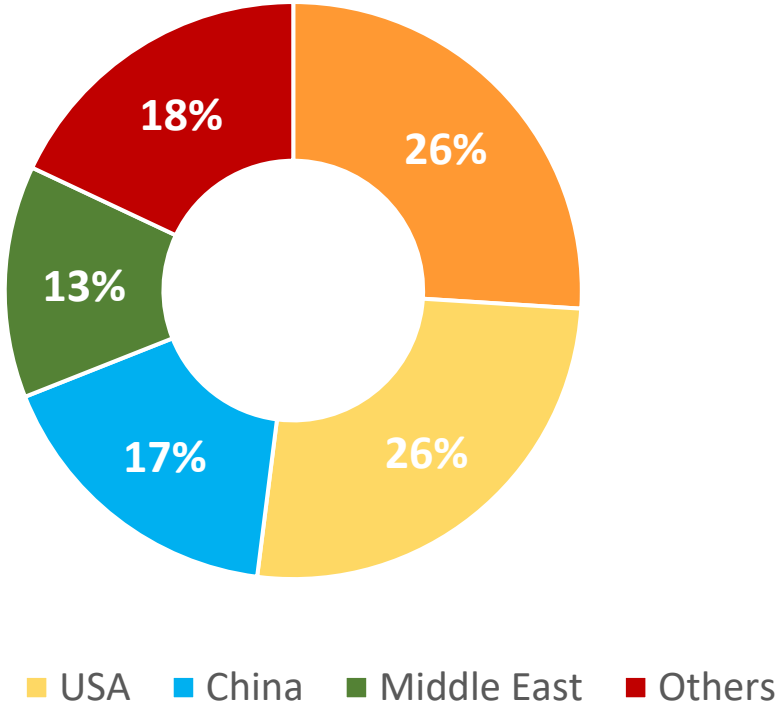
CURTAIN WALL FACADE

Sources: https://archinect.imgix.net/

Size of global curtain wall industry as on 2009 in USD

RECORD OF EXISTING TALL BUILDINGS

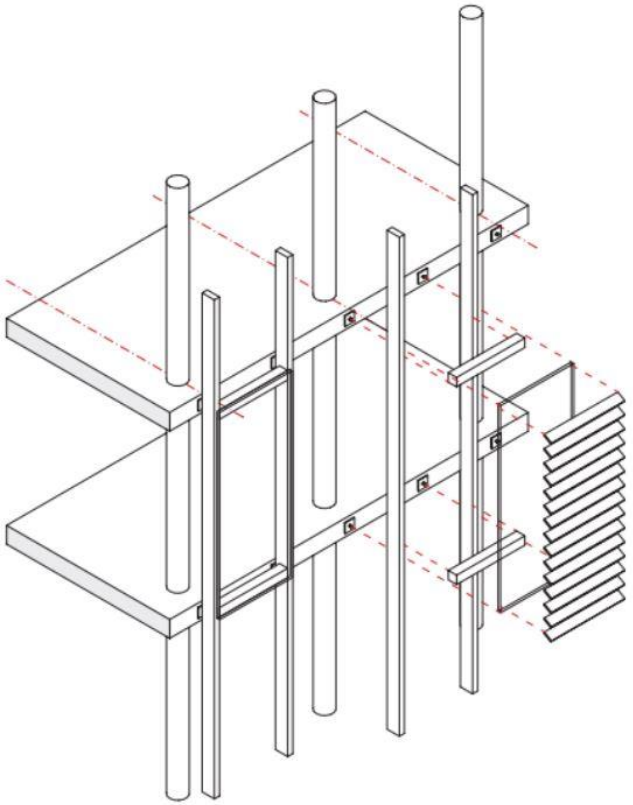
Sources: CSI, S. (2012). A global king of curtain wall in steady growth : Hong Kong, (February).



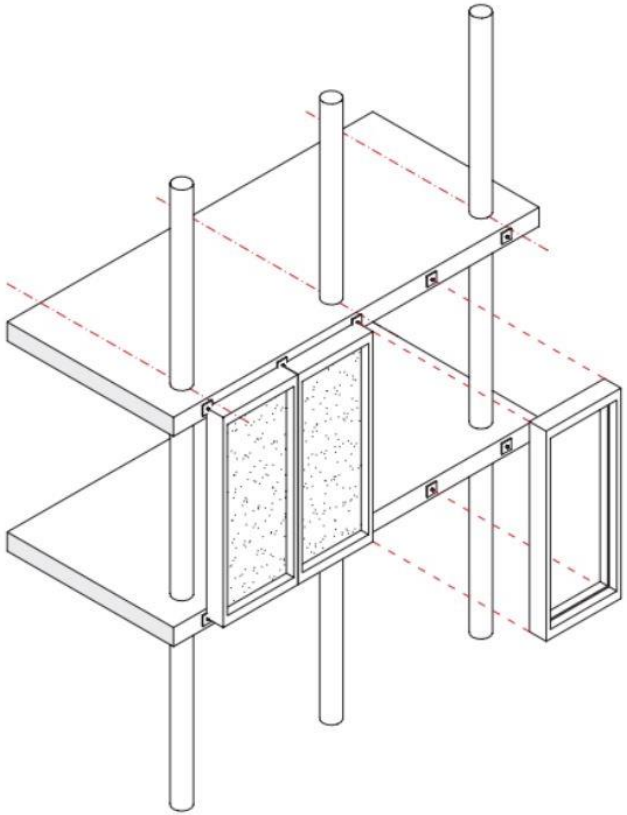
Peak demands per location of global curtain wall industry as on 2009

CURTAIN WALL REGIONAL DEMAND

Sources: CSI, S. (2012). A global king of curtain wall in steady growth : Hong Kong, (February).



Stick Curtain Wall System



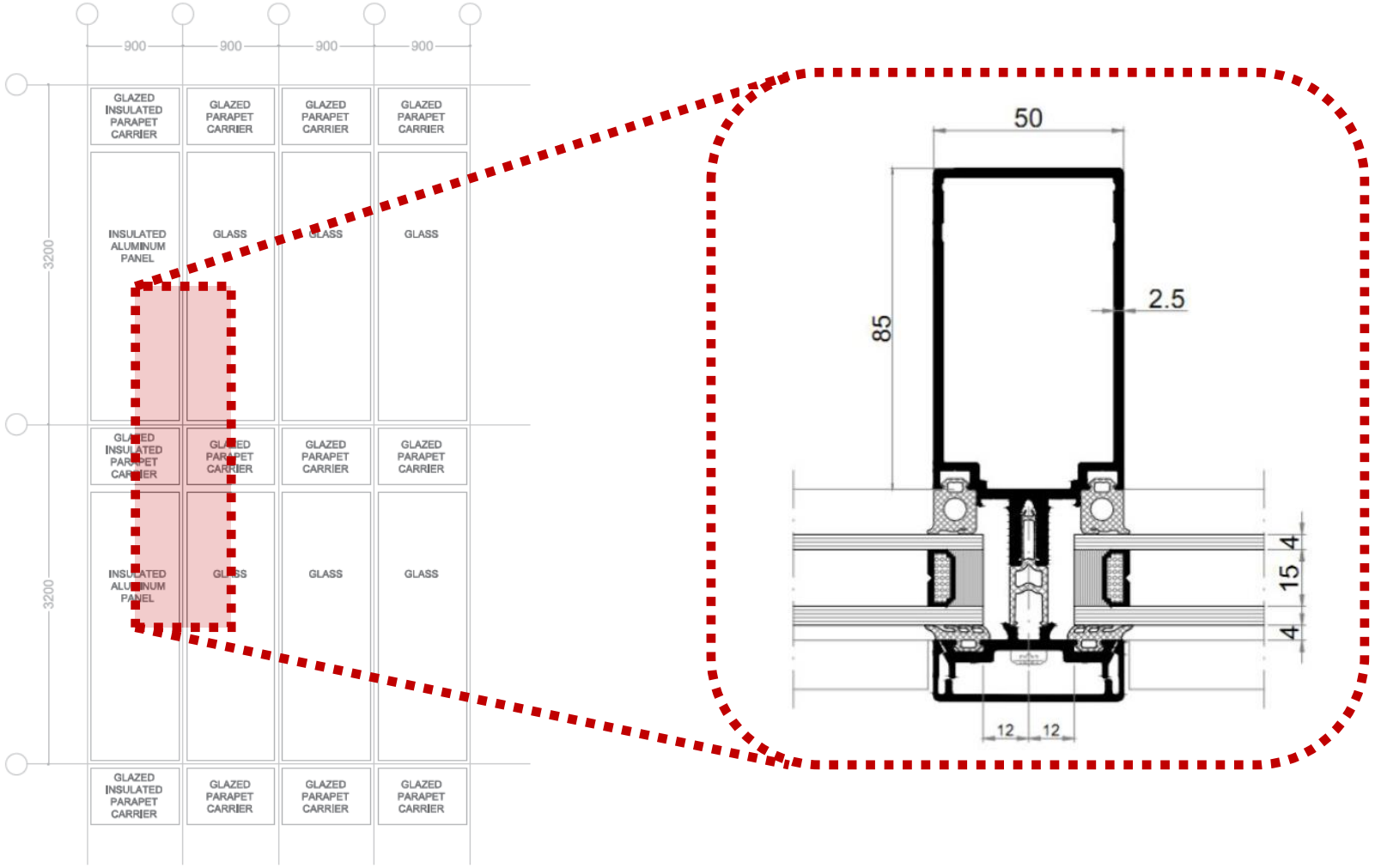
Unitised Curtain Wall System

?

Plug&Play ?

CURTAIN WALL TYPES

Sources: Knaack, U., Klein, T., LBilow, M., & Auer, T. (2007). Facades - Principles of Construction.



CURTAIN WALL CONSTRUCTION

Aluminium

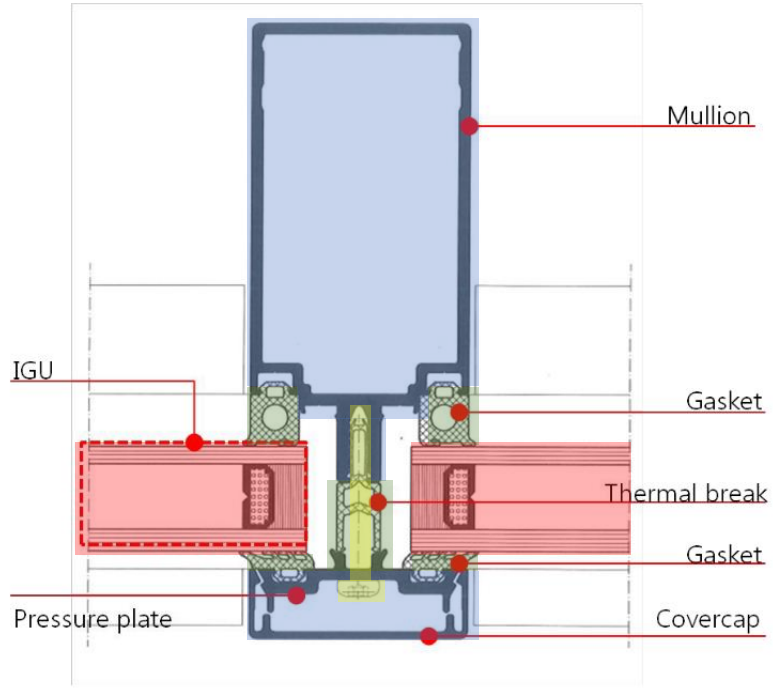
Insulated Glazing

Mixed Plastics

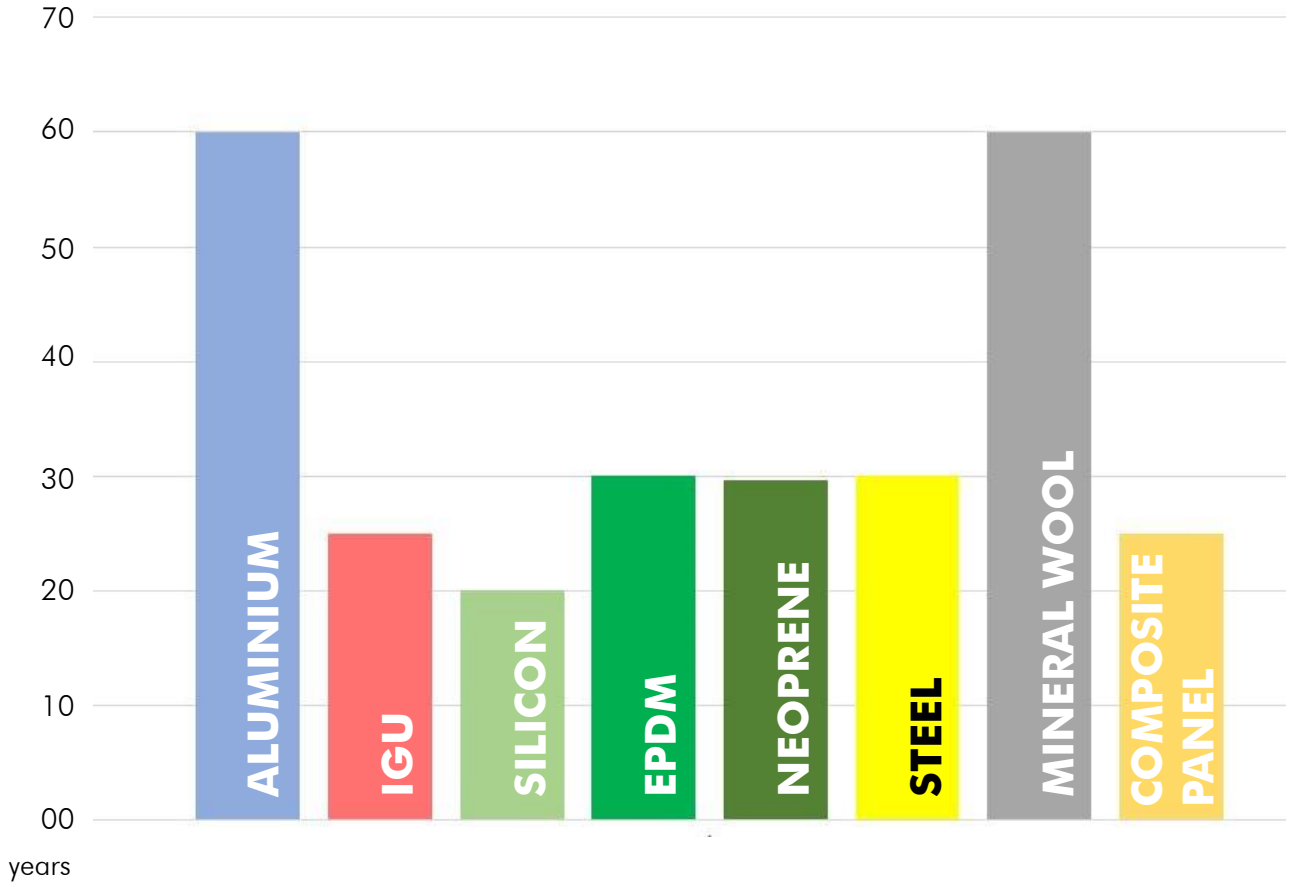
Stainless Steel

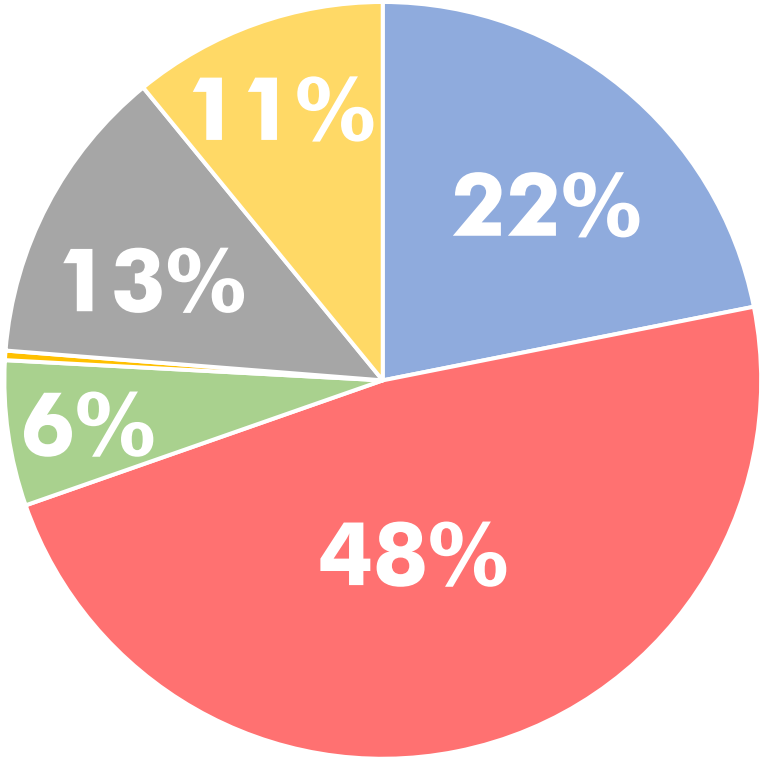
Mineral Wool

Composite Panels

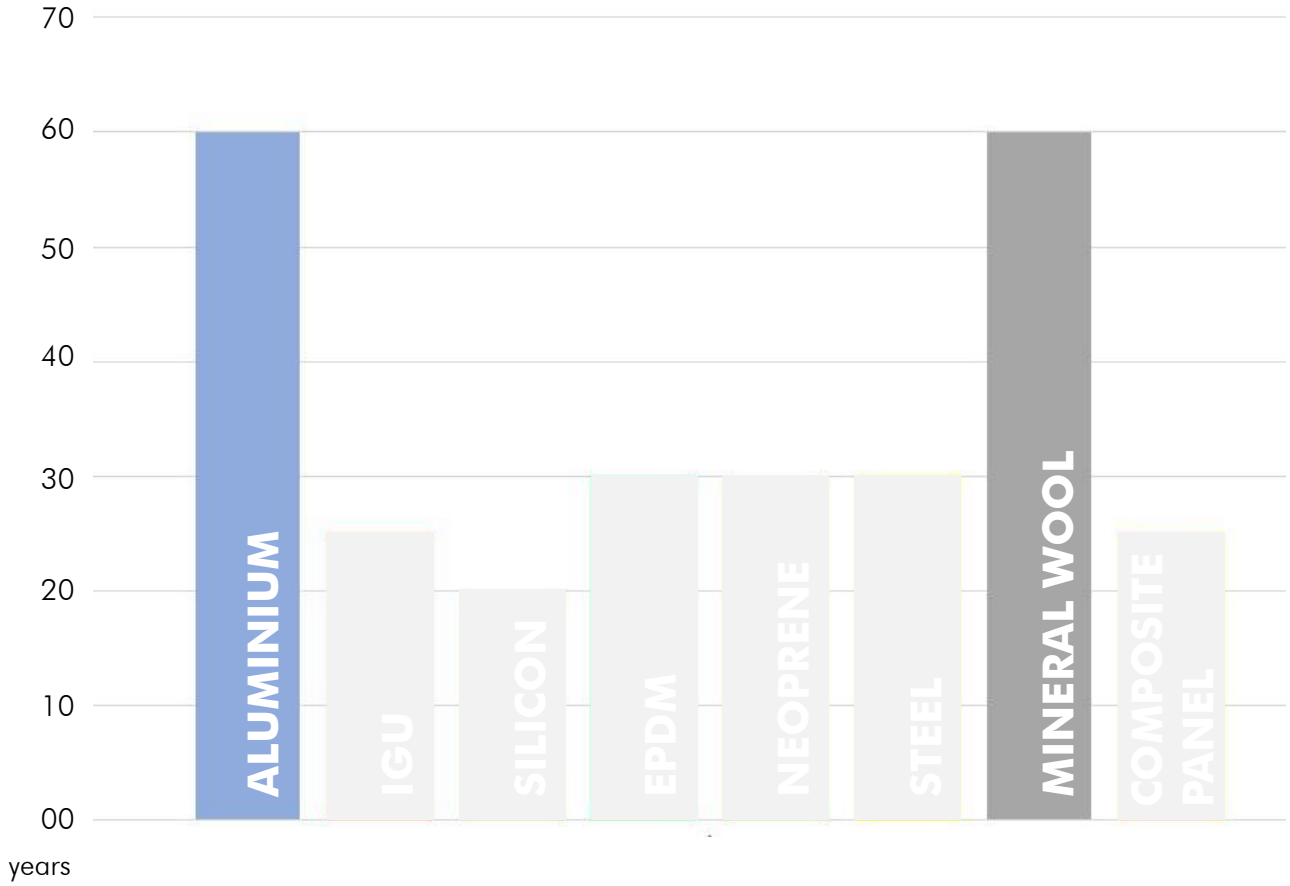


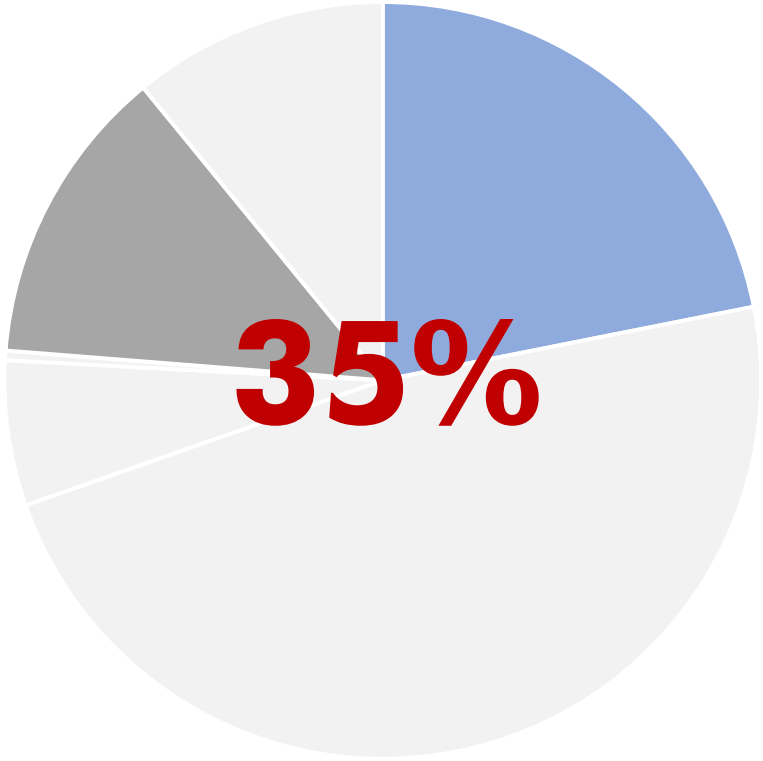
MATERIAL QUANTITY





MATERIAL QUANTITY VS SERVICE LIFE





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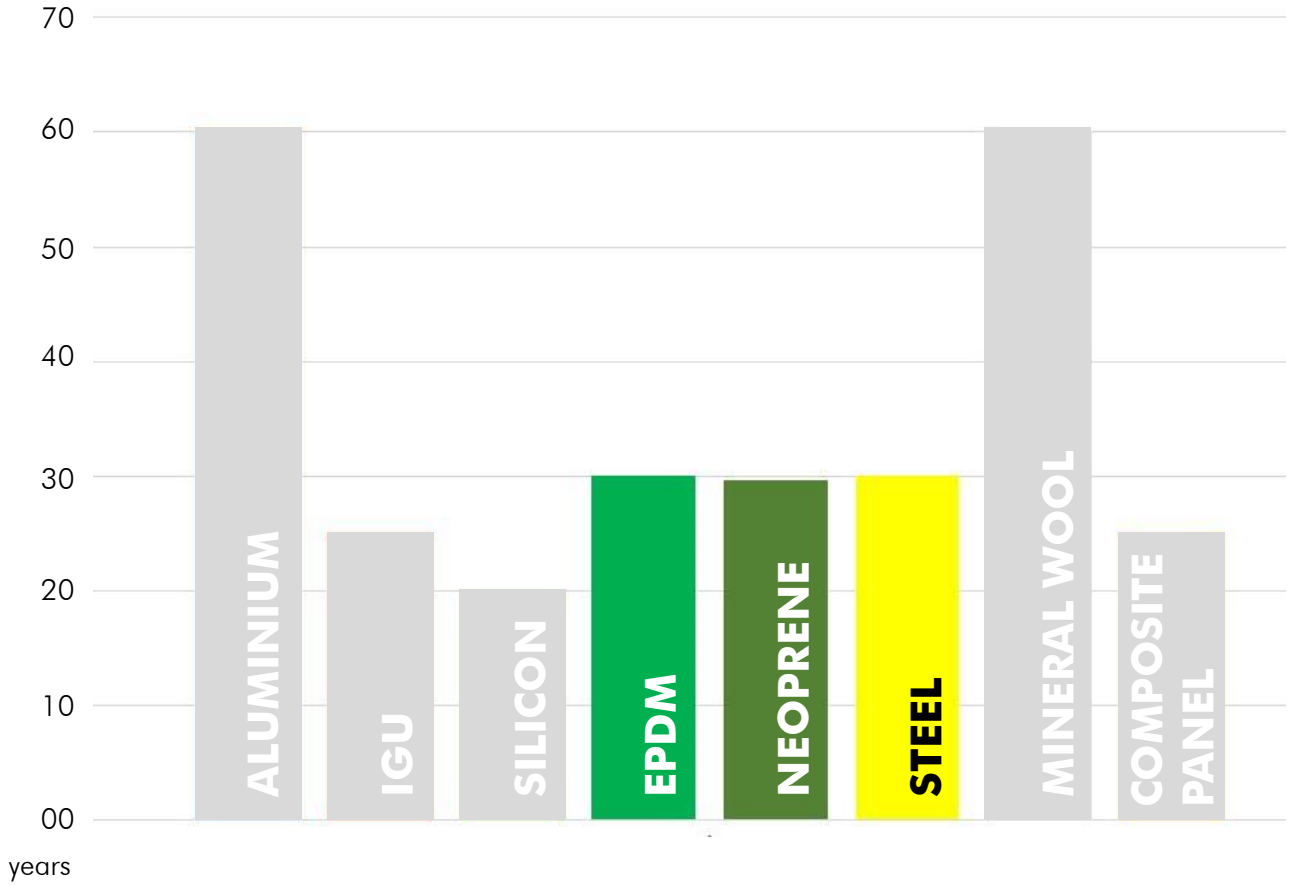

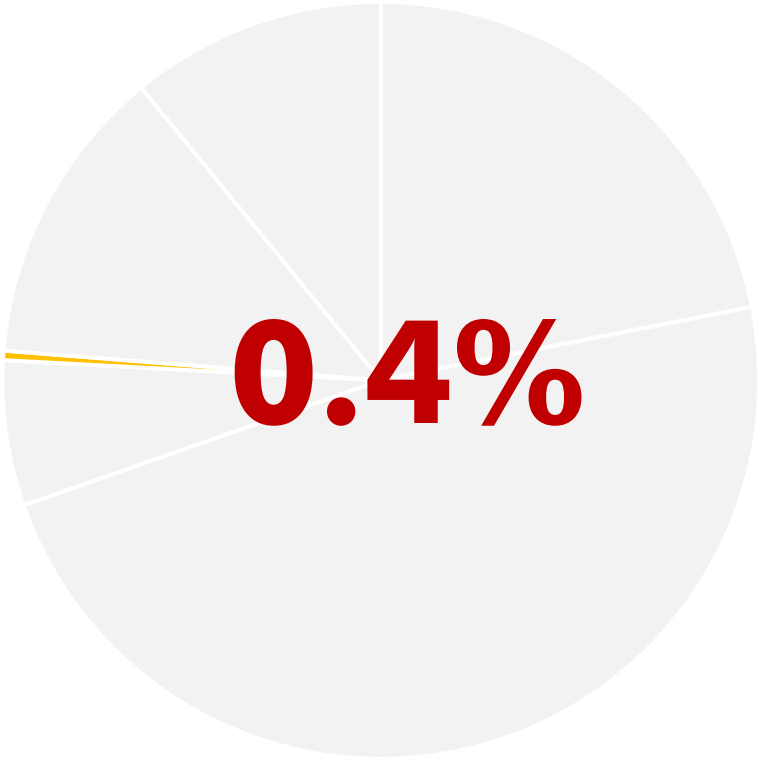

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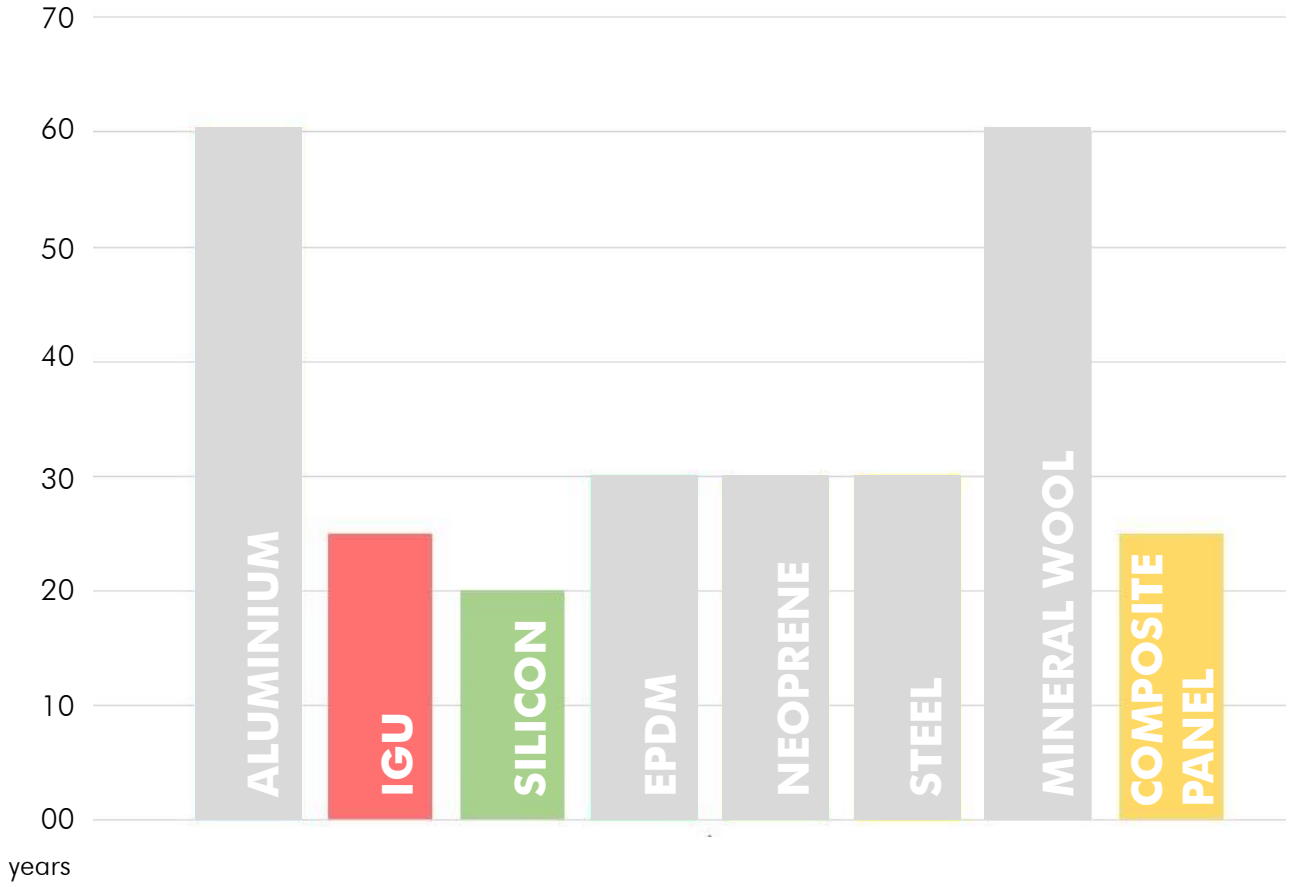
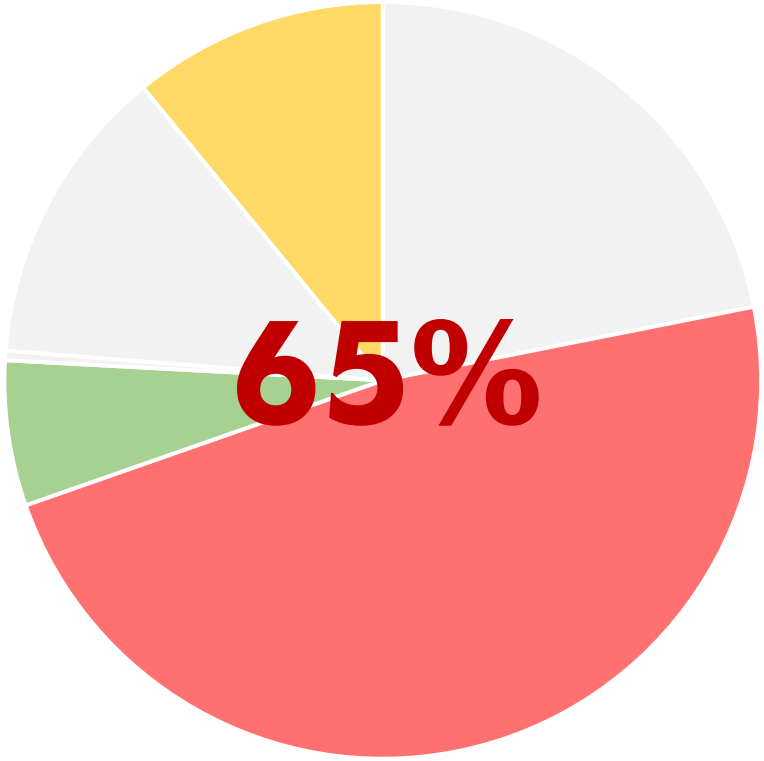
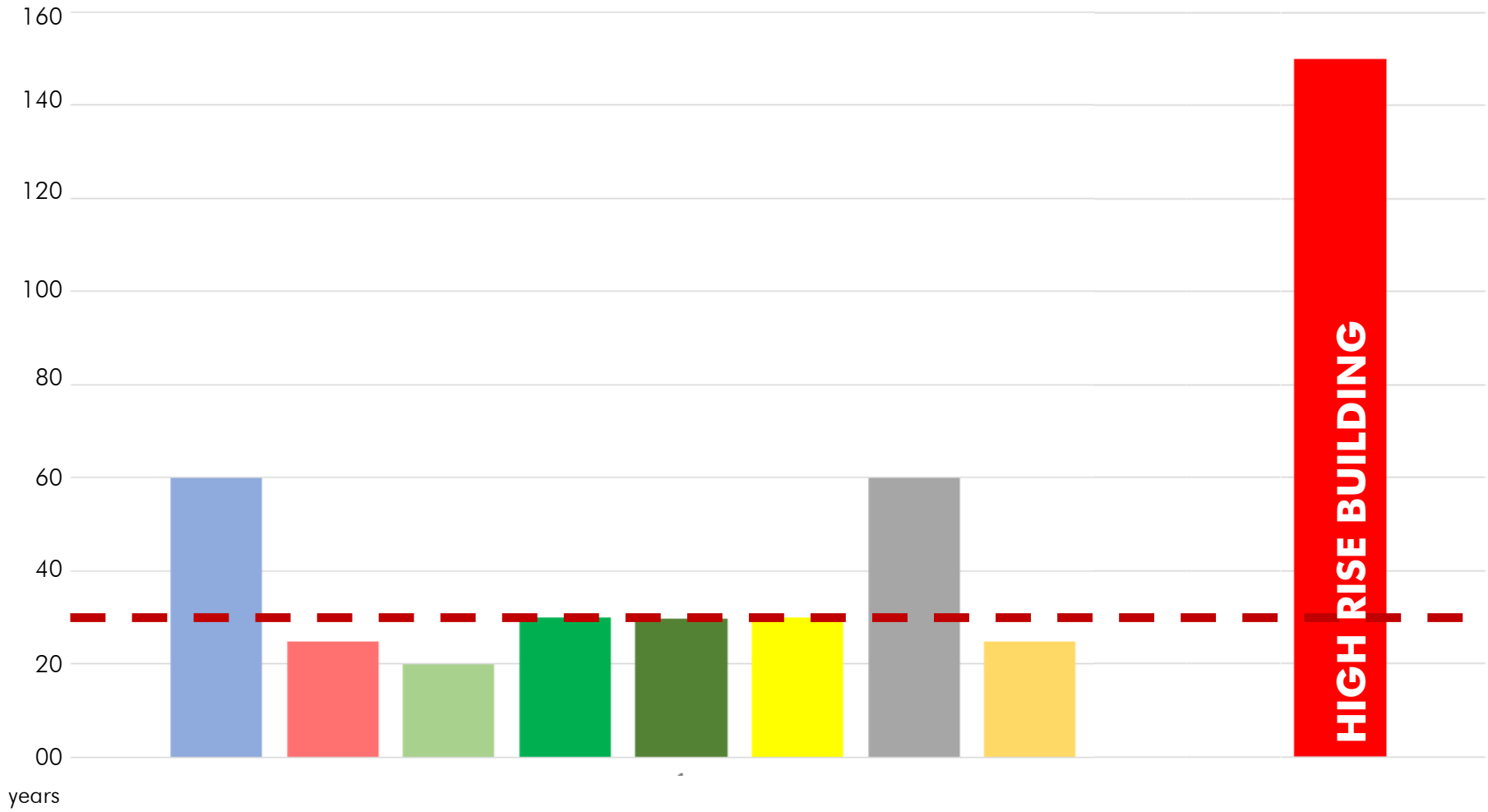




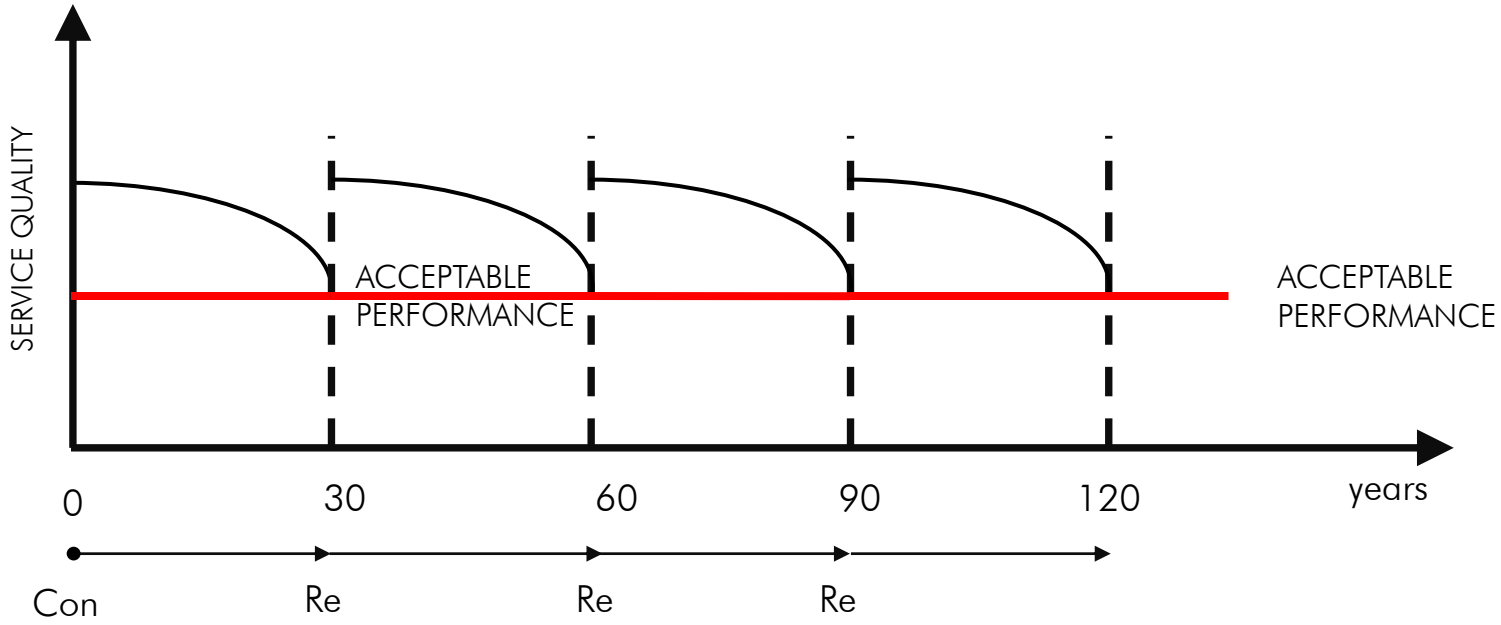
MATERIAL QUANTITY VS SERVICE LIFE

CAUSE OF FAILURES

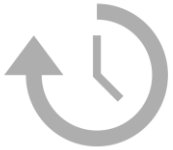
Sources: Various



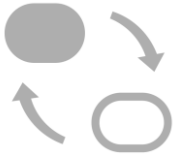
CURTAIN WALL ESL VS BUILDING ESL



Con – Construction
Re – Replacement



PRESENT



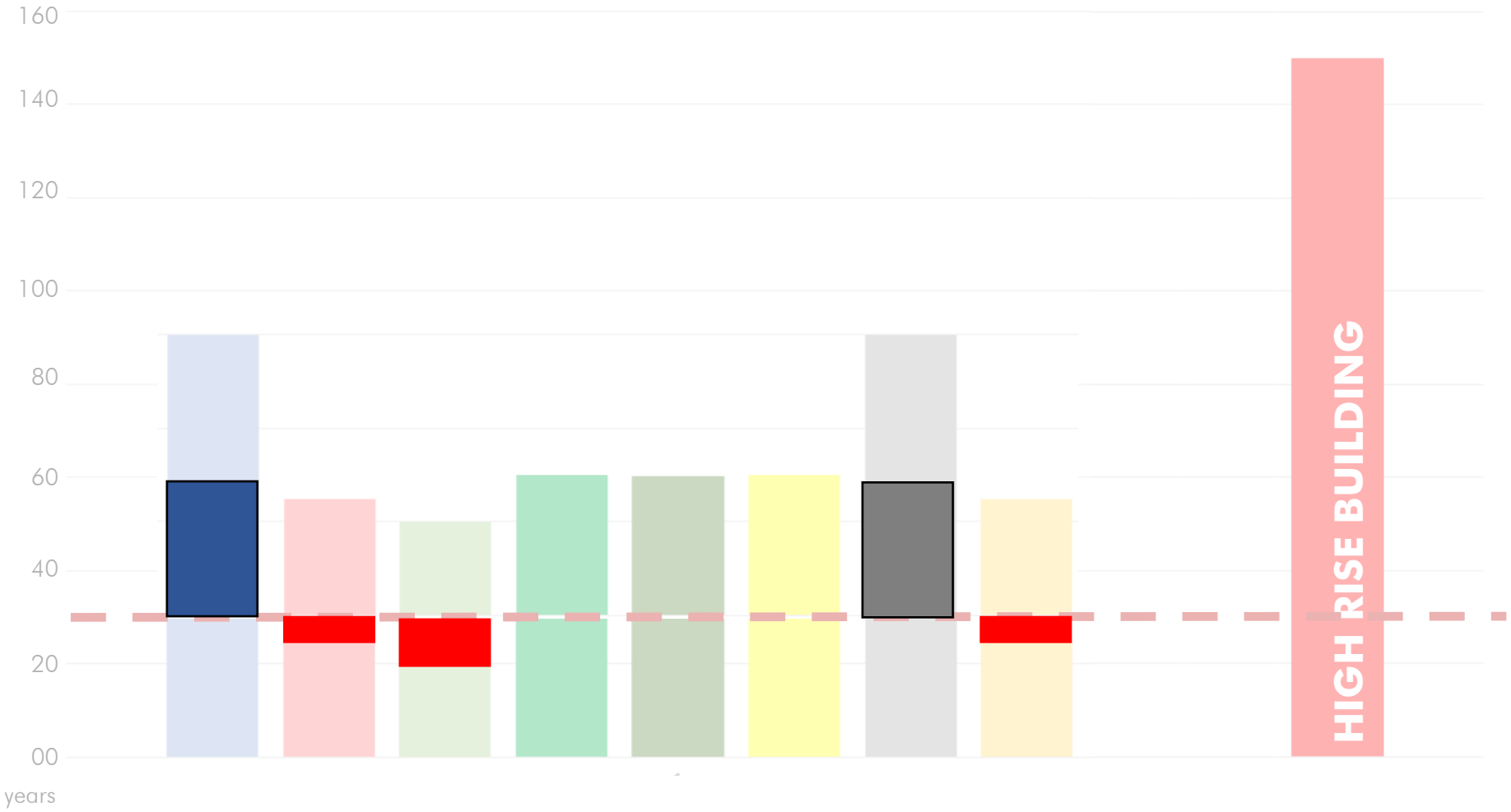
COMPLETE REPLACEMENT

WASTAGE

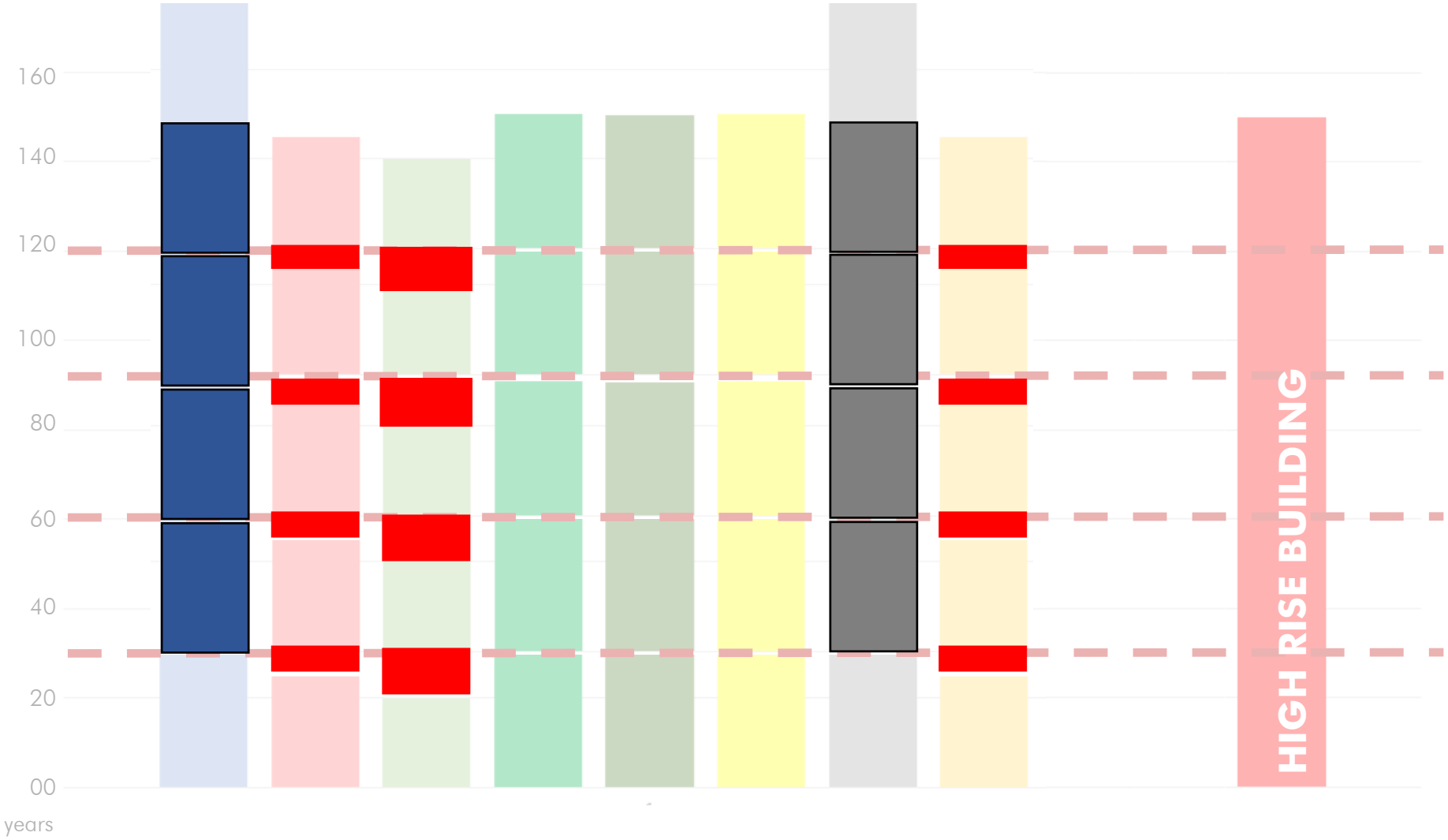
EXPENSIVE

TYPICAL CURTAIN WALL ESL

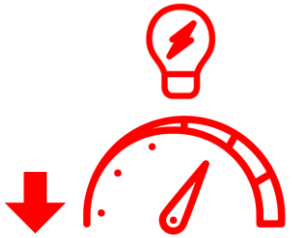
Sources: Kakolyri, T. A. (2015). Sustainability and Service Life of Curtain Walls.



