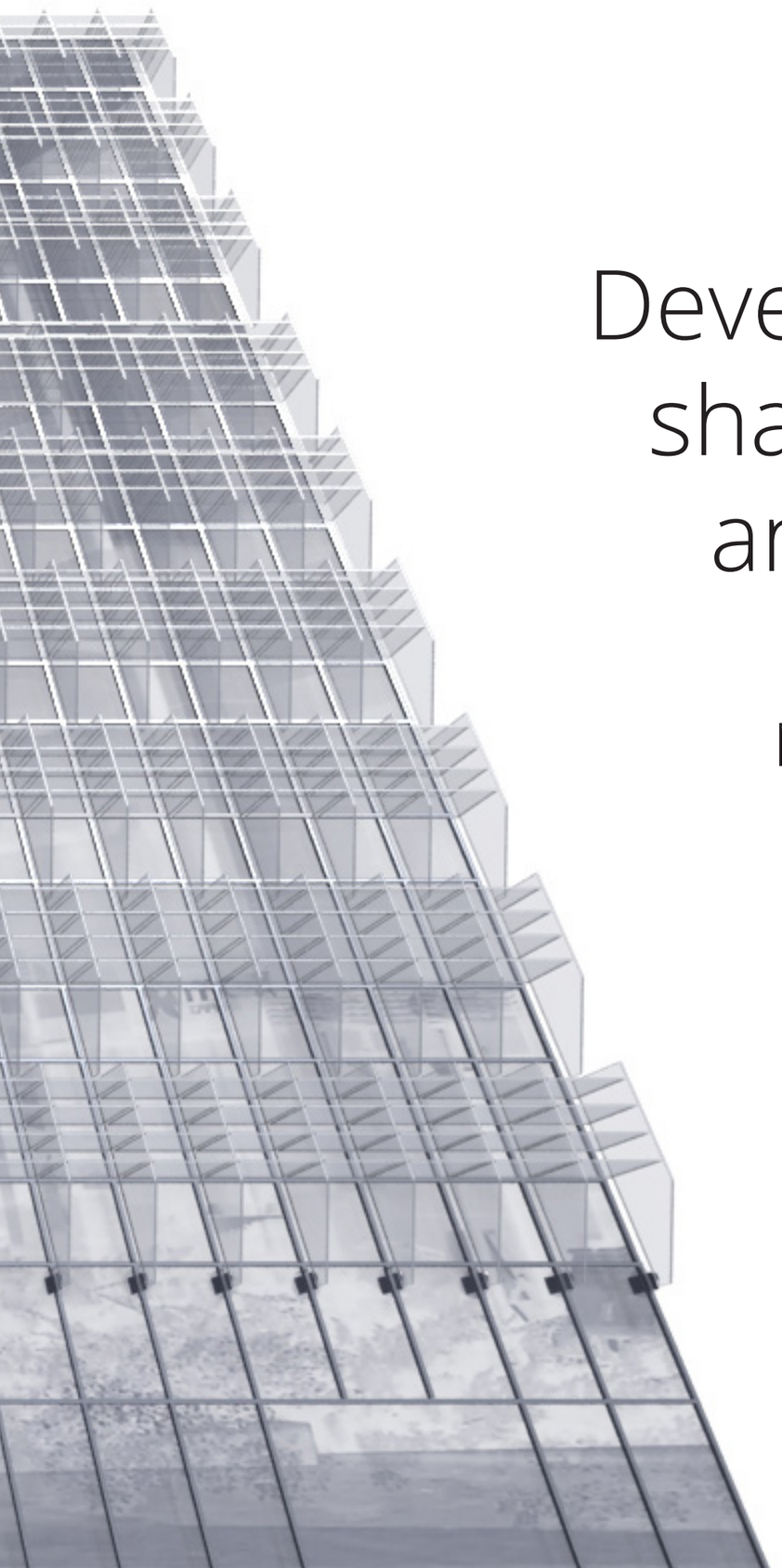


P5 Presentation

Development of an adaptive shading system based on analysis of study cases

Student

Maria Natalia Aloupi | 4410386

Mentors

Dr. -Ing. Marcel Bilow

Dr. Truus de Bruin-Hordijk

Delegate examiner

Rein Have

28/06/2016

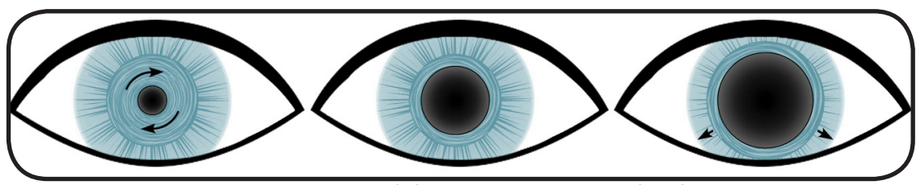
Contents

Introduction

Building Envelope | Barrier between exterior and interior space
Controls the interaction

Daylight in Buildings | Beneficial / harmful

Solar control



Source | http://www.apsubiology.org/anatomy

Adaptation

Thesis Structure

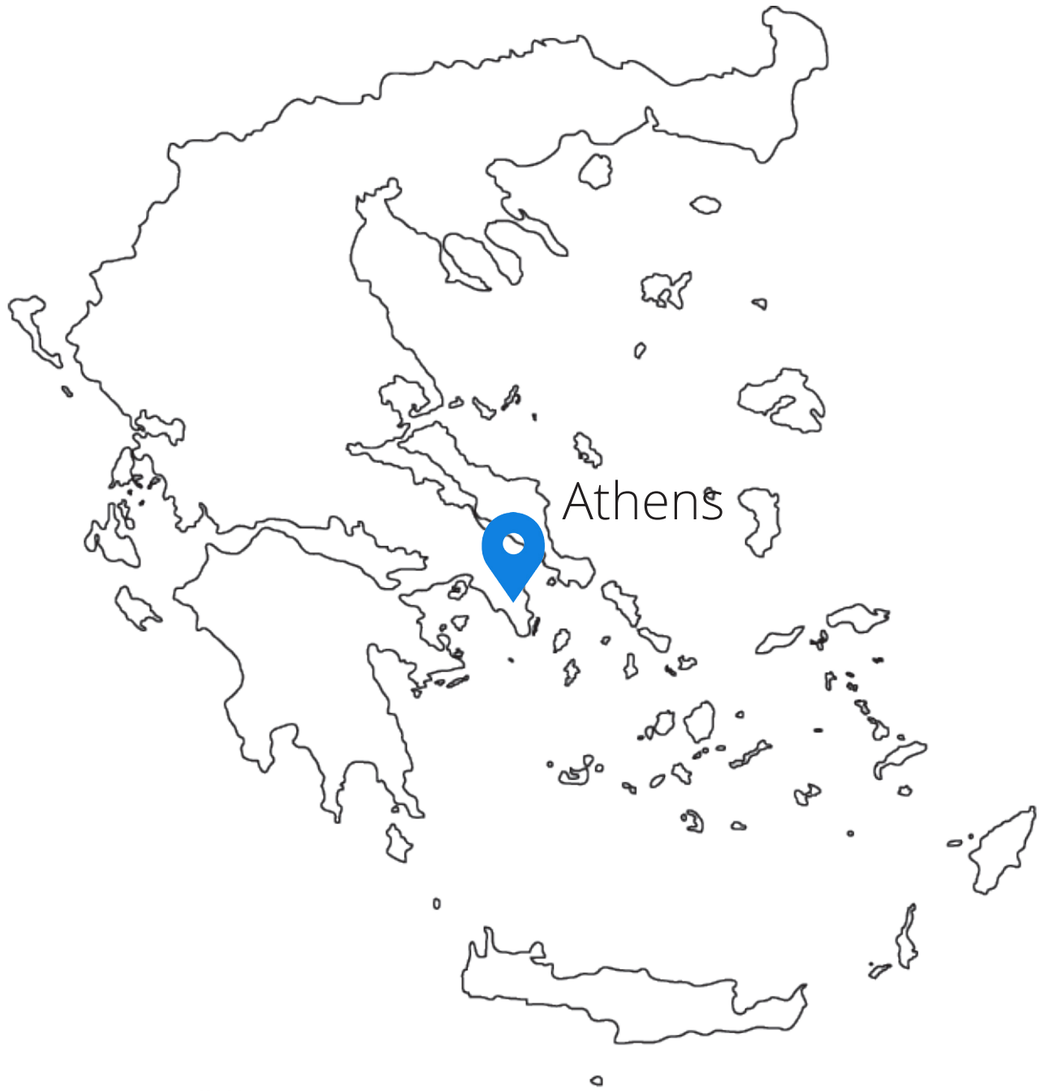
Daylight | Beneficial and harmful
Incoming solar radiation should be controlled

Adaptive sun shading system | Visual comfort

Optimum design for office buildings
Computer simulations
Real-time measurements | Model

Which adaptation mechanism contributes more to the lighting performance of a sun shading system in office buildings?