FAÇADE REPLACEMENT

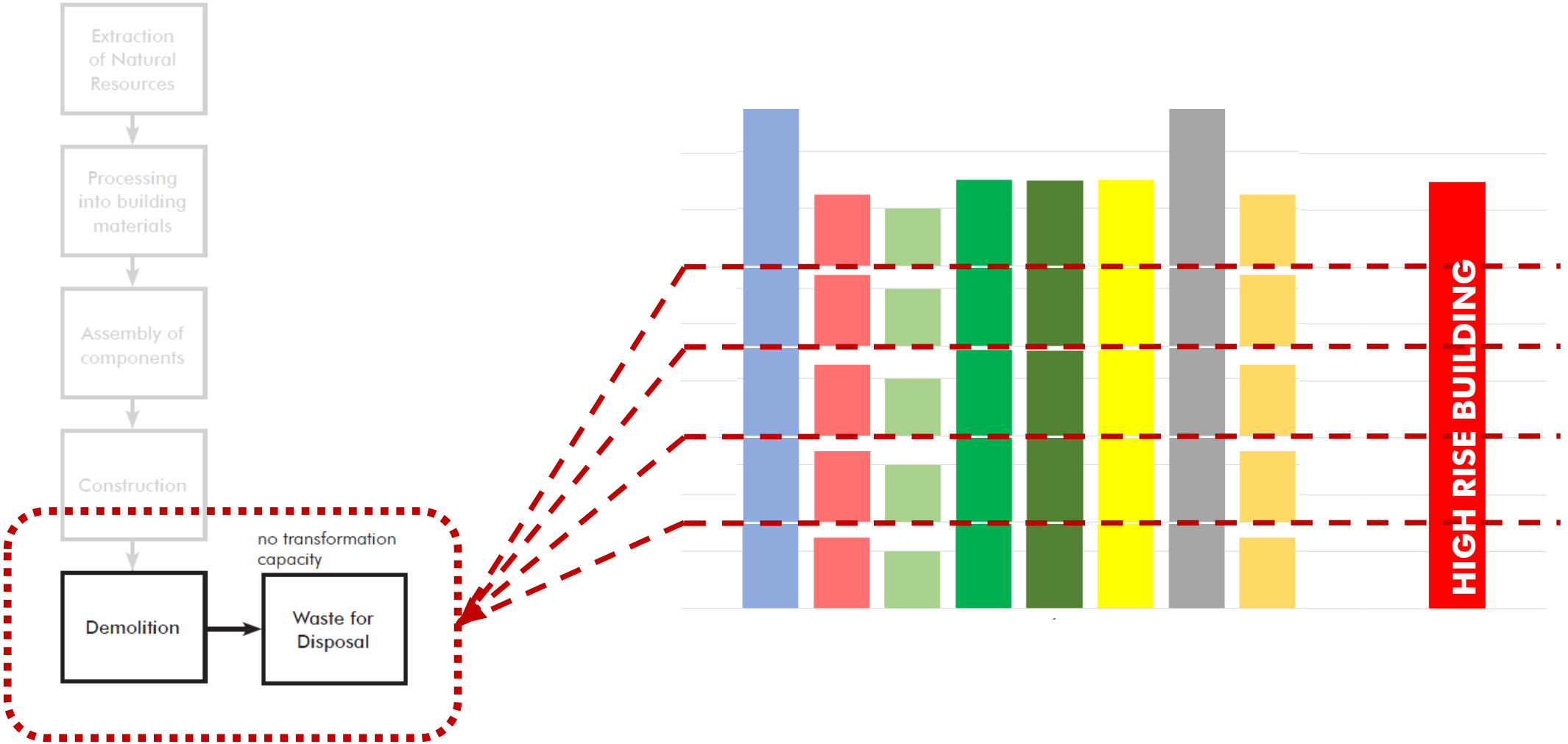


MATERIAL WASTAGE



REDUCED PERFORMANCE

FAÇADE REPLACEMENT OVERTIME



EFFECTS OF REFURBISHMENT

Sources: Durmisevic, E. (2006). Transformable Building structures.

How to sustainably refurbish facades of existing tall building

Problem

- all materials reach ESL
- façade reaches buildings ESL
- reduce Material Wastage

→ design for disassembly

- reduces energy consumption
- contribute in production

→ plug & play

RESEARCH QUESTION

How to sustainably refurbish facades of existing tall building

problem

by creating a plug & play façade system which has integrated functionality

design assignment

- allows disassembly
- integrated technology

RESEARCH QUESTION

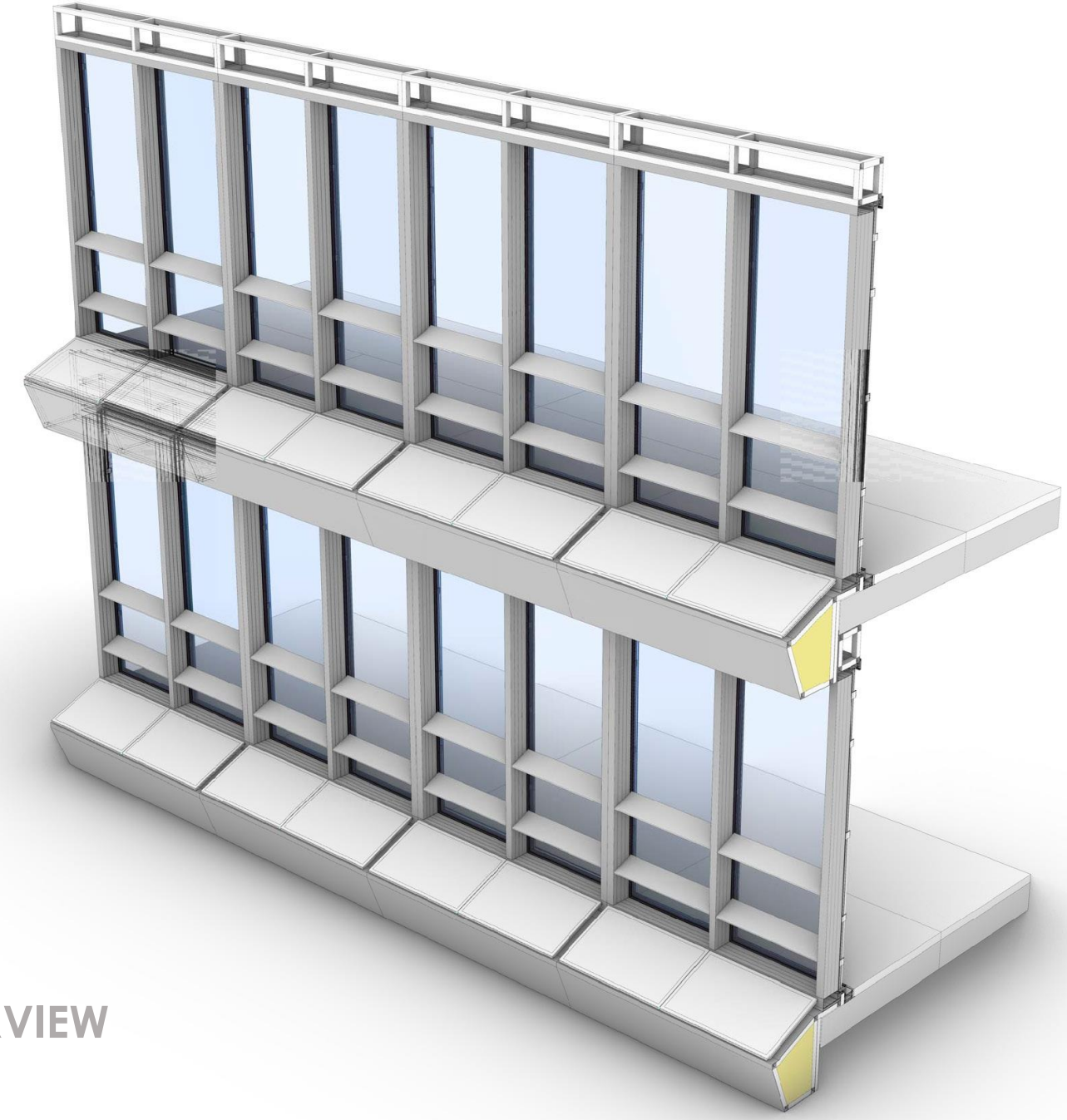
How to sustainably refurbish facades of existing tall building — problem

by creating a plug & play façade system which has integrated functionality — design assignment

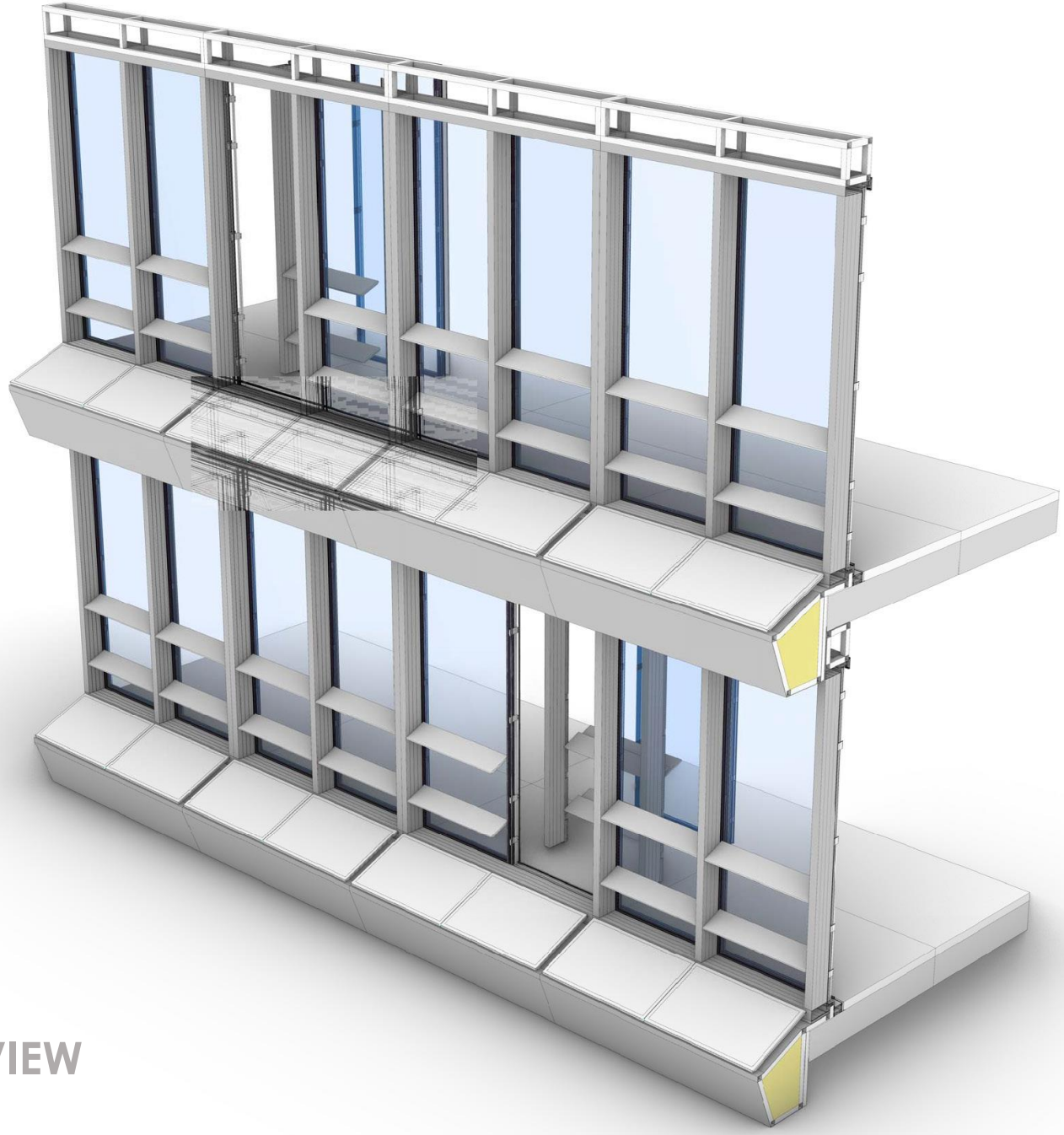
as part of value engineering — assessment

- reduction ·····► material wastage + energy consumption
- production ·····► energy production

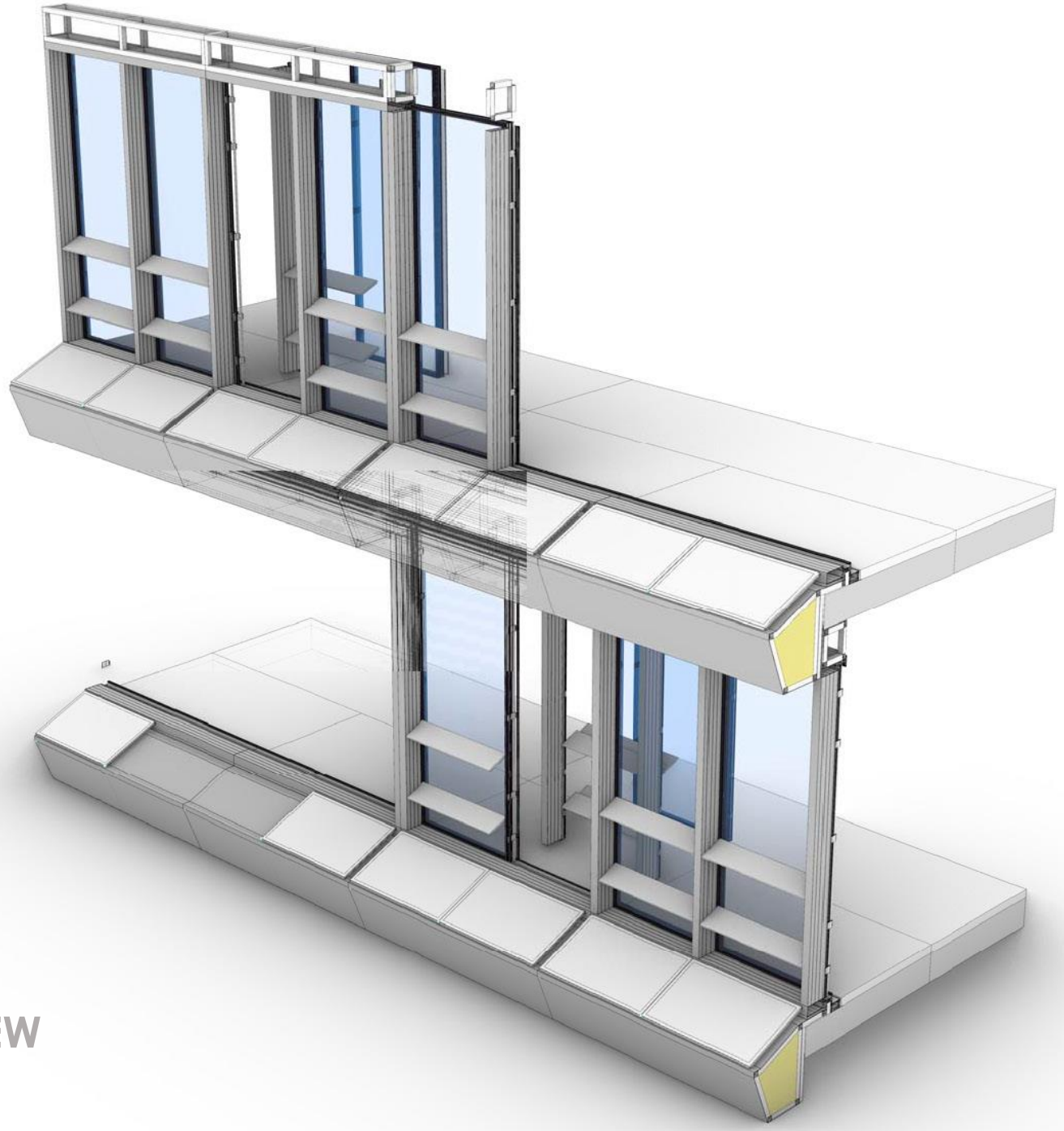
RESEARCH QUESTION



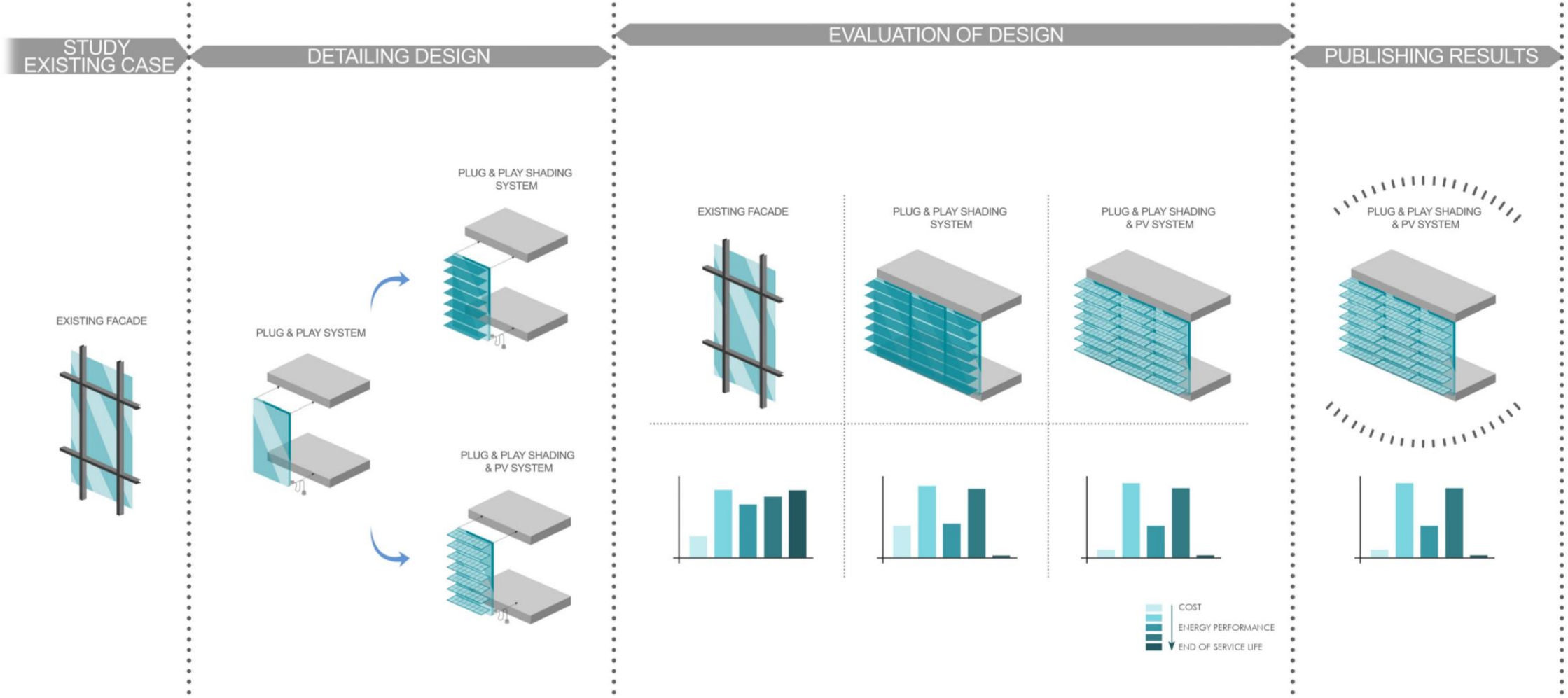
DESIGN OVERVIEW



DESIGN OVERVIEW



DESIGN OVERVIEW



METHODOLOGY

INTERVENTION LOCATION

TEMPERATURE

34 °C

8 – 48 °C

REL. HUMIDITY

60 %

5 – 100 %

INTERVENTION LOCATION

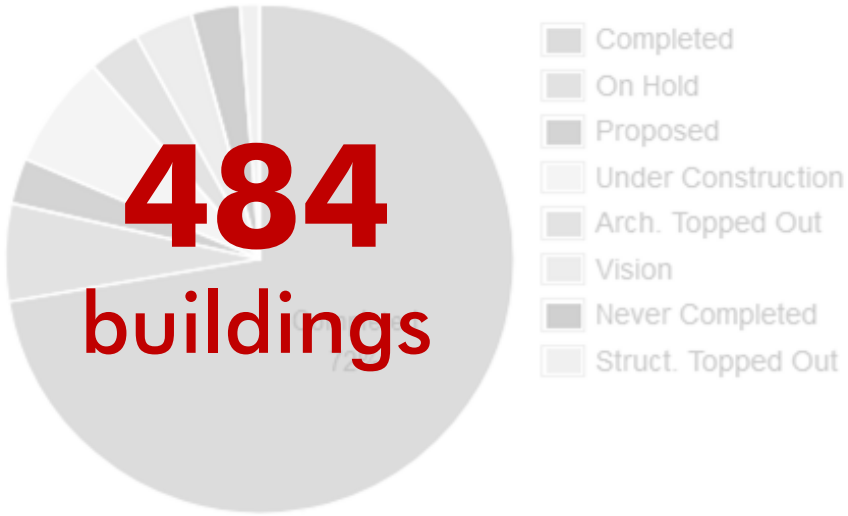
INTERVENTION LOCATION

Sources: https://unsplash.com/photos/Frózexbmjmc

LOCATION - PAST & PRESENT

Sources: https://kitchendecor.club/files/dubai-20-years-ago-today.html

Construction Status



484 buildings

Building Function

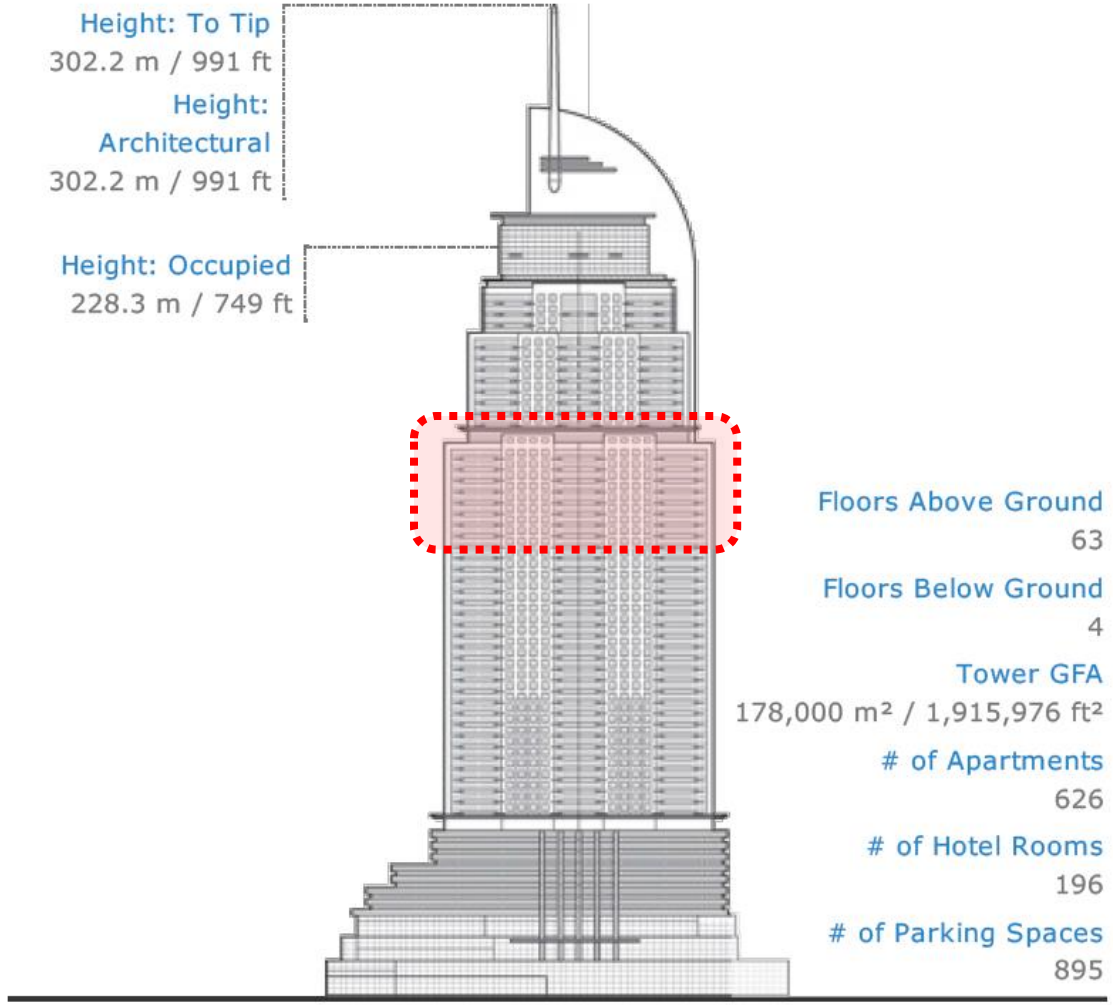
40% Mixed-use & hotels

INTERVENTION LOCATION - RECORD OF EXISTING TALL BUILDINGS

Sources: https://kitchendecor.club/files/dubai-20-years-ago-today.html

CASE STUDY OPPORTUNITY

Sources: https://giphy.com/gifs/fire-dubai-lapse-Jst1zdjaoUEDK



Hotel
typology

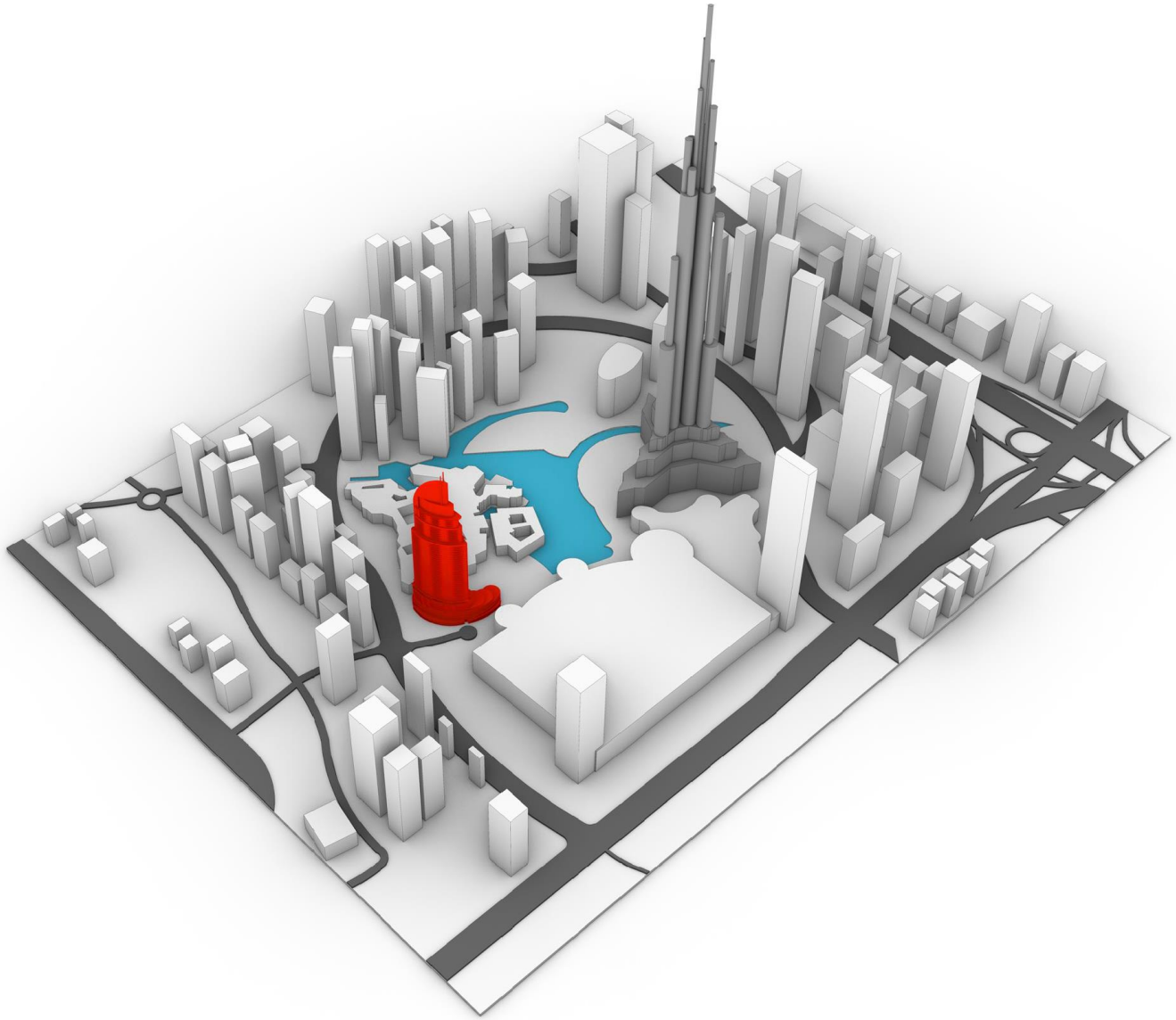
300 meters
height

63
floors

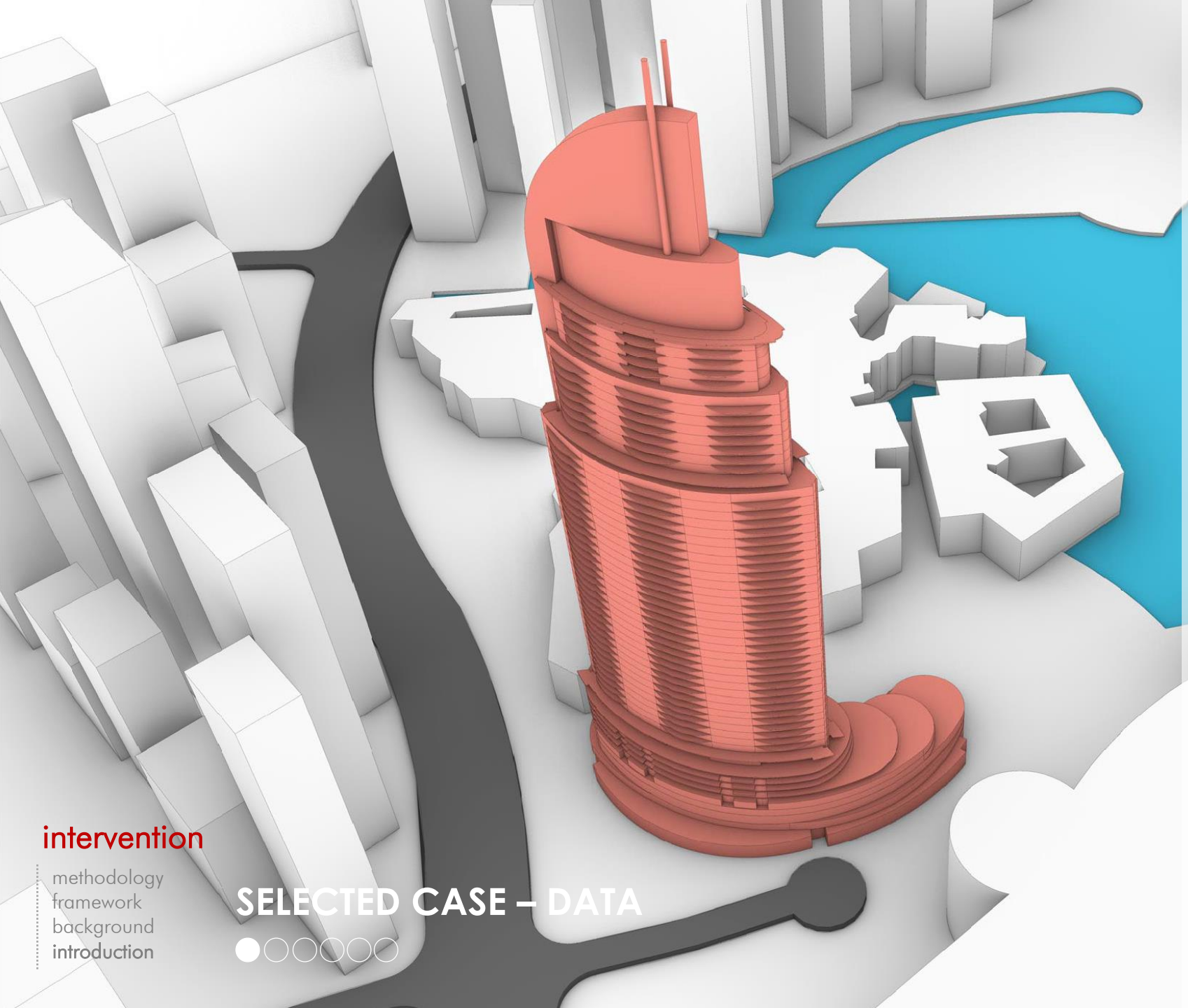
850
rooms

SELECTED CASE – ADDRESS HOTEL DUBAI

Sources: https://kitchendecor.club/files/dubai-20-years-ago-today.html



SELECTED CASE – CONTEXT



10 years
age of the building

28,000 m²
façade surface area

2800 m²
floor surface area

7500-9000
number of façade panels

SELECTED CASE – DATA

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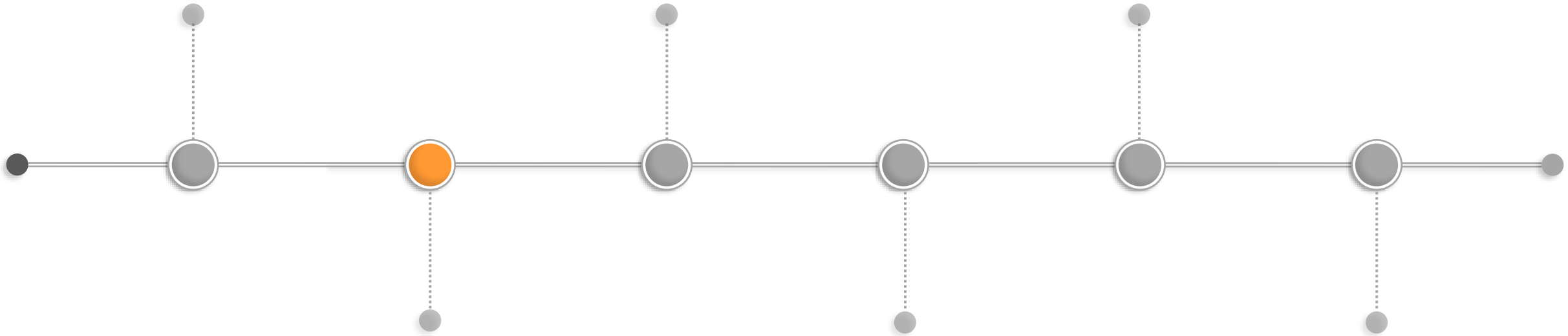

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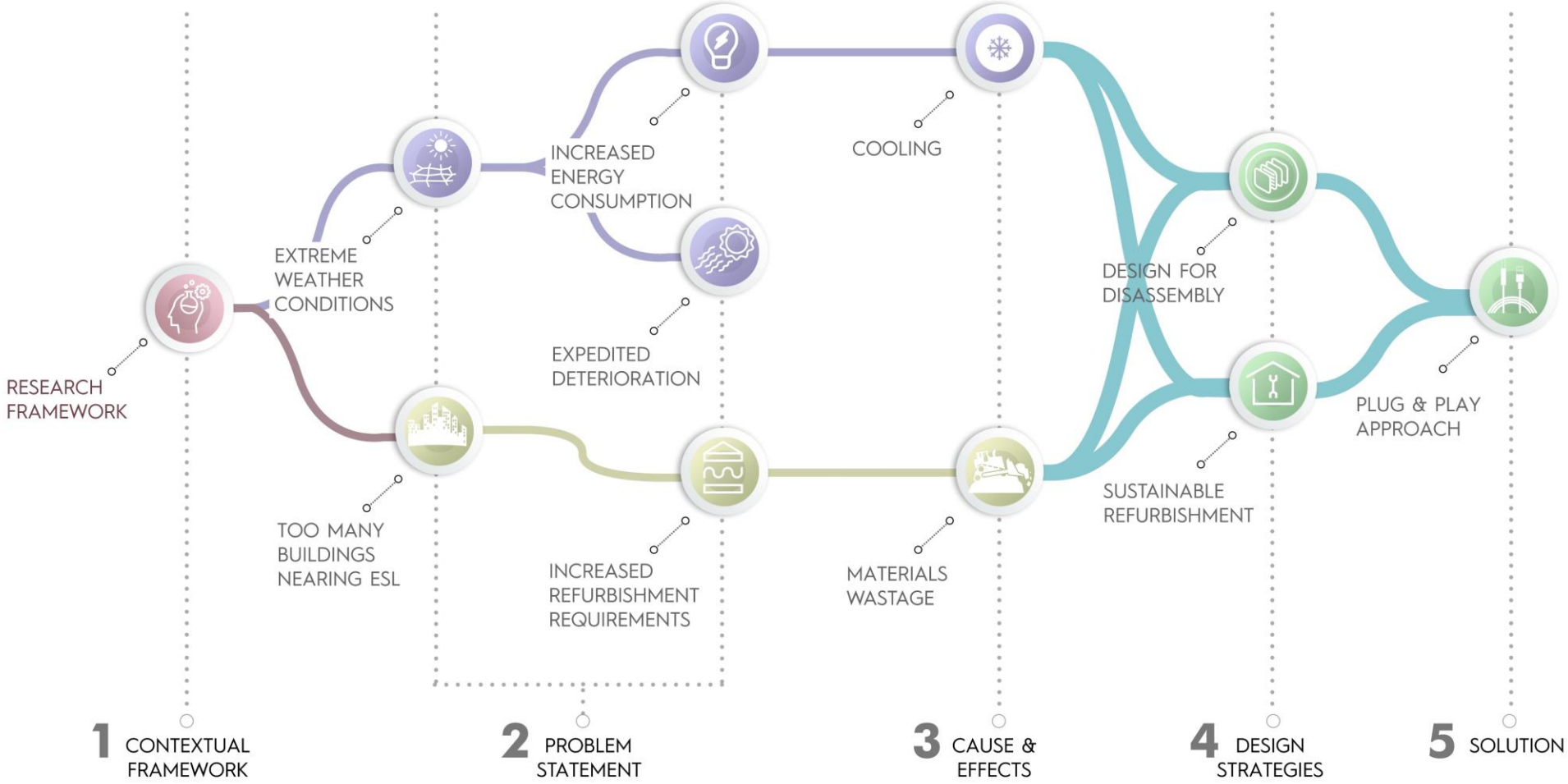
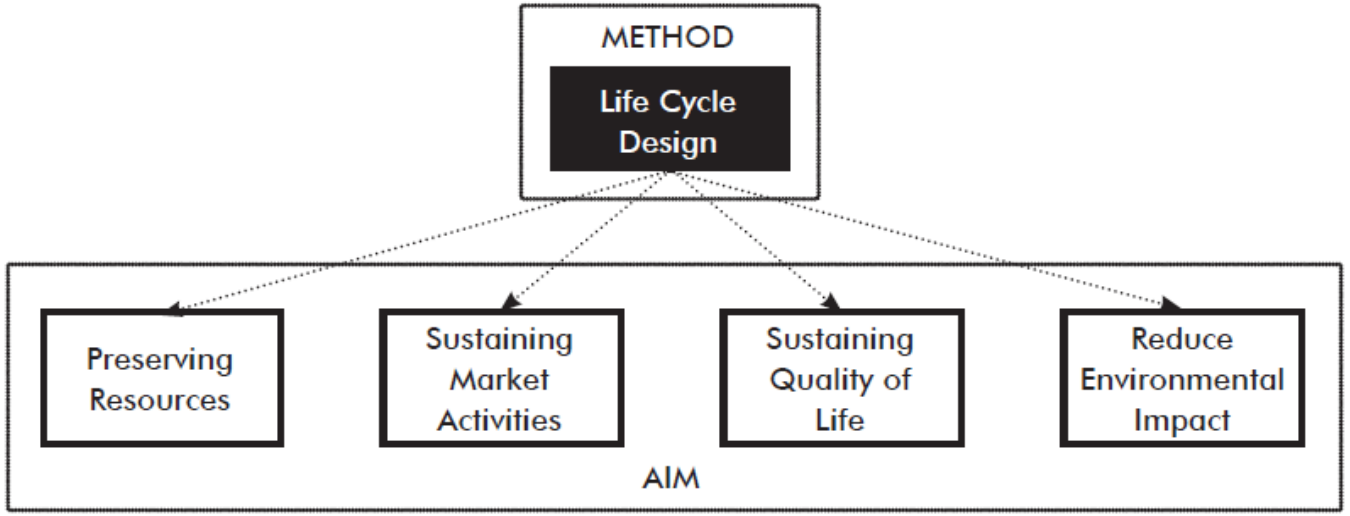


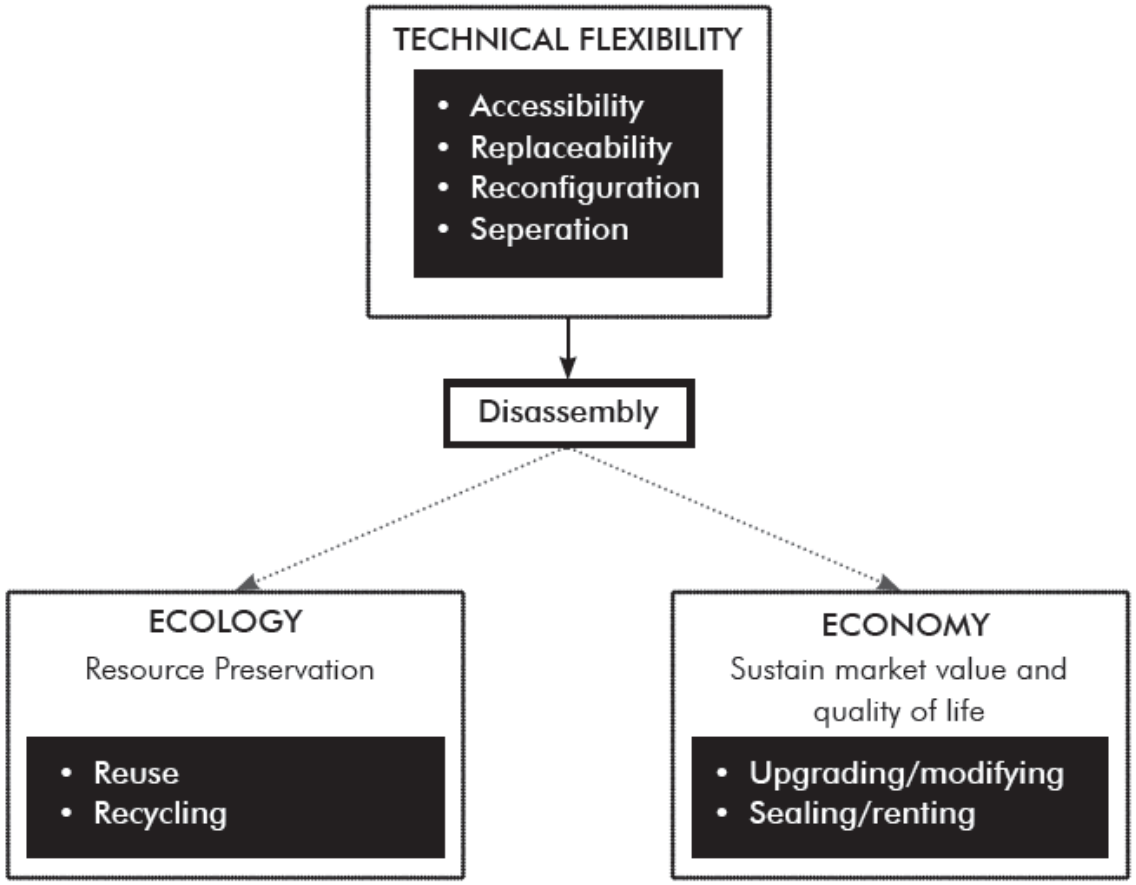
SELECTED CASE – CONTEXT

framework



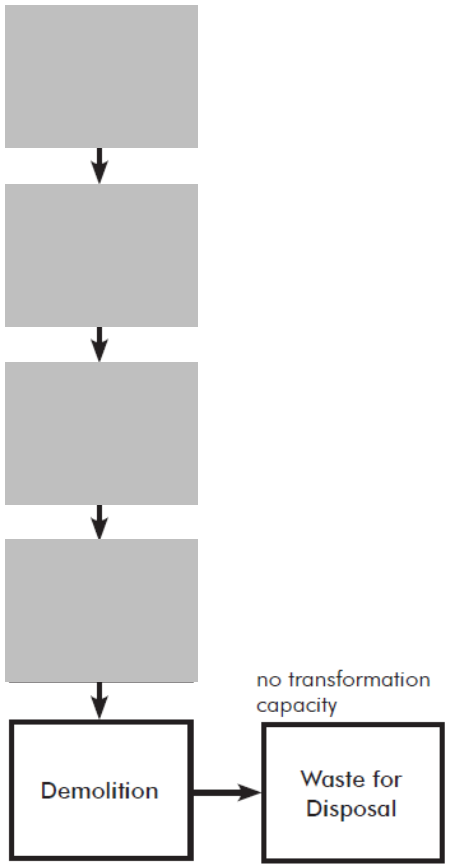
AIM FOR SUSTAINABLE REFURBISHMENT

Sources: Durmisevic, E. (2006). Transformable Building structures.



DESIGN FOR DISASSEMBLY

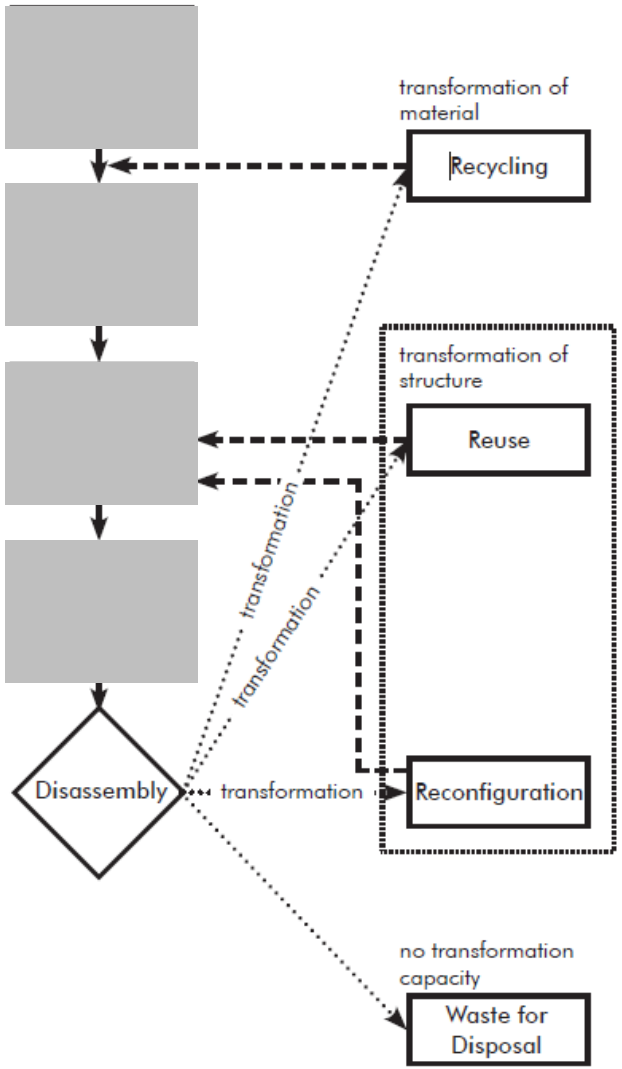
Sources: Durmisevic, E. (2006). Transformable Building structures.



DESIGN FOR DISASSEMBLY

framework

Sources: Durmisevic, E. (2006). Transformable Building structures.



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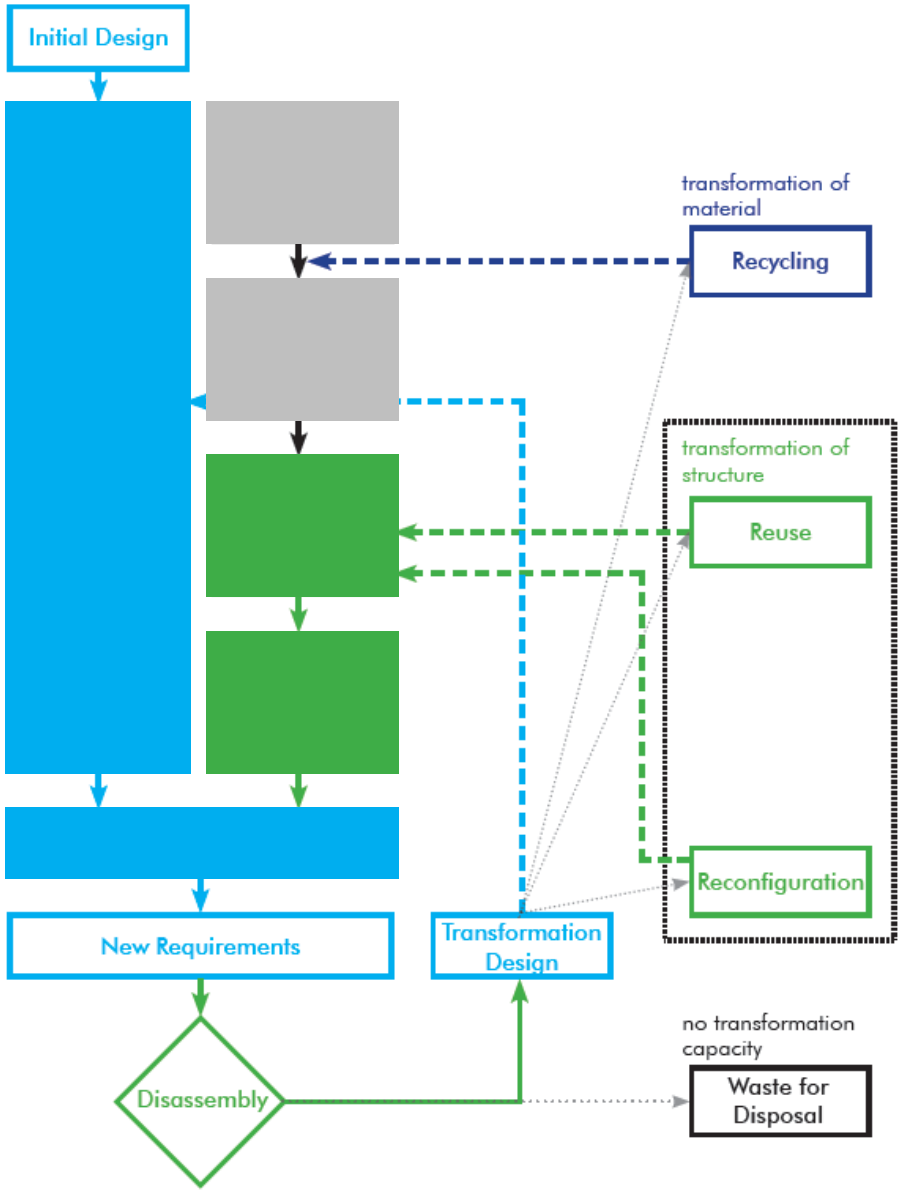
Sources: Durmisevic, E. (2006). Transformable Building structures.



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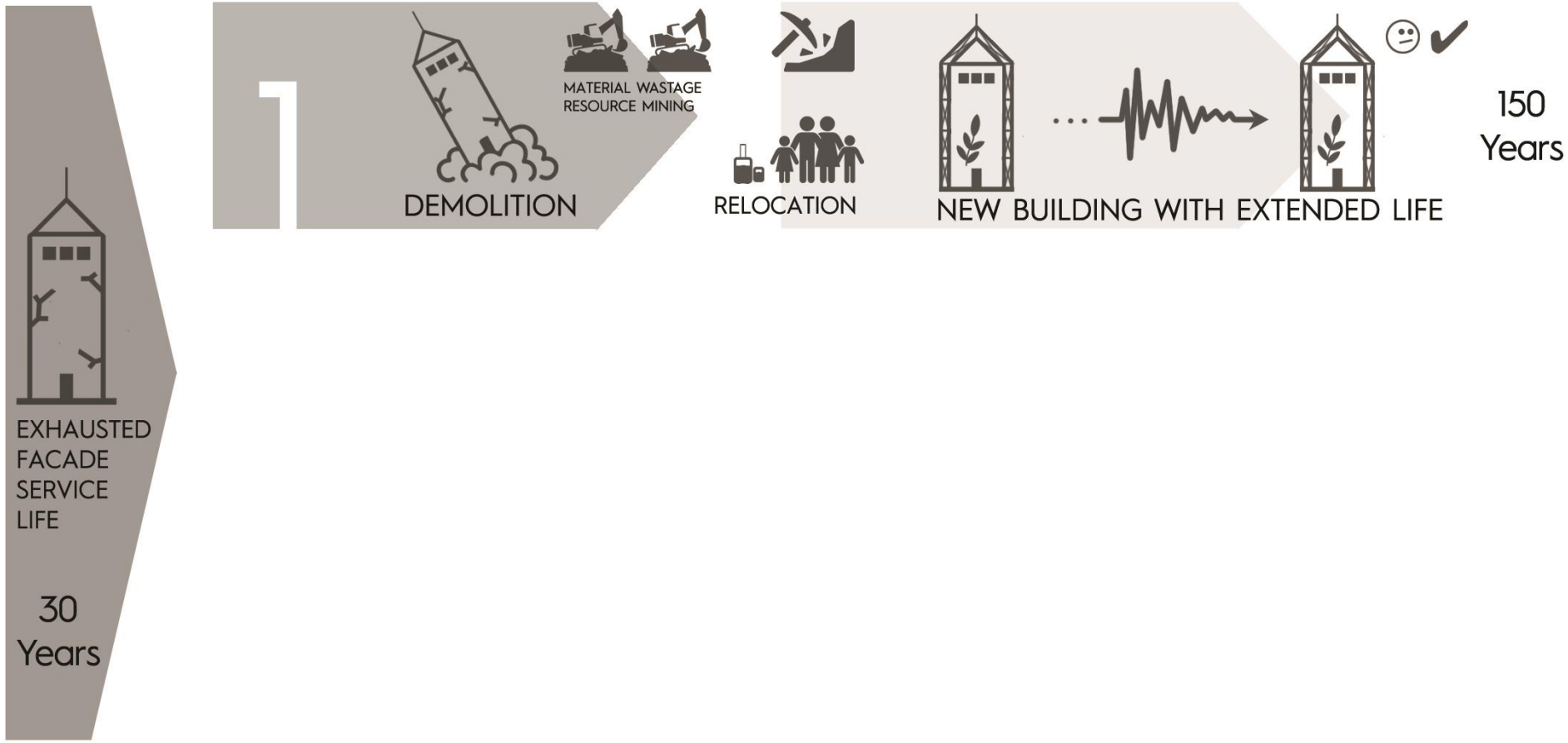
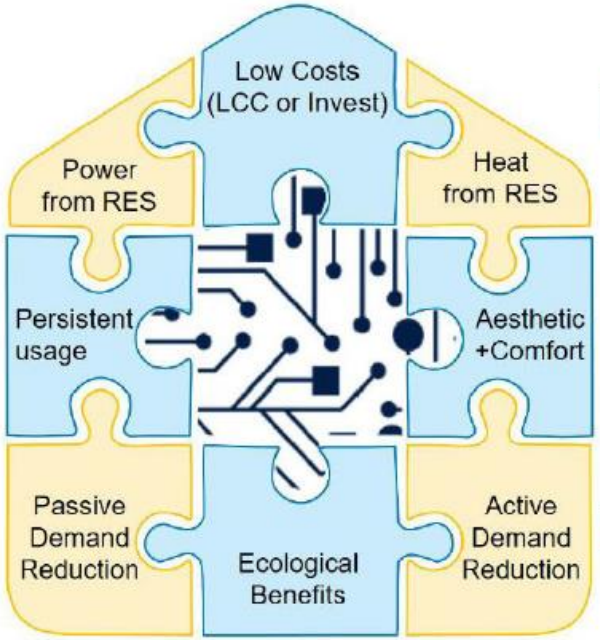


AIM FOR SUSTAINABLE REFURBISHMENT

- Modularity, Exchangeability
- Large Series Prefabrication
- Alternative Business Models/ Leasing

- Photovoltaics
- Power Storage
- District Solutions

- Solarthermal/ Hybrid Modules
- Solar Air Heater
- Electrical Heating/ Cooling



- In front of Existing Facade
- Fast Assembly
- Media Paths in Facade

- Manifold Surfaces
- Increased User Comfort
- Adaptions by User possible

- Wall Insulation
- Window Improvement
- Reduction of Infiltration

- Ventilation with Heat Recovery
- Sun Shading
- Demand-Led Automation

- Low Primary Energy Demand
- Principles of the Circular Economy
- Energetic Amortisation (Embodied Energy)

Sources: Dannapfel, V., Osterhage, T., & Klein, M. (2018).

ENERGY PERFORMANCE INDEX

250-500 kWh/m²
energy consumption of studied tall buildings in the region

172 kWh/m²
energy consumption for cooling of studied tall buildings in the region

90 kWh/m²
energy consumption requirement for nZEB in the region

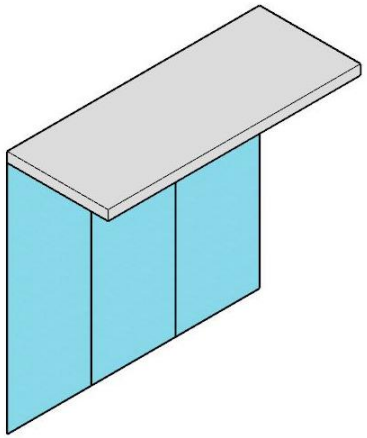
literature summary

LITERATURE – ENERGY PERFORMANCE

Sources:
Al-sallal, K. A. (2016)
EmiratesGBC. (2017)

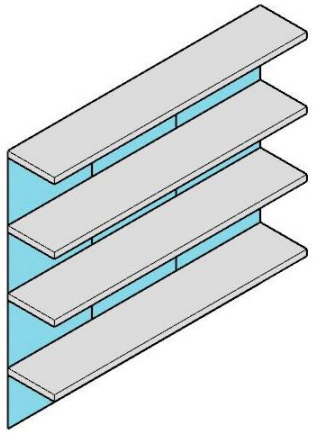
SHADING POTENTIAL

6% SAVINGS



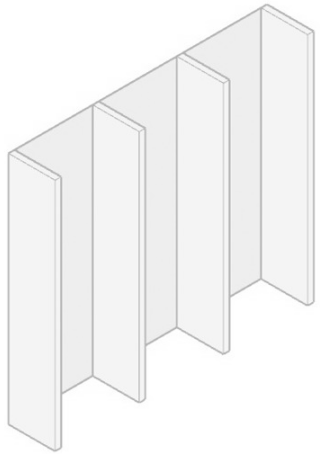
HORIZONTAL OVERHANG

11% SAVINGS



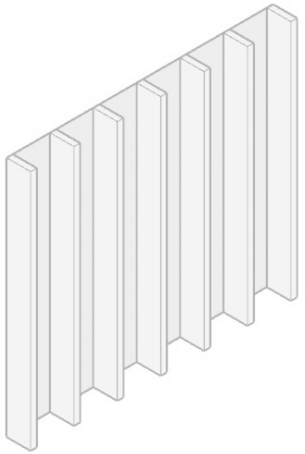
HORIZONTAL LOUVERS

4% SAVINGS



VERTICAL FINS

7% SAVINGS



VERTICAL LOUVERS

Sources:
Al-sallal, K. A. (2016)
EmiratesGBC. (2017)
Shanks, Kirk; Nezamifar, E. (2013)

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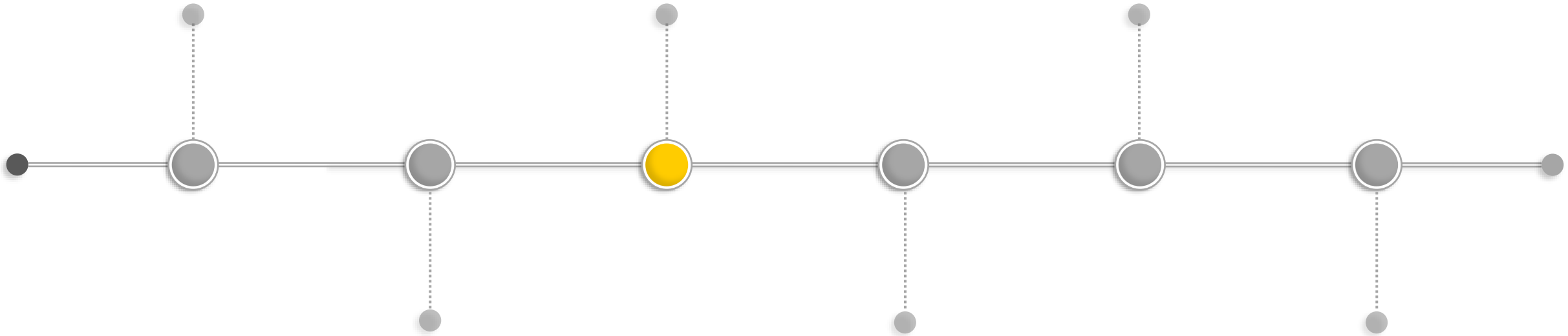

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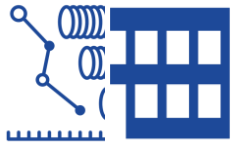


1. **Improve Façade Quality**

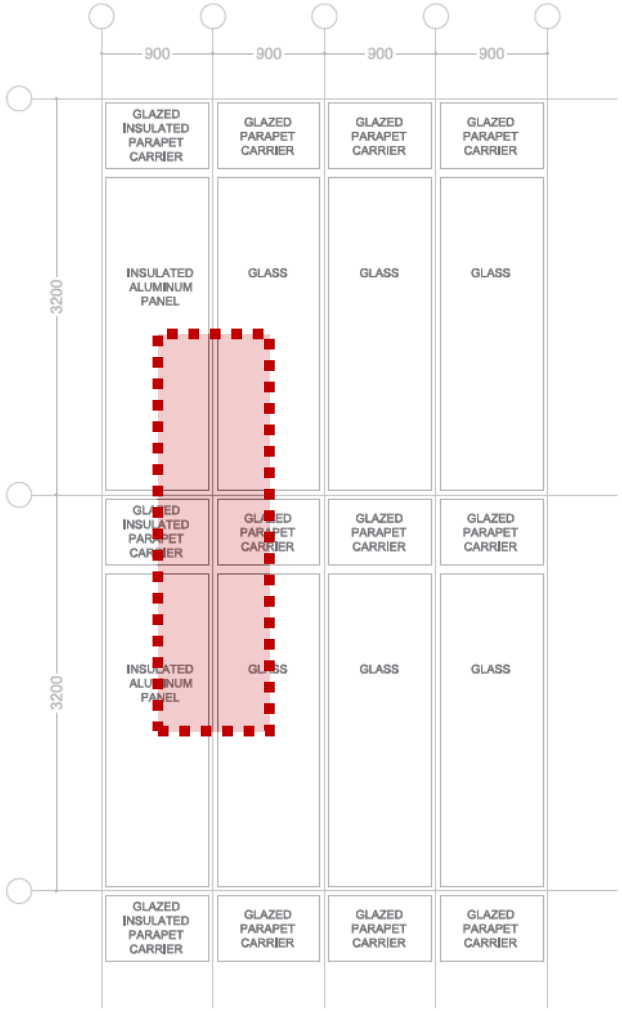
2. **Provide Shading**

3. **Sufficient Daylight Inside**

4. **Align Shading to provide BIPV**

5. **Design for Disassembly**

6. **Design for Accessibility**



150 years
ESL of tall buildings

0.5 years
regular façade maintenance period

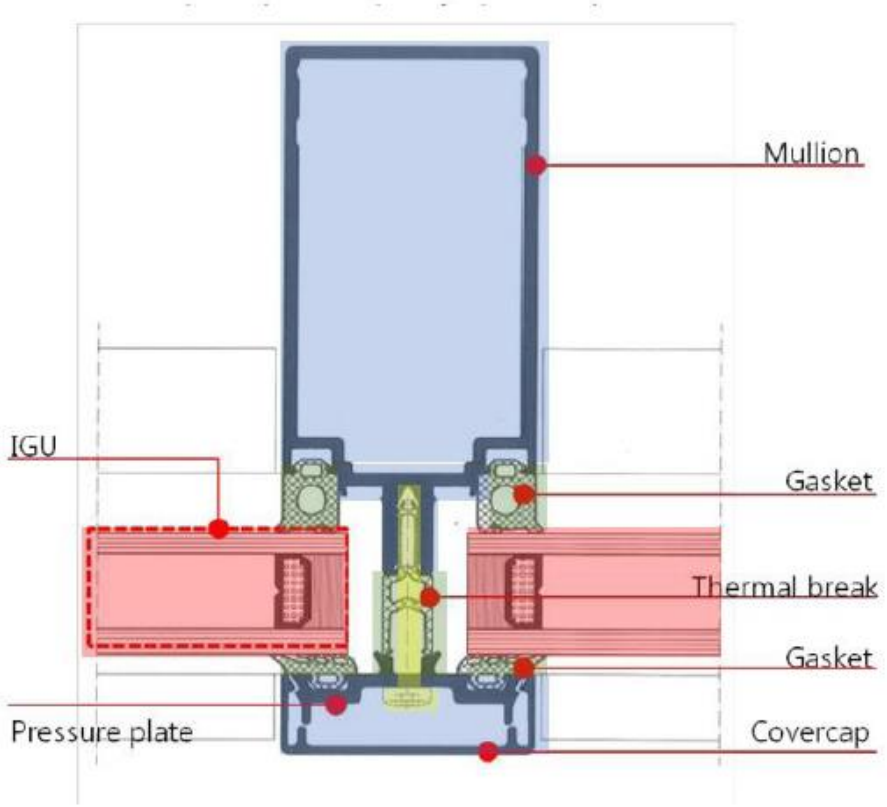
30 years
regular curtain wall ESL

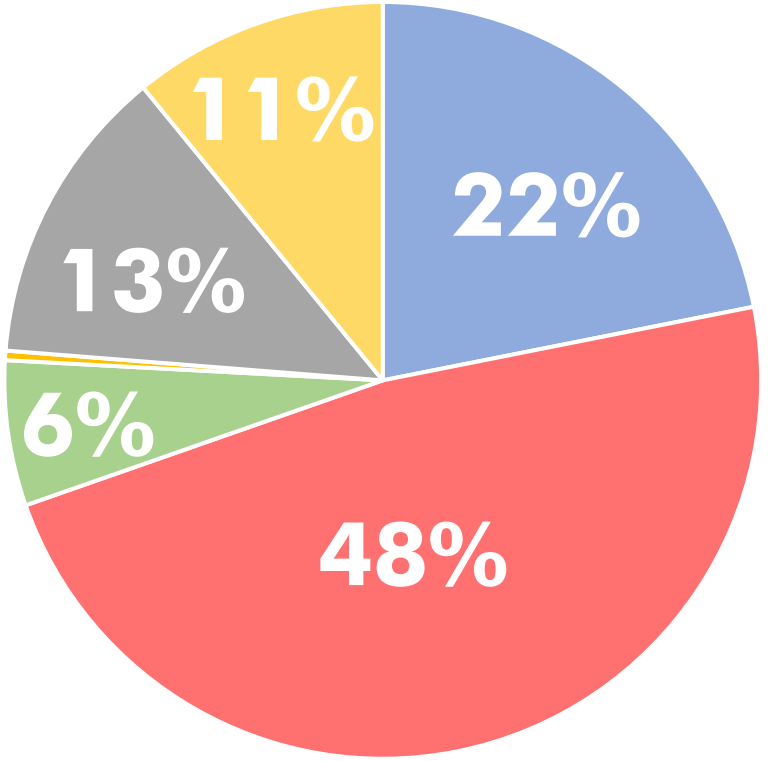
concept design
energy performance - assessment
economic assessment

life cycle assessment

LCA BOUNDARY CONDITIONS

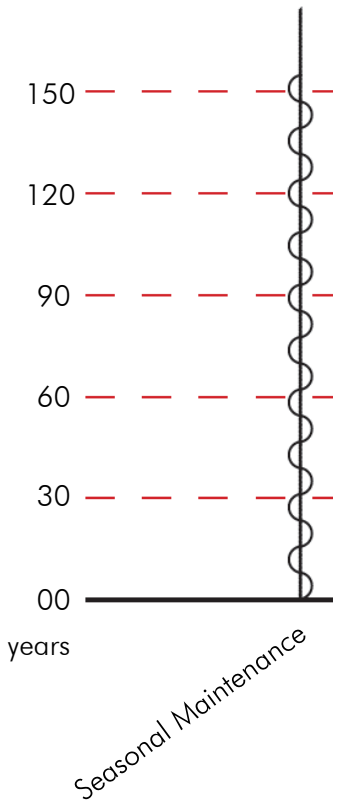
design development ○○●○○○





concept design
energy performance - assessment
economic assessment
life cycle assessment
design development

MATERIALS OVERVIEW

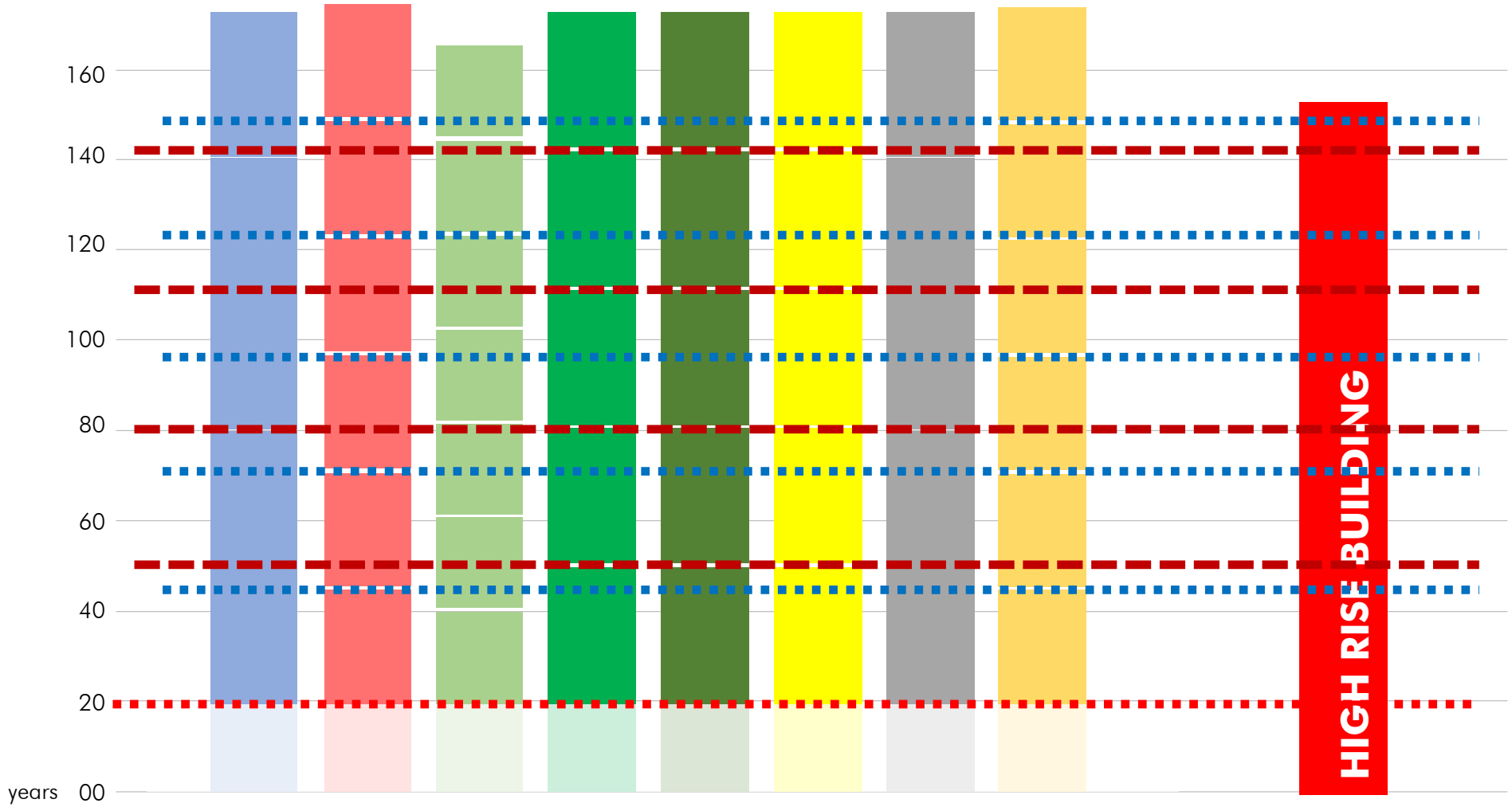


concept design
energy performance - assessment
economic assessment

life cycle assessment

LCA EVALUATION VS MAINTENANCE SCHEDULE

design development ○○●○○○

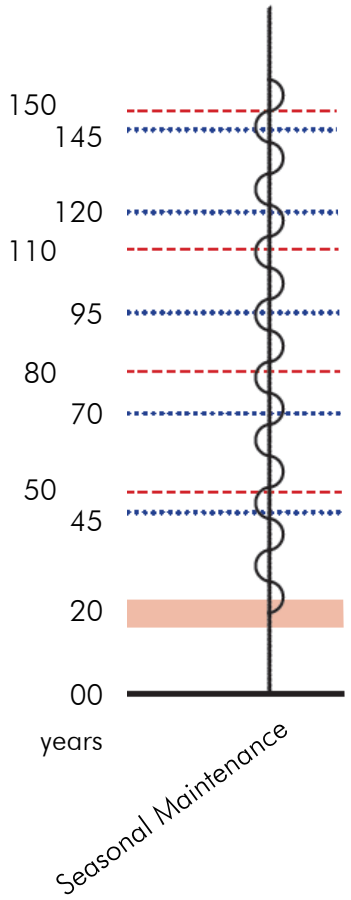


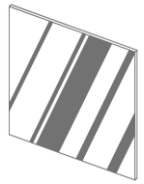
concept design
energy performance - assessment
economic assessment

life cycle assessment

PROPOSED LIFE CYCLE

design development





7 cycles

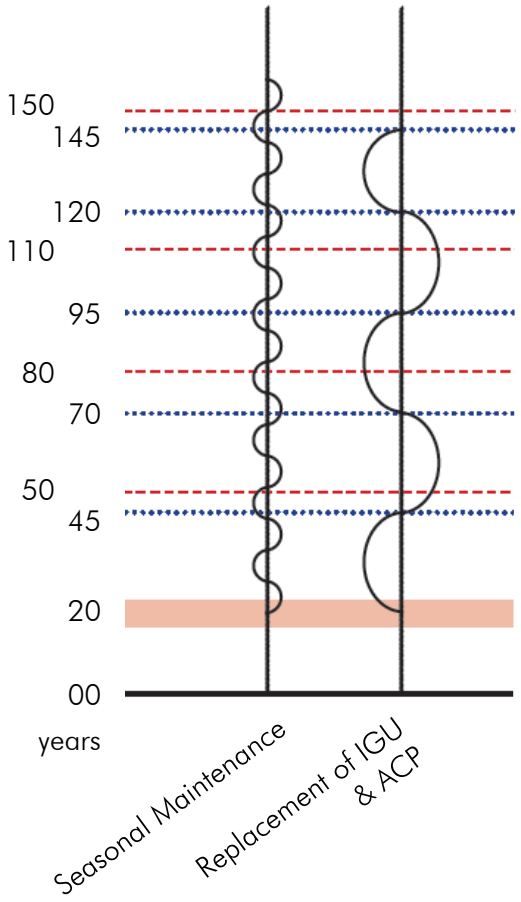
Silicon

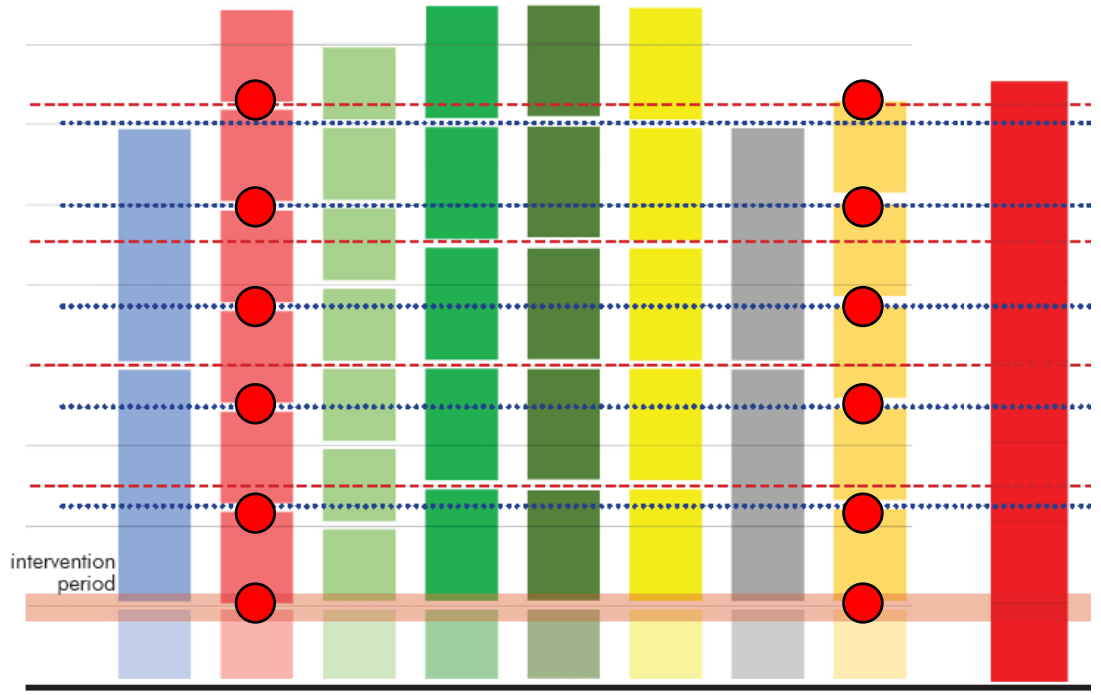
concept design
energy performance - assessment
economic assessment

life cycle assessment

PROPOSED LC VS MAINTENANCE SCHEDULE

design development ○○●○○○





6 cycles

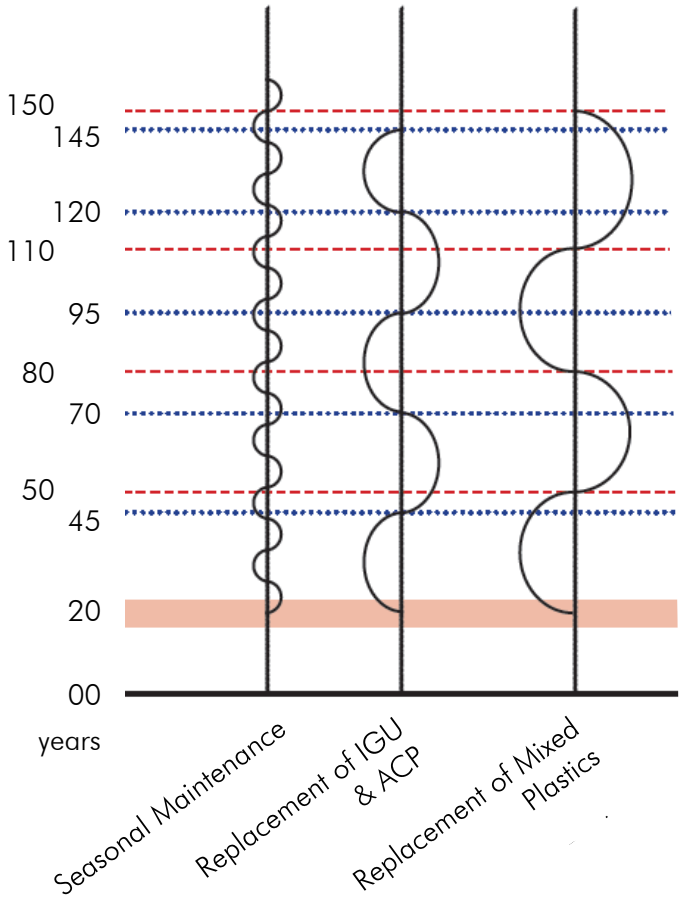
Insulated Glazing Composite Panels

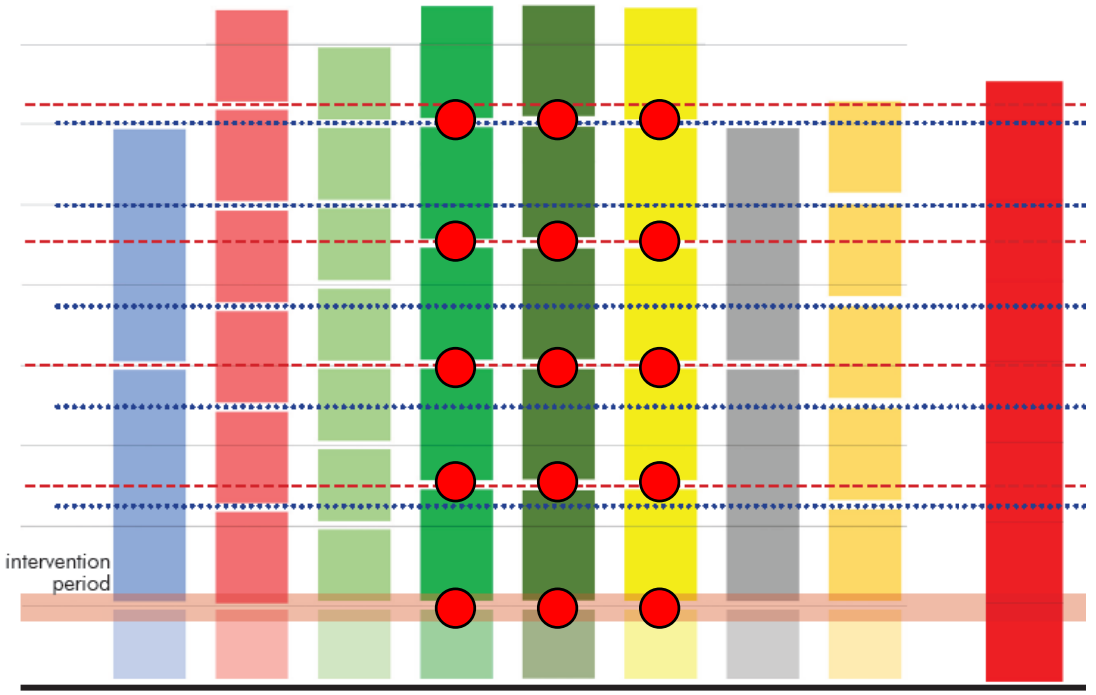
concept design
energy performance - assessment
economic assessment

life cycle assessment

PROPOSED LC VS MAINTENANCE SCHEDULE

design development ○○●○○○





5 cycles

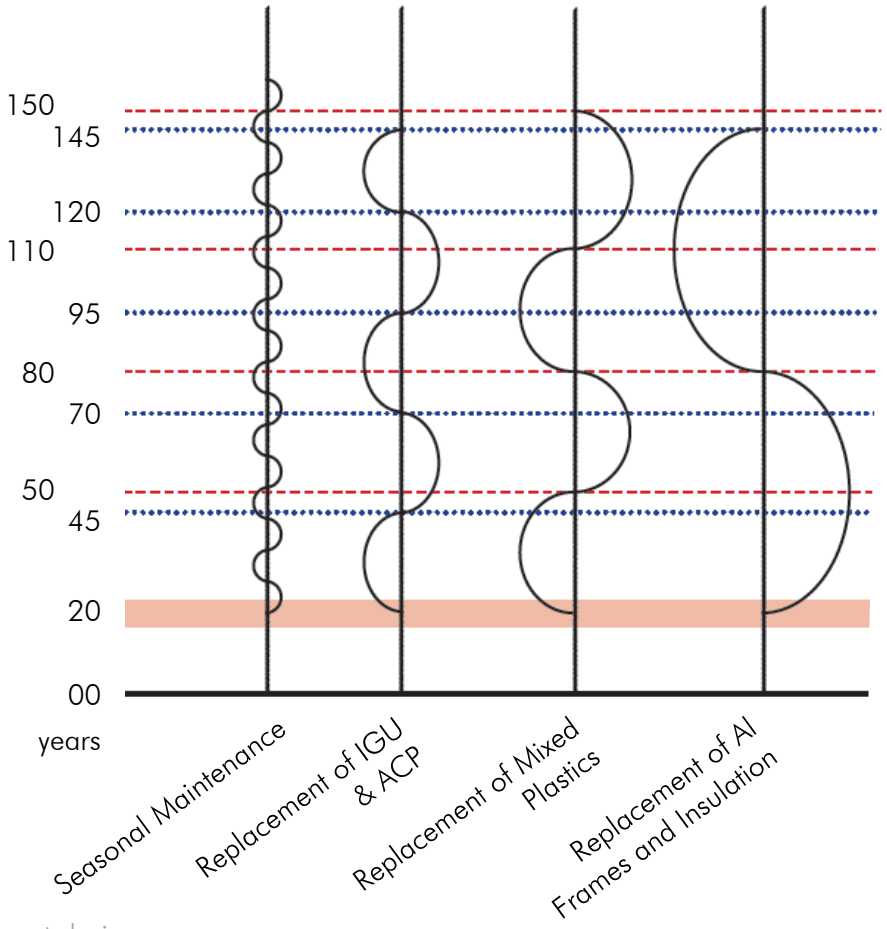
Mixed Plastics

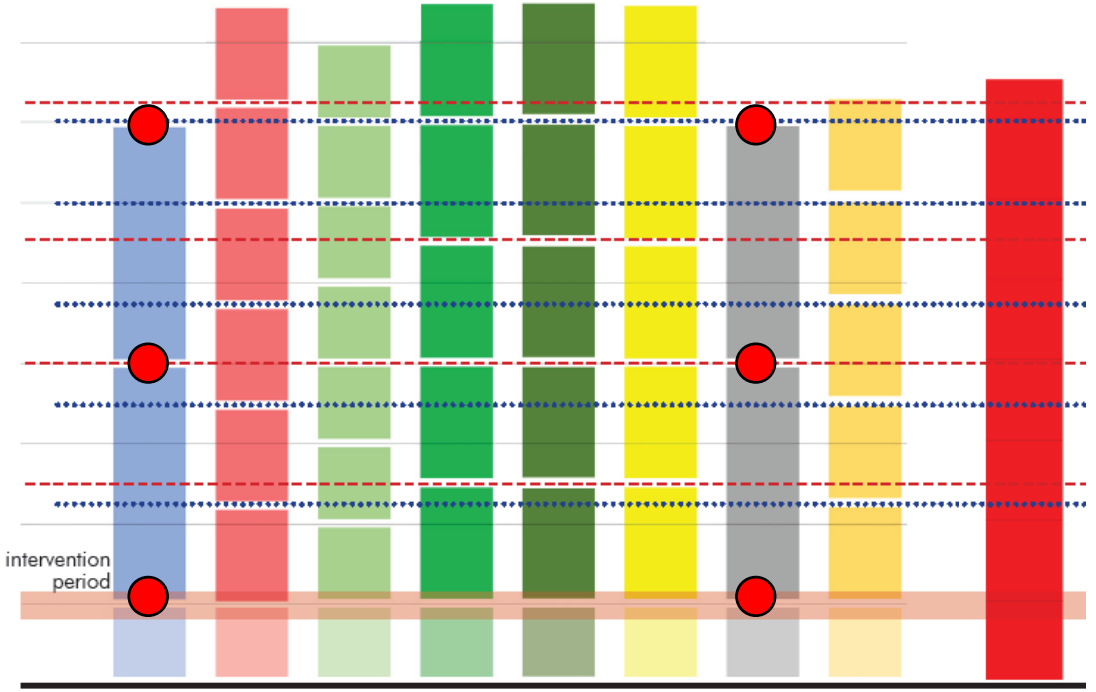
concept design
energy performance - assessment
economic assessment