Mediterranean Climate

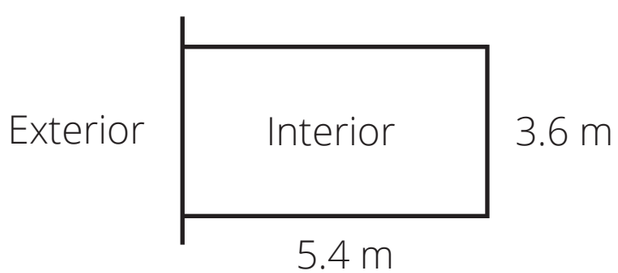


21 March, June & December

8:00 - 18:00

Temperate Climate

Office building



Vision & Environmental conditions

Relative brightness

Glare

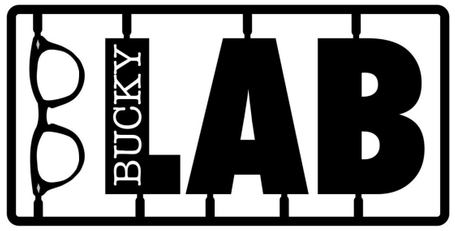
Luminance ratio

Visual comfort

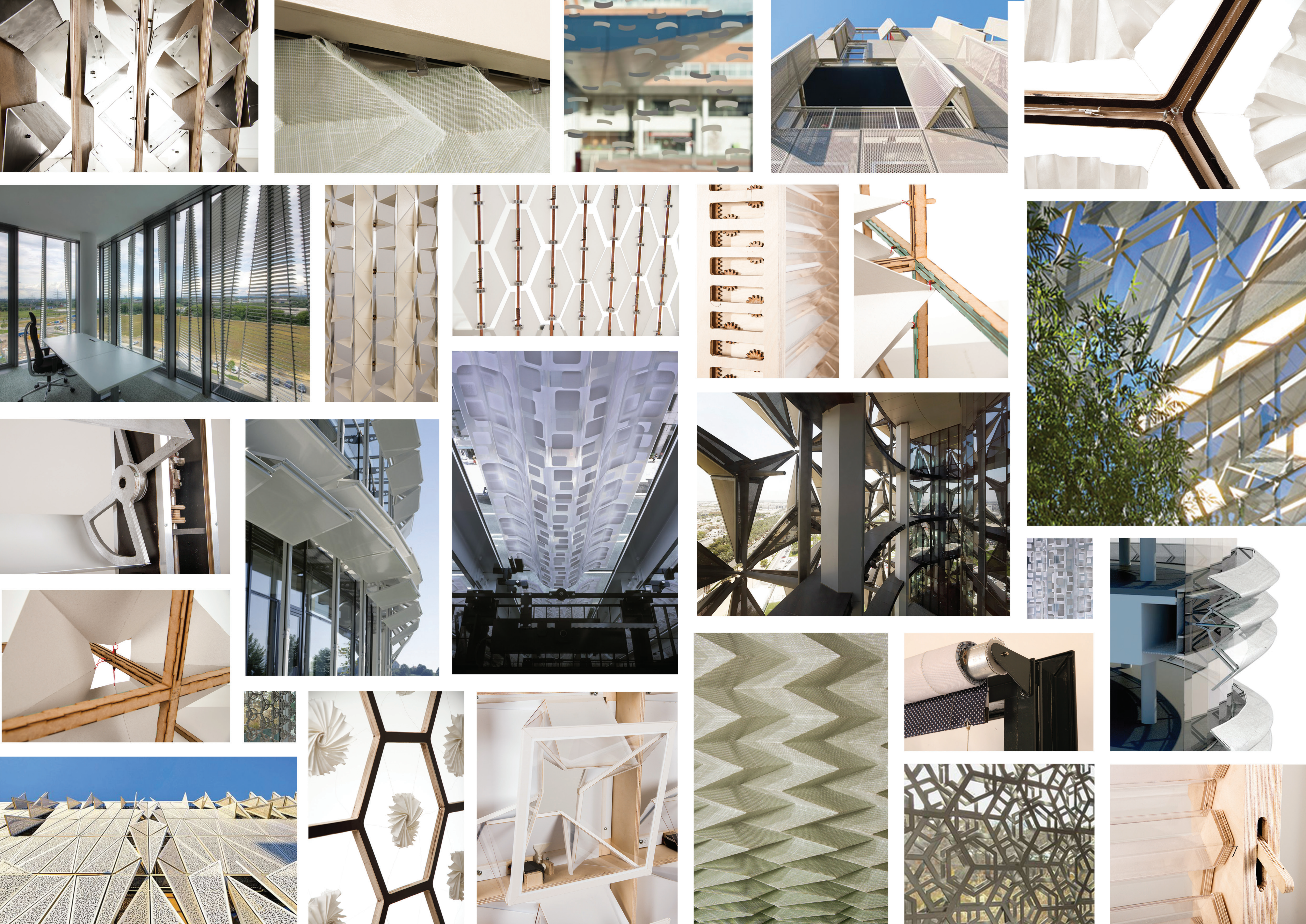
Quantity	Quality	Distribution
Illuminance level (lux)	Glare index	Direct/Diffuse light
Luminance value (cd/m^2)	Luminance ratio	Pattern of shadows

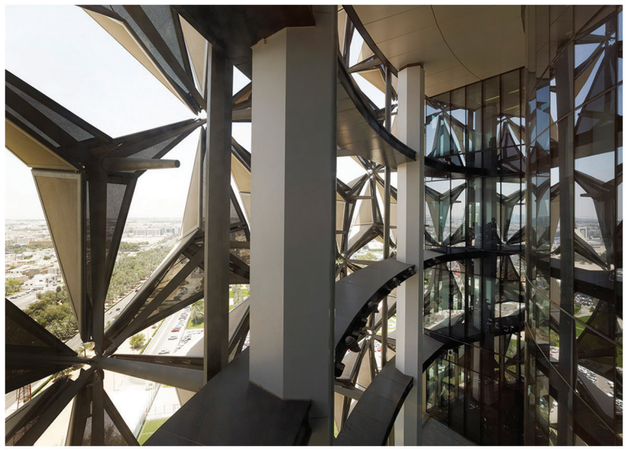
Study cases

10 academic projects



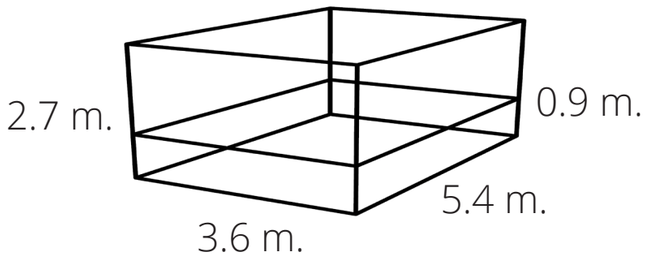
10 real projects





Simulations

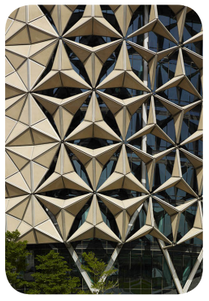
10th floor



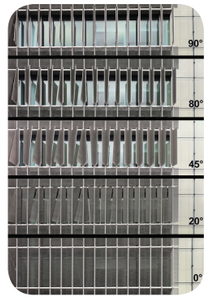
Dynamic shading systems - Manual Control

Translucent panels 20% transmittance

South



West



3 states | Open - Half closed - Closed

3 dates | 21 March, June & December

8:00 - 18:00

Procedure

Annual glare analysis

Daylight autonomy | Daysim report

Indoor visualizations

Procedure

Annual glare analysis

Daylight autonomy | Daysim report

Indoor visualizations

Requirements

Daylit area$_{500lux}$ [50%] **|** > 80% of floor area

Daylight autonomy **|** > 80% for active occupant behavior

Useful daylight illuminance [50%] **|** > 60% of floor area

Glare **|** < 0.3% of occupied hours

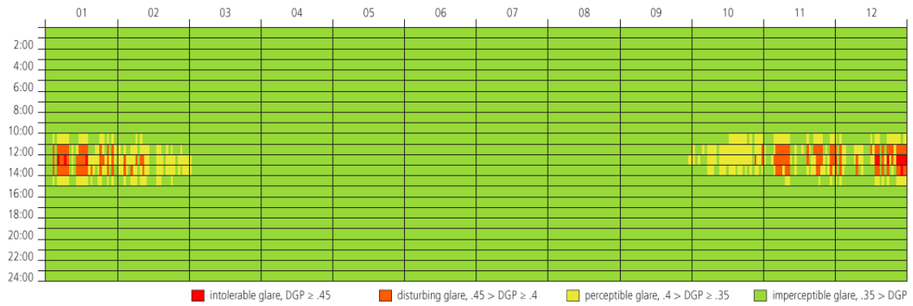
Luminance ratio **|** task field > 1/5 | ergorama > 1/10 | panorama > 1/30

No direct daylight

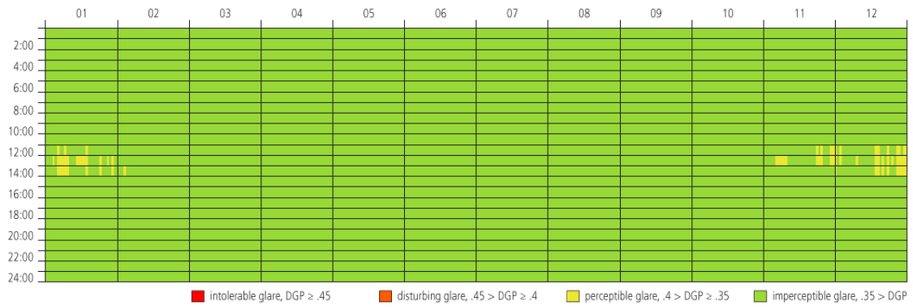
Kiefer technic showroom

Daylit area | DA_{500lux}[50%] > 80% of floor area **=** 98% ✔
Daylight autonomy | DA > 80% for active occupant behavior = 84% ✔
Useful daylight illuminance | percentage of space with a UDI<100-2000LUX [50%] > 60% for the active occupant behavior = 68% ✔
Glare | 0.3% of occupied hours = 0% ✔

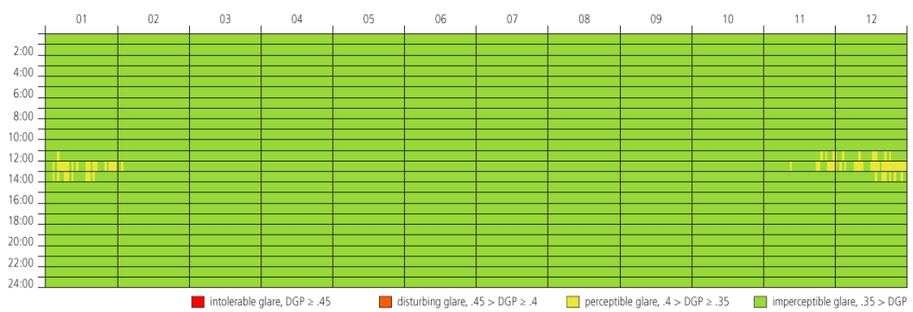
Open state



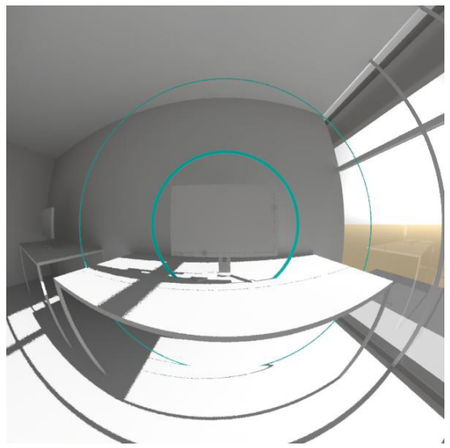
Half-closed state

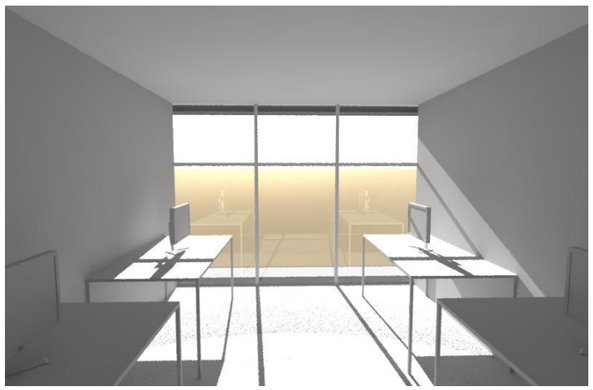


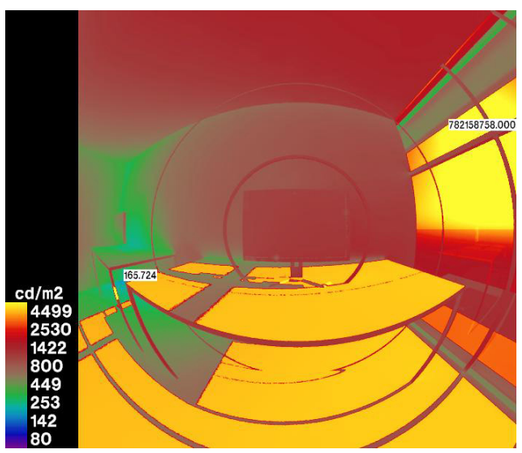
Closed state

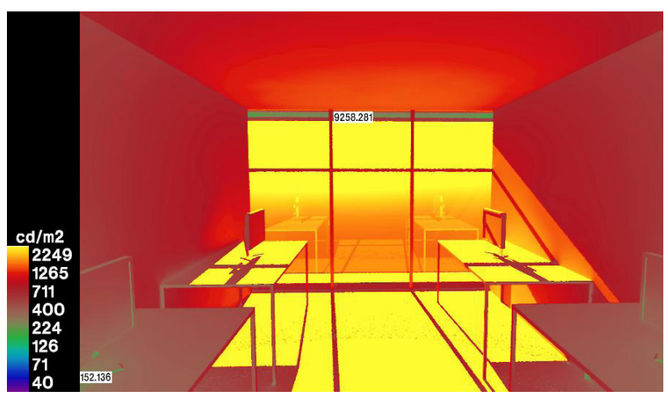


21st December - 12:00









Comparisons

South orientation

Requirements	Al bahar towers	Kiefer technic showroom
DA_{500lux}[50%] >80%	67%	98%
DA >80%	65%	64%
$UDI_{<100-2000LUX}$ [50%] > 60%	79%	88%
Glare < 0.3%	0%	0%

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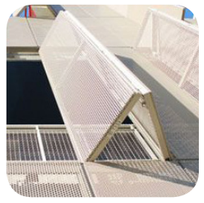
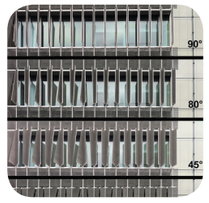
West orientation





Requirements	Tessellate	Cherokee lofts	ThyssenKrupp
DA_{500lux}[50%] >80%	84%	89%	85%
DA >80%	69%	81%	78%
$UDI_{<100-2000LUX}$ [50%] > 60%	73%	71%	75%
Glare < 0.3%	0.6%	0.1%	0.3%

Comparison

South orientation

Requirements	Al bahar towers	**Kiefer technic showroom**
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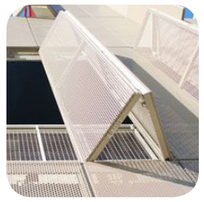
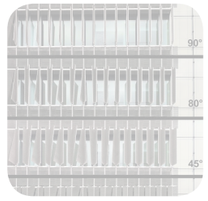
West orientation





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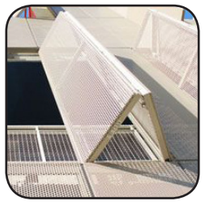
Comparisons

West orientation



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Preliminary conclusions

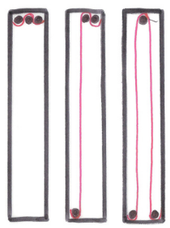
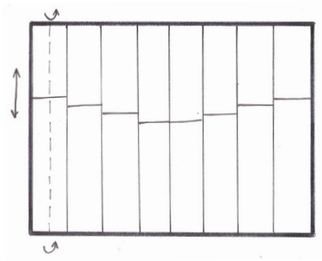
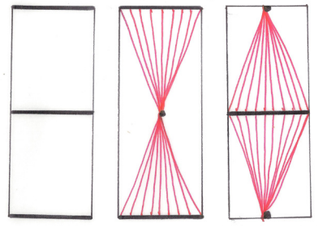
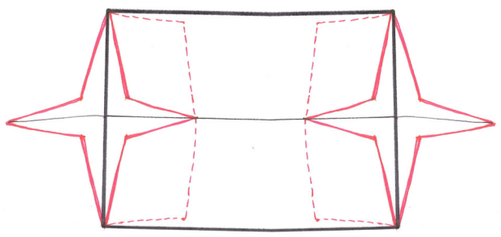
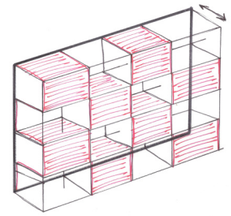
- Horizontal shading elements - south oriented façades
- Vertical shading elements - west oriented façades

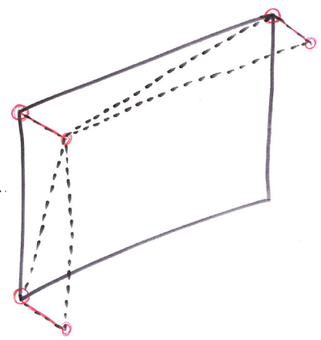
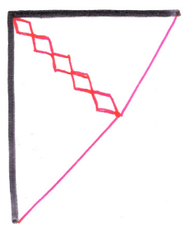
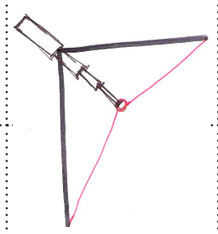
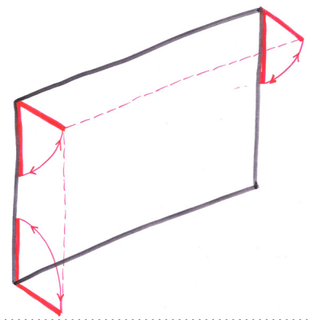
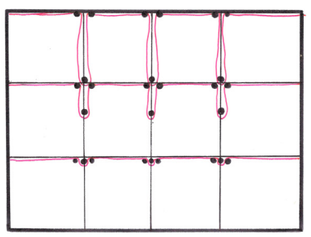
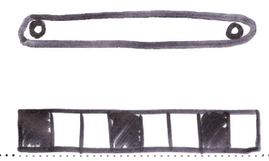
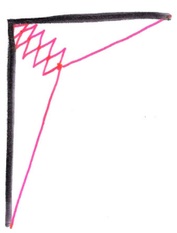
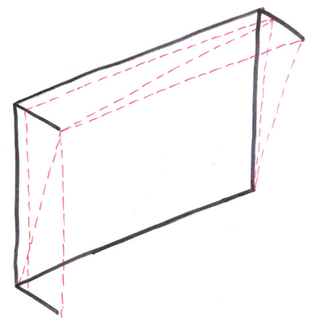
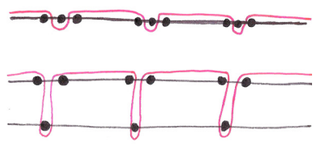
Preliminary conclusions

- Horizontal shading elements - south oriented façades
- Vertical shading elements - west oriented façades

- Generalized rules
- Horizontal and vertical shading elements for all orientations

Design research

Concept	Fabric layers	Calatrava garage door	Twisting ropes	Origami foldable fins	3-dimentional interweaving
Prelimi-nary ideas					