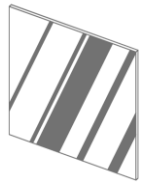
life cycle assessment

PROPOSED LC VS MAINTENANCE SCHEDULE

design development







3 cycles

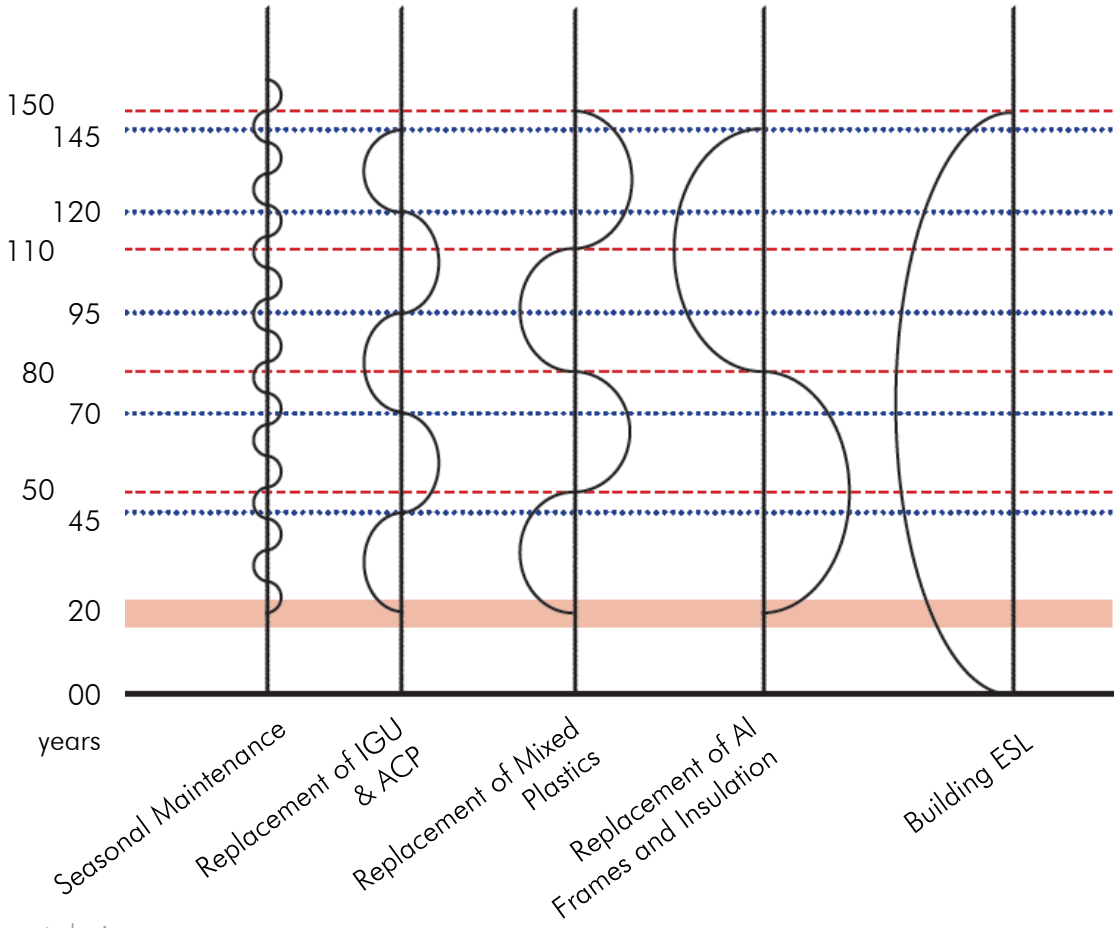
Aluminum Frames
Insulation Material

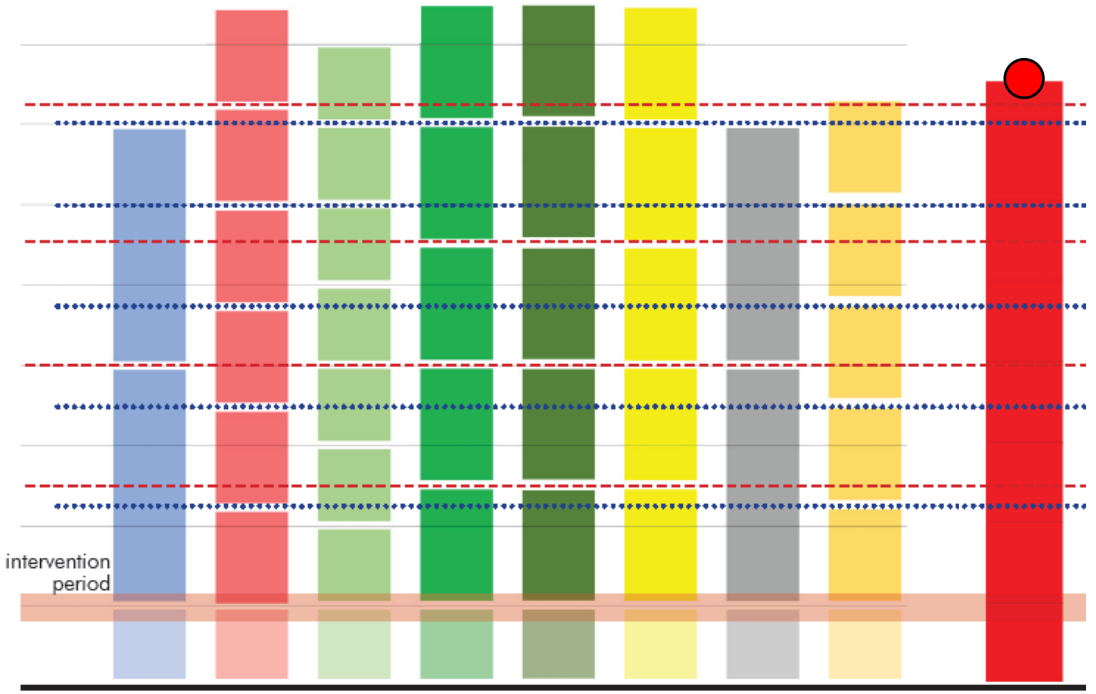
concept design
energy performance - assessment
economic assessment

life cycle assessment

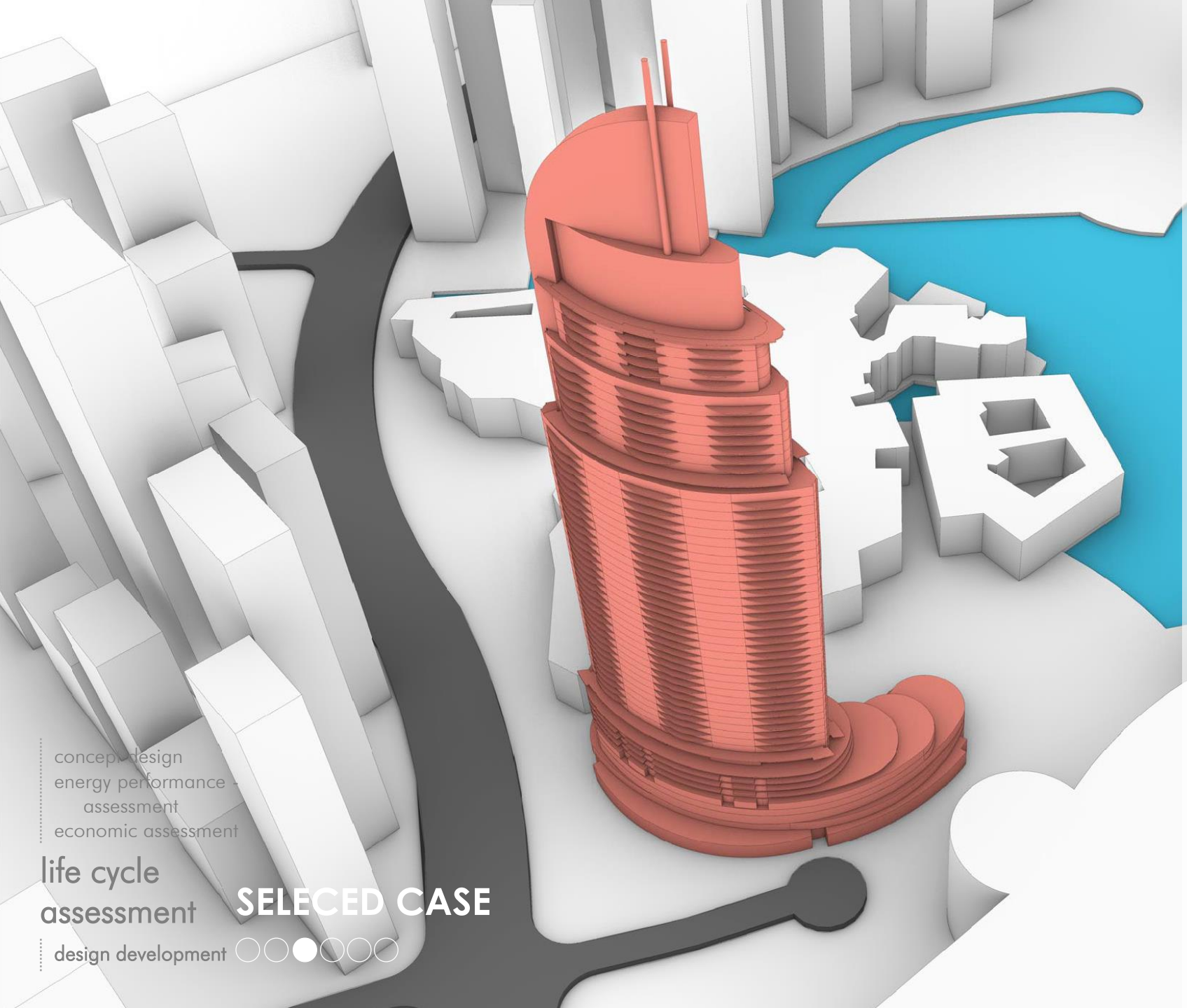
PROPOSED LC VS MAINTENANCE SCHEDULE

design development ○○●○○○





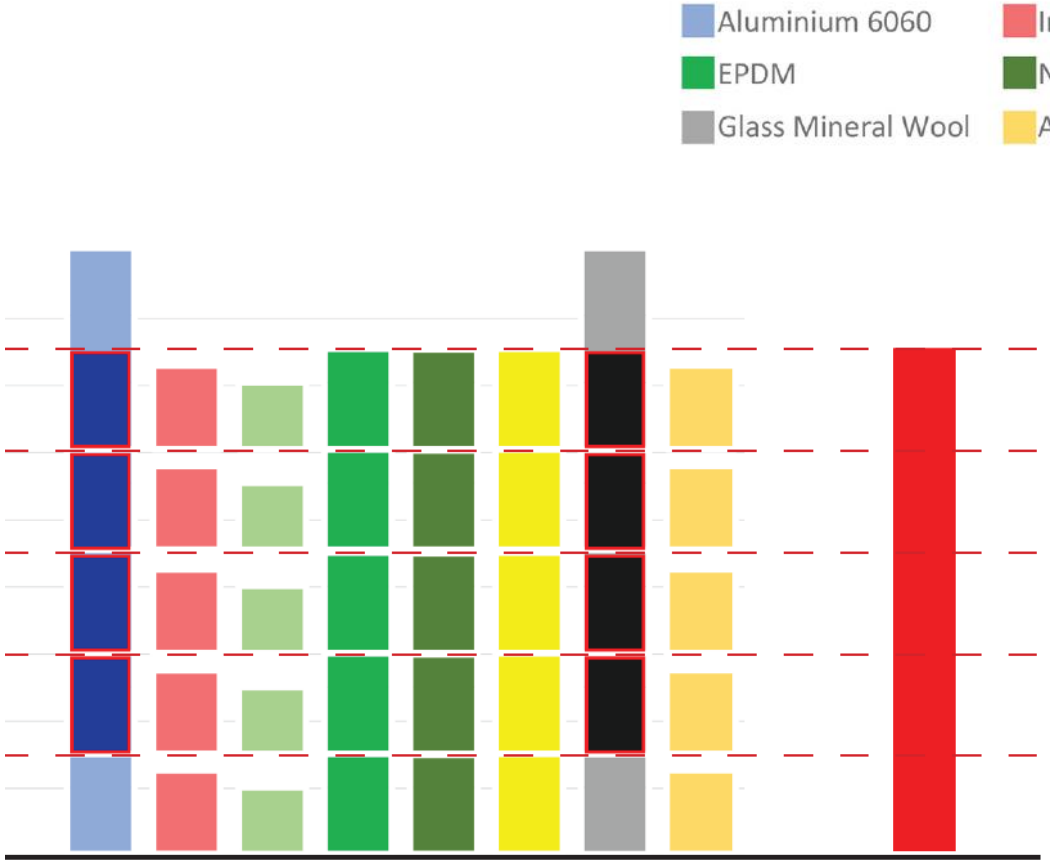
PROPOSED LC VS MAINTENANCE SCHEDULE

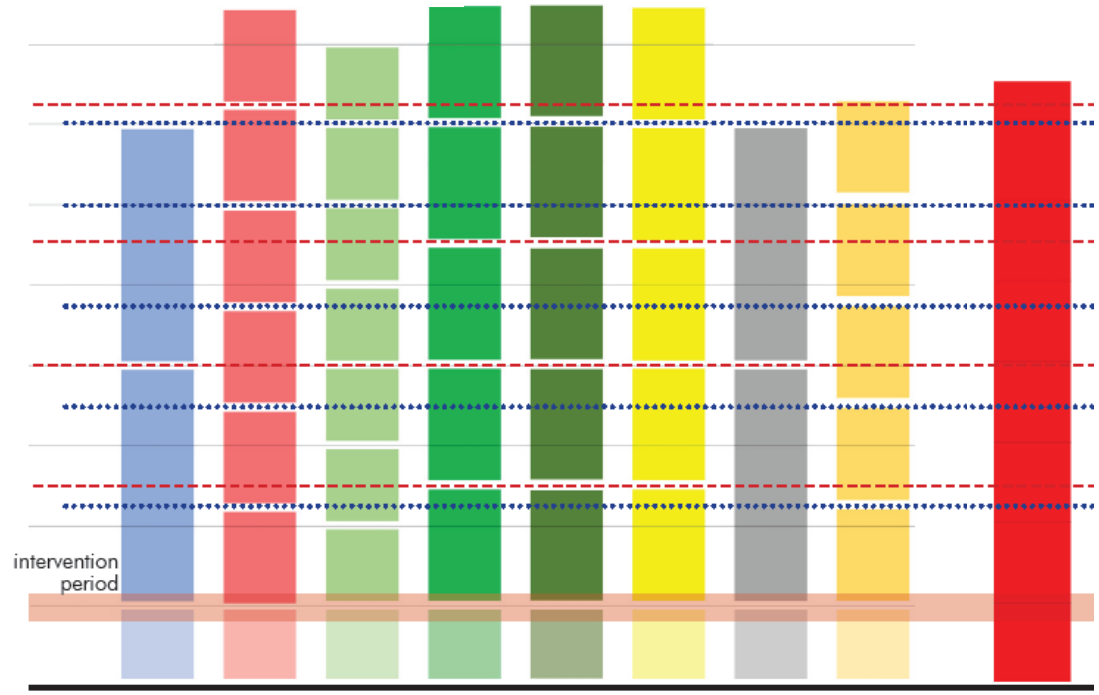


concept design
energy performance assessment
economic assessment
life cycle assessment
design development

SELECED CASE

3,900 tons
mass of the façade
at a given time





19,500 tons
for old system of façade refurbishment

16,200 tons
for proposed system of façade refurbishment

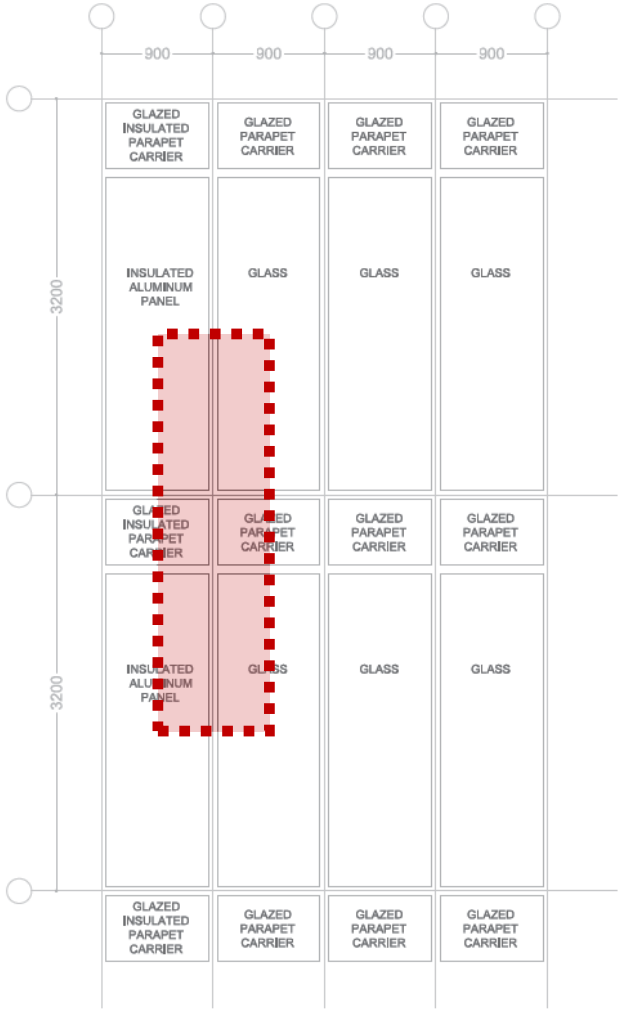
3,300 tons
amount of material which can be saved

concept design
energy performance - assessment
economic assessment

life cycle assessment

design development

LCA MATERIAL COMPARISON



150 years
ESL of tall buildings

4 nos
construction workers

30 years
average age of BMU

0.5 years
regular façade maintenance period

48 hr/wk
working hours

1.7 million
cost of one BMU

30 years
regular curtain wall ESL

600 €/m
monthly wages

30 years
BMU heavy maintenance period

22.5 tons
capacity of selected truck

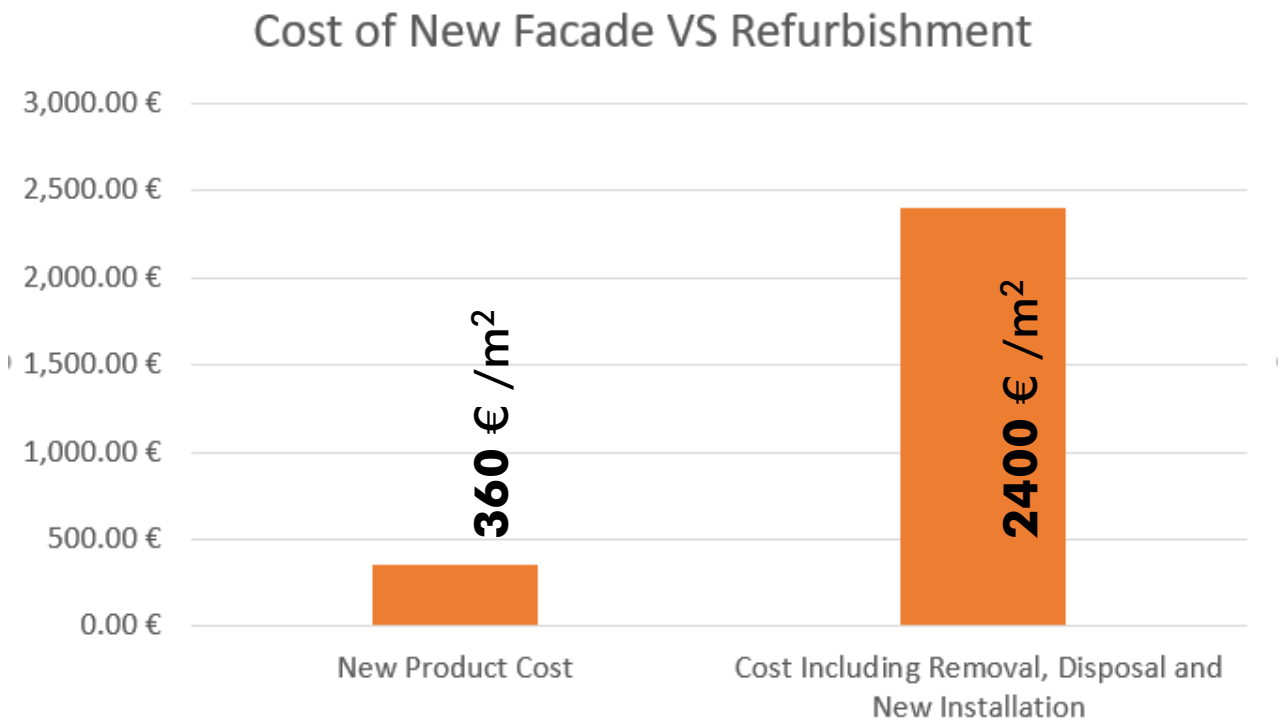
0.6 €
diesel price

3.0 km/l
mileage of truck

GENERAL | LABOR | MAINTENENCE | TRANSPORTATION

concept design
energy performance - assessment
economic assessment
life cycle assessment
design development

ECONOMIC ASSESSMENT BOUNDARY CONDITIONS



ECONOMIC ASSESSMENT

Sources: Market Survey
Turner & Townsend. (2016).

<Net costs from each scenario>

$$C_{net} = HL + E + W_1{*}S + T{*}\Sigma (W_n{*}K_i) + \Sigma W_n{*}P/D_j - \Sigma W_n{*}R_k$$

Labor | Machinery | Sorting | Transportation | Recycling or Disposal | Recovery | [Cost in different phases]

Where,

H: Execution hour (h),

L: Labor cost(€/h),

E: Equipment cost(€),

S: Cost of sorting process (€/kg),

T: Cost of transportation (€/kgkm),

K_i: Travel distances (km)

W: Weight of materials (kg)

P/D_j: Cost of recycling or disposal process(€/kg)

(1)P_{alu} : Aluminum recycling, (2)P_{gl}: Glass recycling, (3) P_{pla}: Plastic incineration and (4)D_{re} : Residue landfill

R_k: Revenue from material or energy recovery

(1)R_{sc}: Aluminium Scrap(€/kg), (2)R_{pro}: Secondary Aluminum profile(€/ kg), (3)R_{gl}: Secondary glazing unit(€/ kg), (4)Re: Electricity (€/ kg) = (€/kWh)*(kWh/kg)

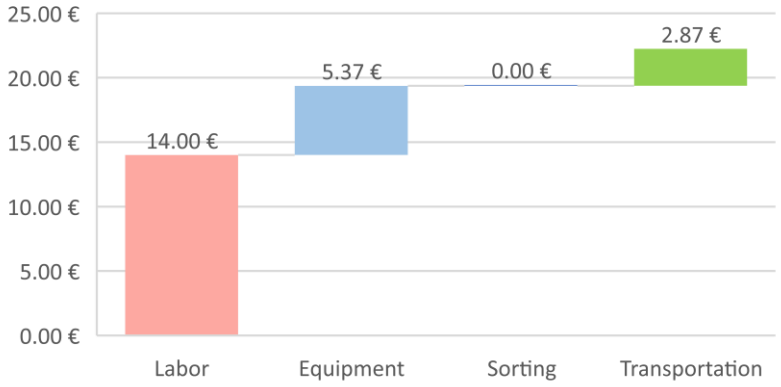
ECONOMIC ASSESSMENT

Sources: M. Kim, 2013 following methods by Symonds along with ARGUS, COWI and PRC Bouwcentrum, 1999

<Net costs from each scenario>

$$C_{net} = HL + E + W_1*S + T*\Sigma (W_n*K_i)$$

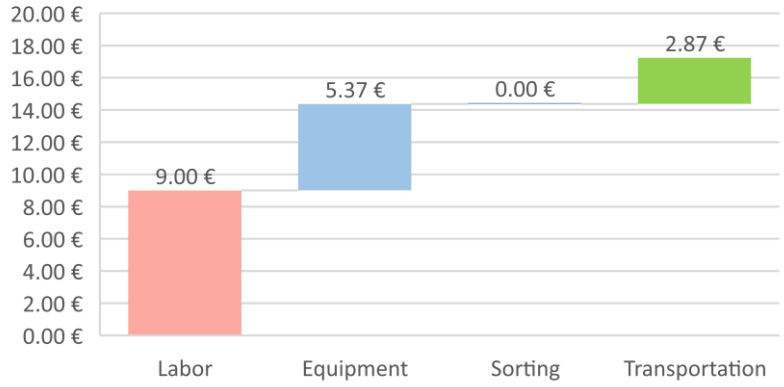
Labor Machinery Sorting Transportation



4 workers

1 hr/m²

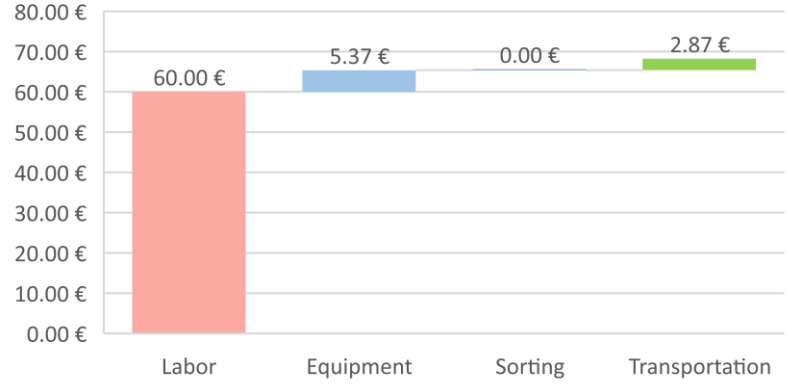
2,300 kms



4 workers

0.5 hr/m²

2,300 kms



4 workers

5 hr/m²

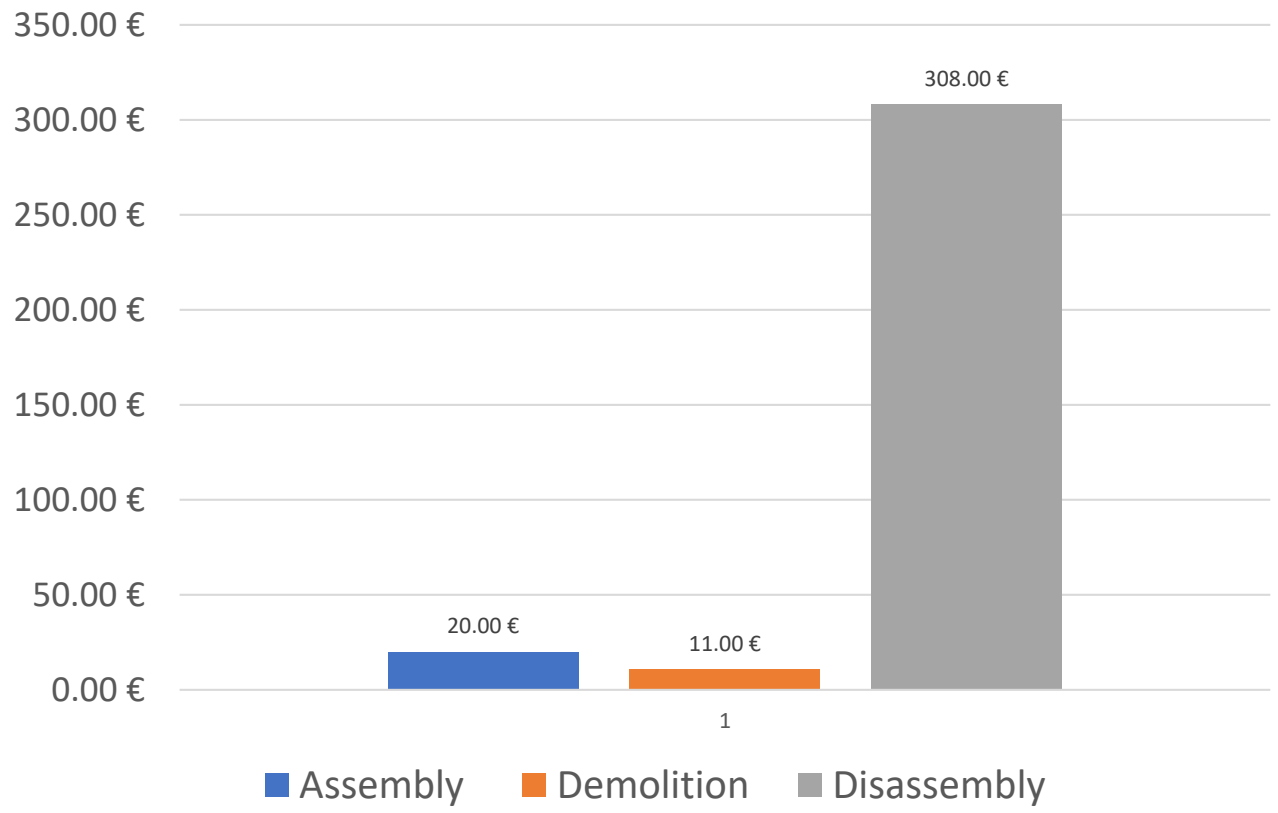
2,300 kms

concept design
energy performance - assessment

economic assessment

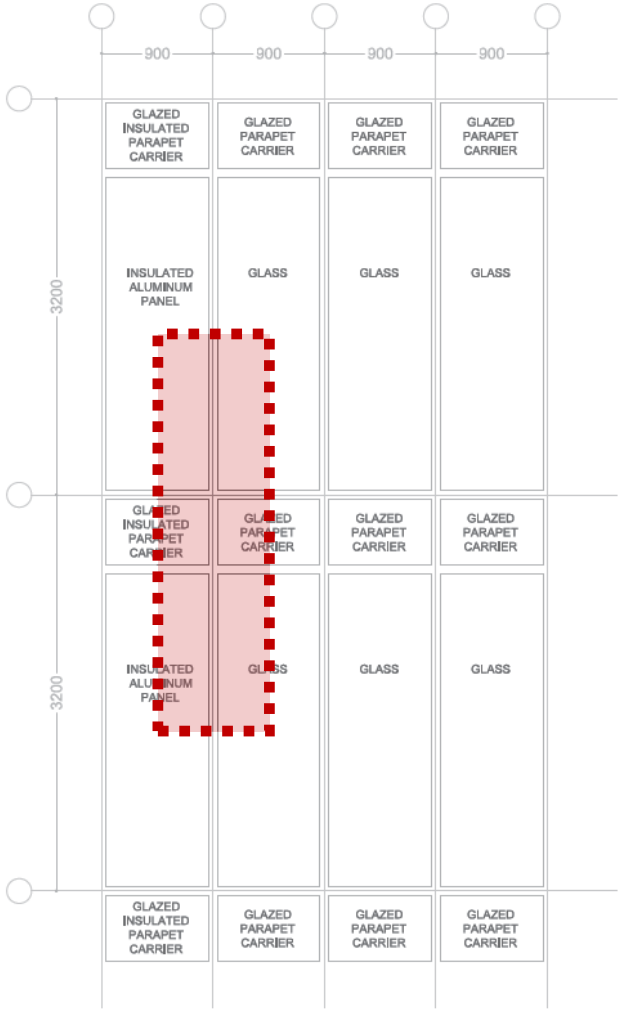
life cycle assessment
design development

ECONOMIC ASSESSMENT – EXISTING FACADE



concept design
energy performance - assessment
economic assessment
life cycle assessment
design development

ECONOMIC ASSESSMENT – EXISTING FACADE



concept design
energy performance - assessment

economic assessment

life cycle assessment
design development

PROPOSED ECONOMIC BOUNDARY CONDITIONS

GENERAL

150 years
ESL of tall buildings

0.5 years
regular façade maintenance period

30 years
regular curtain wall ESL

LABOR

2 nos
construction workers

48 hr/wk
working hours

600 €/m
monthly wages

MAINTENENCE

30 years
average age of BMU

1.7 million
cost of one BMU

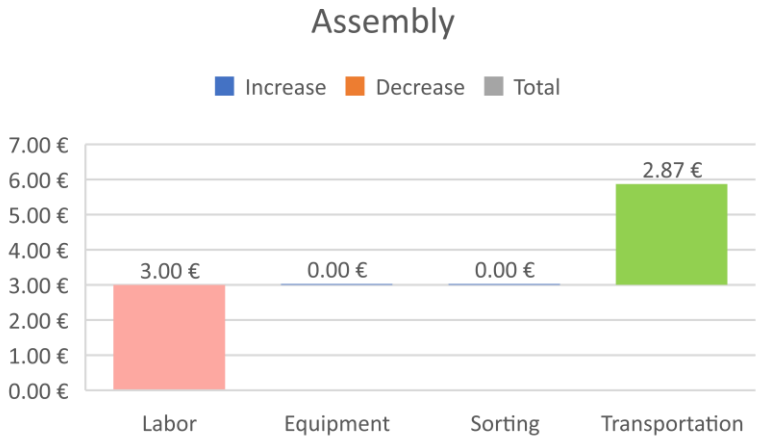
30 years
BMU heavy maintenance period

TRANSPORTATION

22.5 tons
capacity of selected truck

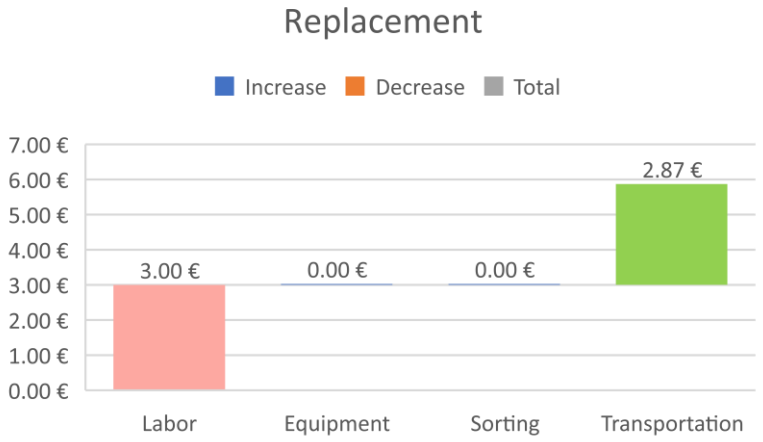
0.6 €
diesel price

3.0 km/l
mileage of truck



2 workers

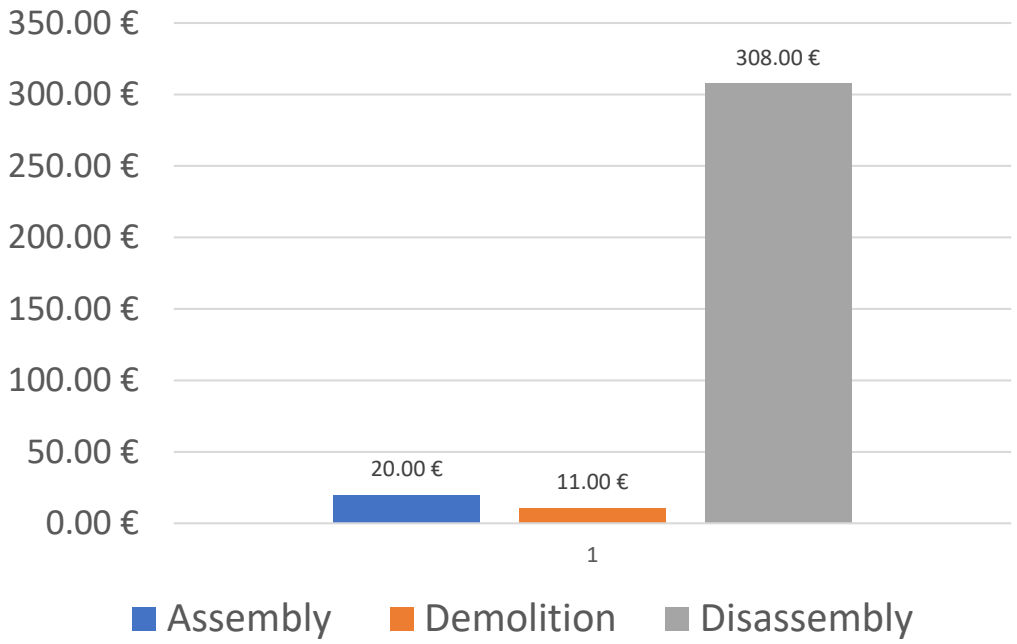
.5 hr/m²

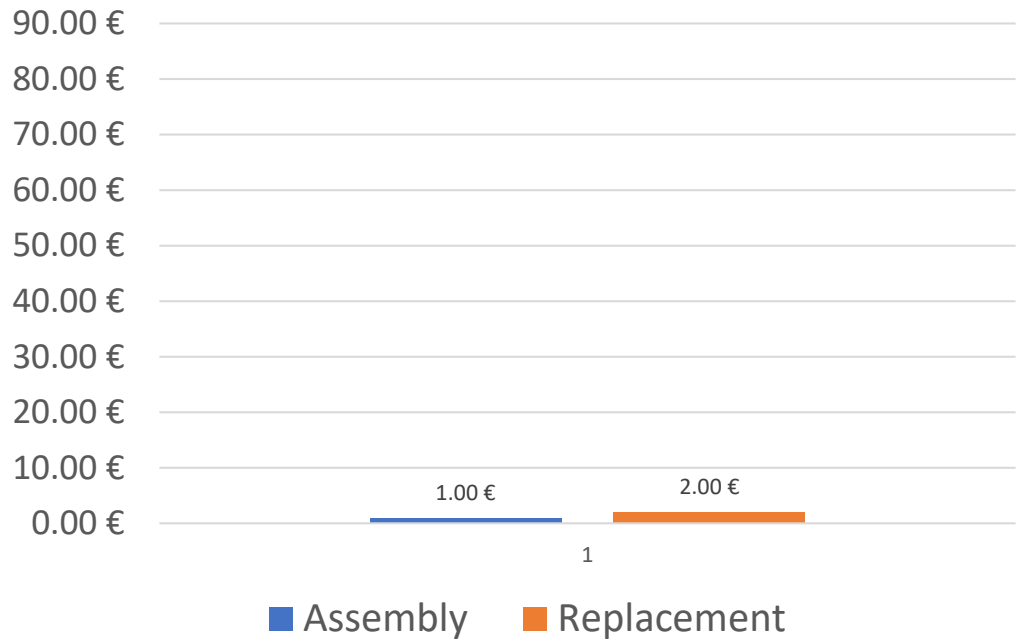


2 workers

.5 hr/m²

ECONOMIC ASSESSMENT – PROPOSED FACADE





concept design
energy performance - assessment

economic assessment

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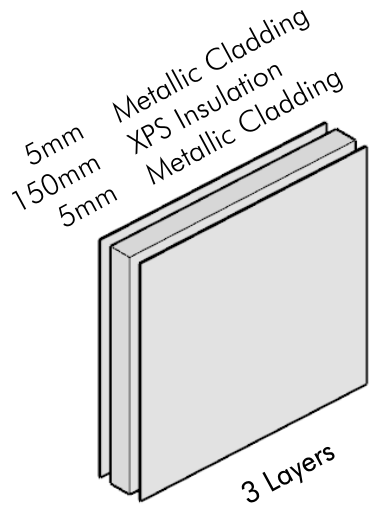
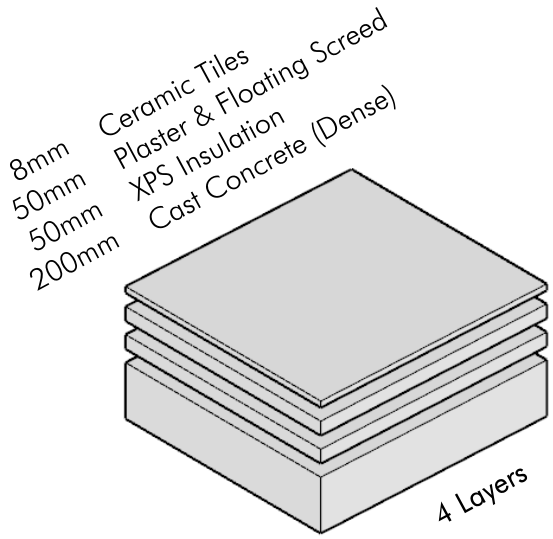
design development

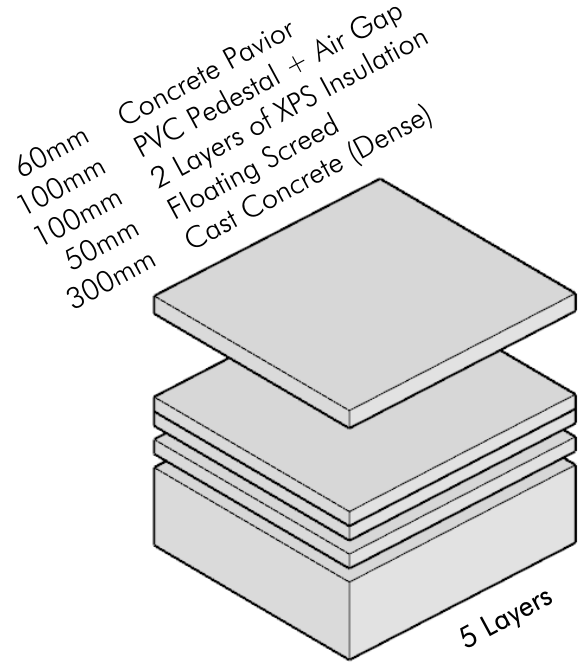
ECONOMIC ASSESSMENT – SUMMARY OF RESULTS



OPAQUE PANEL

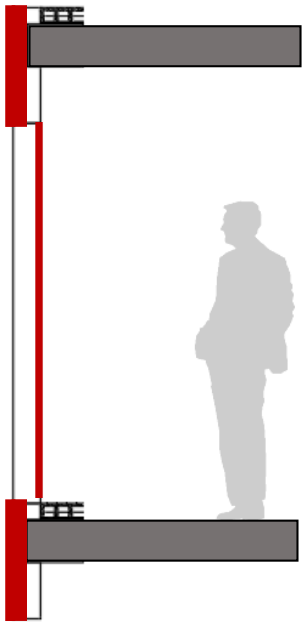


INTERNAL SLAB

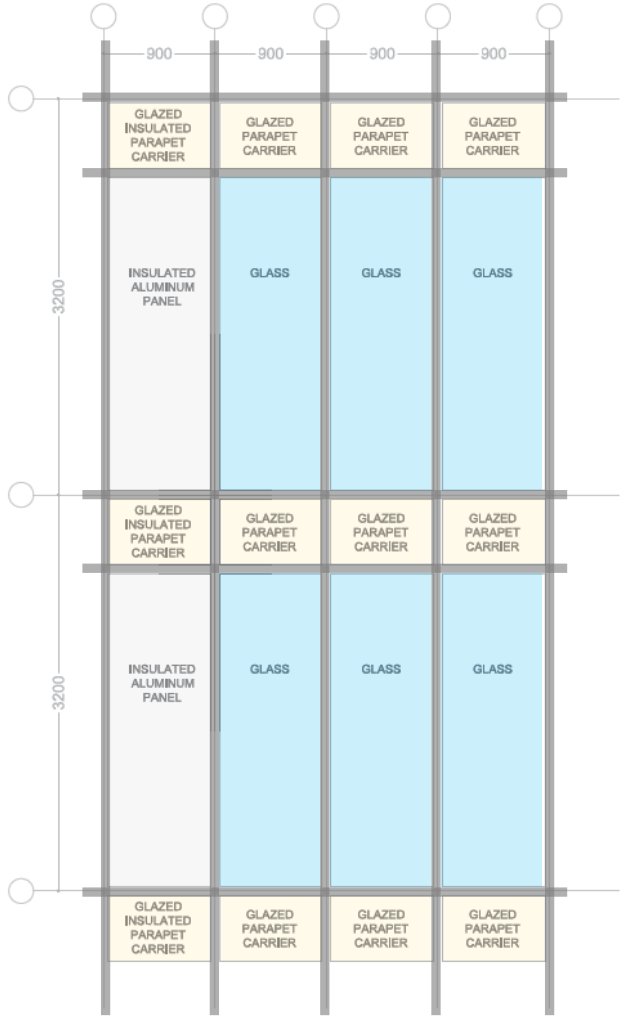


ROOF AND GROUND SLAB

EXISTING BUILDING – BOUNDARY CONDITIONS



CONCEPT DESIGN – STAGE 1 – IMPROVE U-VALUE



concept design

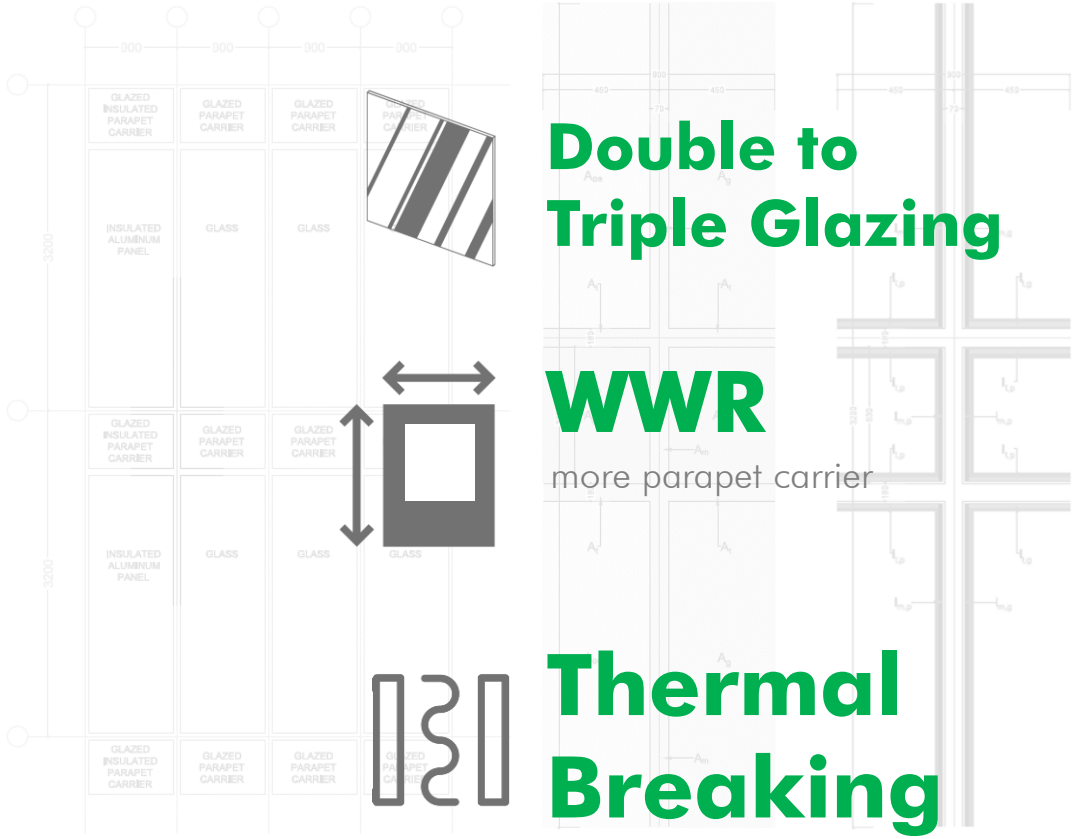
energy performance assessment

economic assessment
life cycle assessment
design development

ENERGY ANALYSIS – U VALUE CALCULATION

Existing Facade

Proposed PnP Facade

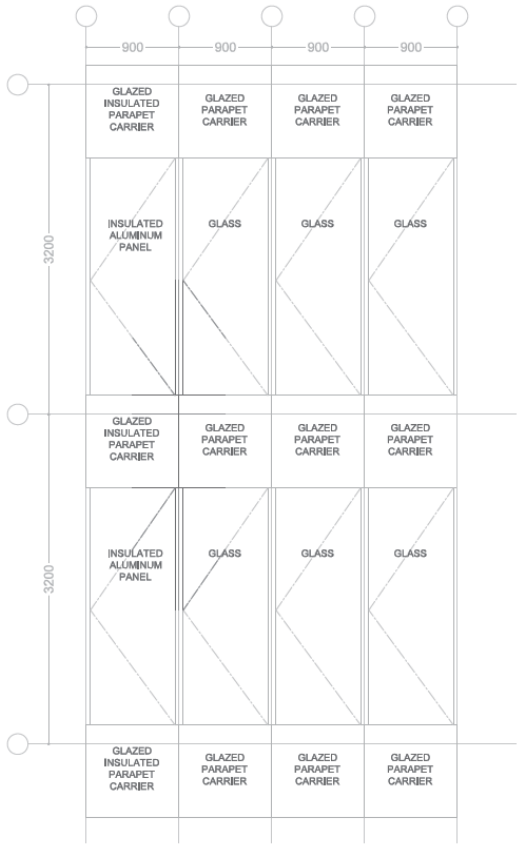


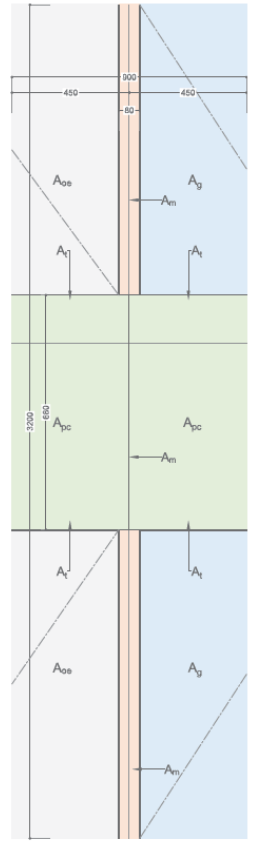
Double to Triple Glazing

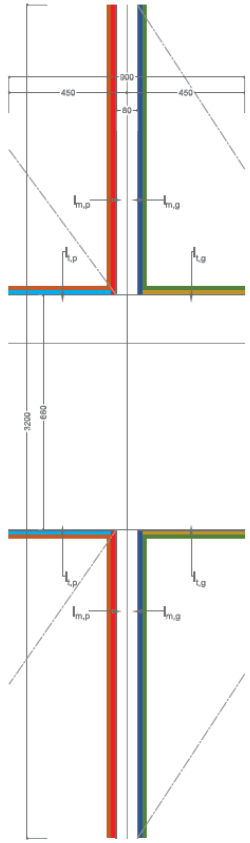
WWR

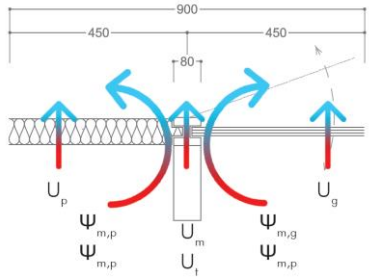
more parapet carrier

Thermal Breaking









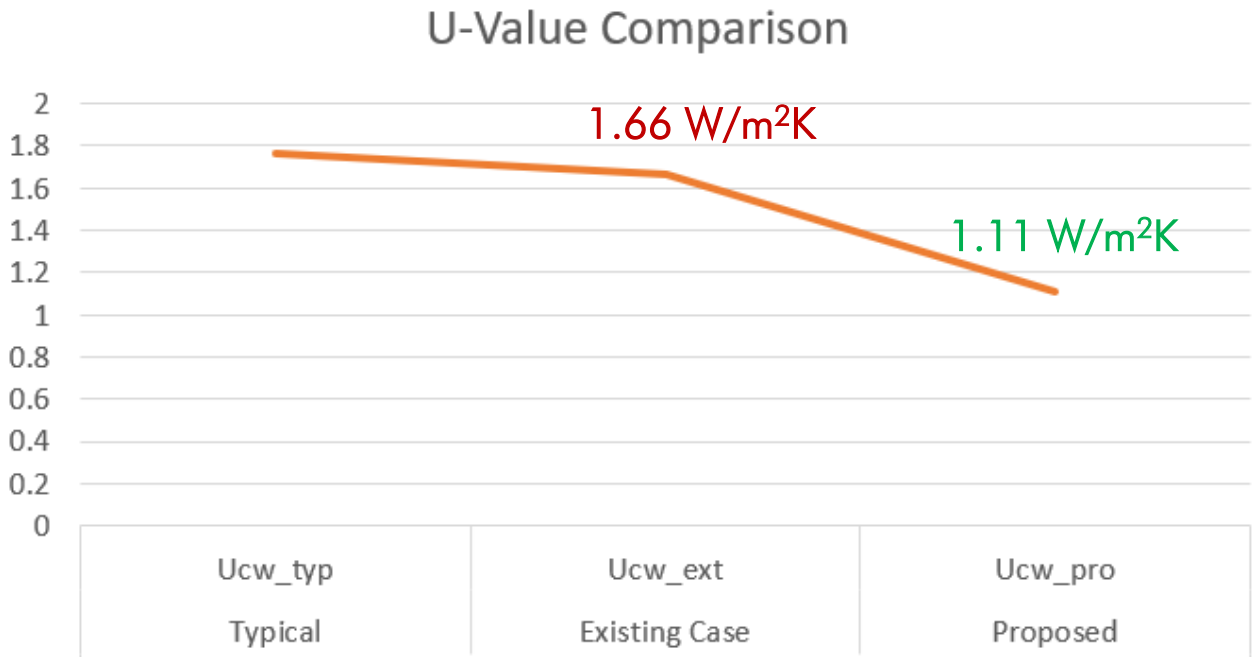
concept design

energy performance assessment

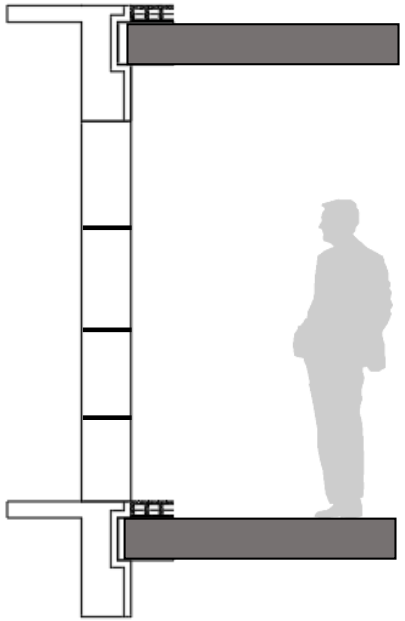
economic assessment
life cycle assessment
design development

ENERGY ANALYSIS – U VALUE CALCULATION

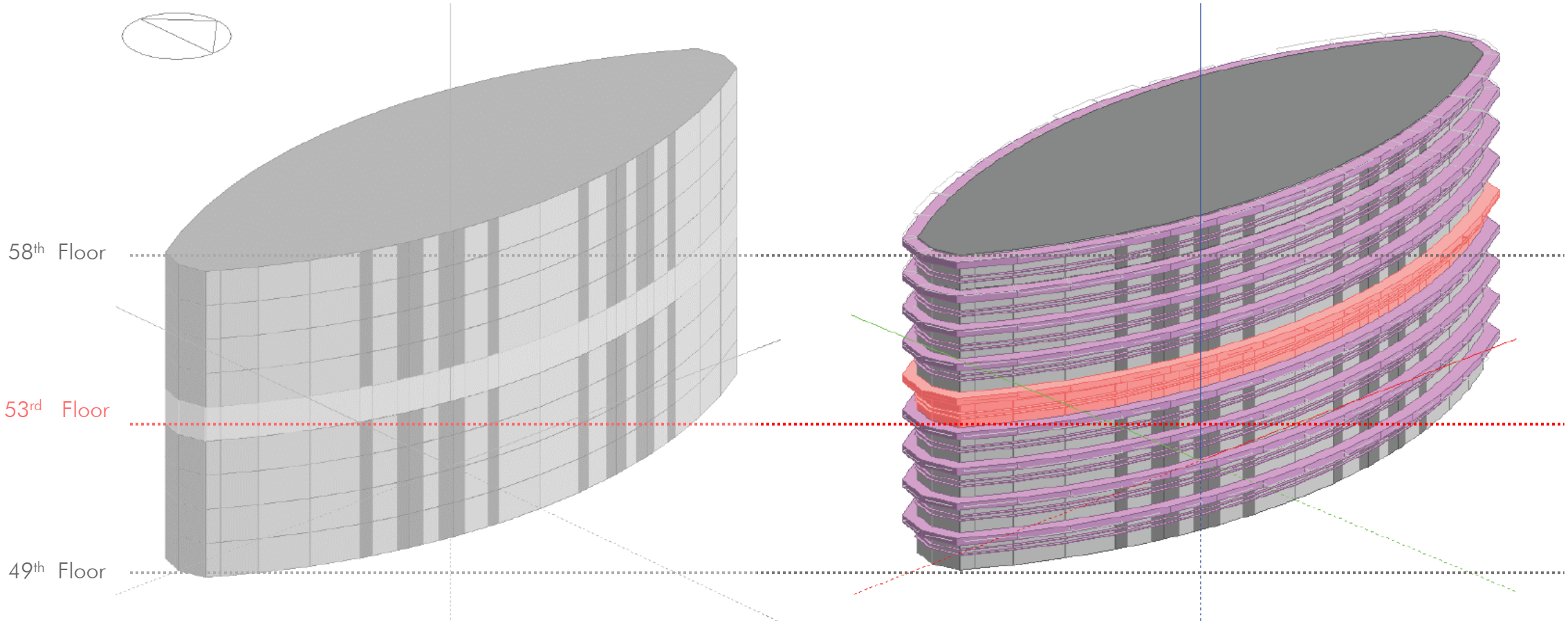
$$U_{cw} = \sum \frac{A_g{*}U_g + A_p{*}U_p + A_f{*}U_f + A_m{*}U_m + A_p{*}U_p + A_t{*}U_t + l_{f,g}{*}\Psi_{f,g} + l_{m,g}{*}\Psi_{m,g} + l_{t,g}{*}\Psi_{t,g} + l_p{*}\Psi_p + l_{m,f}{*}\Psi_{m,f} + l_{t,f}{*}\Psi_{t,f}}{A_{CW}}$$



ENERGY ANALYSIS – U VALUE CALCULATION



CONCEPT DESIGN – STAGE 2 – PROVIDE SHADING



Existing Façade Base Case

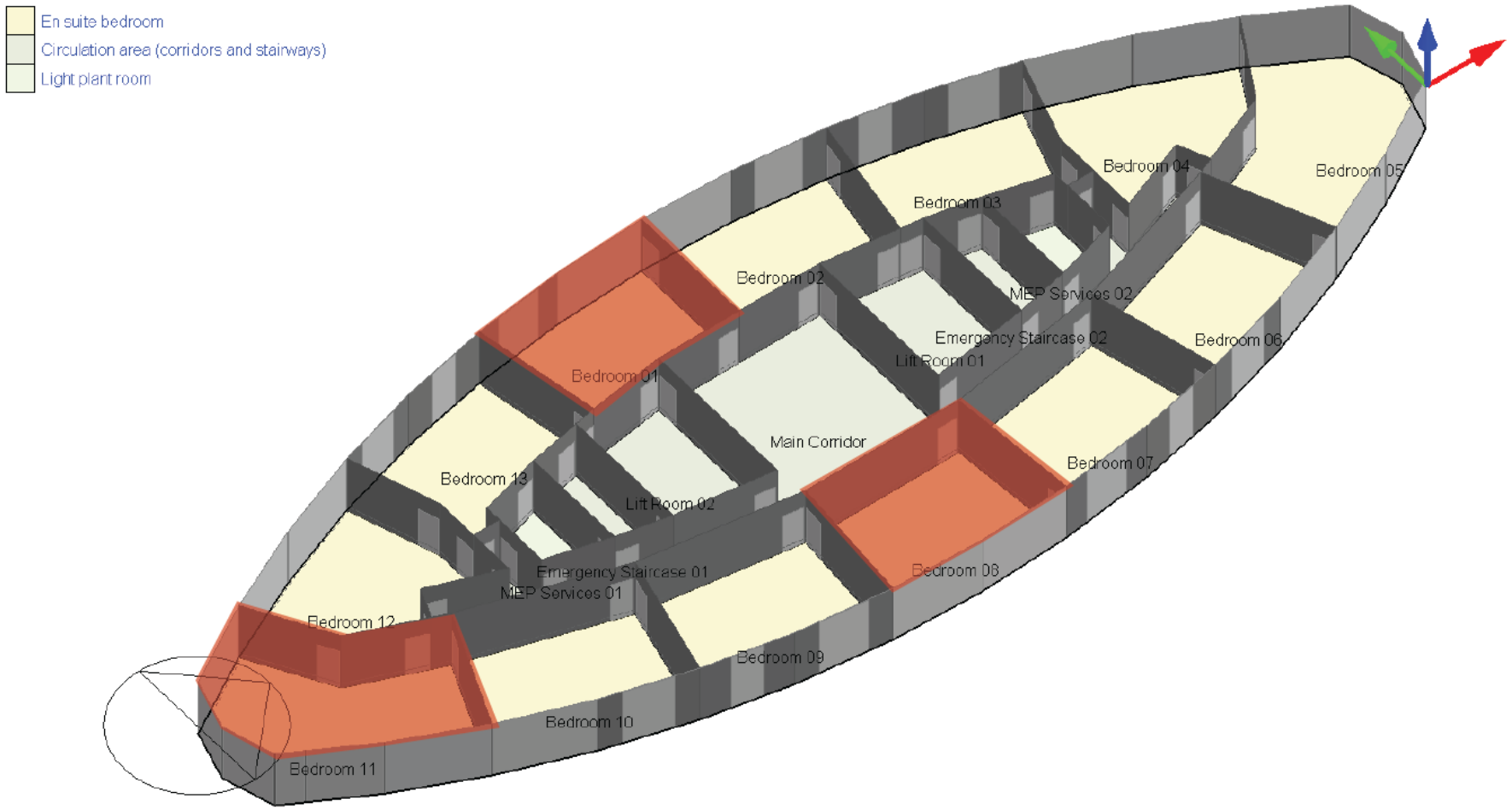
Proposed Façade with Shading

concept design

energy performance assessment

economic assessment
life cycle assessment
design development

ENERGY ANALYSIS – SHADING ANALYSIS



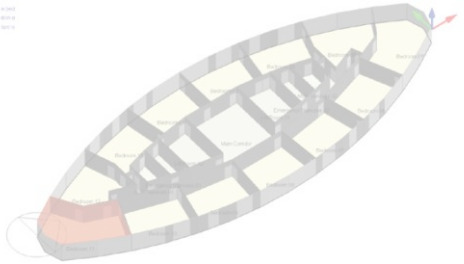
53rd Floor Base Case

concept design

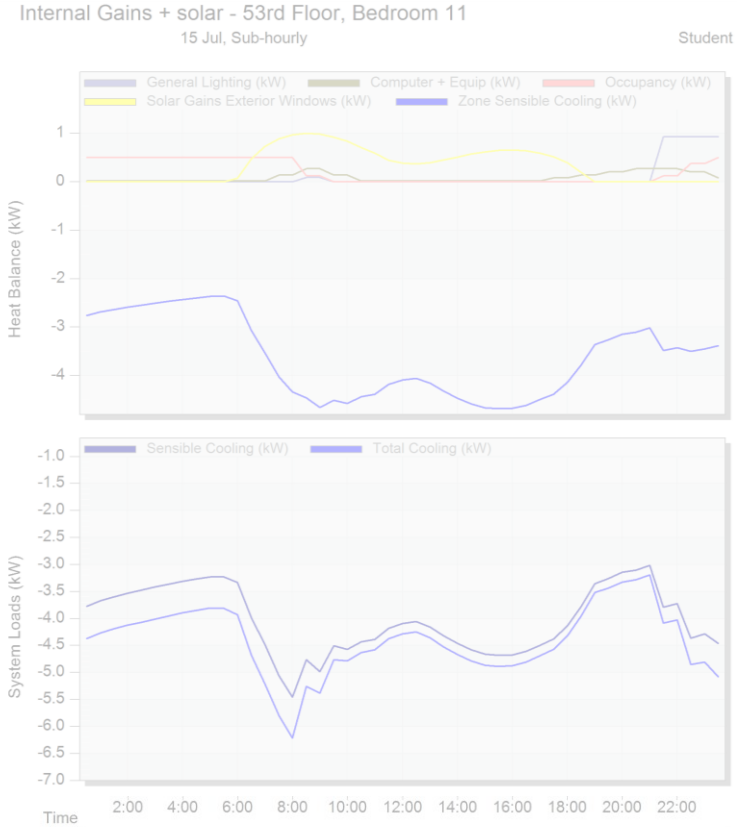
energy performance assessment

economic assessment
life cycle assessment
design development

ENERGY ANALYSIS – SHADING ANALYSIS

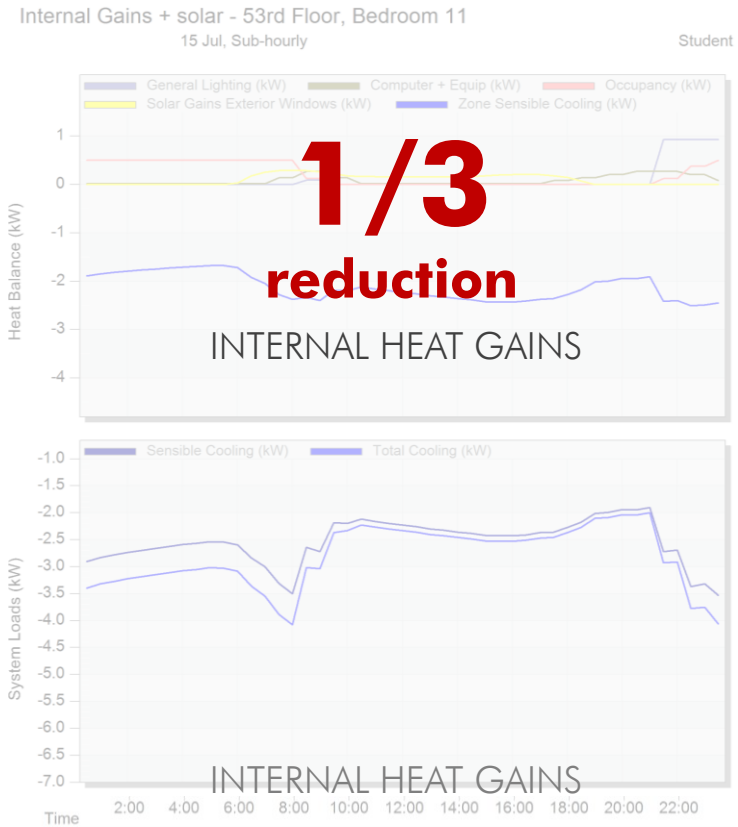


SOUTH



	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
General Lighting (kW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
Computer + Equip (kW)	0.02	0.02	0.02	0.14	0.14	0.02	0.02	0.02	0.08	0.21	0.27
Occupancy (kW)	0.51	0.51	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Solar Gains Exterior Windows (kW)	0.00	0.00	0.08	0.97	0.84	0.39	0.51	0.66	0.39	0.00	0.00
Zone Sensible Cooling (kW)	-2.59	-2.43	-2.45	-4.34	-4.57	-4.09	-4.46	-4.67	-4.14	-3.14	-3.42
Sensible Cooling (kW)	-3.53	-3.31	-3.34	-5.46	-4.57	-4.09	-4.46	-4.67	-4.14	-3.14	-3.72
Total Cooling (kW)	-4.12	-3.90	-3.93	-6.21	-4.79	-4.28	-4.67	-4.87	-4.32	-3.32	-4.03
Total Latent Load (kW)	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06

Existing Façade Base Case



	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
General Lighting (kW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
Computer + Equip (kW)	0.02	0.02	0.02	0.14	0.14	0.02	0.02	0.02	0.08	0.21	0.27
Occupancy (kW)	0.51	0.51	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Solar Gains Exterior Windows (kW)	0.00	0.00	0.03	0.30	0.18	0.16	0.16	0.21	0.15	0.00	0.00
Zone Sensible Cooling (kW)	-1.79	-1.71	-1.71	-2.38	-2.19	-2.23	-2.36	-2.43	-2.27	-1.94	-2.39
Sensible Cooling (kW)	-2.73	-2.59	-2.59	-3.50	-2.19	-2.23	-2.36	-2.43	-2.27	-1.94	-2.69
Total Cooling (kW)	-3.22	-3.08	-3.08	-4.08	-2.33	-2.33	-2.46	-2.53	-2.37	-2.03	-2.91
Total Latent Load (kW)	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06

Proposed Façade with Shading

concept design

energy performance assessment

economic assessment
life cycle assessment
design development

ENERGY ANALYSIS – SHADING ANALYSIS

Base Case

240 kWh/m²
energy consumption of existing case study

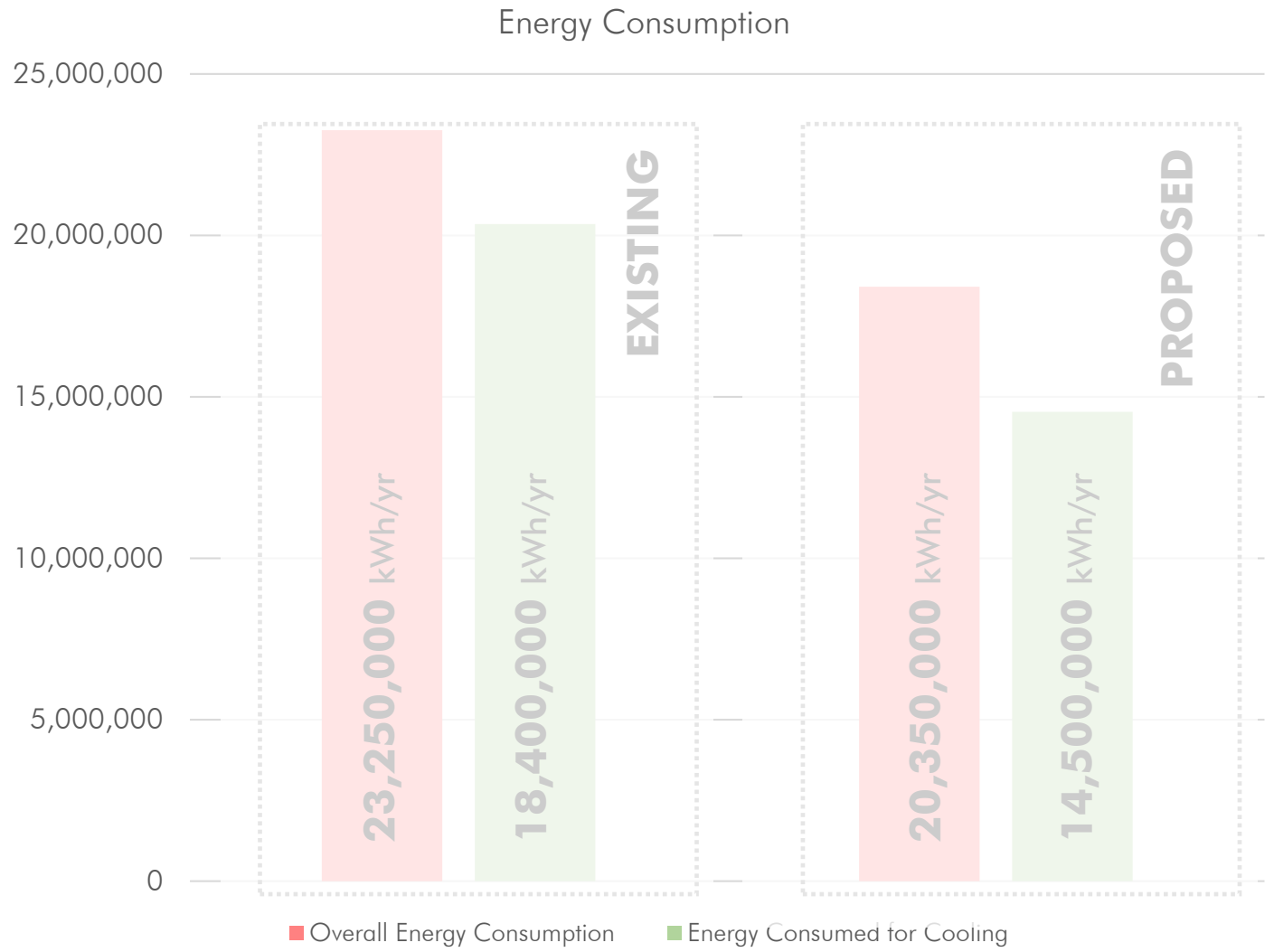
210 kWh/m²
energy consumption for cooling of existing case study

Proposed Case

190 kWh/m²
energy consumption of existing case study with proposed modifications

160 kWh/m²
energy consumption for cooling of existing case study with proposed modifications

ENERGY ANALYSIS – SHADING ANALYSIS



28%
energy savings by reduction

455,000 €/ yr
amount utility expenses saved by reduction per year

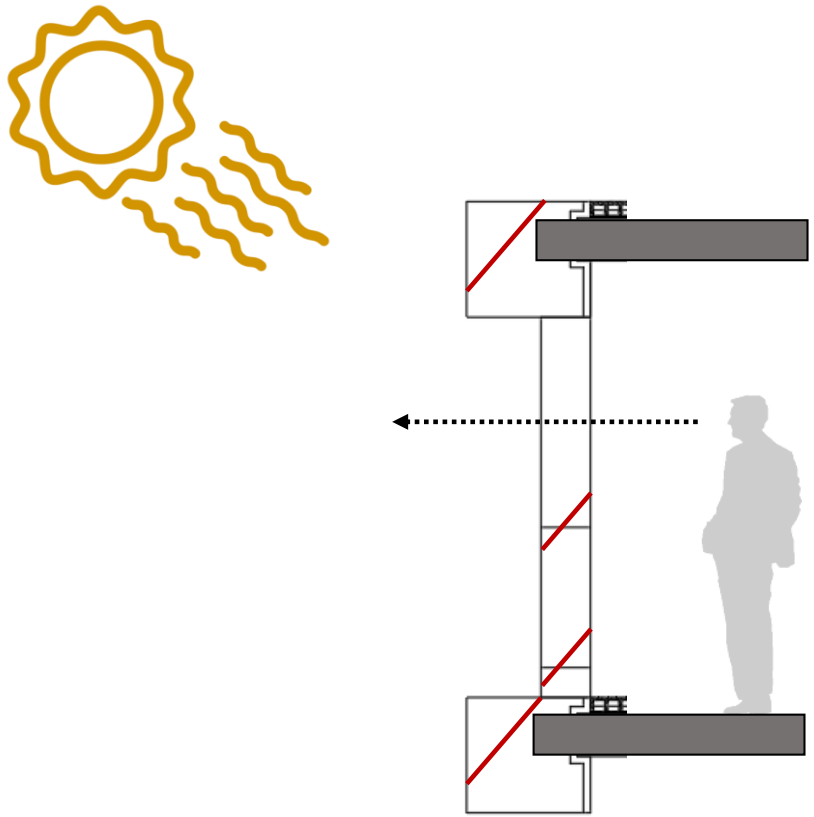
هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

concept design

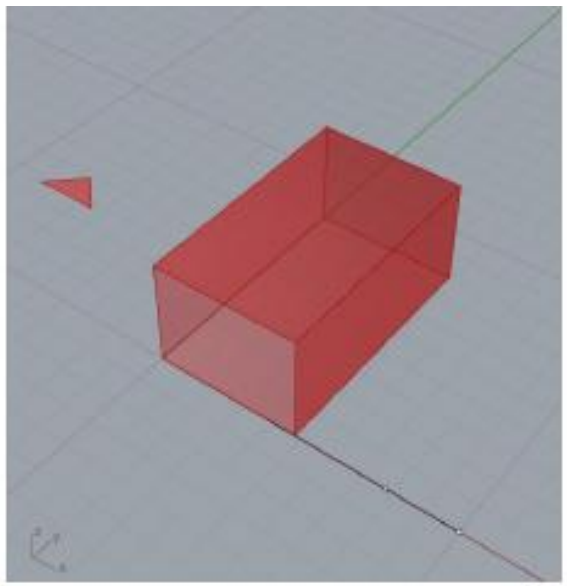
energy performance assessment

economic assessment
life cycle assessment
design development

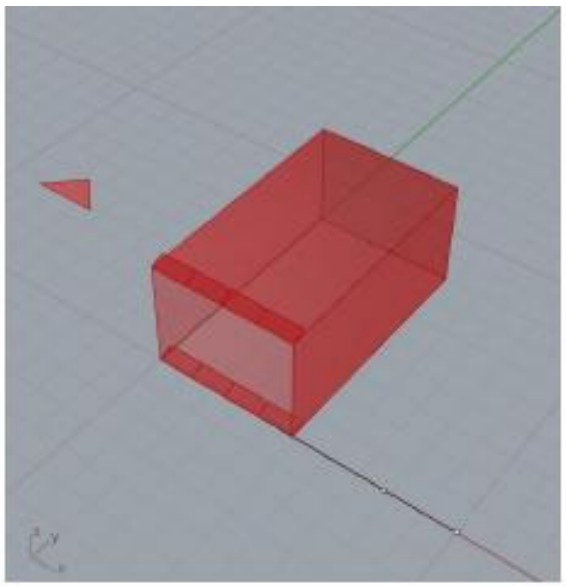
ENERGY ANALYSIS – SHADING ANALYSIS



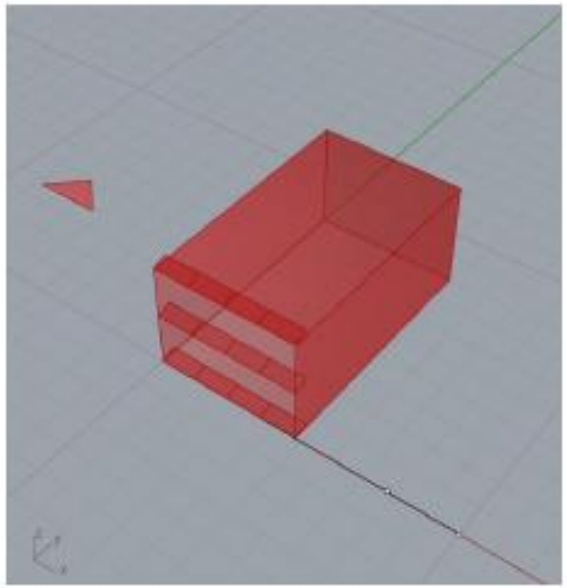
CONCEPT DESIGN – STAGE 3 – ADJUST LOUVERS AND TILT ANGLES



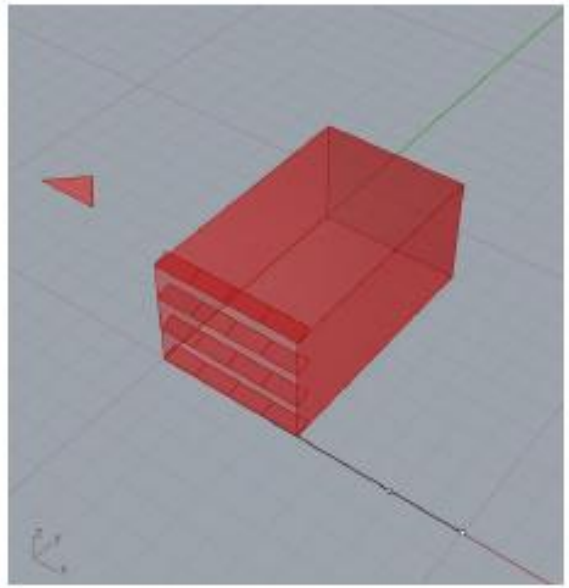
NO HORIZONTAL LOUVERS



1 - HORIZONTAL LOUVER

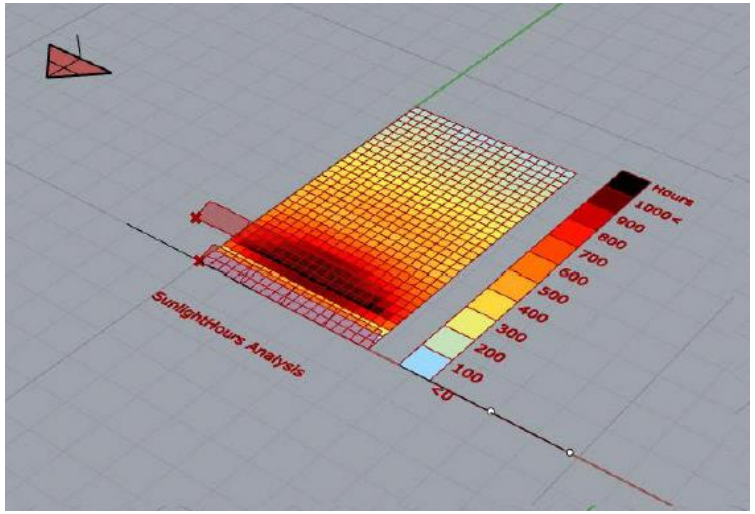


2 - HORIZONTAL LOUVER

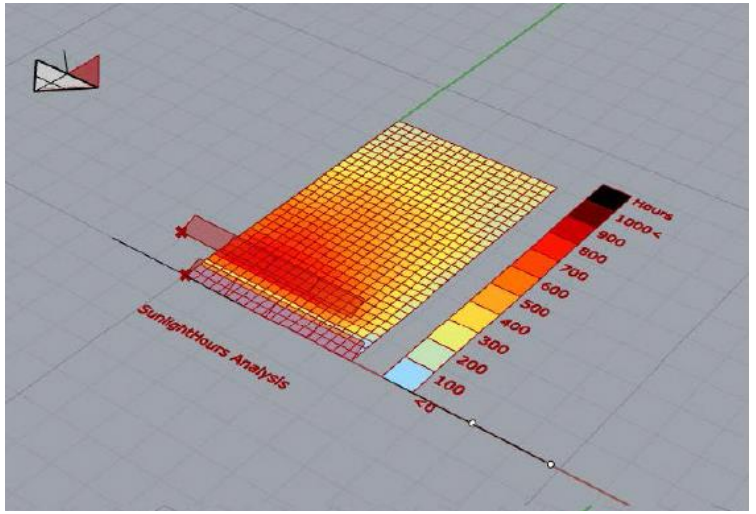


3 - HORIZONTAL LOUVER

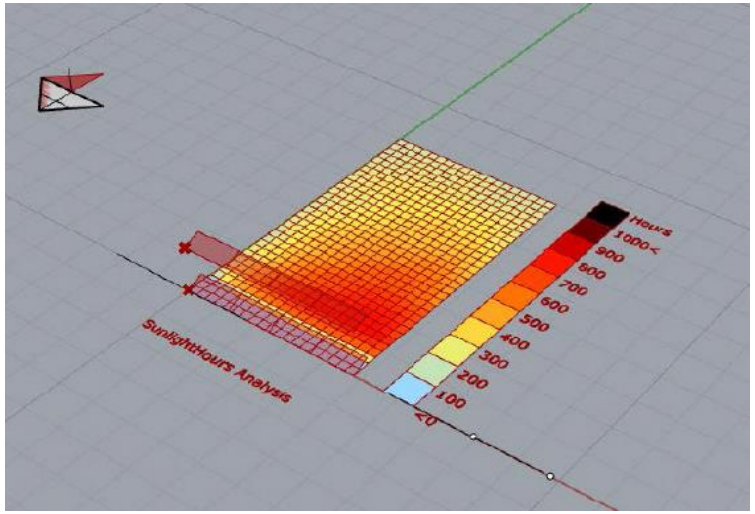
DESIGN REQUIREMENTS - INDOOR ILLUMINATION



SOUTH



EAST



WEST

2 nos
ideal number of panels for
All orientations

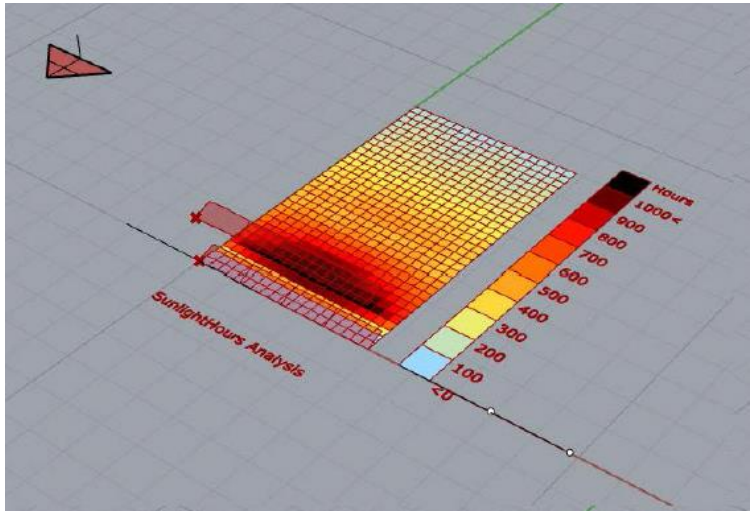
500 – 1000 lux
average indoor illumination
levels

concept design

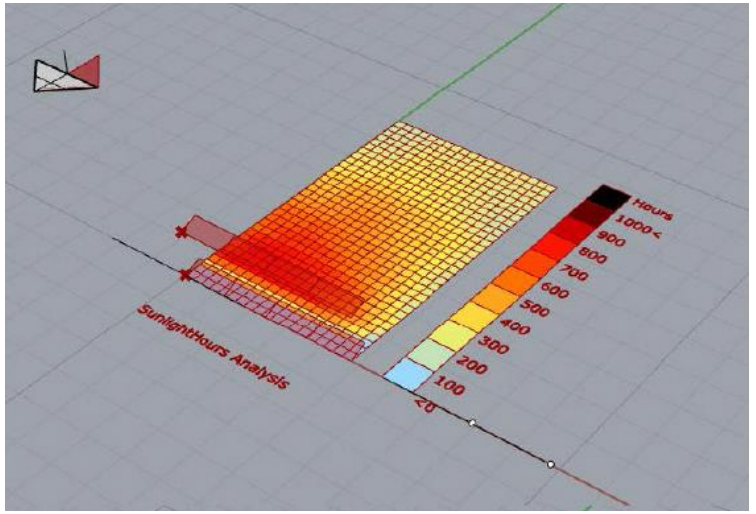
energy performance assessment

economic assessment
life cycle assessment
design development

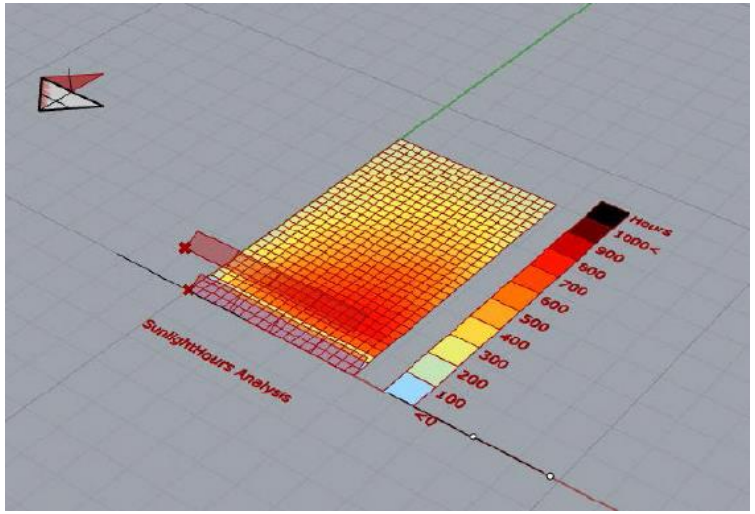
DESIGN REQUIREMENTS - INDOOR ILLUMINATION



SOUTH



EAST



WEST

2 nos
ideal number of panels for
All orientations

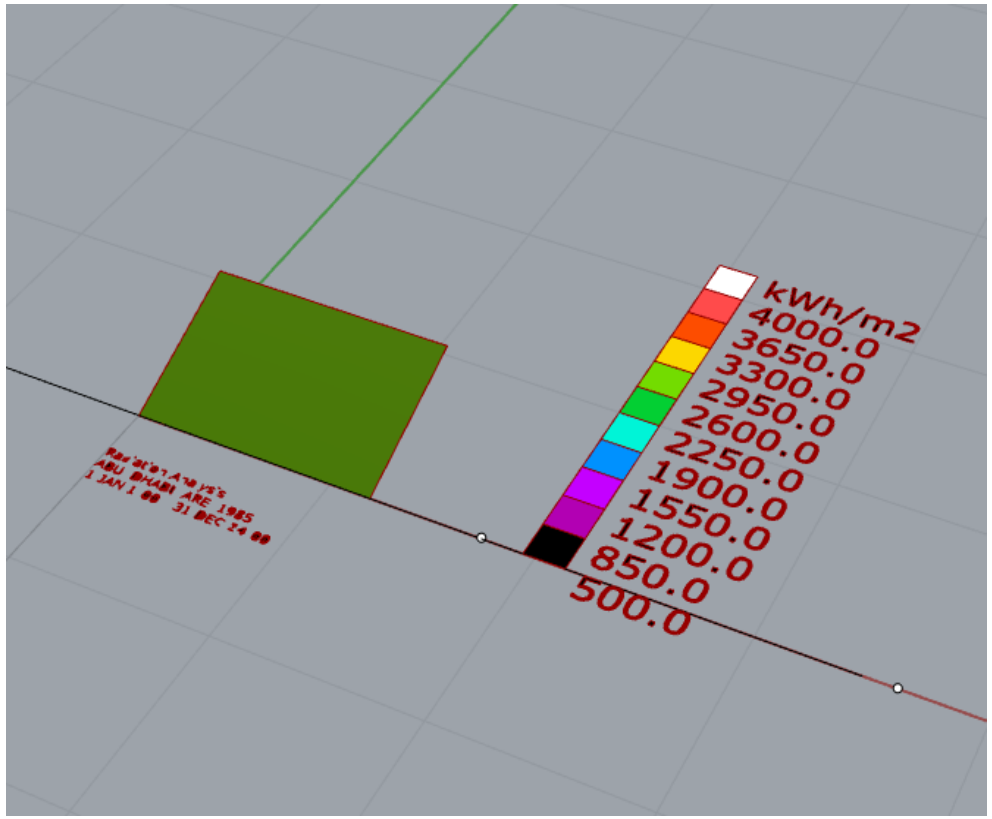
500 – 1000 lux
average indoor illumination
levels

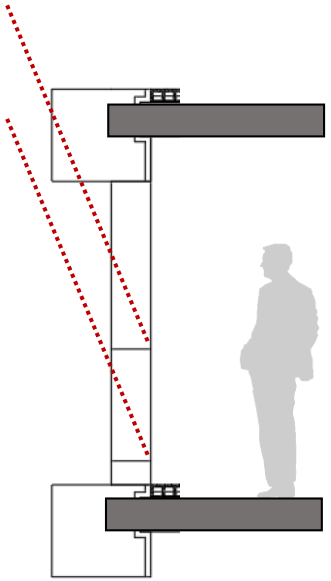
concept design

energy performance assessment

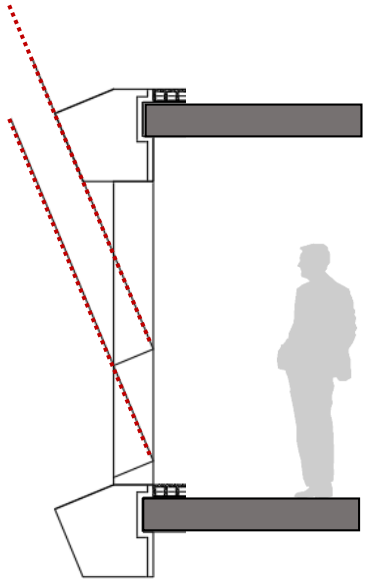
economic assessment
life cycle assessment
design development

DESIGN REQUIREMENTS - INDOOR ILLUMINATION

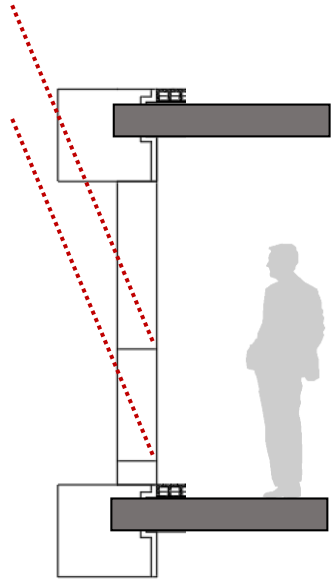




0°
tilt angle

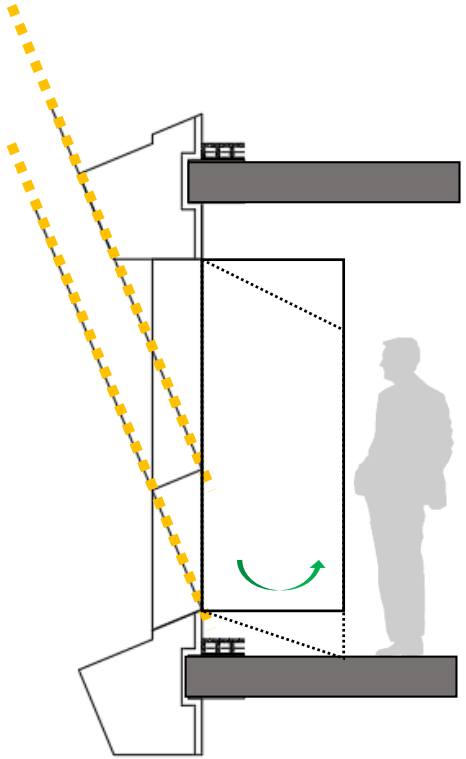


22°
tilt angle



0°
tilt angle

DESIGN REQUIREMENTS – SHADING TILT ANGLE



CONCEPT DESIGN – STAGE 4 – ACCESSIBILITY & DISASSEMBLY

FAÇADE OVERVIEW

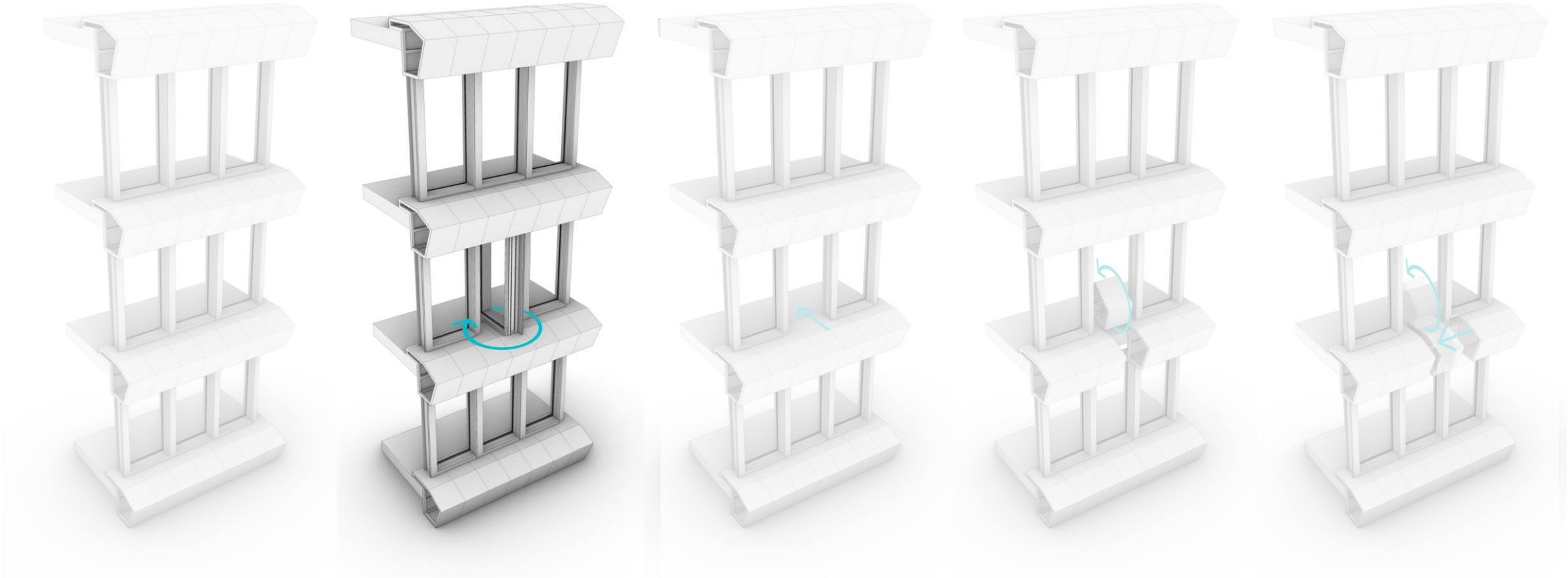
OPERBLE PANEL

DISASSEMBLY

concept design

energy performance - assessment
economic assessment
life cycle assessment
design development

CONCEPT DESIGN – ACCESSIBILITY & MAINTENENCE



FAÇADE OVERVIEW

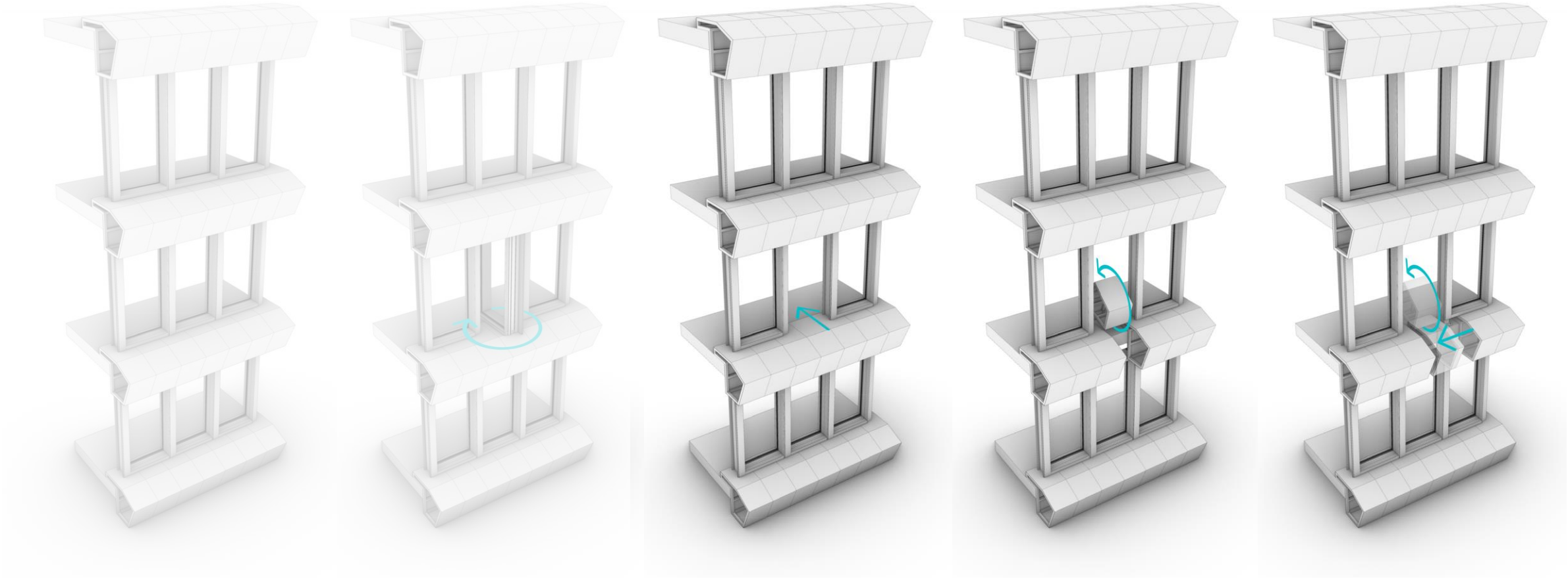
OPERBLE PANEL

DISASSEMBLY

concept design

energy performance - assessment
economic assessment
life cycle assessment
design development

CONCEPT DESIGN – ACCESSIBILITY & MAINTENENCE



FAÇADE OVERVIEW

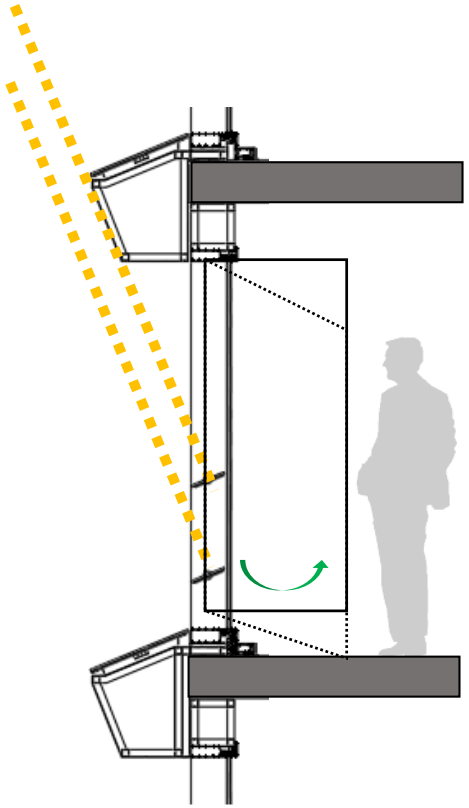
OPERBLE PANEL

DISASSEMBLY

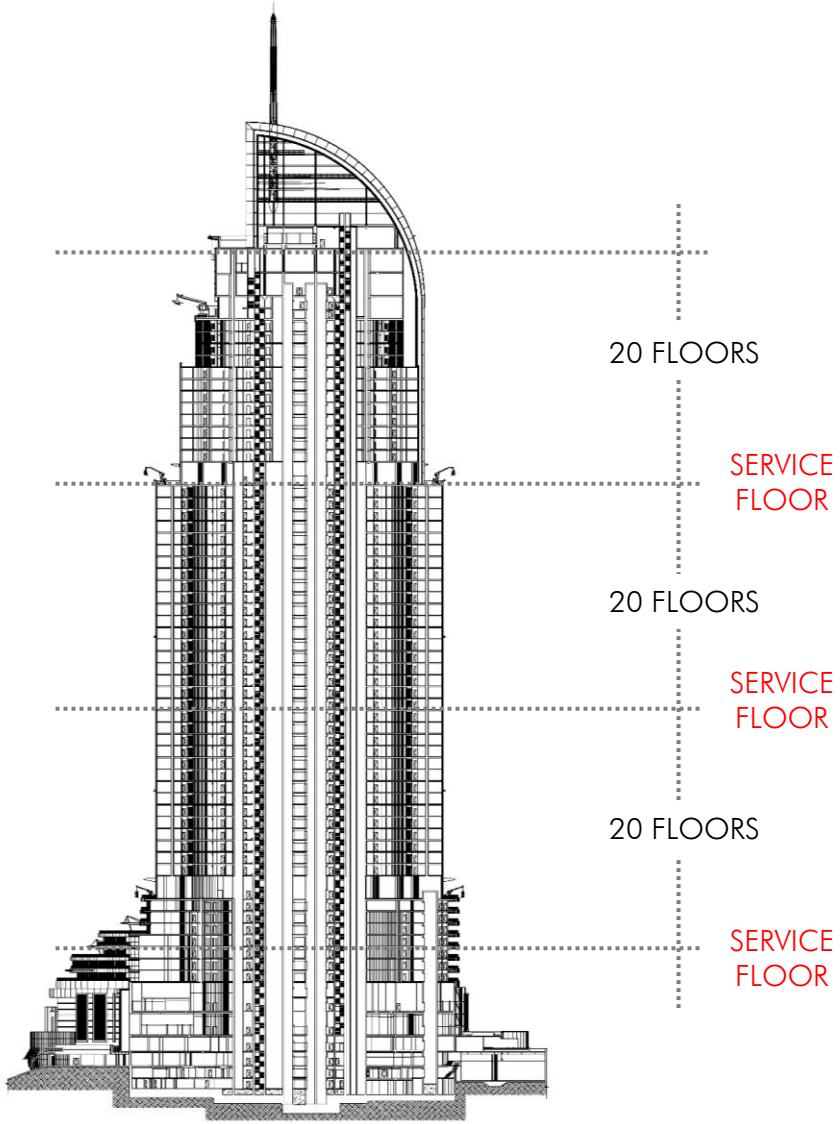
concept design

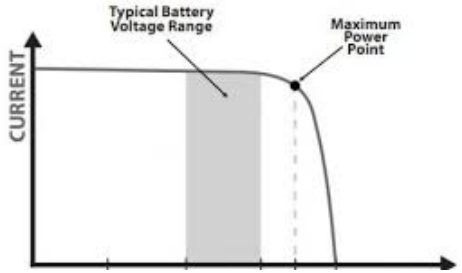
energy performance - assessment
economic assessment
life cycle assessment
design development