Concept	Stretchable fabric as movement mechanism	3 point expansion for both vertical and horizontal shading	Scissors	Pistons	Brackets Curtain system	Stretchable fabric cre-ating 3-dimentional shading system	Non-elastic fab-ric rolling like a conveyor belt
1st state							
2nd state							

Shading system for east/west and south orientation

Shading system for east/west and south orientation

Adaptive

Simple (construction & maintenance)

Concept

Fixed 3-dimentional grid (horizontal & vertical elements)

Concept

Fixed 3-dimentional grid (horizontal & vertical elements)

Transparency vs. Translucency

Concept

Fixed 3-dimentional grid (horizontal & vertical elements)

Transparency vs. Translucency

Smart glass (perpendicular to facade vs glazing)

Concept

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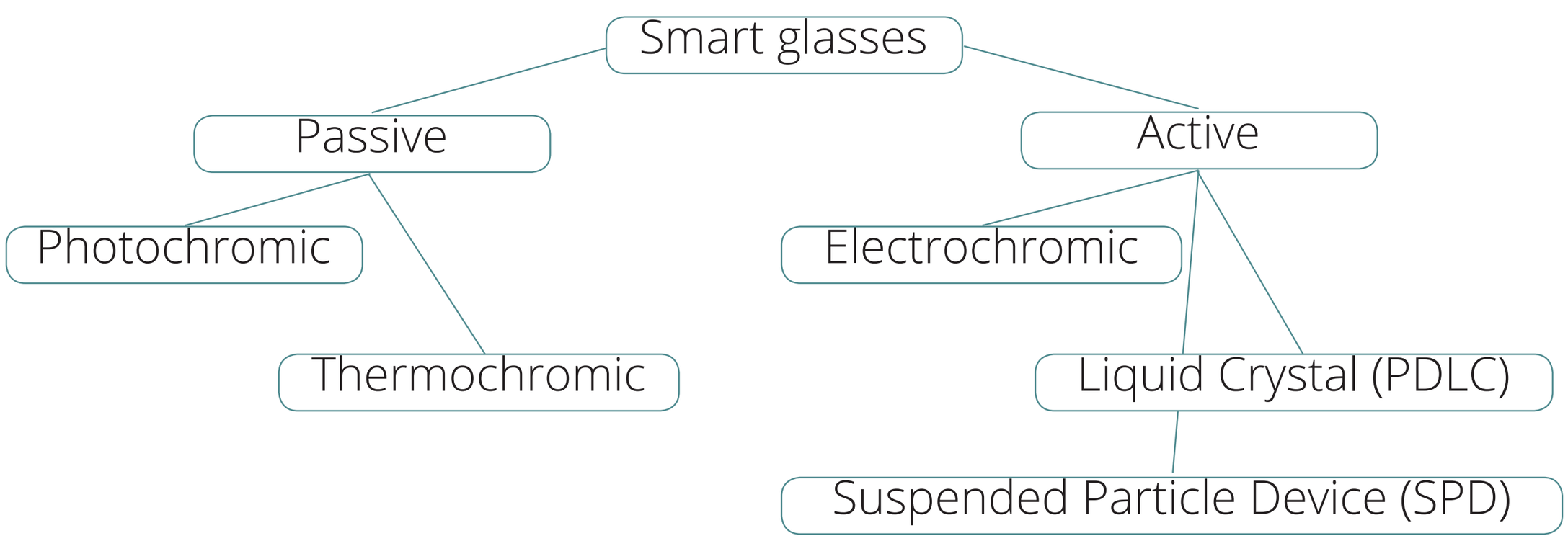

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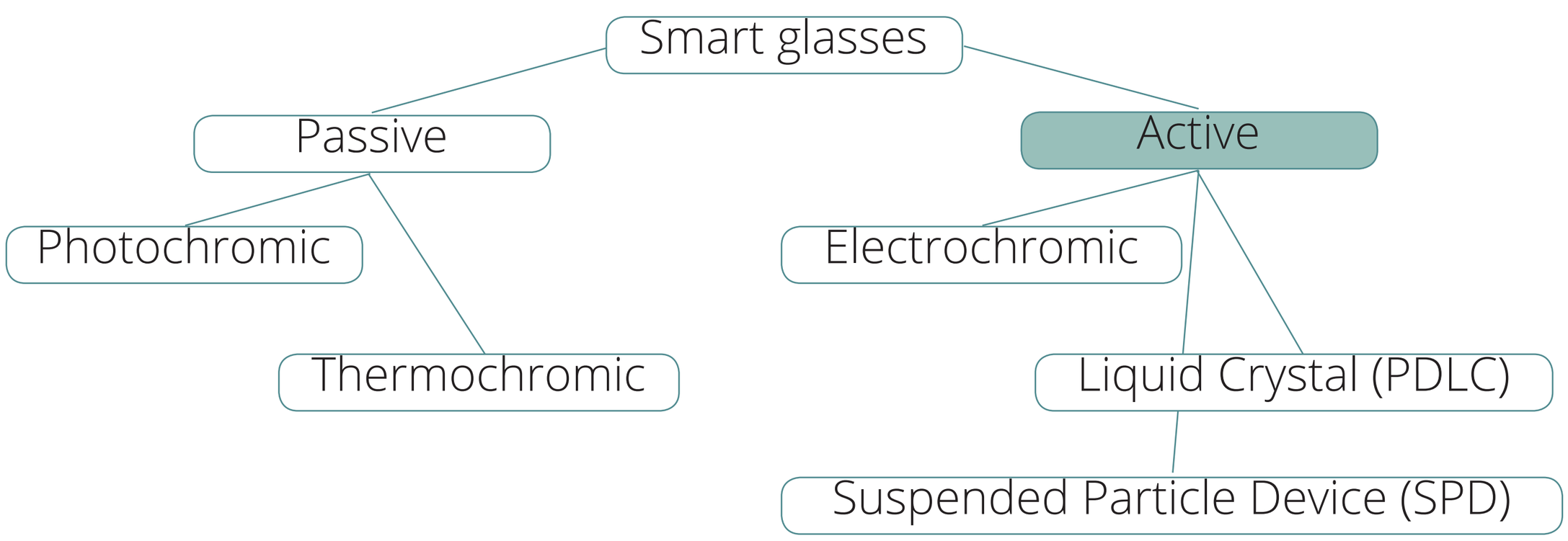

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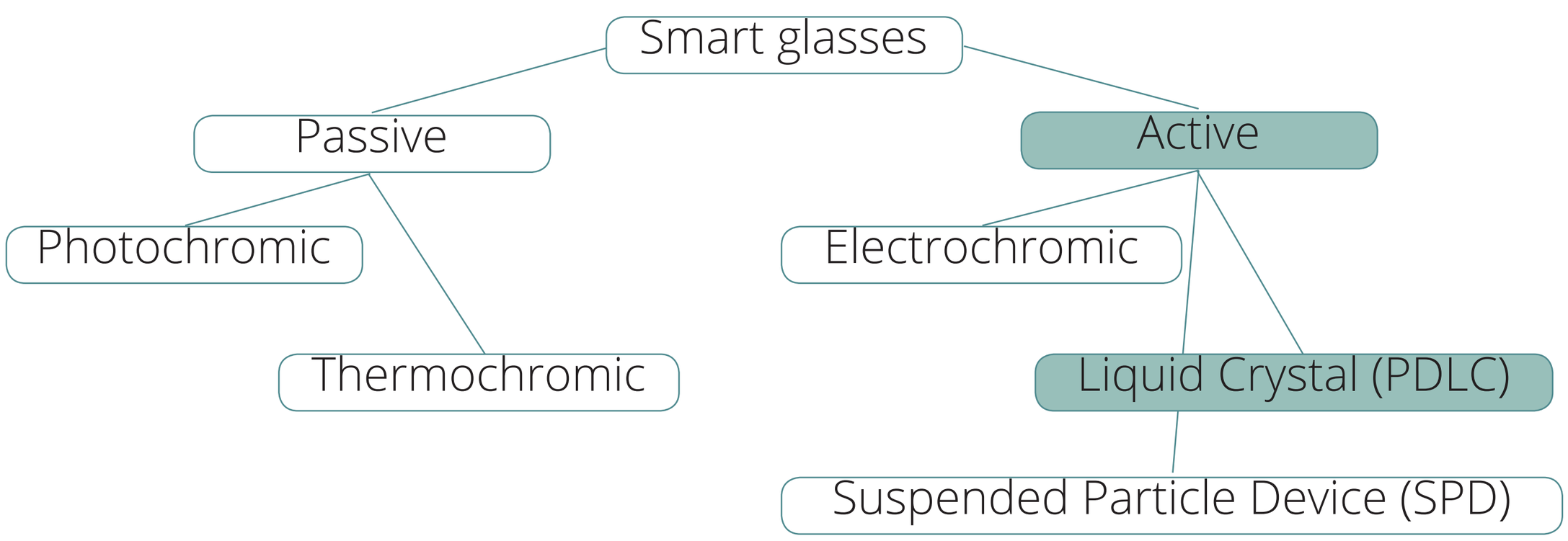
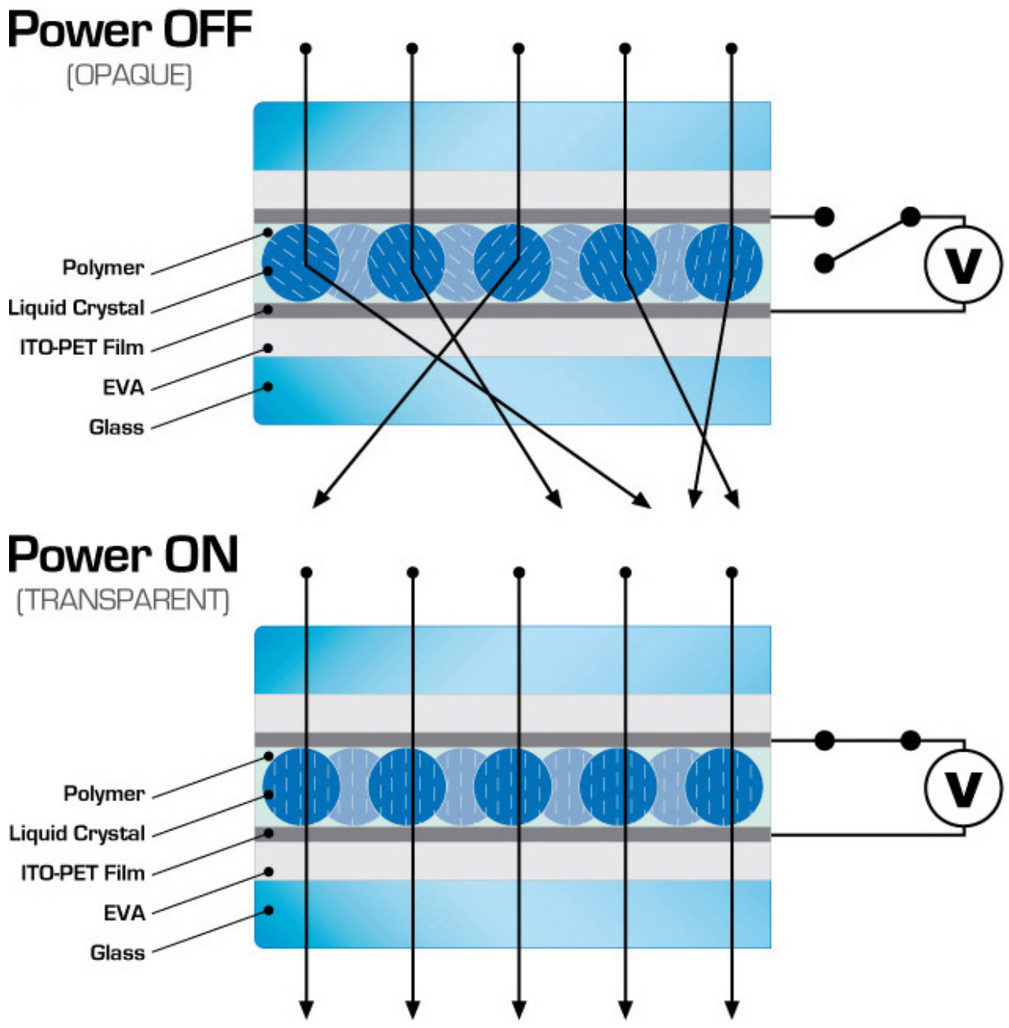