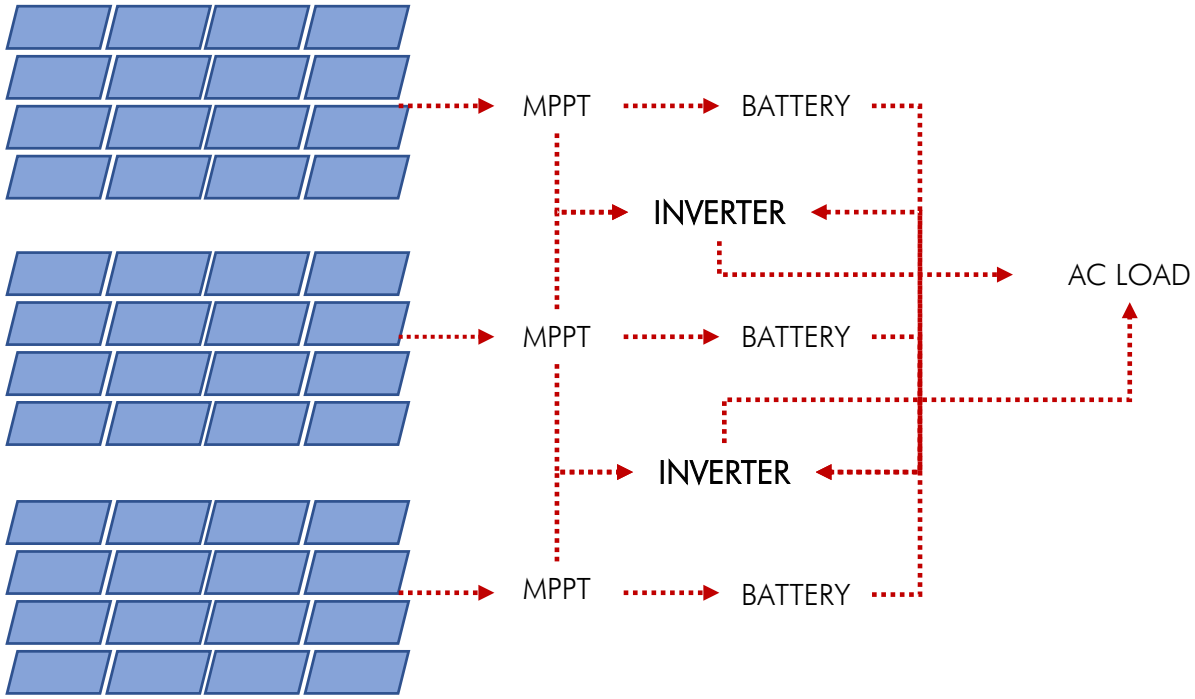
CONCEPT DESIGN – ACCESSIBILITY & MAINTENENCE



CONCEPT DESIGN – STAGE 5 – SOLAR PANEL INTERGRATION





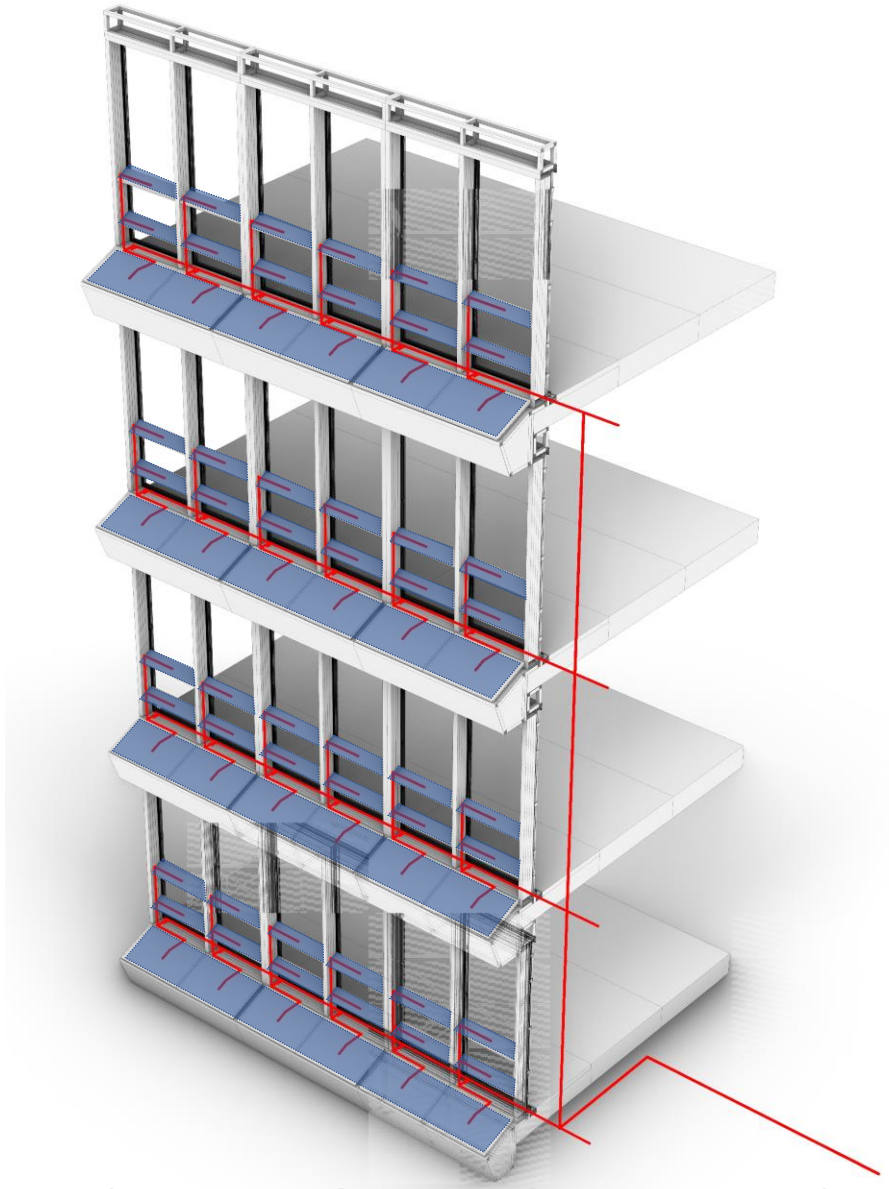


concept design

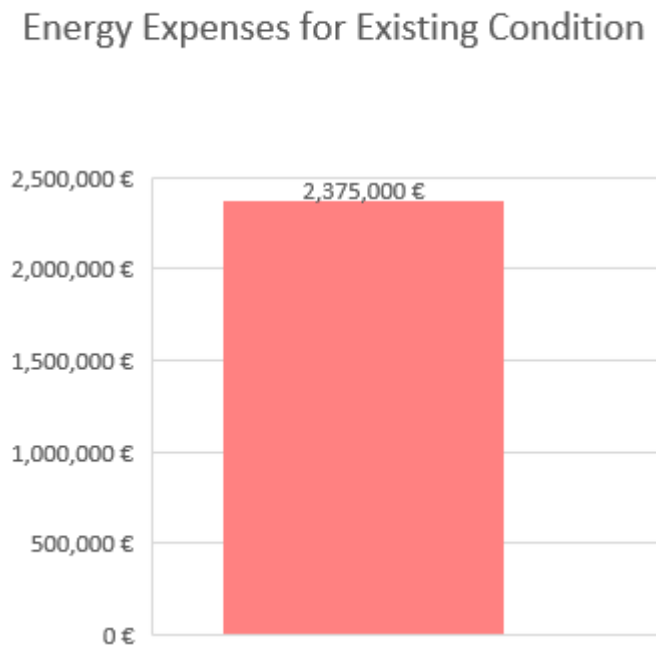
energy performance assessment

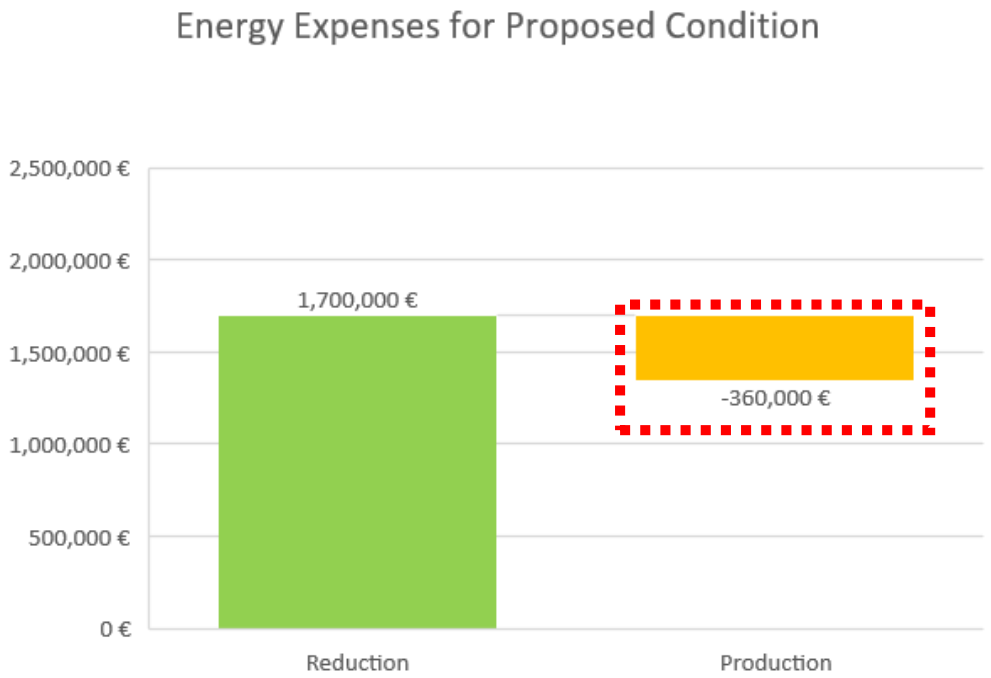
economic assessment
life cycle assessment
design development

DESIGN REQUIREMENTS – INTERGRATING PV PANELS



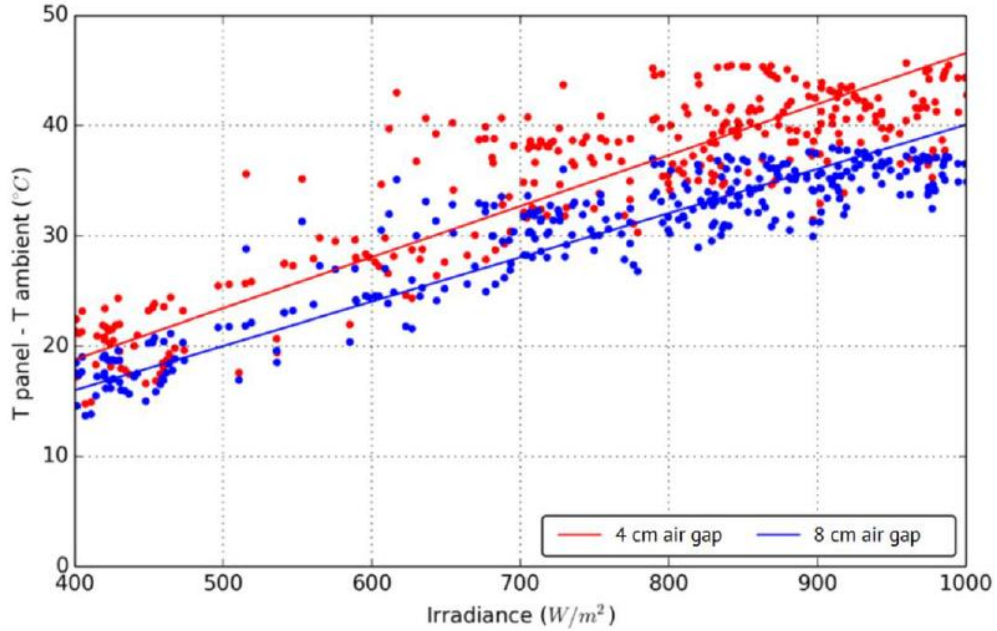
DESIGN REQUIREMENTS – INTERGRATING PV PANELS





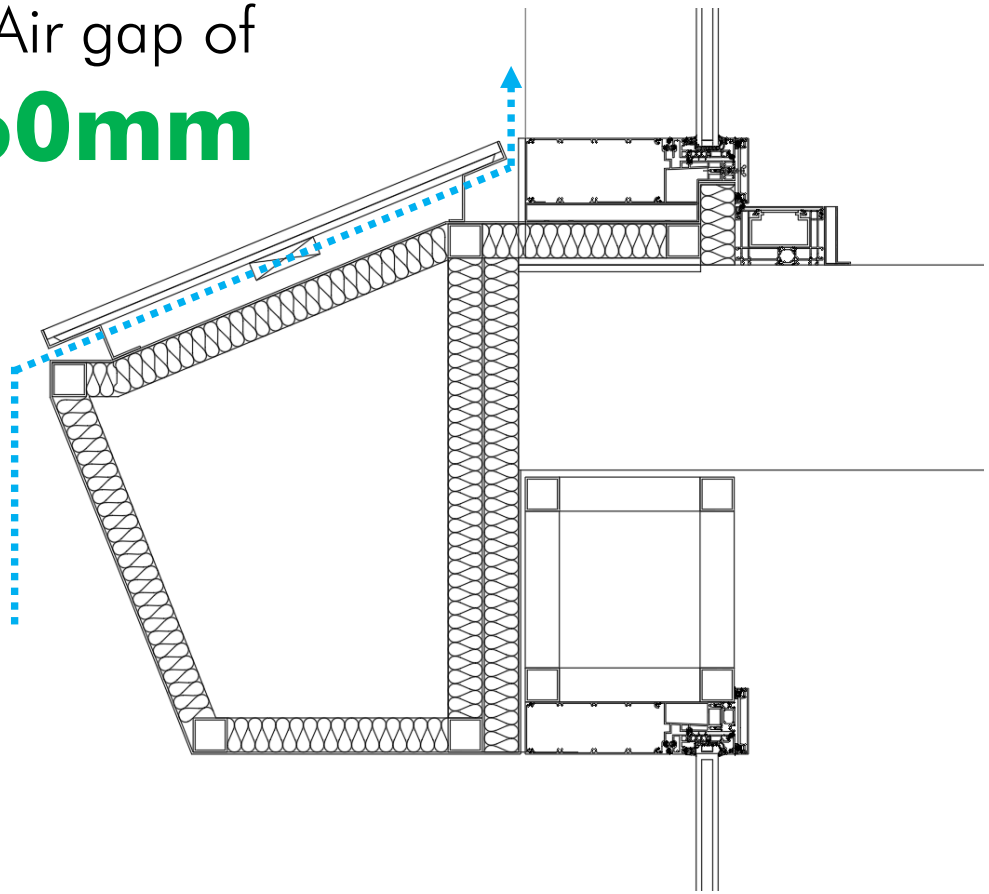
concept design
energy performance
assessment
economic assessment
life cycle assessment
design development

DESIGN REQUIREMENTS – INTERGRATING PV PANELS



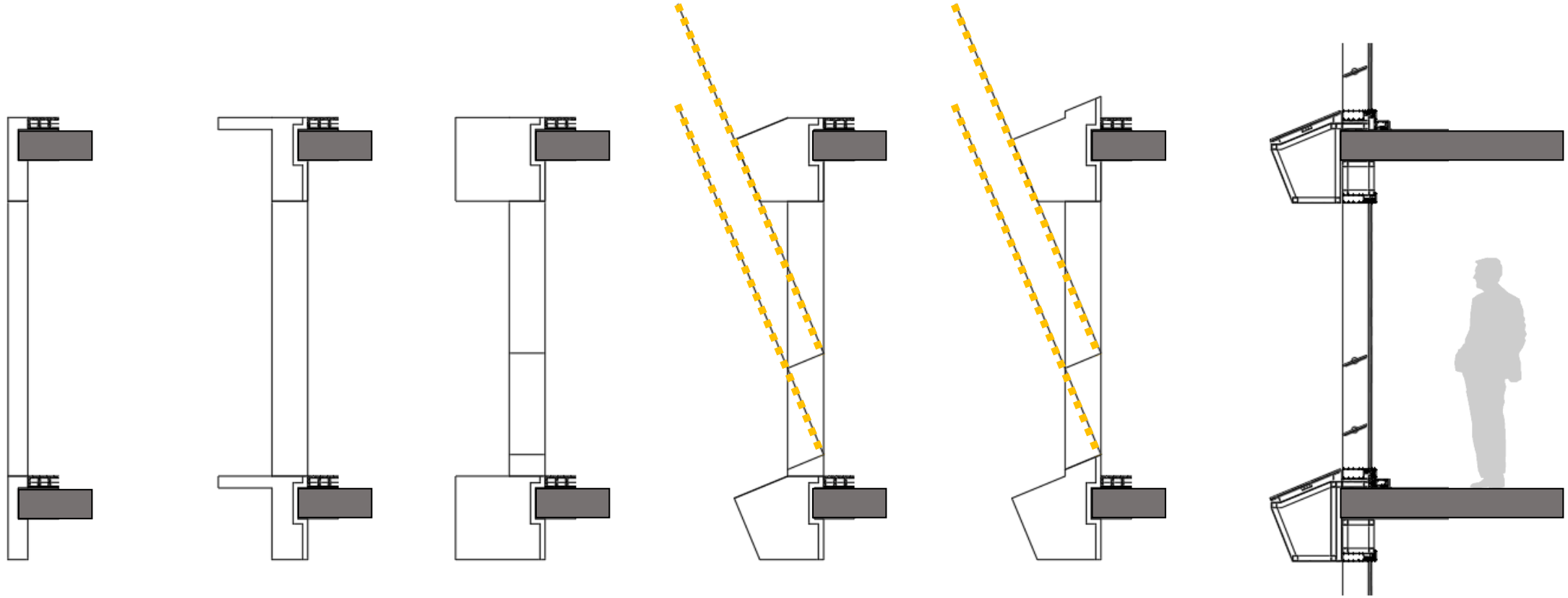
Effect of a ventilation air gap behind the PV panels in a BIPV roof

Air gap of
60mm



Design of the upper part of the BIPV Shading

DESIGN REQUIREMENTS – INTERGRATING PV PANELS



concept design

energy performance - assessment
economic assessment
life cycle assessment
design development

CONCEPT DESIGN – DESIGN DEVELOPMENT

intervention
methodology
framework
background

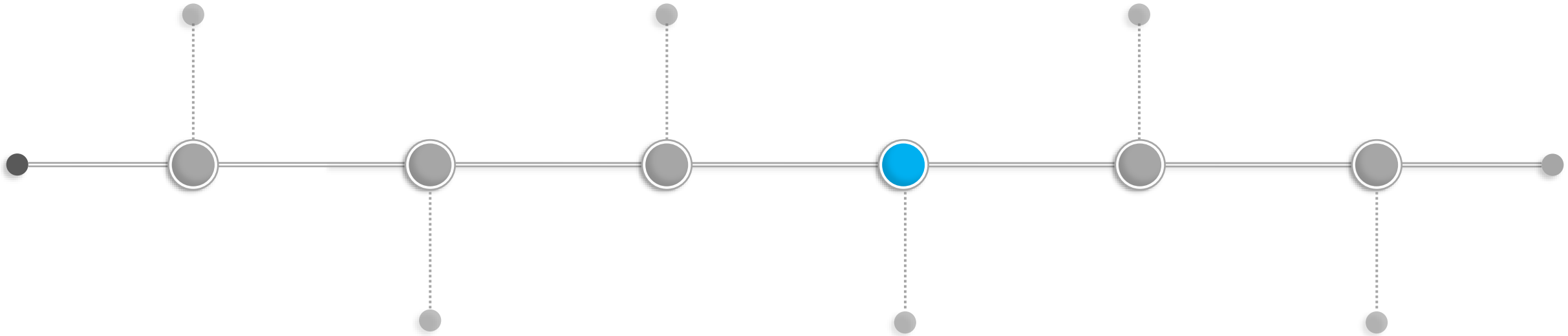
introduction

life cycle assessment
economic assessment
energy performance assessment
concept design

design development

evaluation

sustainability evaluation



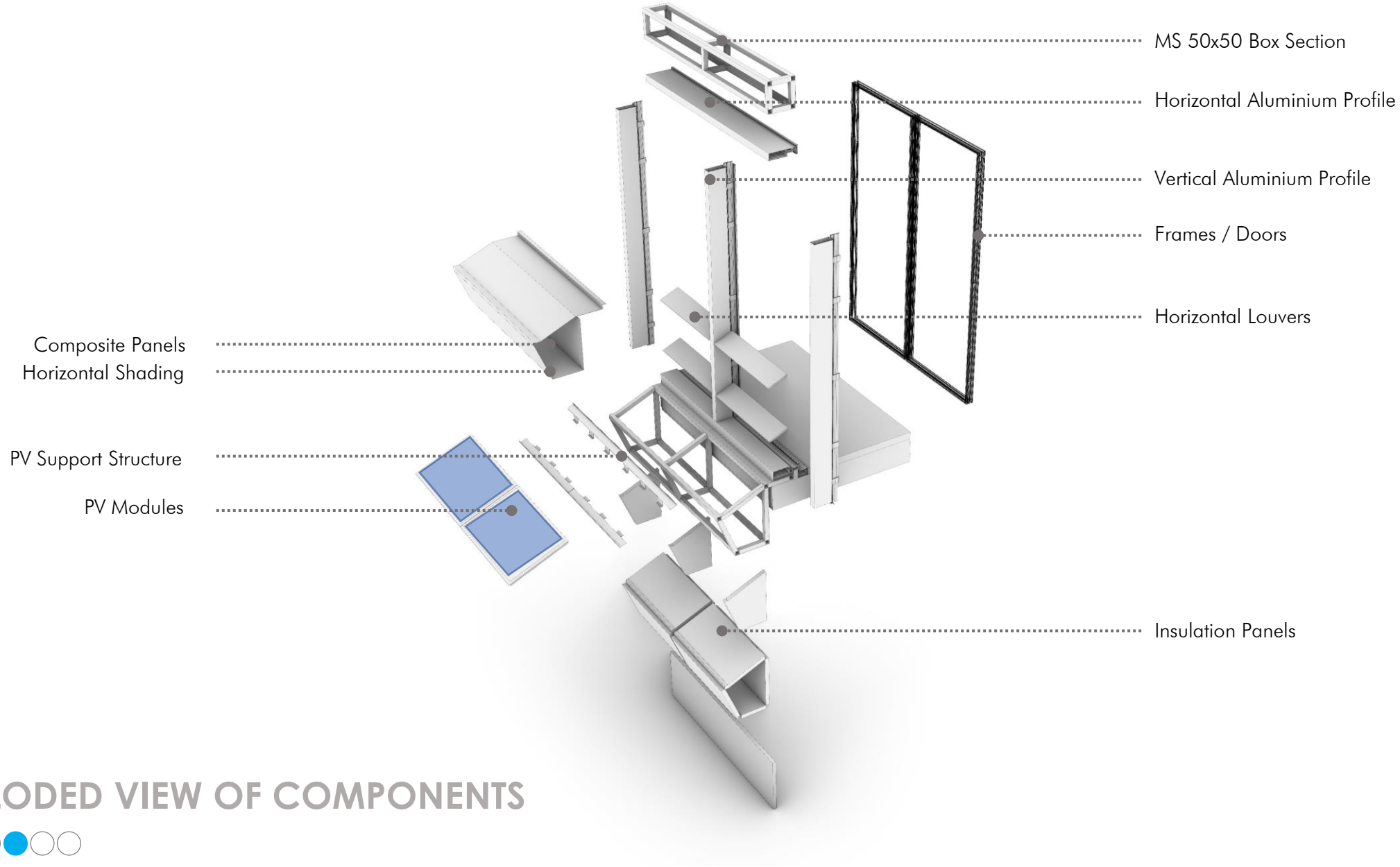
framework

sustainable façade refurbishment
mppf
literature summary

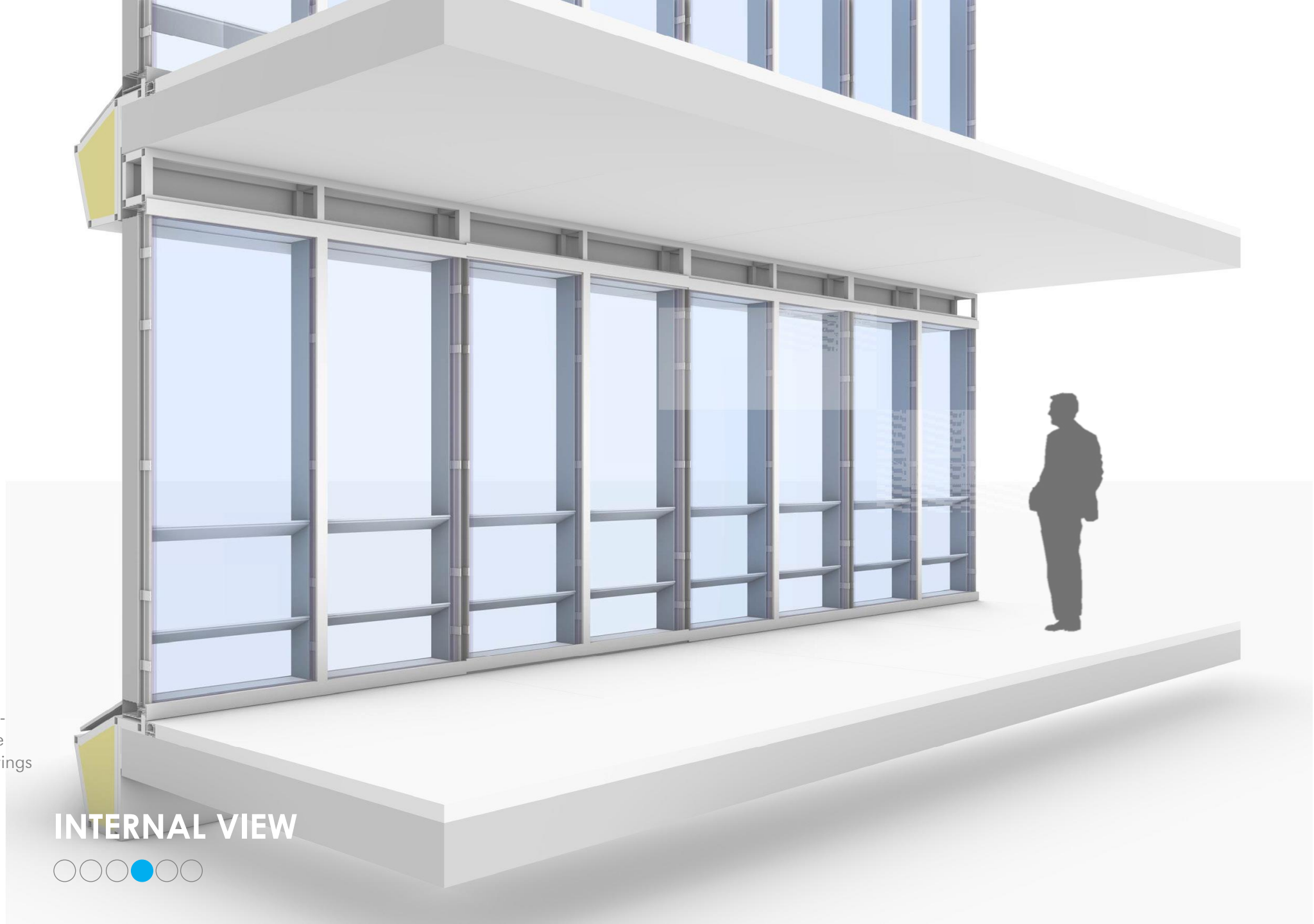
design

design proposal
technical drawings
assembly and maintenance

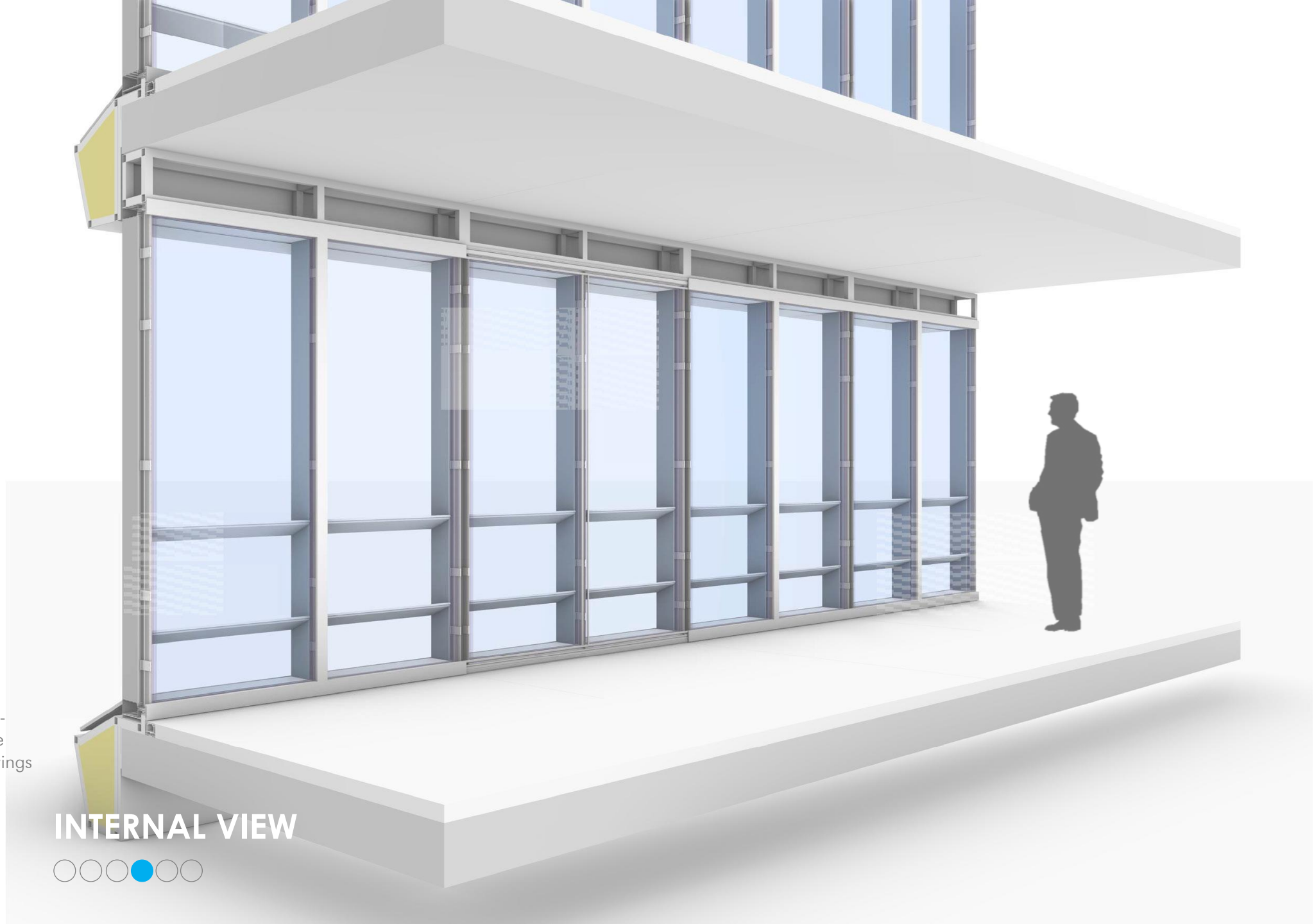
conclusion



EXPLODED VIEW OF COMPONENTS



INTERNAL VIEW

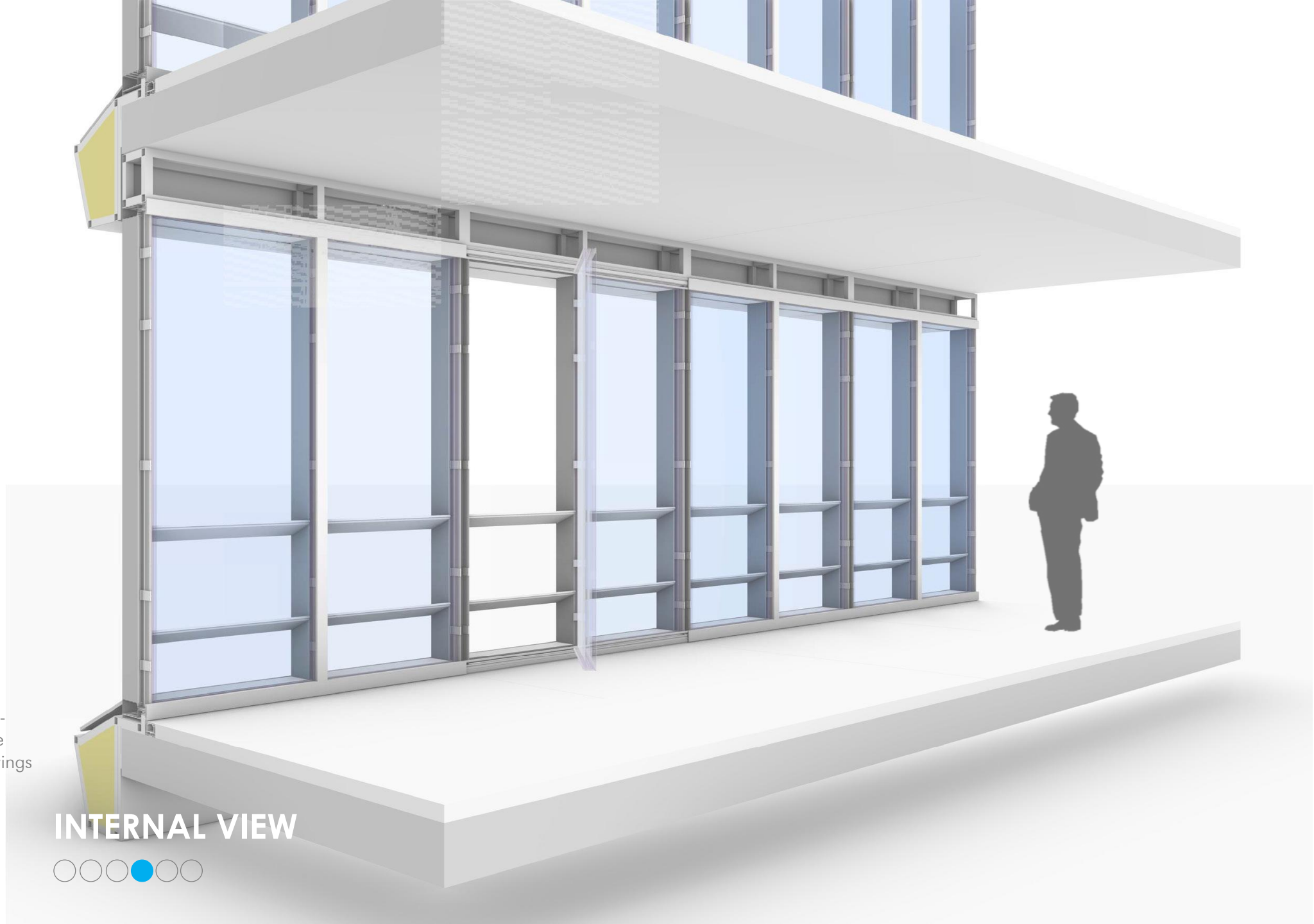


assembly and - maintenance technical drawings

design proposal

design

INTERNAL VIEW



assembly and -
maintenance
technical drawings

design
proposal

design

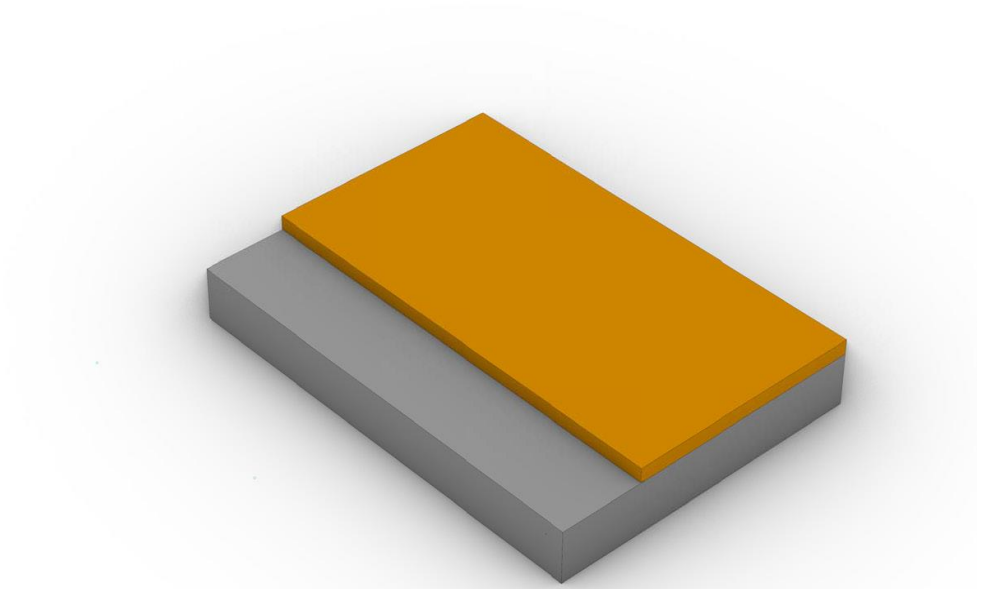
INTERNAL VIEW

assembly and -
maintenance
technical drawings

design
proposal

design

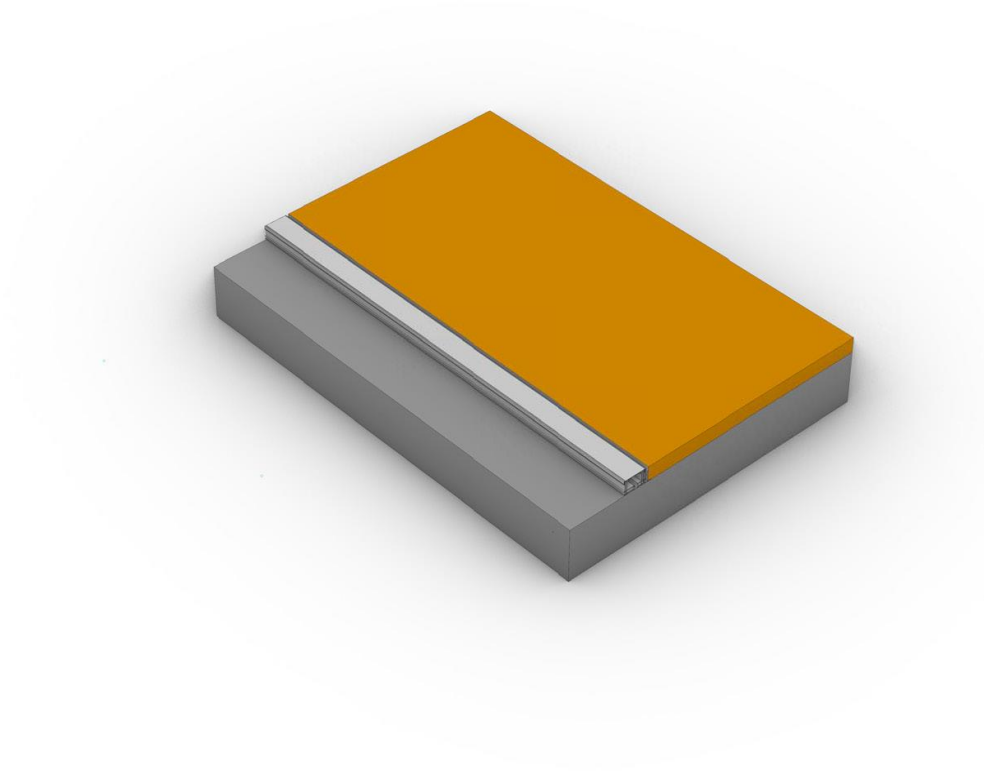
INTERNAL VIEW



assembly and
maintenance

technical drawings
design proposal
design

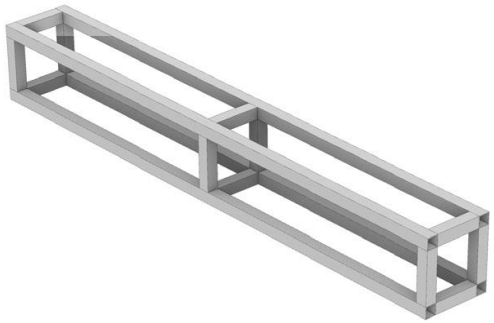
CONSTRUCTION - ASSEMBLY

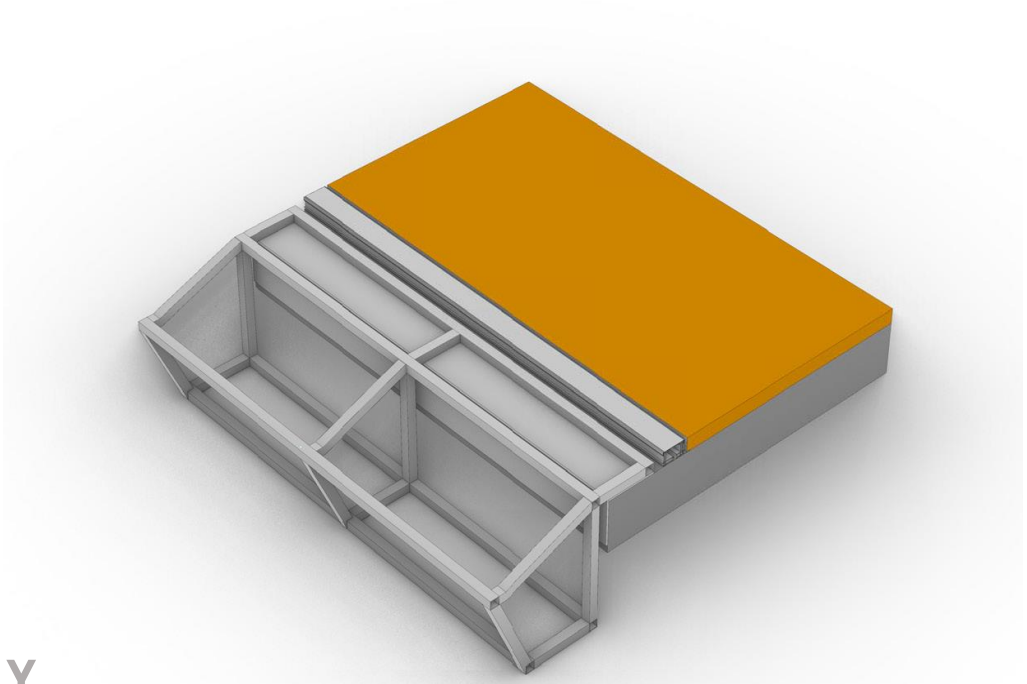


assembly and
maintenance

technical drawings
design proposal
design

CONSTRUCTION - ASSEMBLY

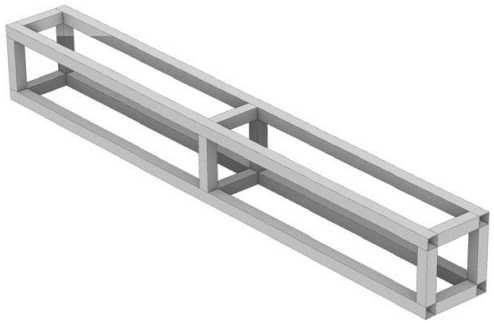


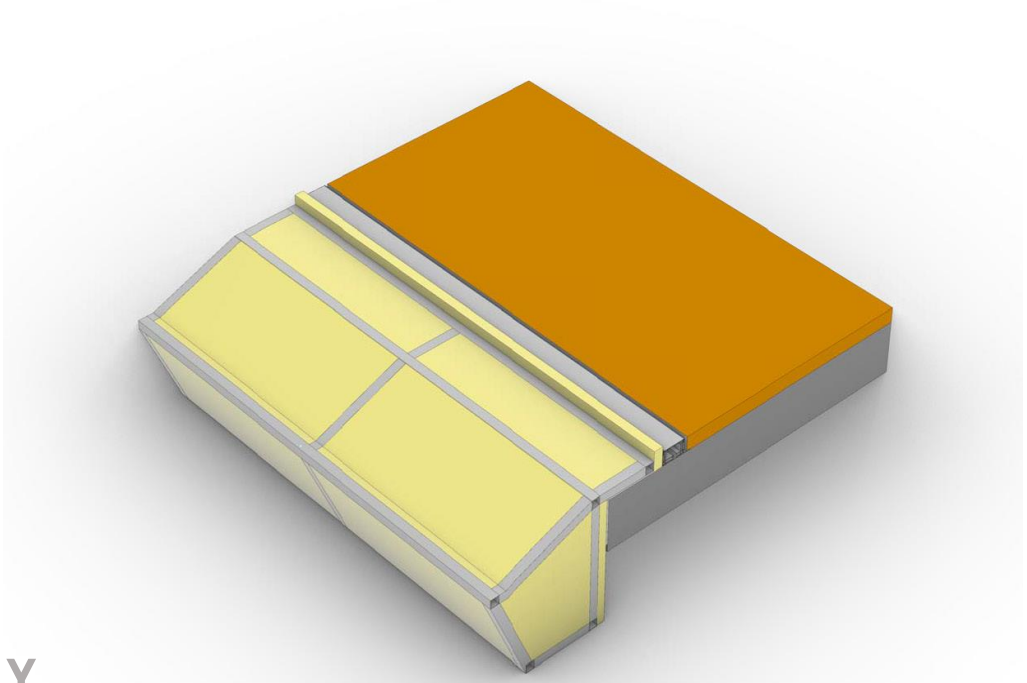


assembly and
maintenance

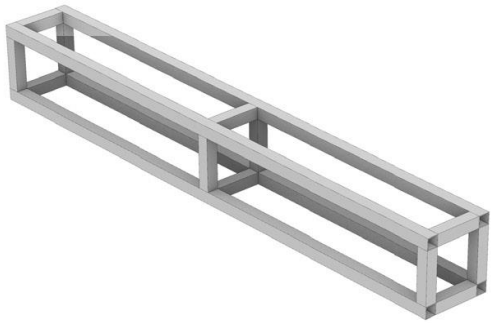
technical drawings
design proposal
design