PDLC smart glass



Transmittance (Translucent) | 67%
Transmittance (Transparent) | 75%
Solar reduction | 40%
Switching time |< 0.1s

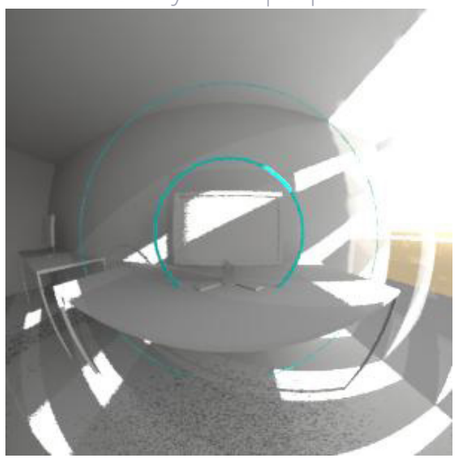
Sun sensors

Defining Geometry

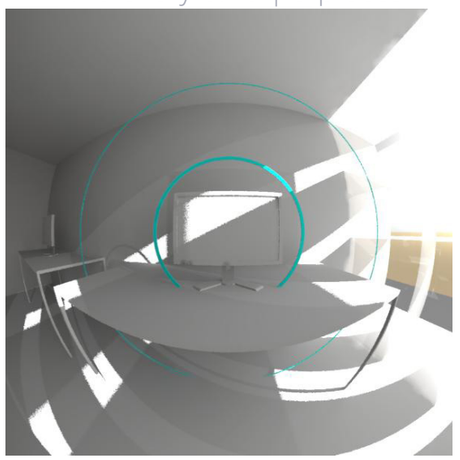
Depth - distance combination

21/12 14:00 South orientation

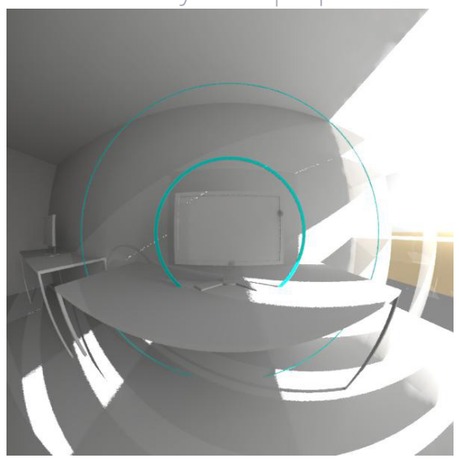
1.20 every 0.80 | 3 pieces



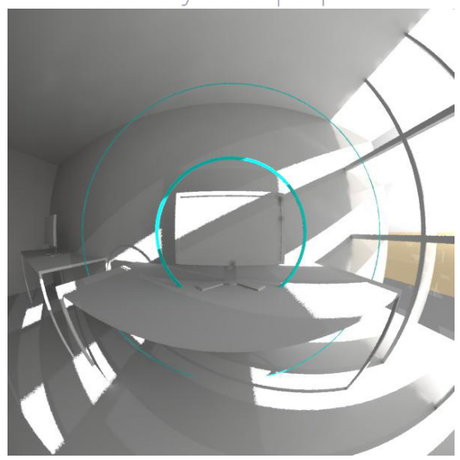
1.20 every 0.70 | 3 pieces



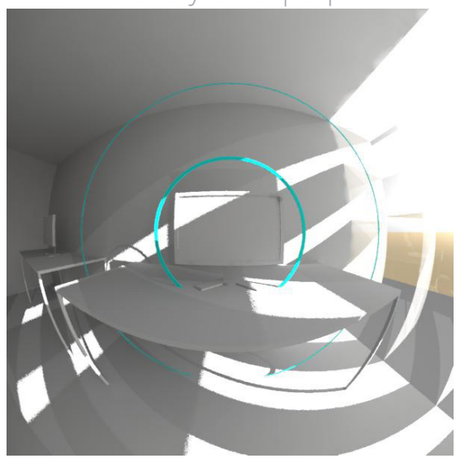
1.20 every 0.60 | 3 pieces



1.00 every 0.80 | 3 pieces

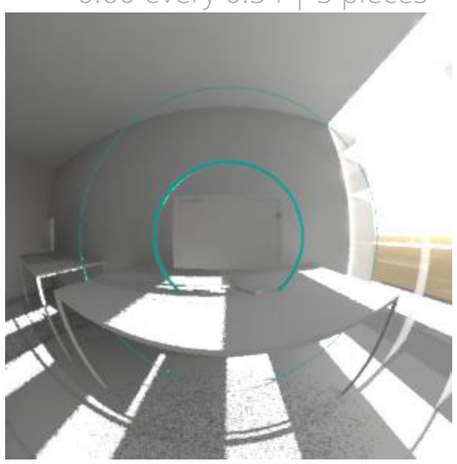


1.00 every 0.70 | 3 pieces