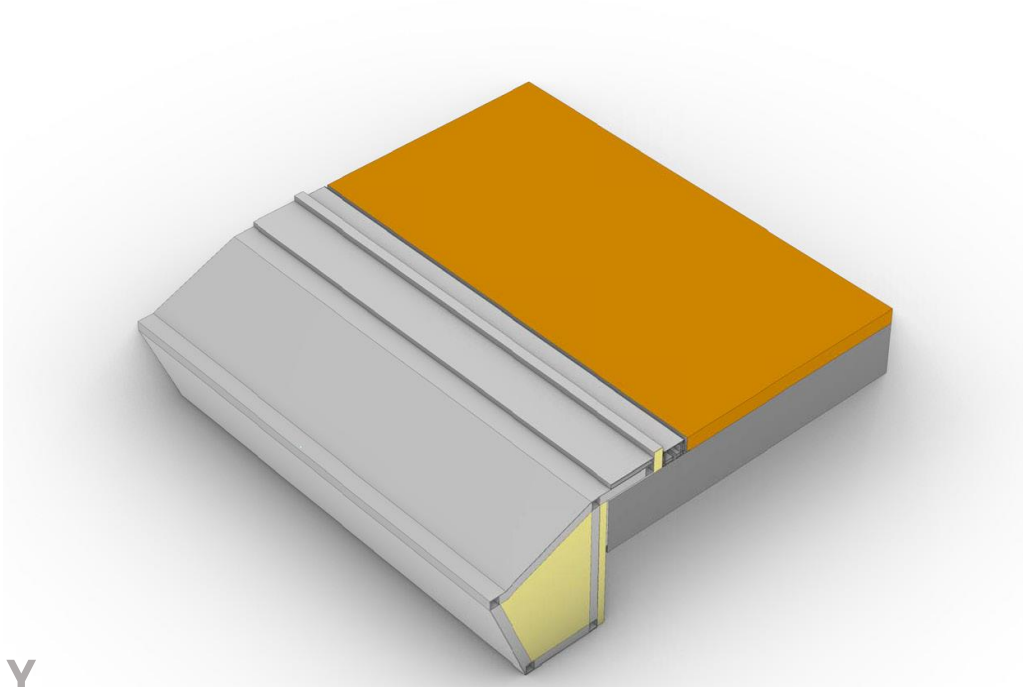
CONSTRUCTION - ASSEMBLY



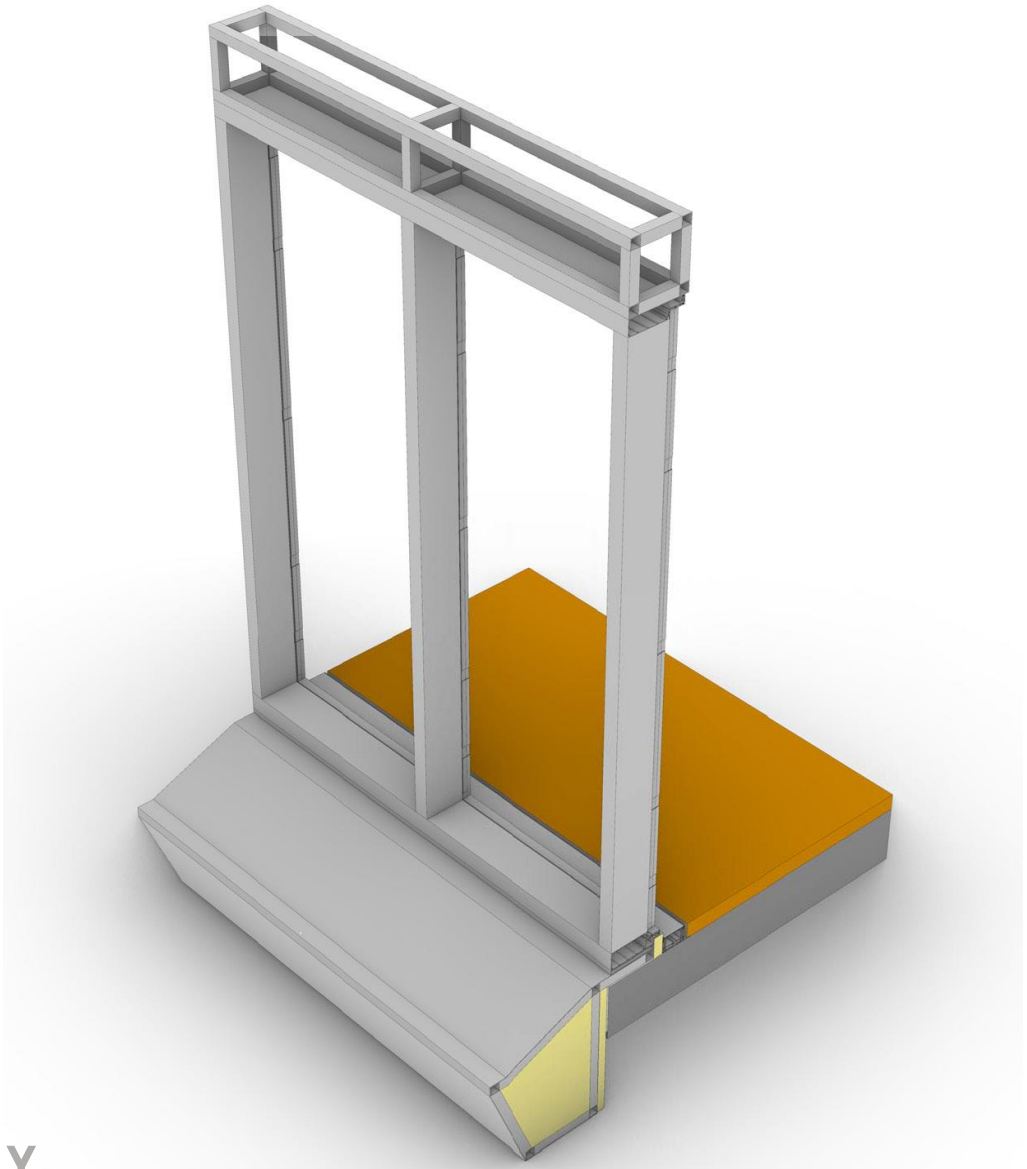


CONSTRUCTION - ASSEMBLY





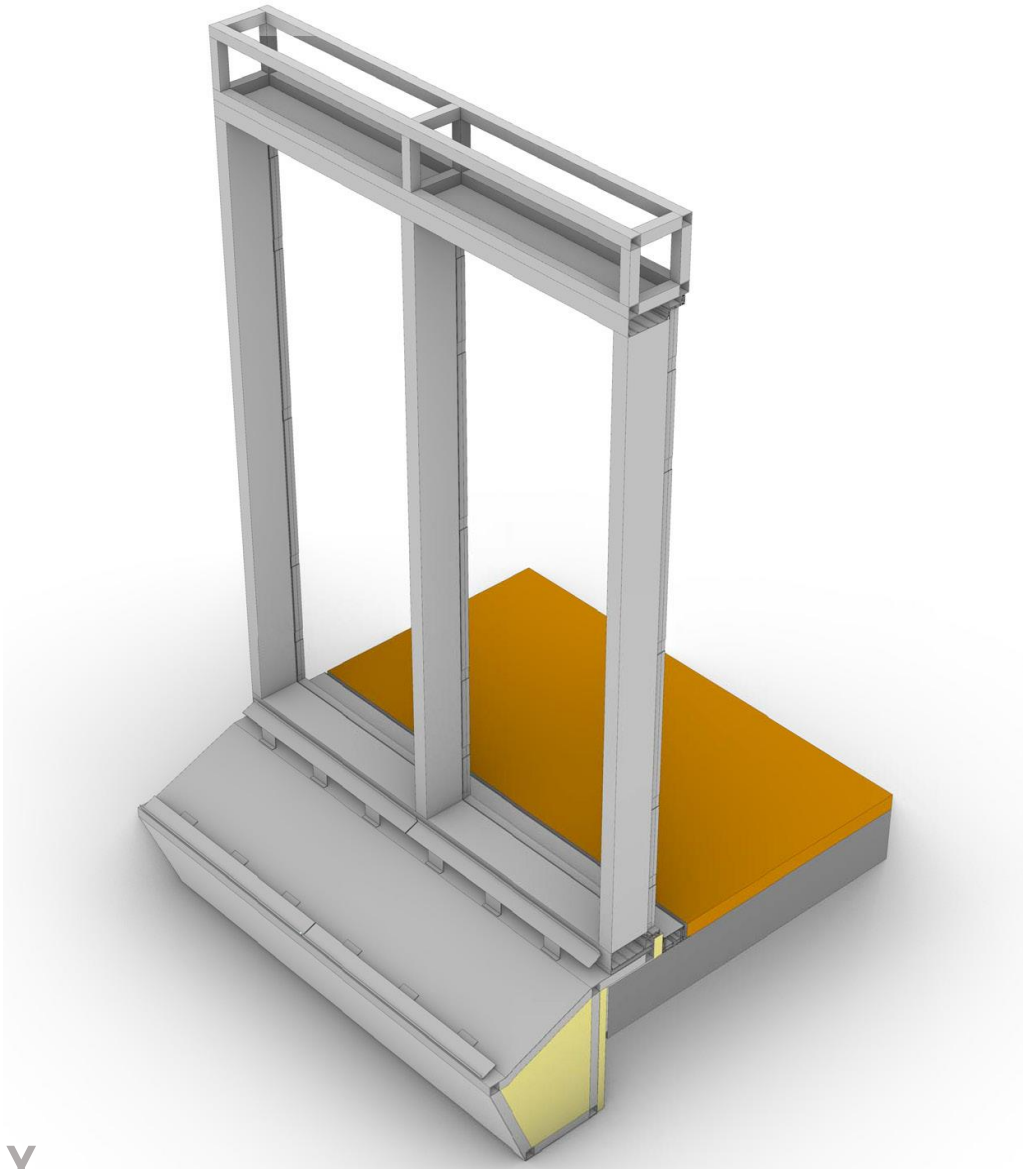
CONSTRUCTION - ASSEMBLY



assembly and
maintenance

technical drawings
design proposal
design

CONSTRUCTION - ASSEMBLY



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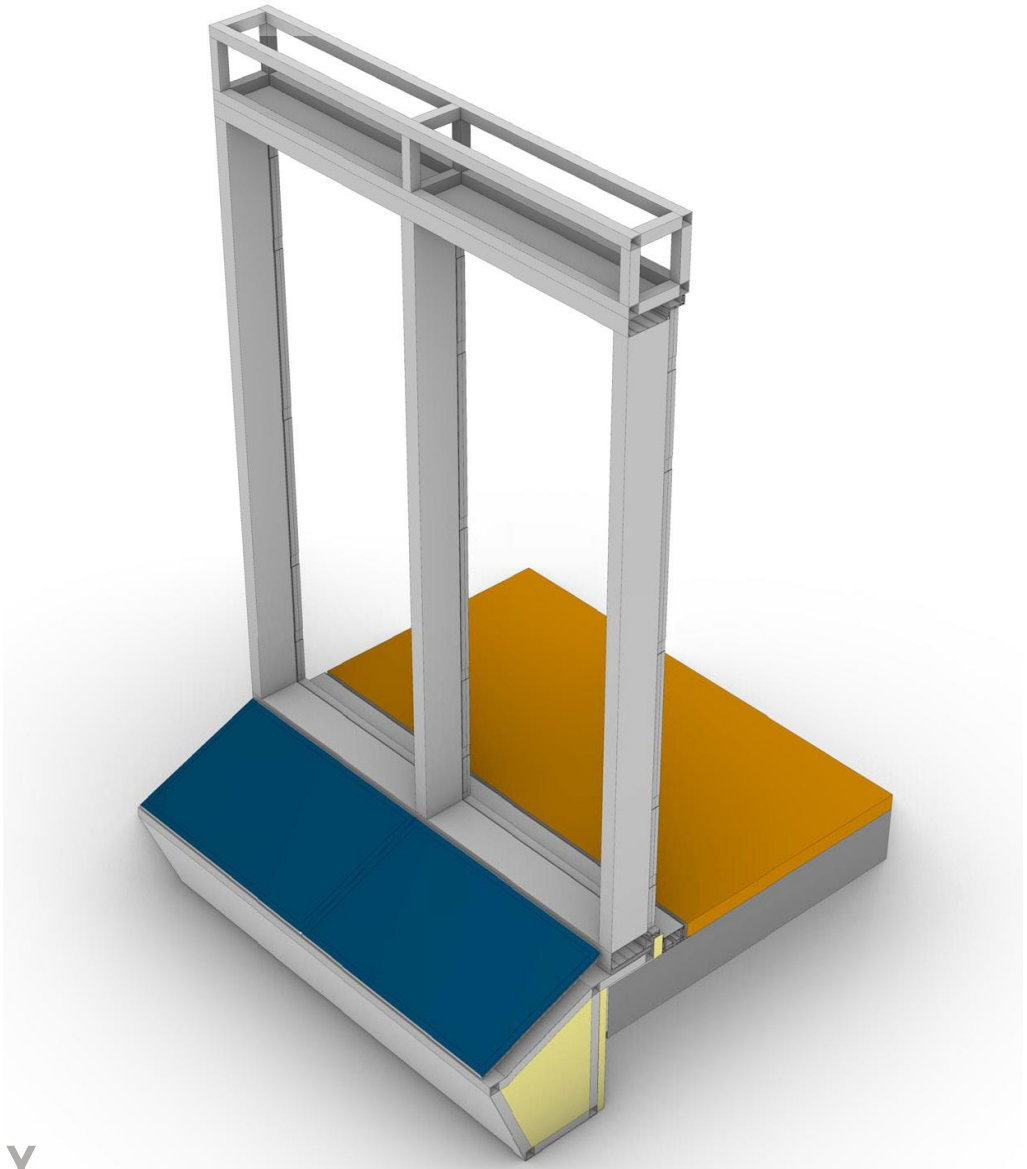

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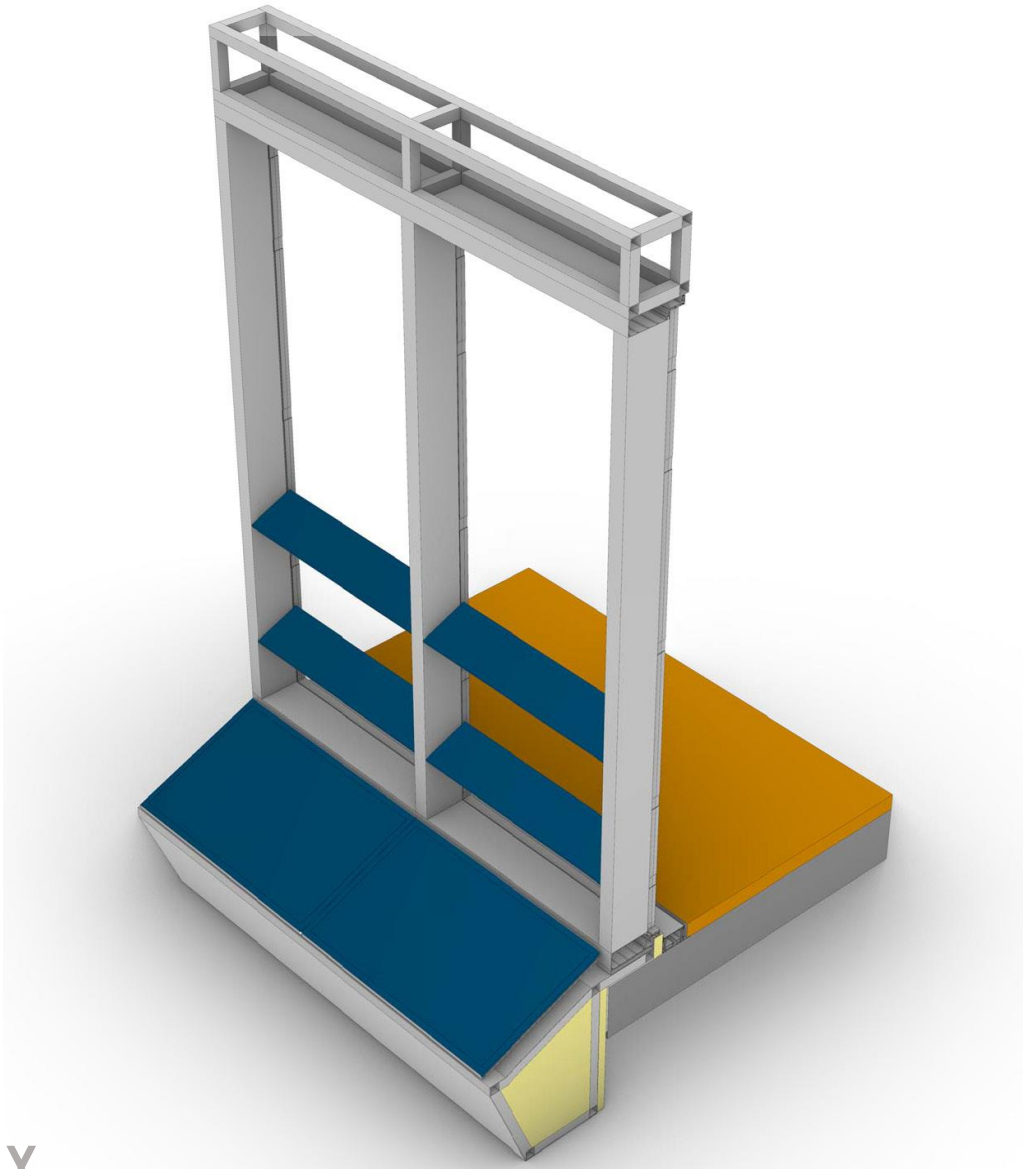

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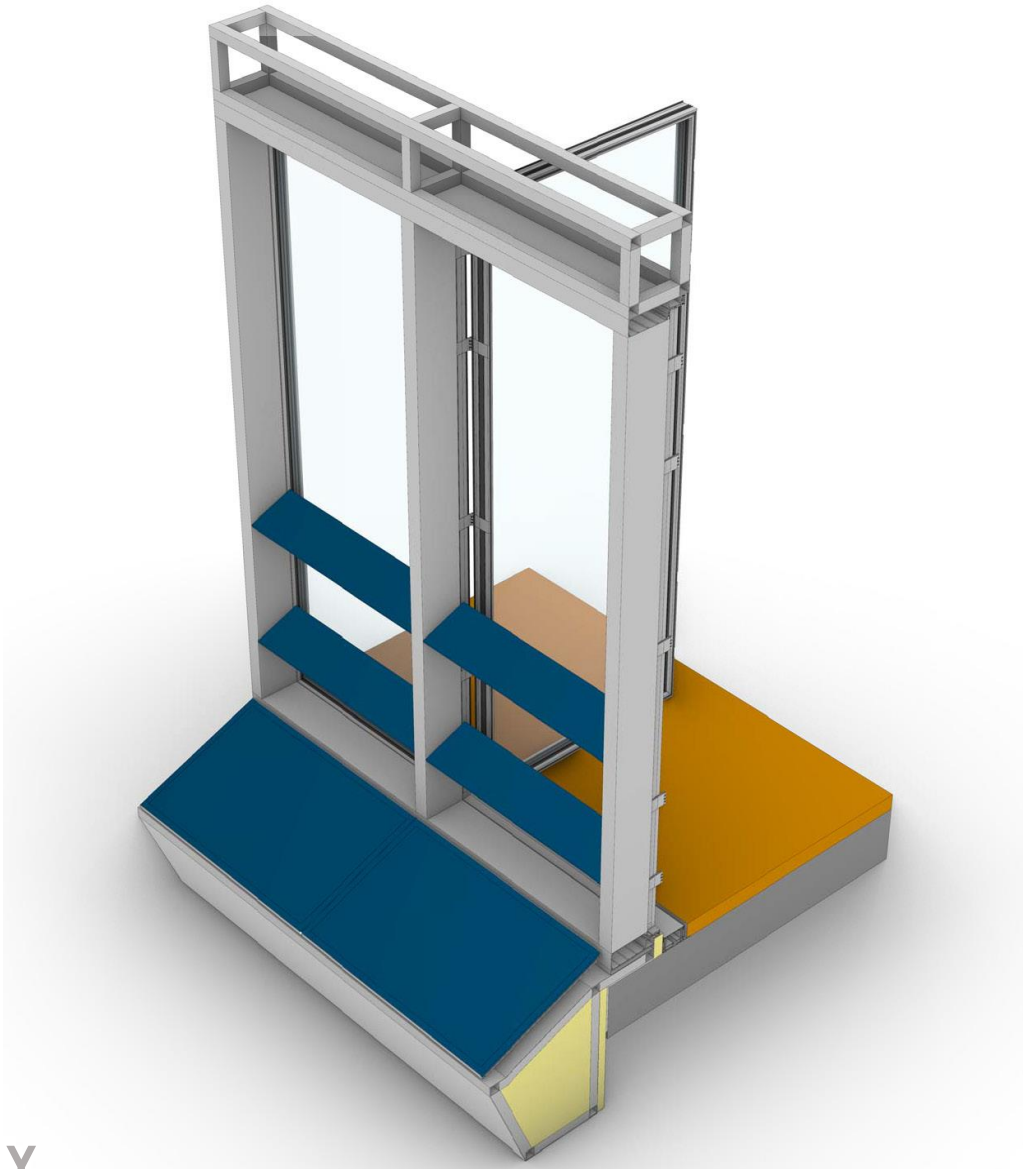

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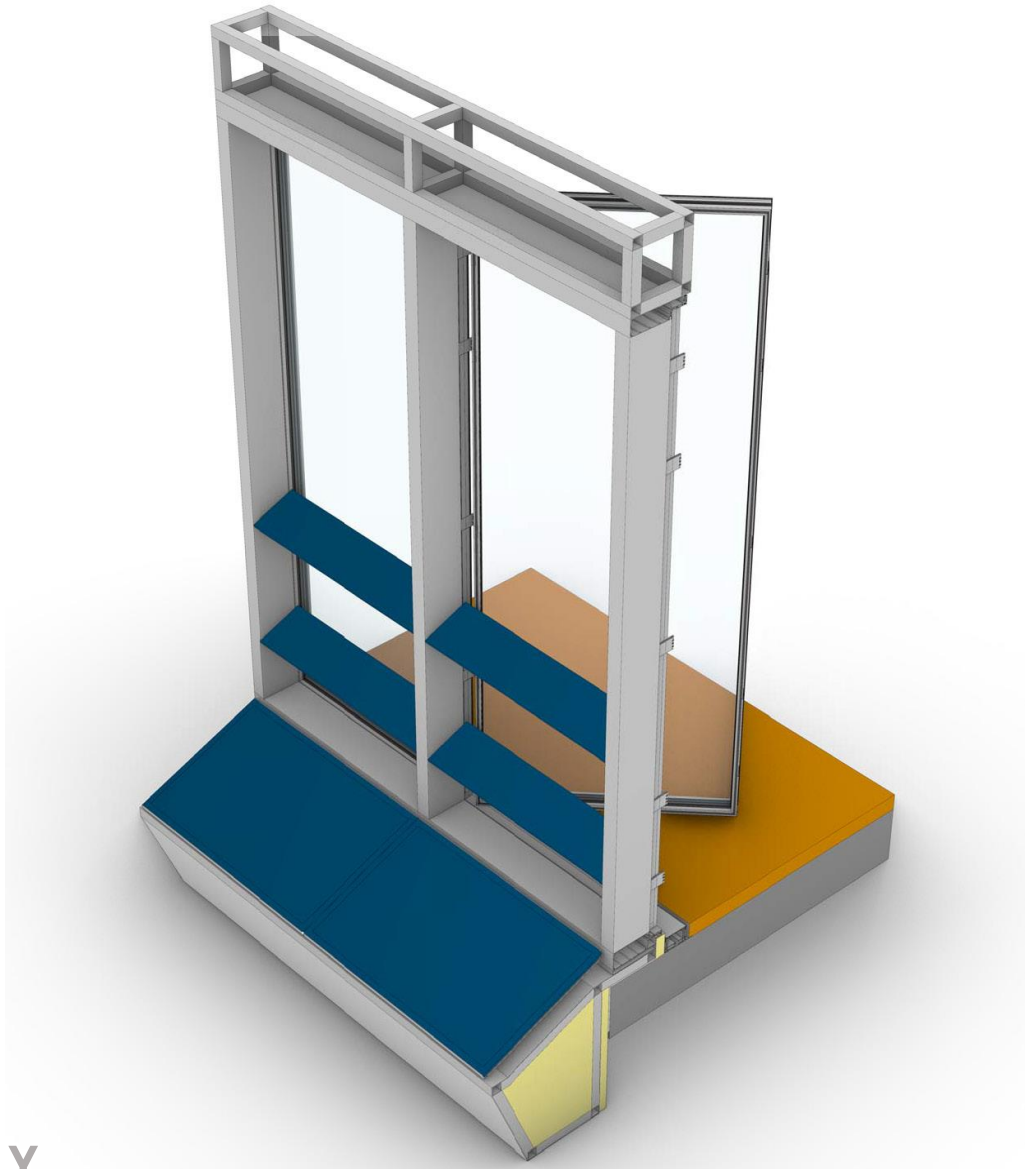

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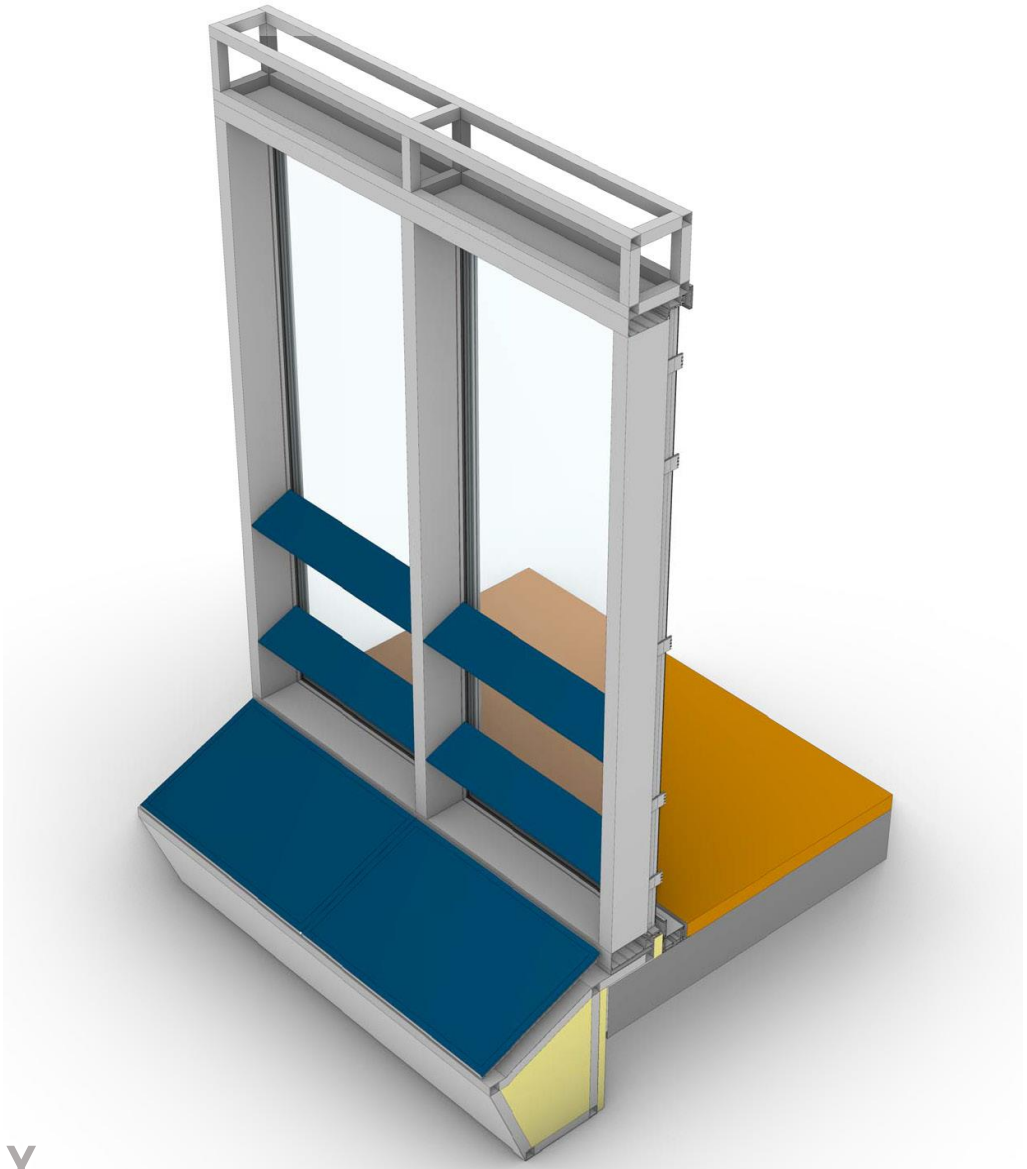

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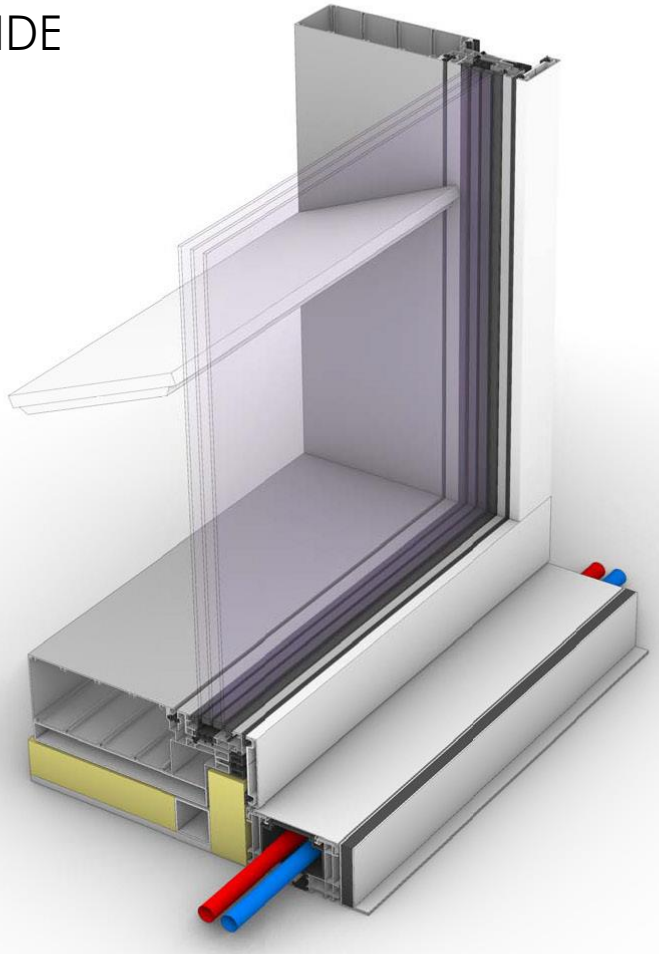

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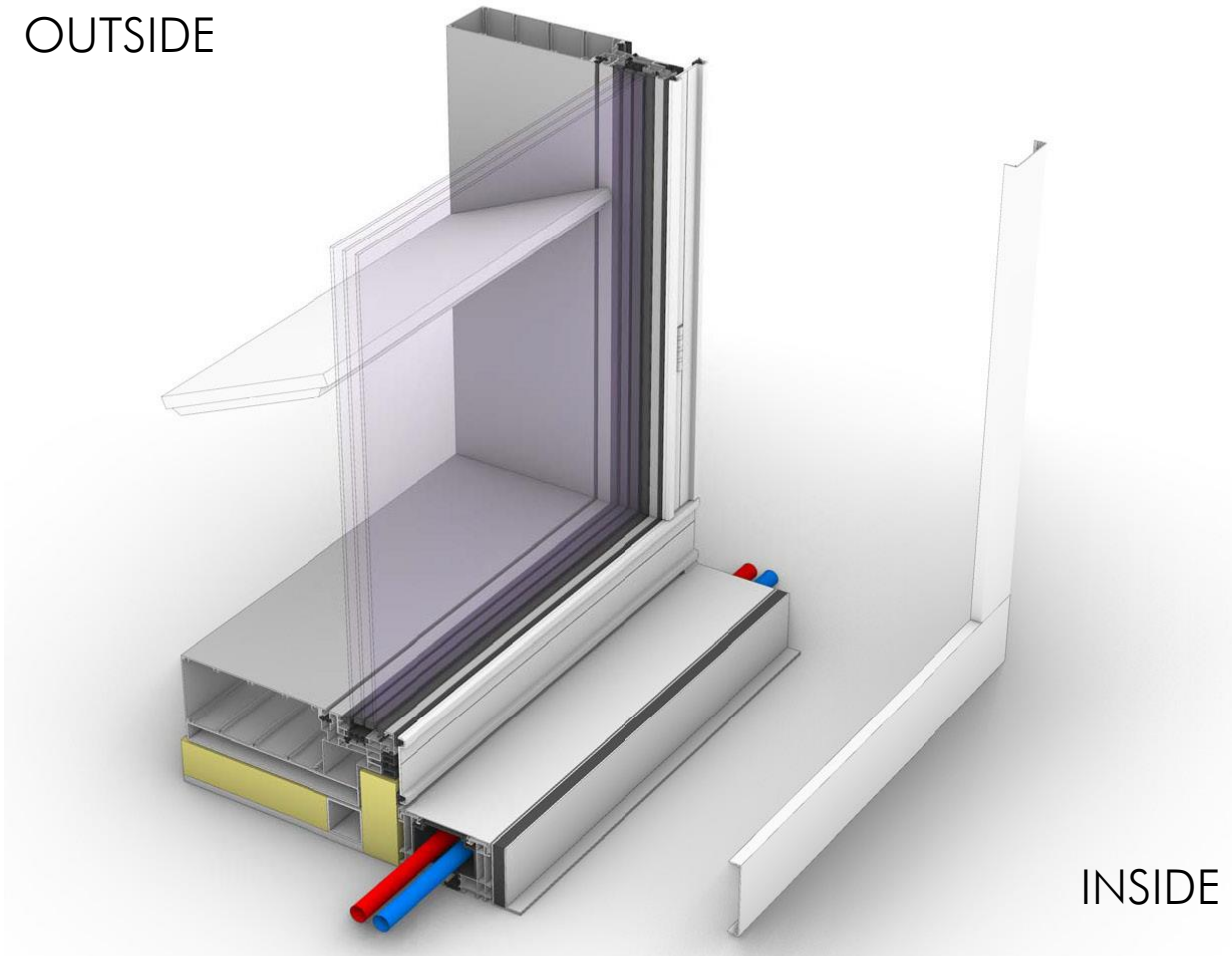

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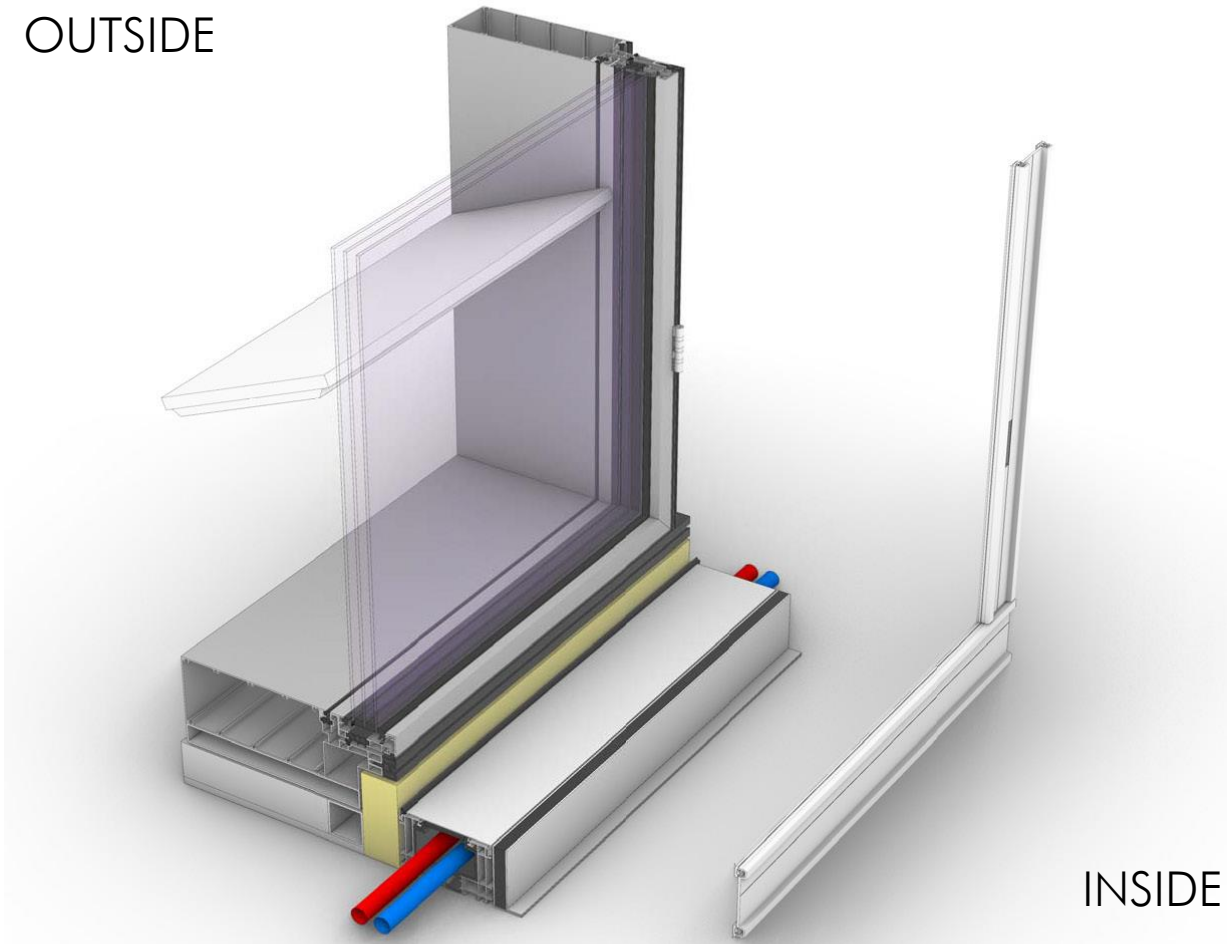

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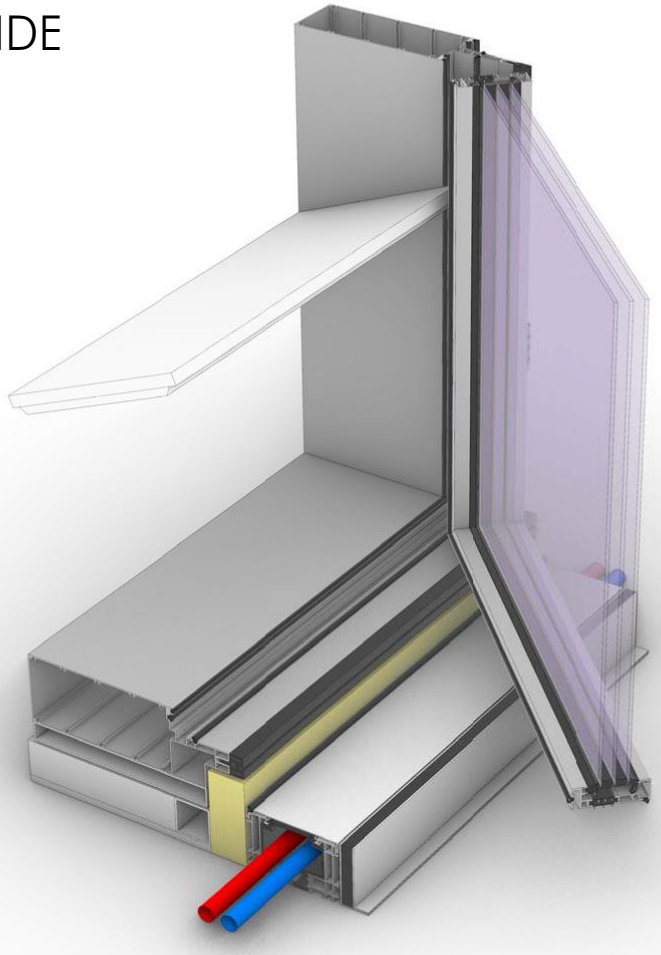

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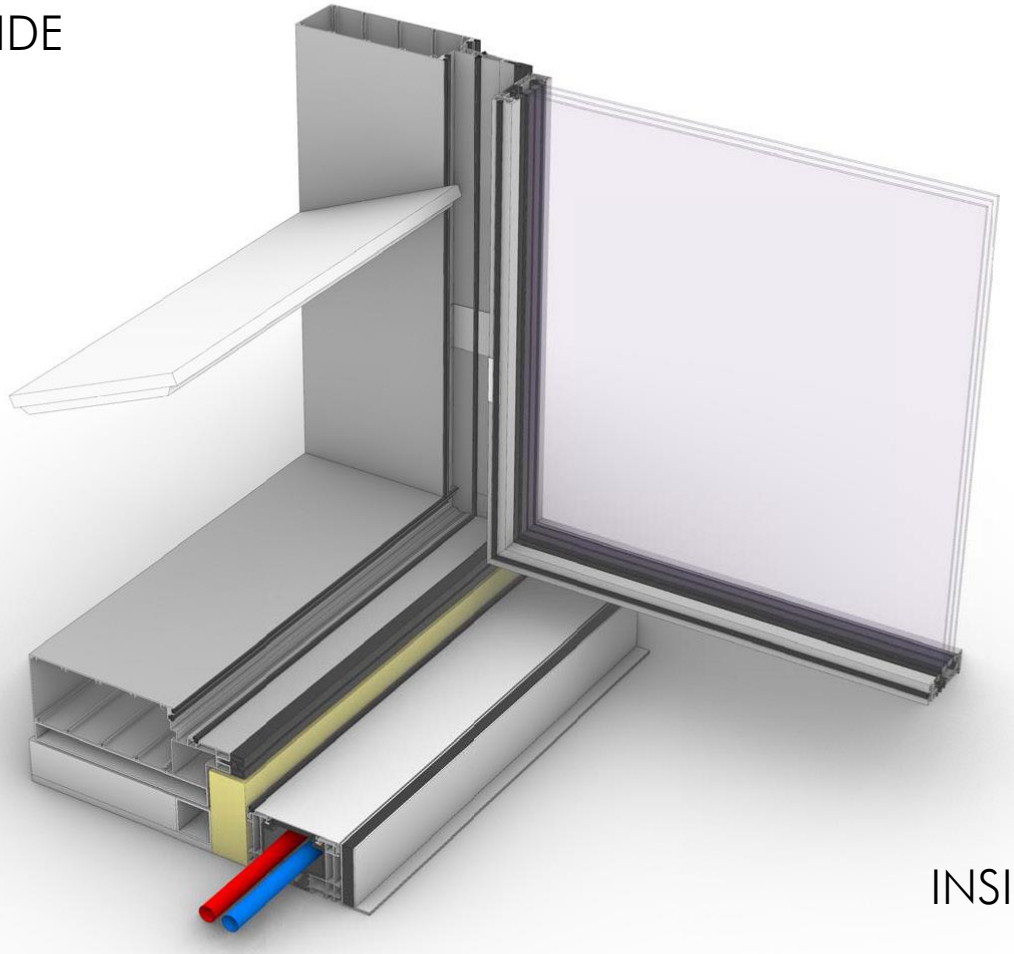

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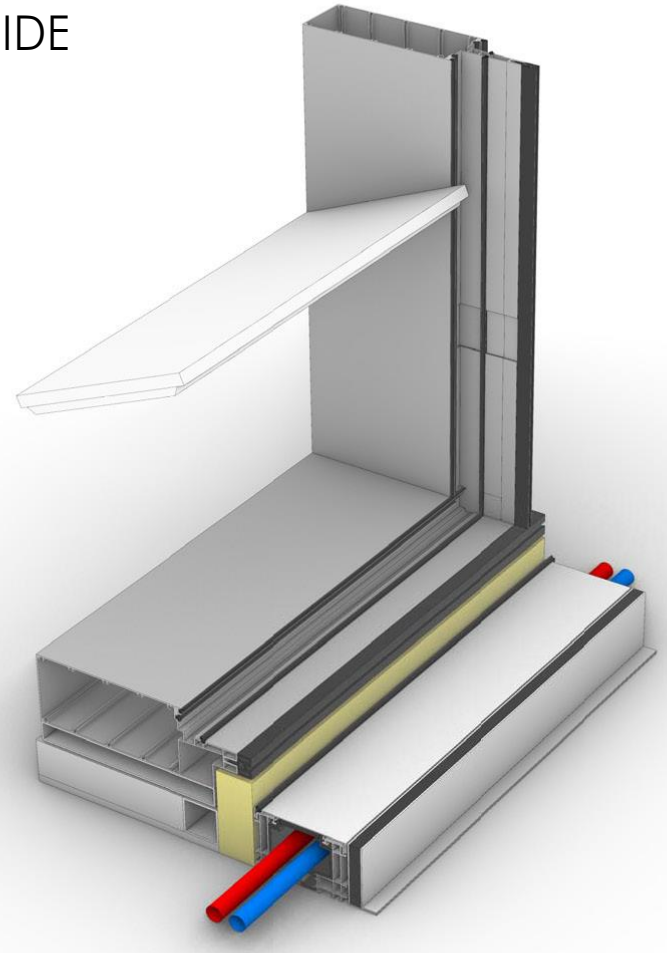

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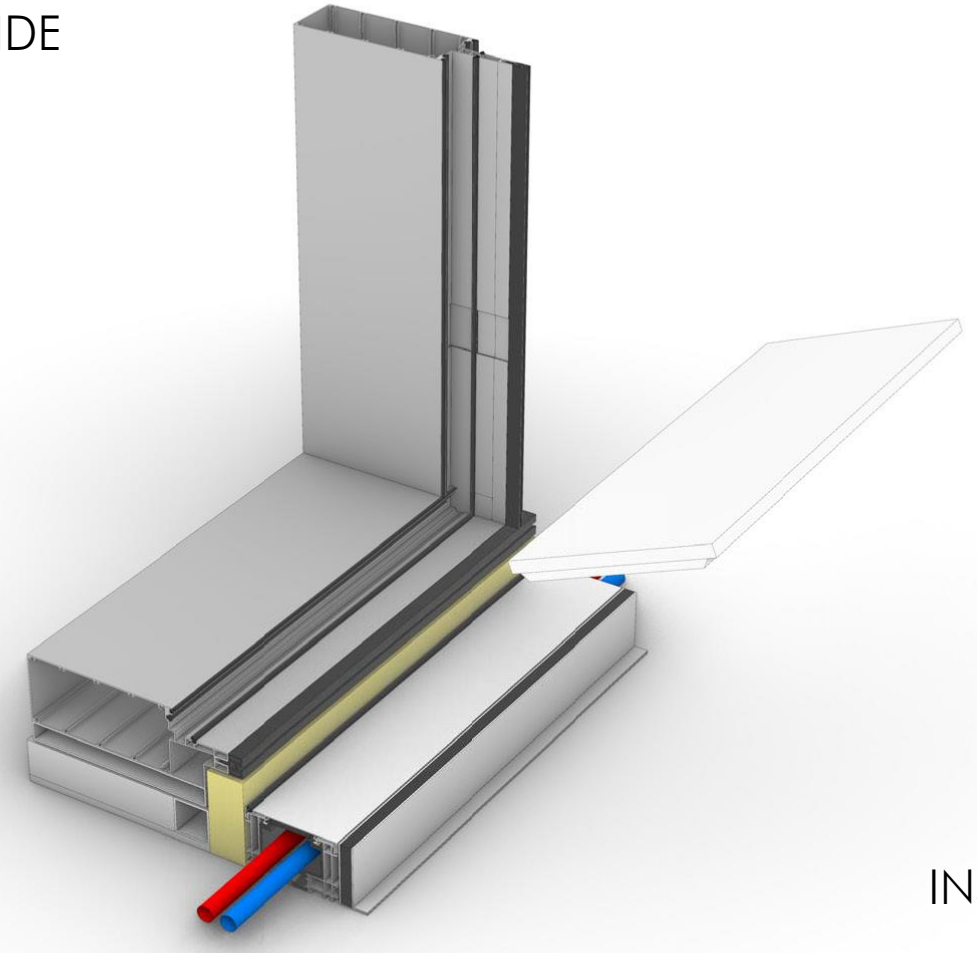