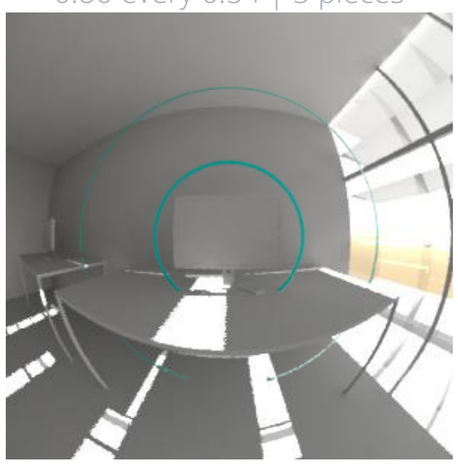


21/12 12:00 South orientation

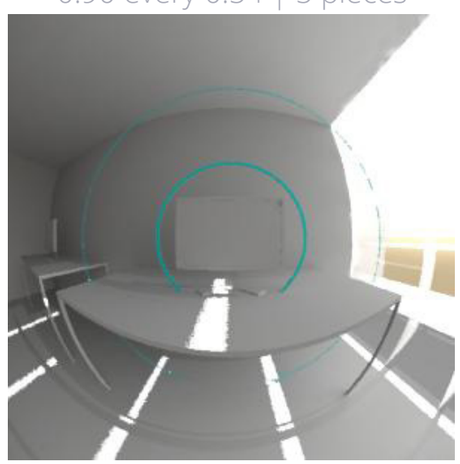
0.60 every 0.54 | 5 pieces



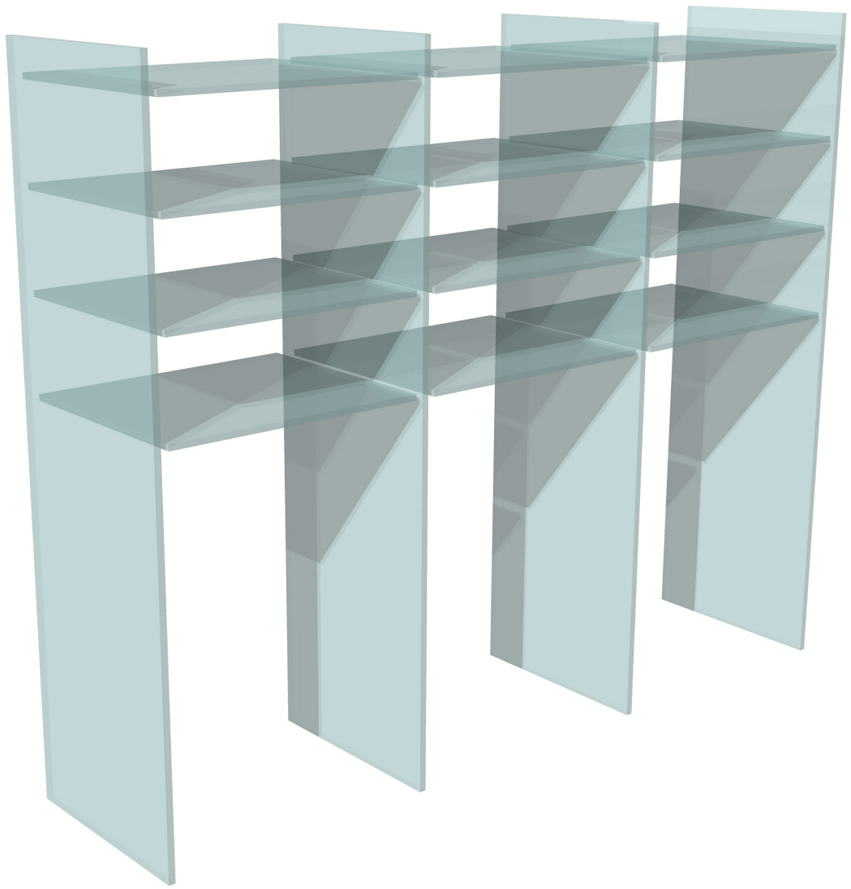
0.80 every 0.54 | 5 pieces



0.90 every 0.54 | 5 pieces



Defining Geometry



Depth | 0.9 m.

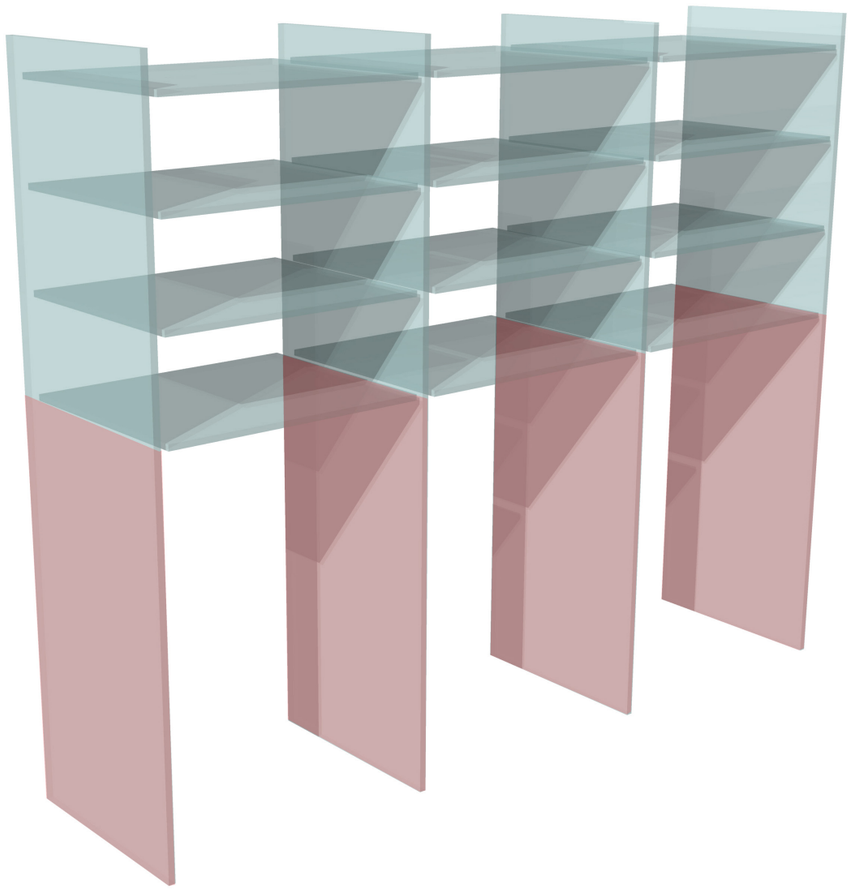
Vertical distance | 0.4 m.

Horizontal distance | 1.2 m.

4 vertical pieces

4 horizontal rows (12 pieces)

Defining Geometry



Depth | 0.9 m.

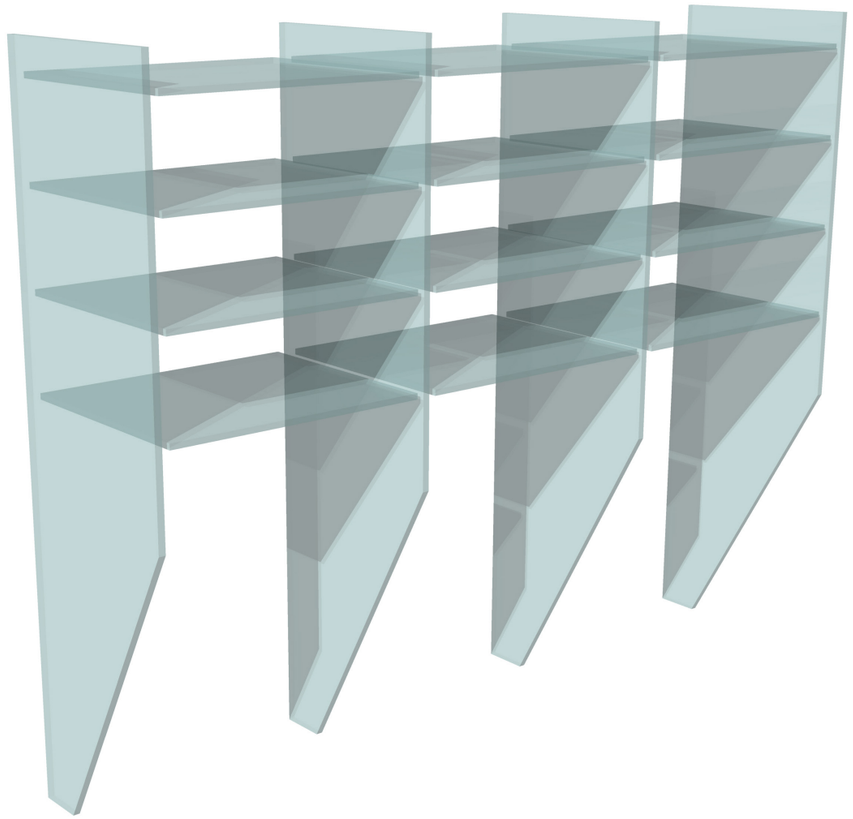
Vertical distance | 0.4 m.

Horizontal distance | 1.2 m.

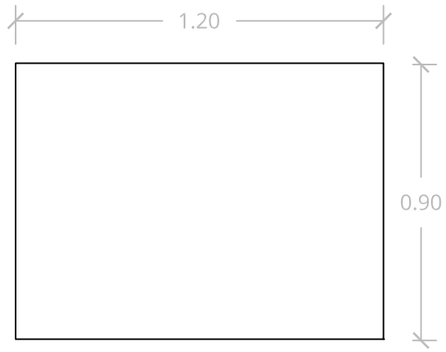
4 vertical pieces

4 horizontal rows (12 pieces)

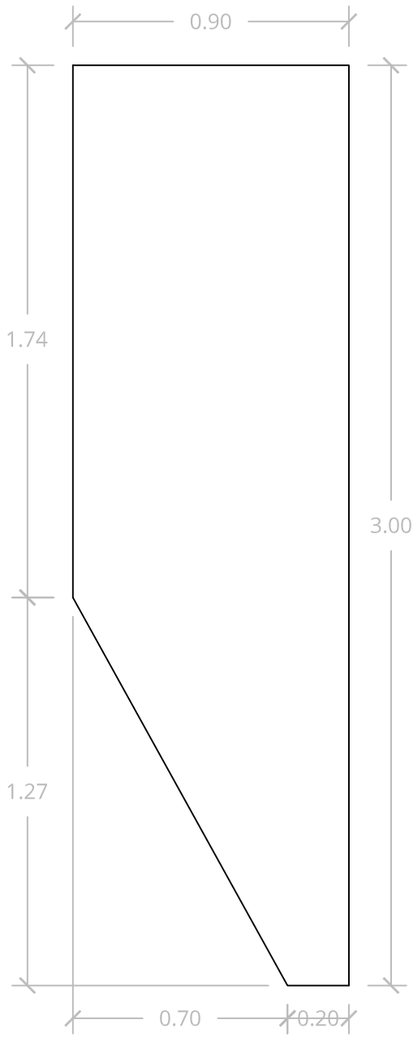
Proposed Geometry



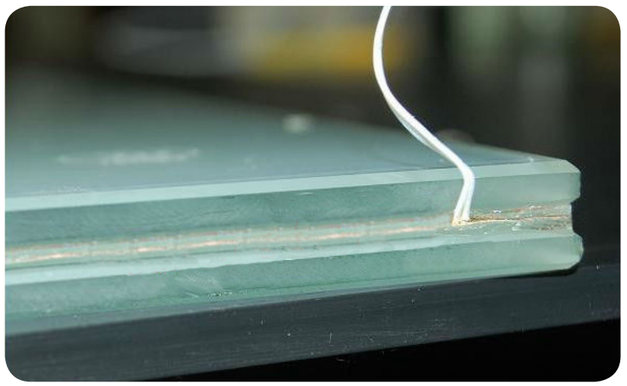
X 12 PIECES



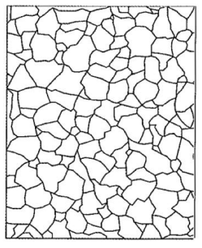
X 4 PIECES



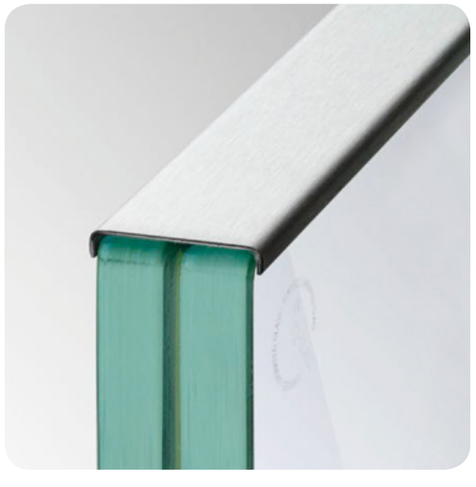
Shading Configuration



GAOMING GLASS
PDLC smart glass



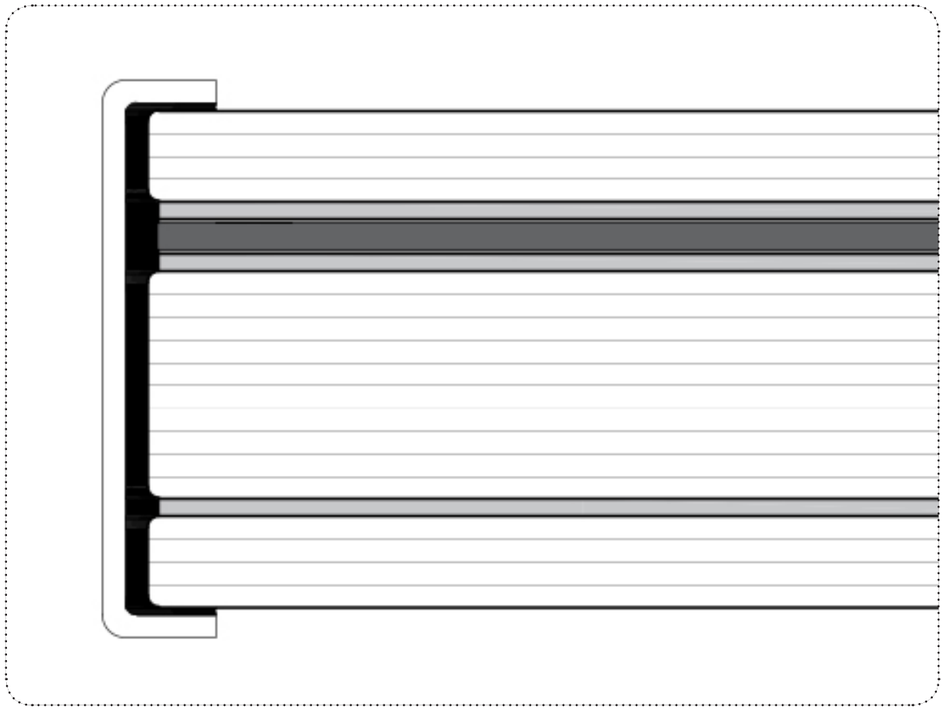
Breakage pattern - Tempered glass



S3i |Aluminum cap rail

Heat-strengthened glass sheet (10mm)

Two sacrificial layers - tempered glass sheets (4mm)



Glass connections

- Framed glazing
- Clamped connections
- Laminated connections
- Bolt connections
- Friction grip connections

Framed glazing, Clamped connections, Laminated connections → Intact glass sheet

Bolt connections, Friction grip connections → Drilled glass sheet

Glass connections

Framed glazing
Clamped connections
Laminated connections
Bolt connections
Friction grip connections

Intact glass sheet

Drilled glass sheet

Apple cube, Laminated connection
James O’Callaghan

Glass connections

Framed glazing
Clamped connections
Laminated connections

Intact glass sheet

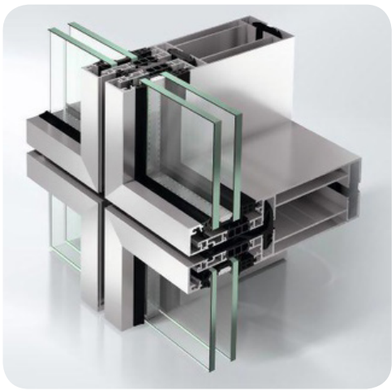
Bolt connections
Friction grip connections

Drilled glass sheet

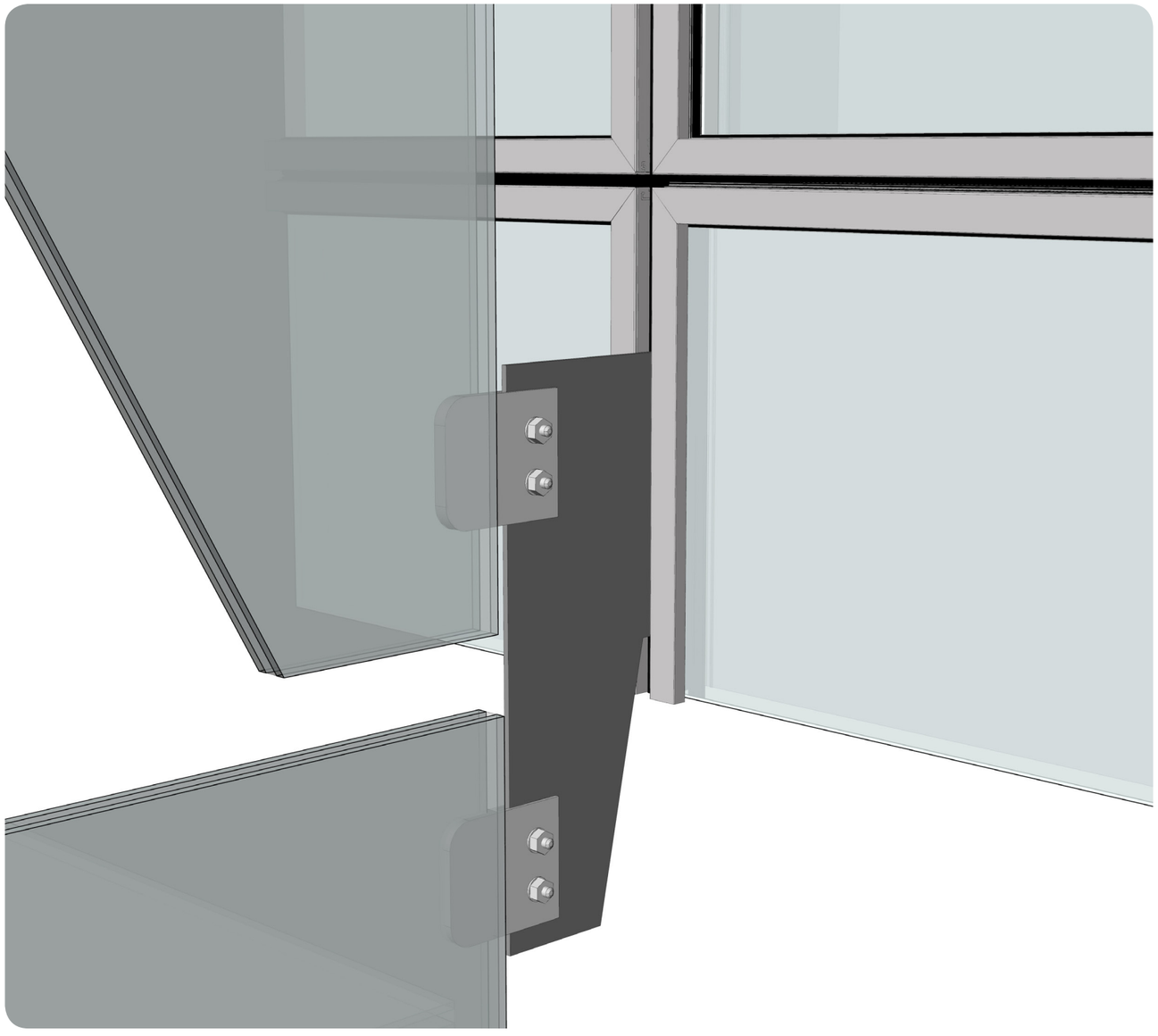
Apple cube, Laminated connection
James O'Callaghan

Facade structure analysis

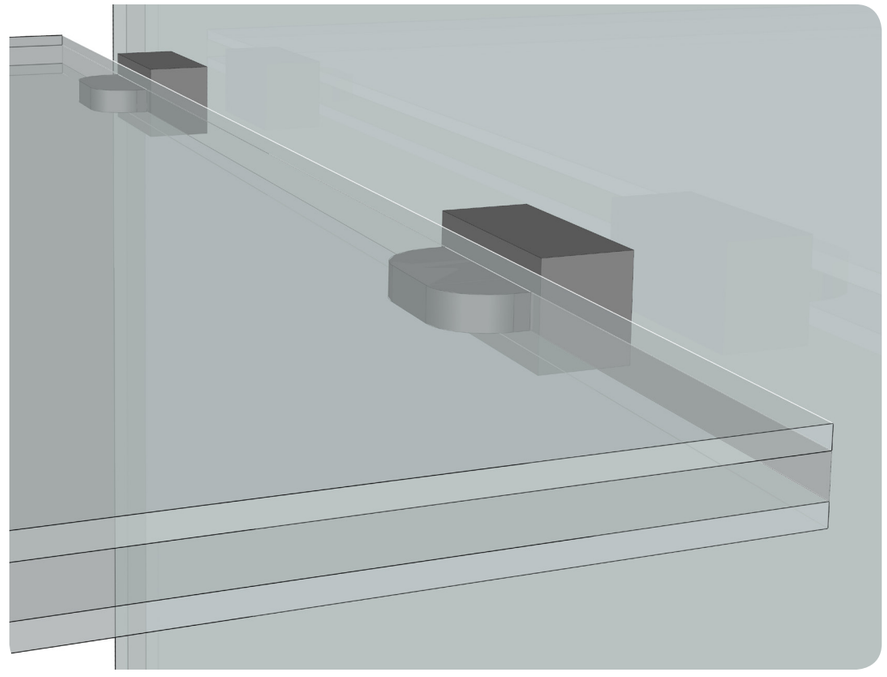
Schueco USC 65 unitized curtain wall system