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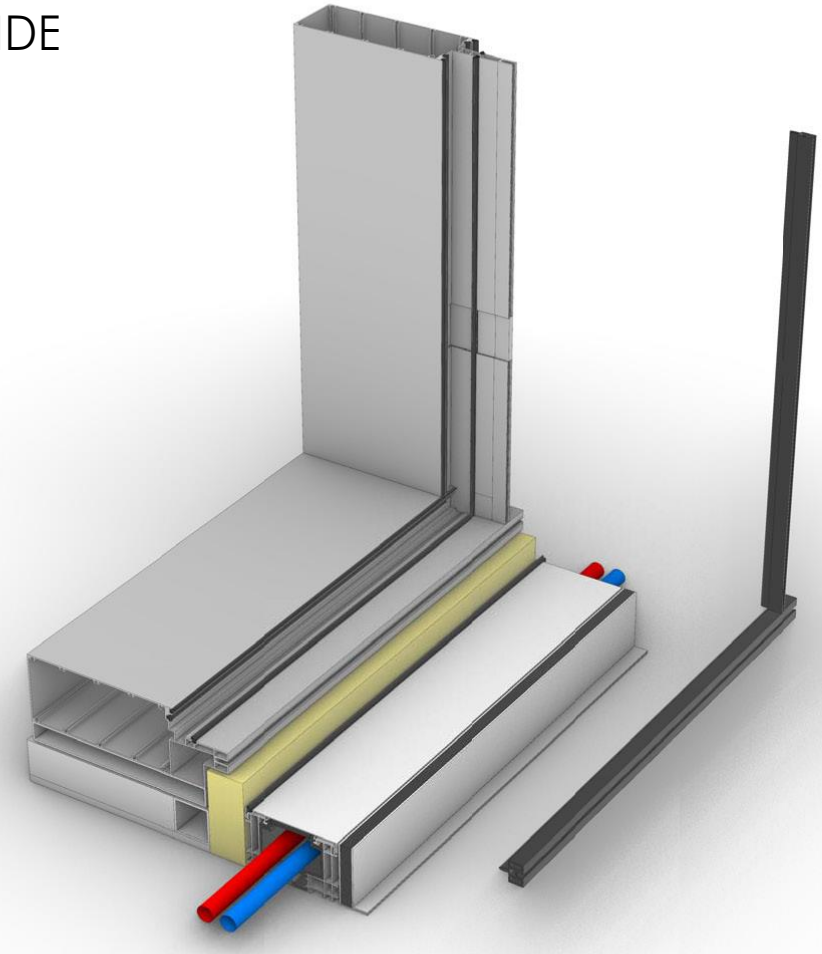

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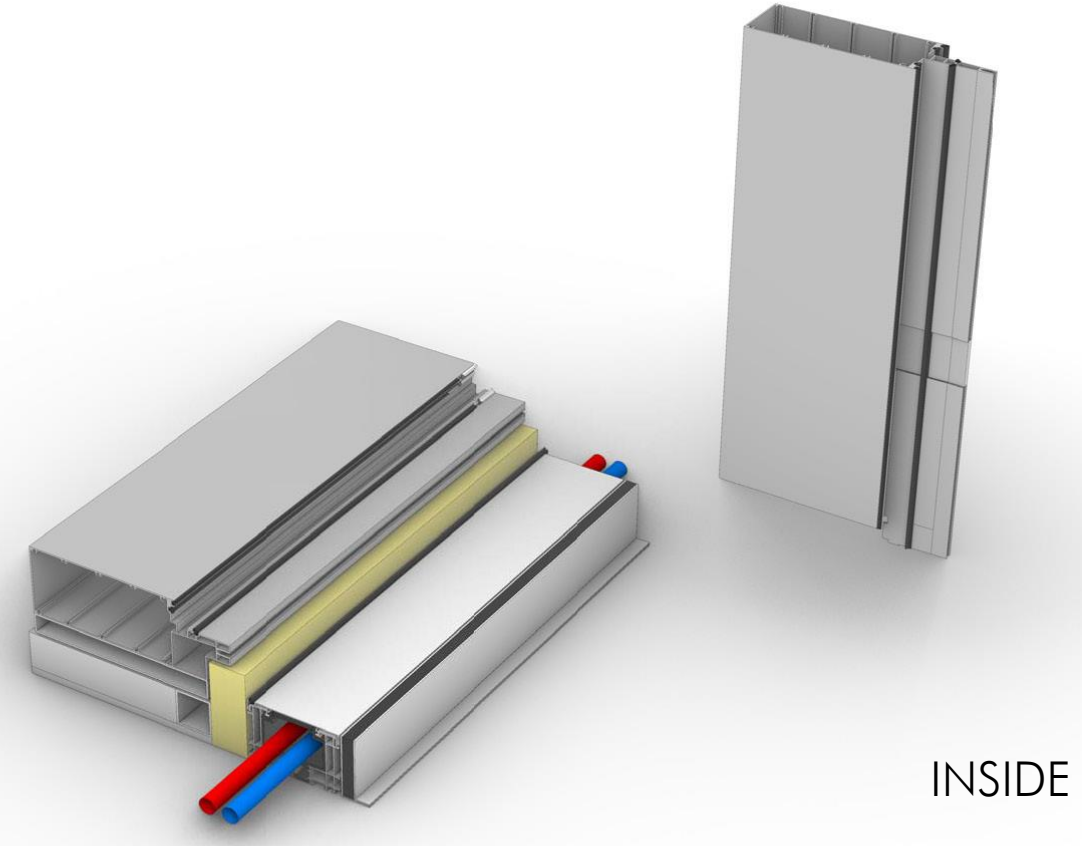

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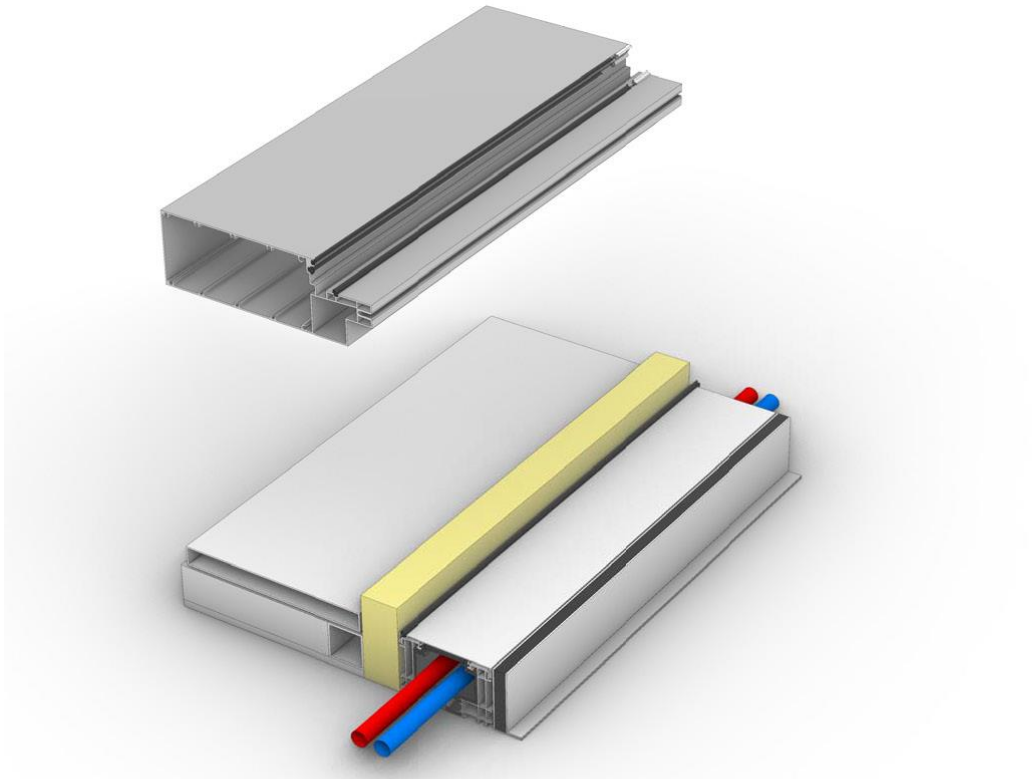

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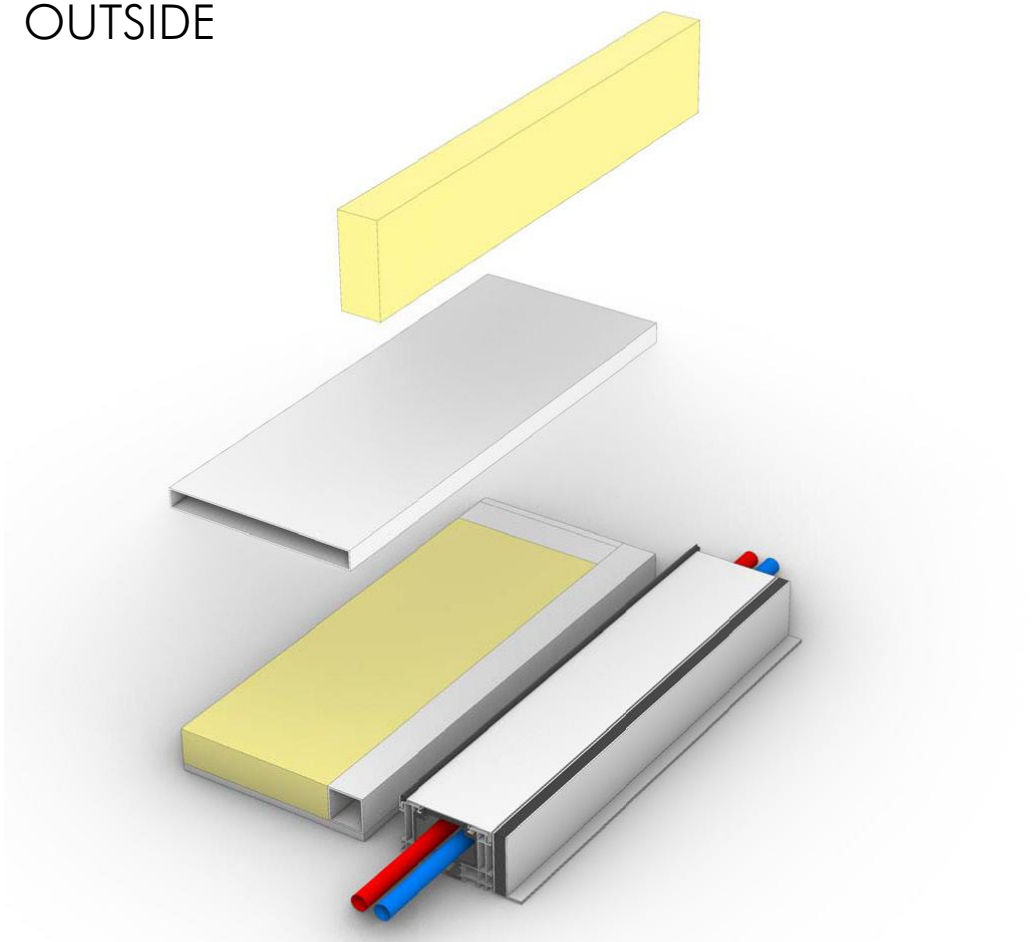

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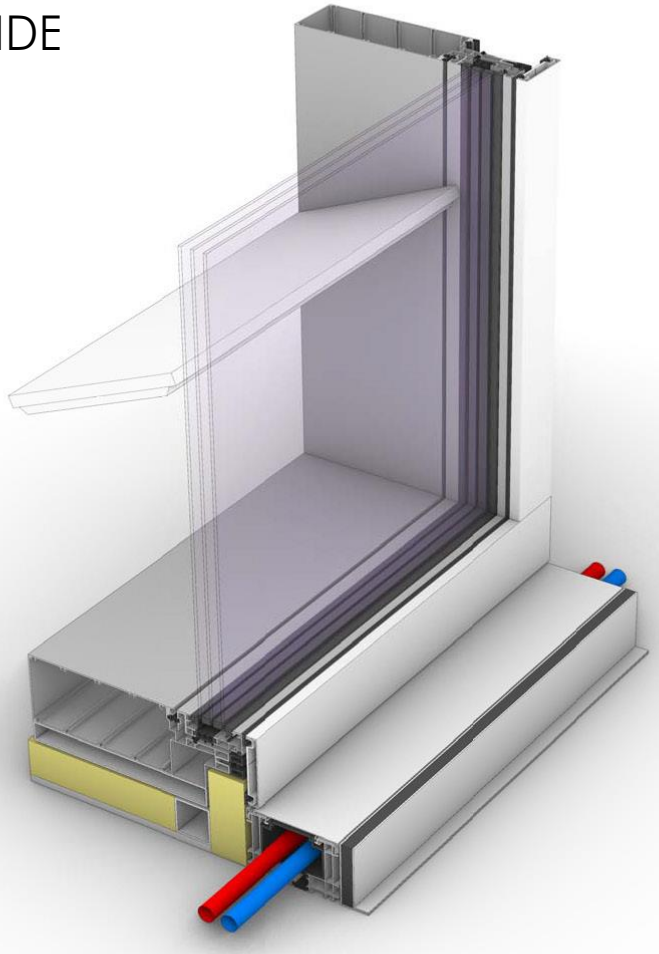

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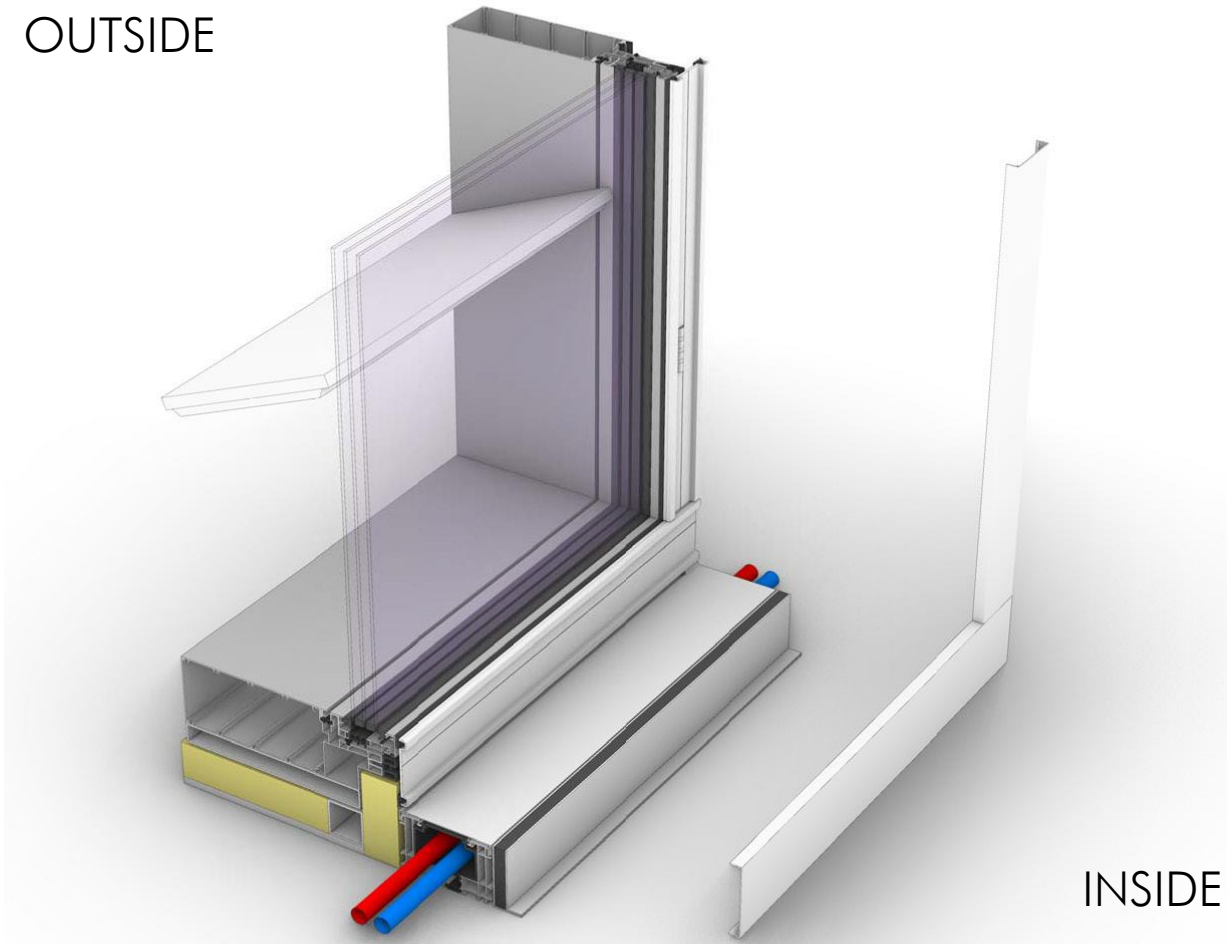

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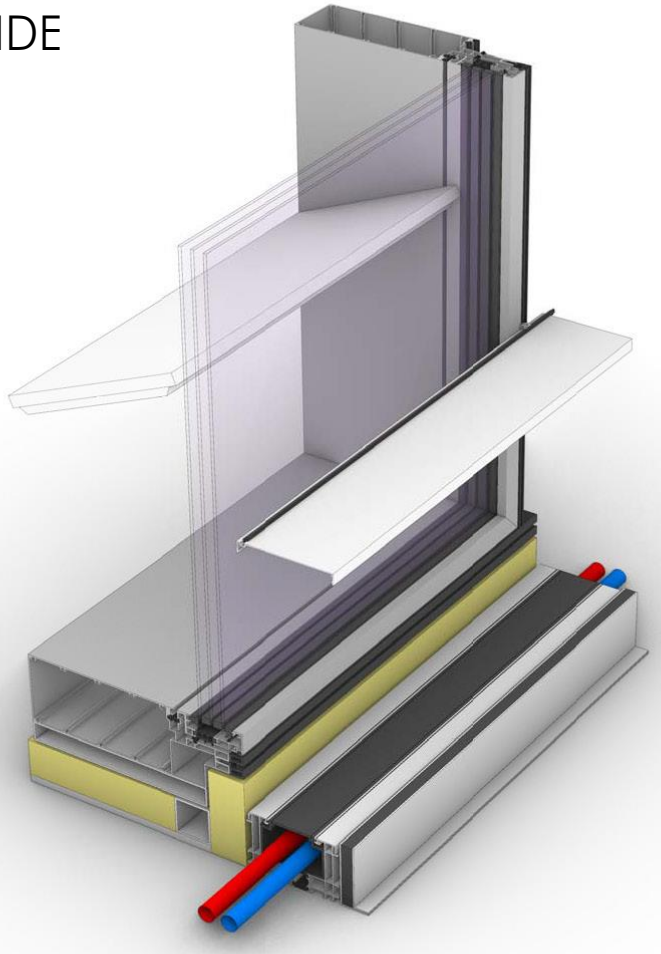

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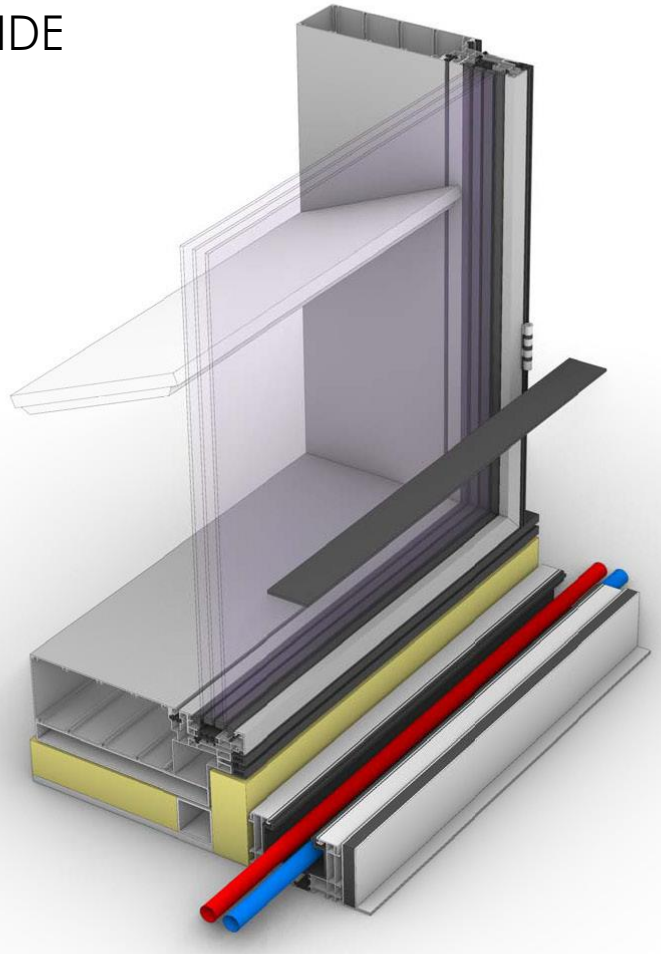

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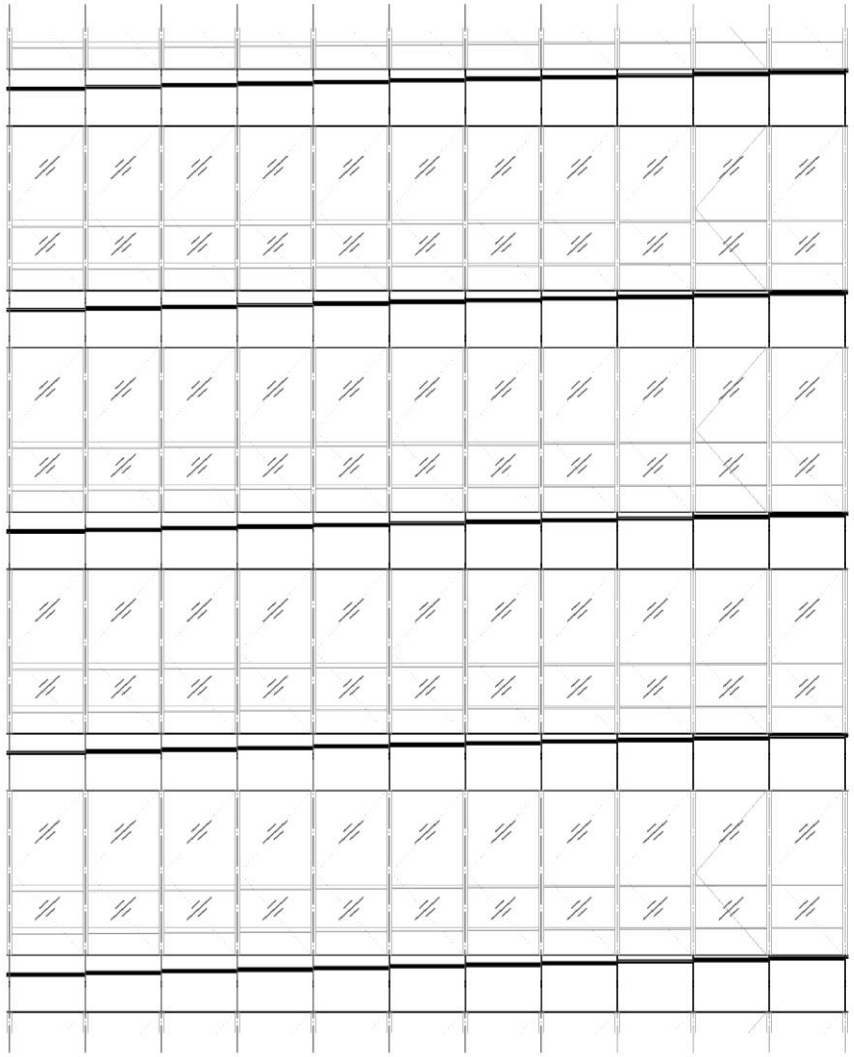
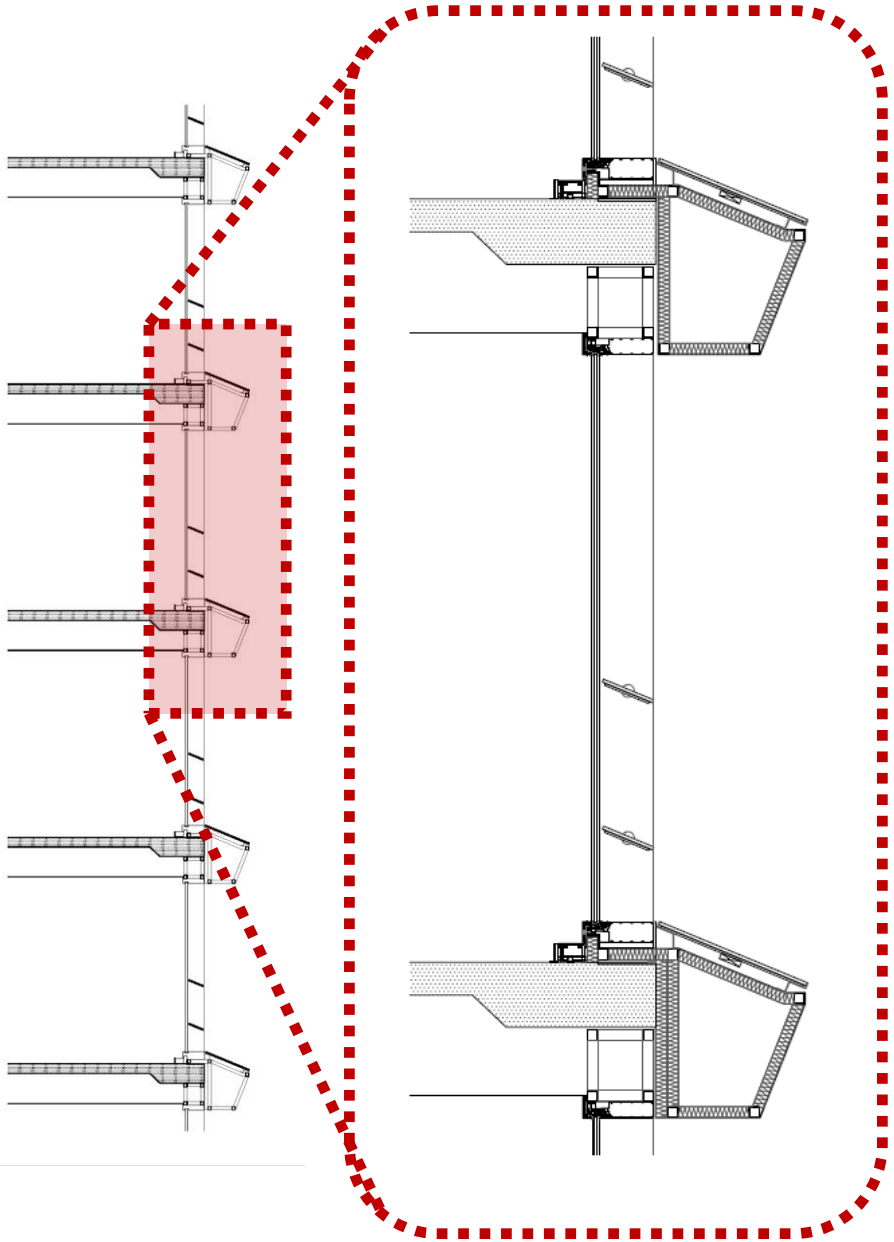
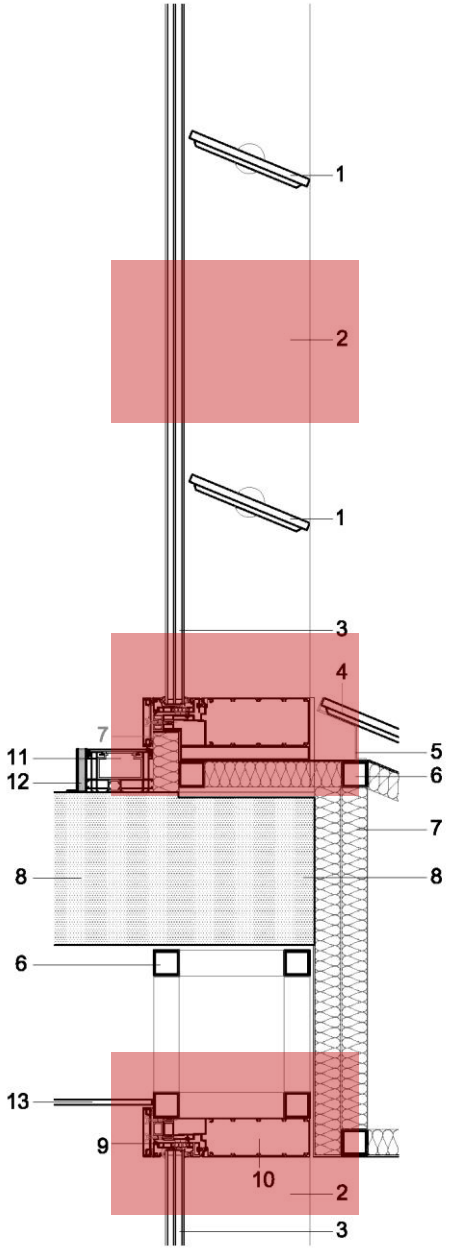
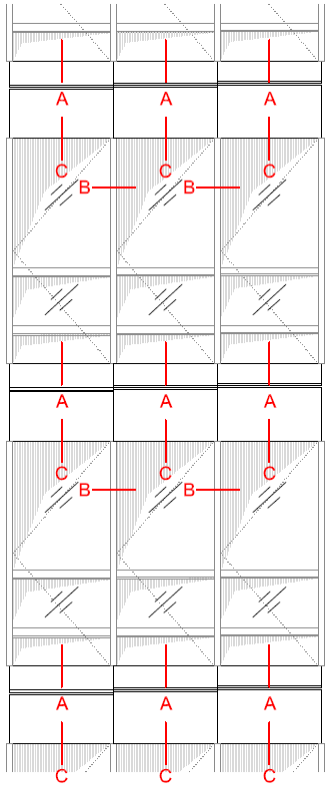


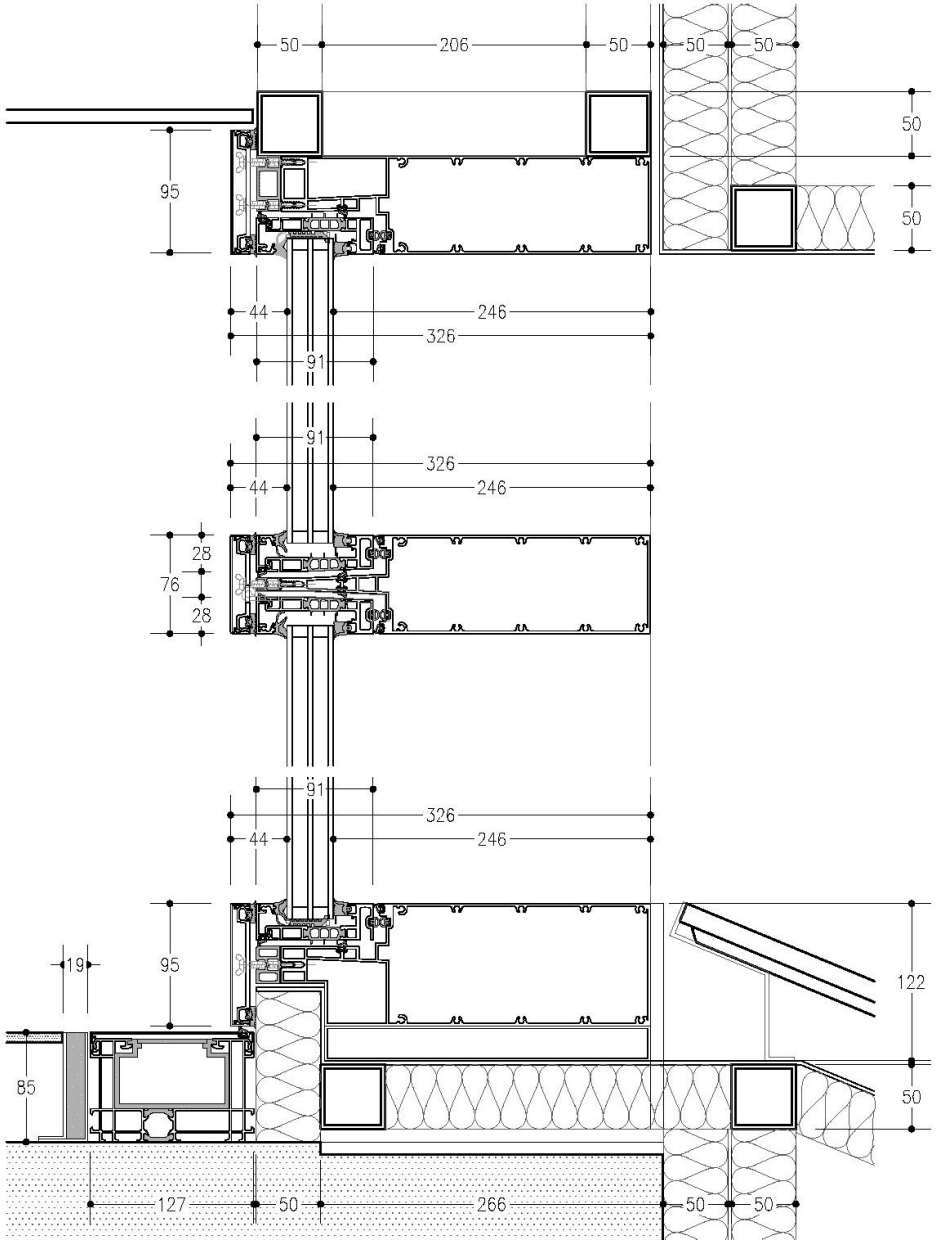


ELEVATION & SECTION



DESIGN DOCUMENTATION





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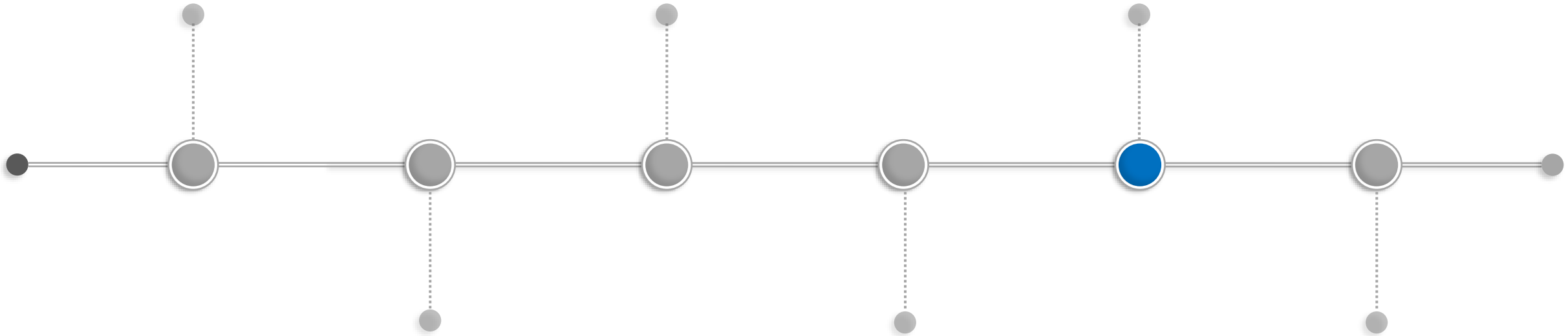
life cycle assessment
economic assessment
energy performance assessment
concept design

design development

evaluation

sustainability evaluation



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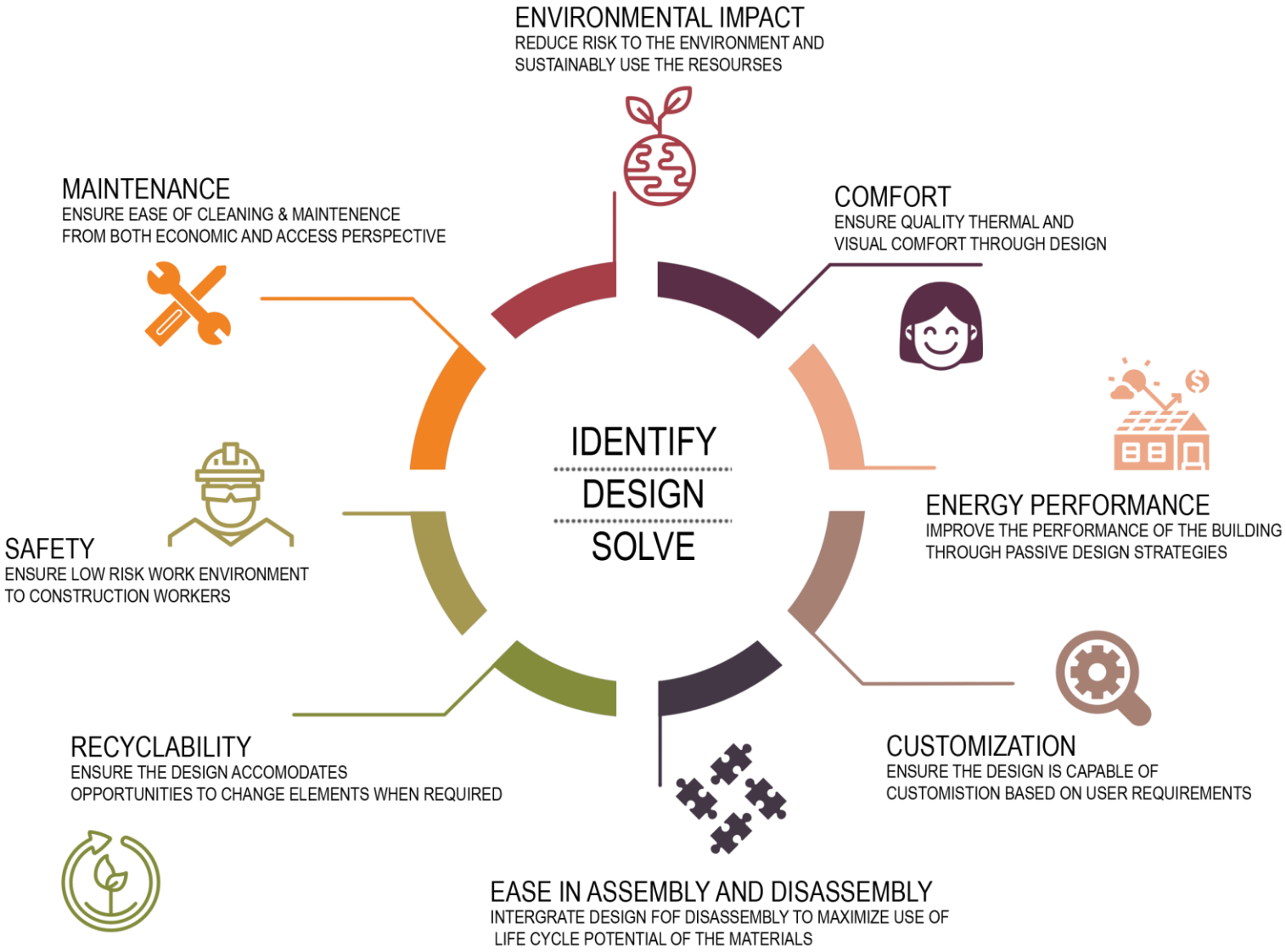
ENVIRONMENTAL IMPACT
REDUCE RISK TO THE ENVIRONMENT AND
SUSTAINABLY USE THE RESOURSES
COMFORT
ENSURE QUALITY THERMAL AND
VISUAL COMFORT THROUGH DESIGN
ENERGY PERFORMANCE
IMPROVE THE PERFORMANCE OF THE BUILDING
THROUGH PASSIVE DESIGN STRATEGIES
CUSTOMIZATION
ENSURE THE DESIGN IS CAPABLE OF
CUSTOMISTION BASED ON USER REQUIREMENTS
EASE IN ASSEMBLY AND DISASSEMBLY
INTERGRATE DESIGN FOF DISASSEMBLY TO MAXIMIZE USE OF
LIFE CYCLE POTENTIAL OF THE MATERIALS
RECYCLABILITY
ENSURE THE DESIGN ACCOMODATES
OPPORTUNITIES TO CHANGE ELEMENTS WHEN REQUIRED
SAFETY
ENSURE LOW RISK WORK ENVIRONMENT
TO CONSTRUCTION WORKERS
MAINTENANCE
ENSURE EASE OF CLEANING & MAINTENENCE
FROM BOTH ECONOMIC AND ACCESS PERSPECTIVE
IDENTIFY
DESIGN
SOLVE

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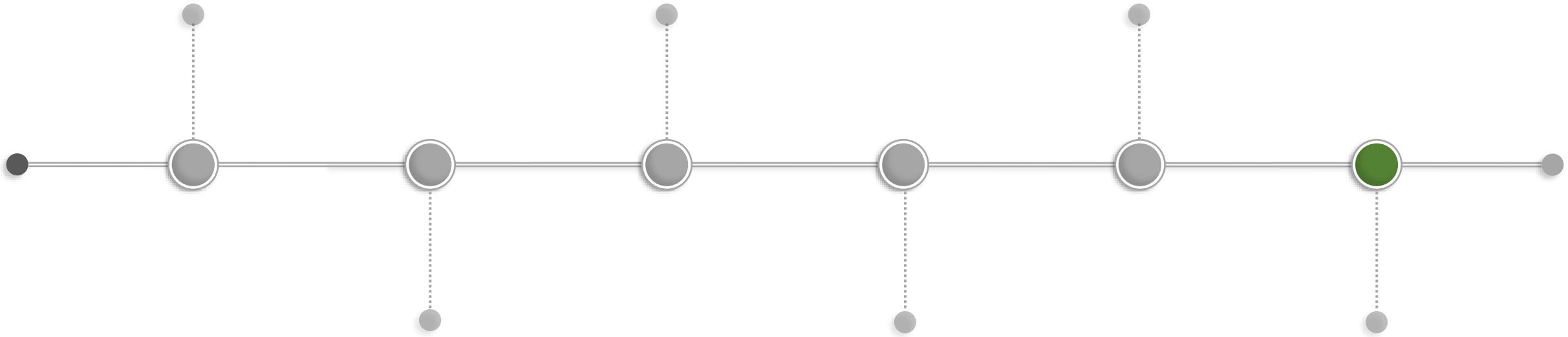

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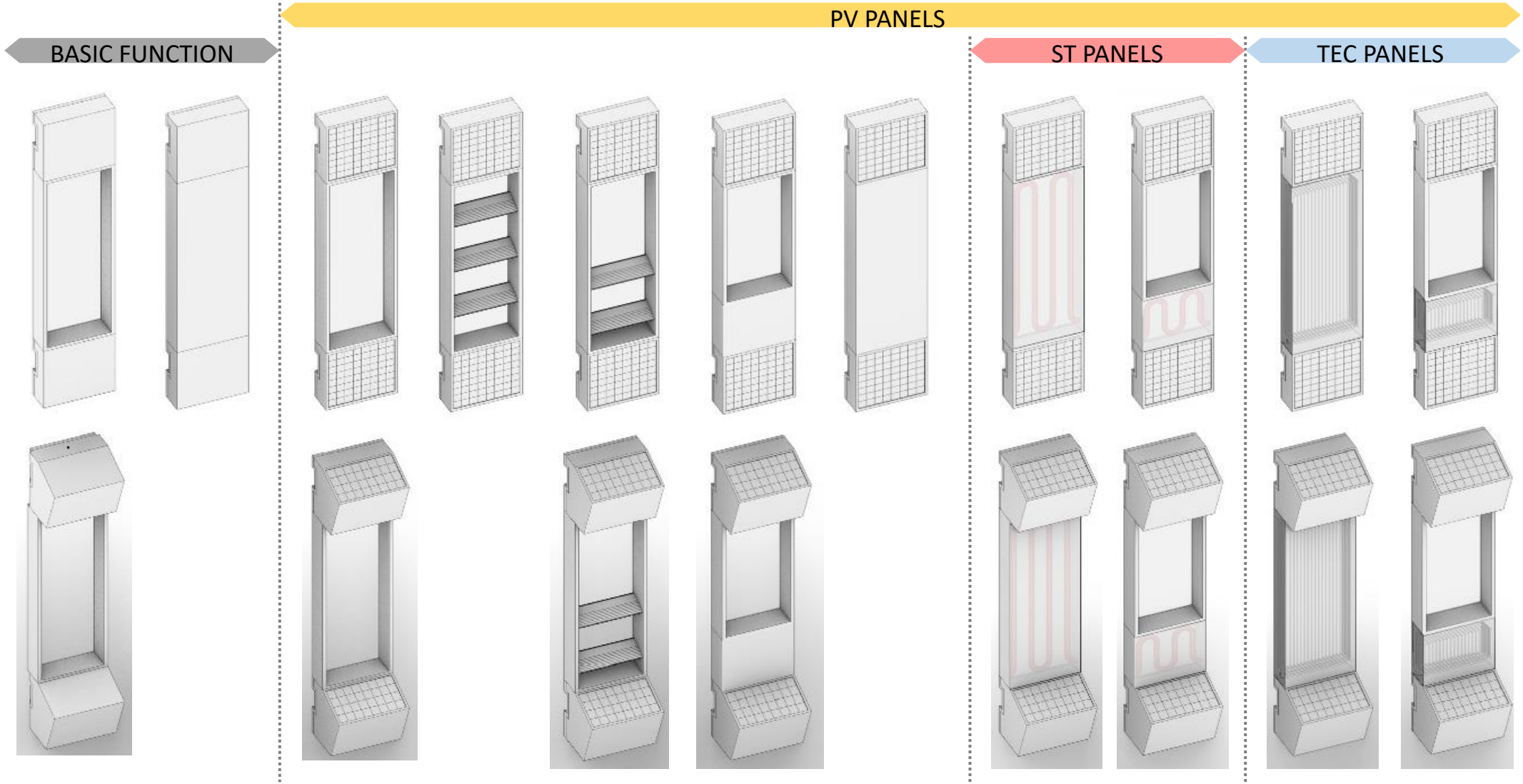


DESIGN OPTIONS

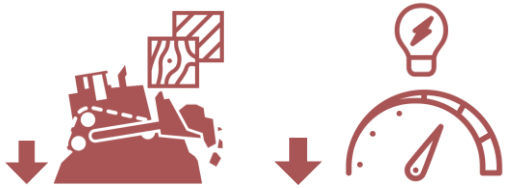
Existing Façade Base Case

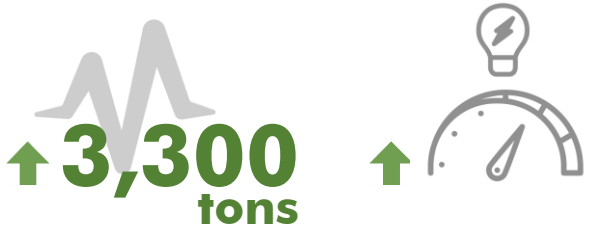
Proposed Façade with Shading

1 ESL

30 years
regular curtain wall ESL

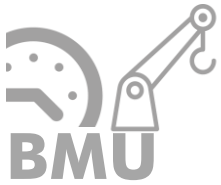
replaced, repaired, maintained regularly





3,300 tons

2 COST



4 nos
construction workers

2 nos
construction workers

CONCLUSION

3 ENERGY

Existing Façade Base Case

no energy production

existing façade is the base case for reduction

Proposed Façade with Shading

3 million kWh/year
approximate amount of energy produced by PV

360,000 €/yr
approximate amount of utility expenses produced by PV

455,000 €/yr
approximate amount of utility expenses saved by reduction