Connections to floor slab & between glass panels

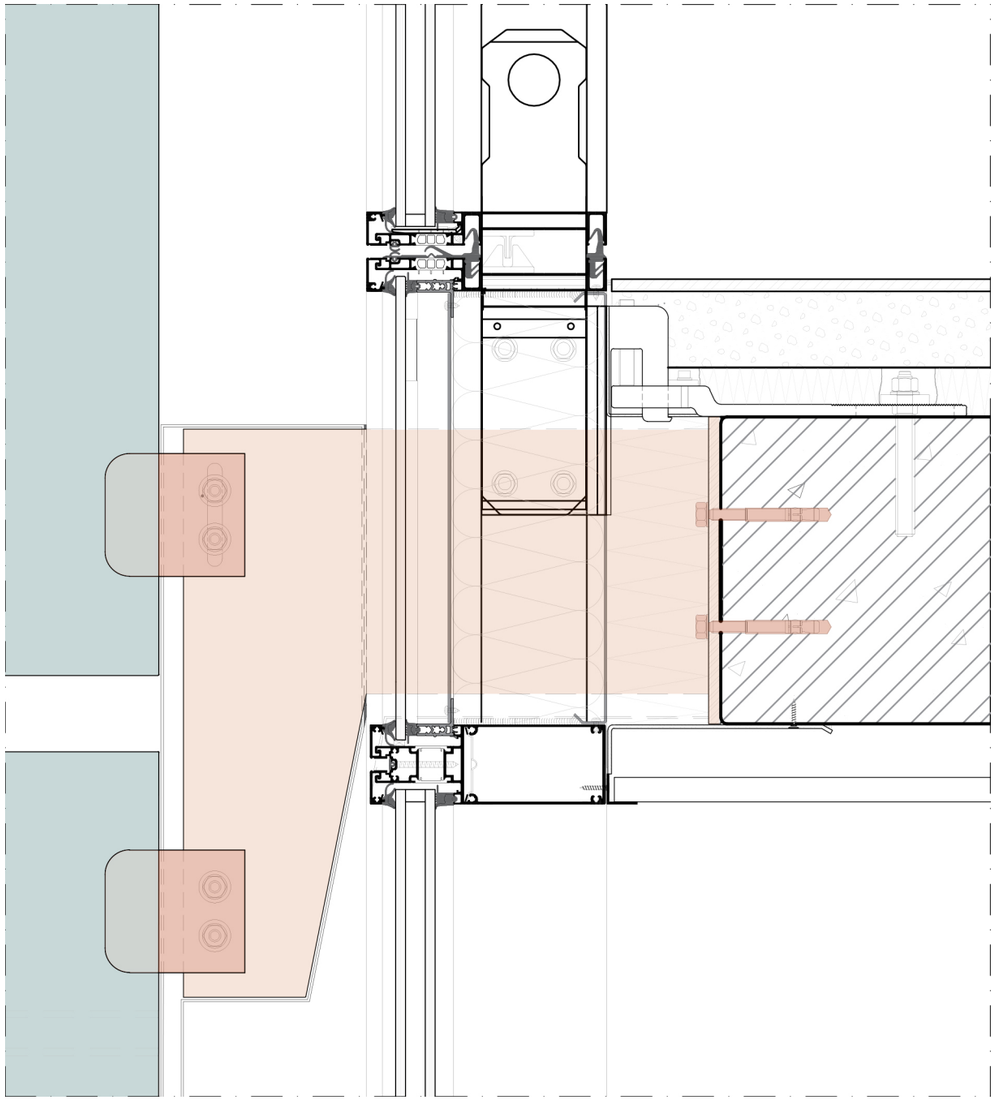


Floor slab connections

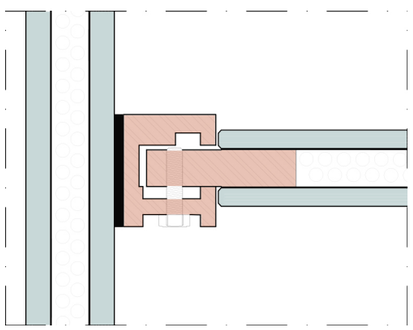


Connection between two glass panels

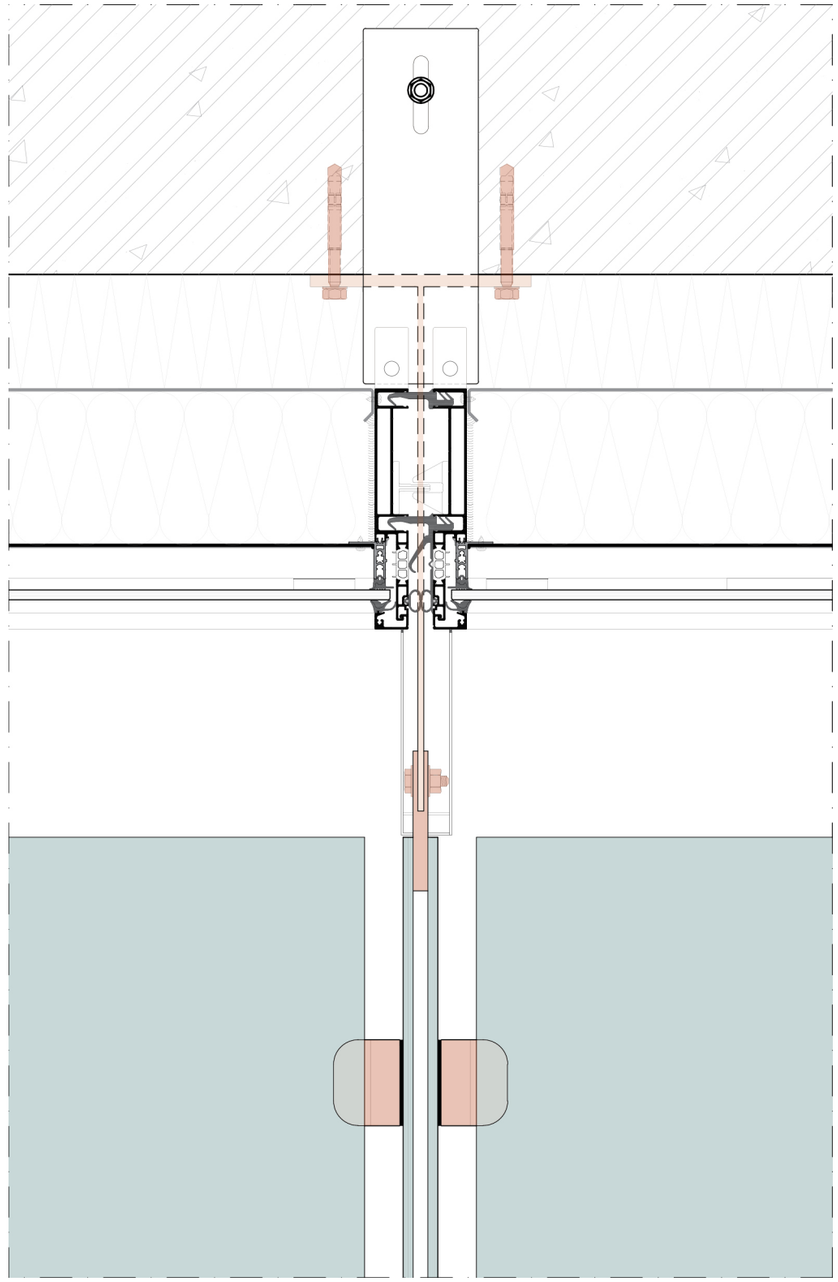
Vertical & Horizontal section detail | Polymer connection detail



Vertical section

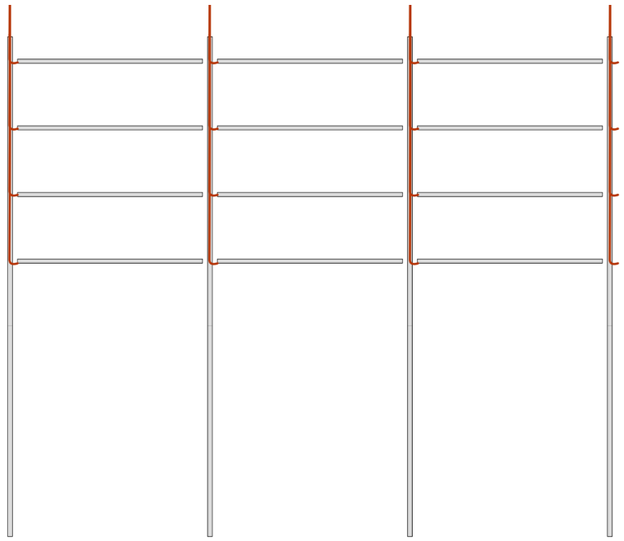


Polymer connection

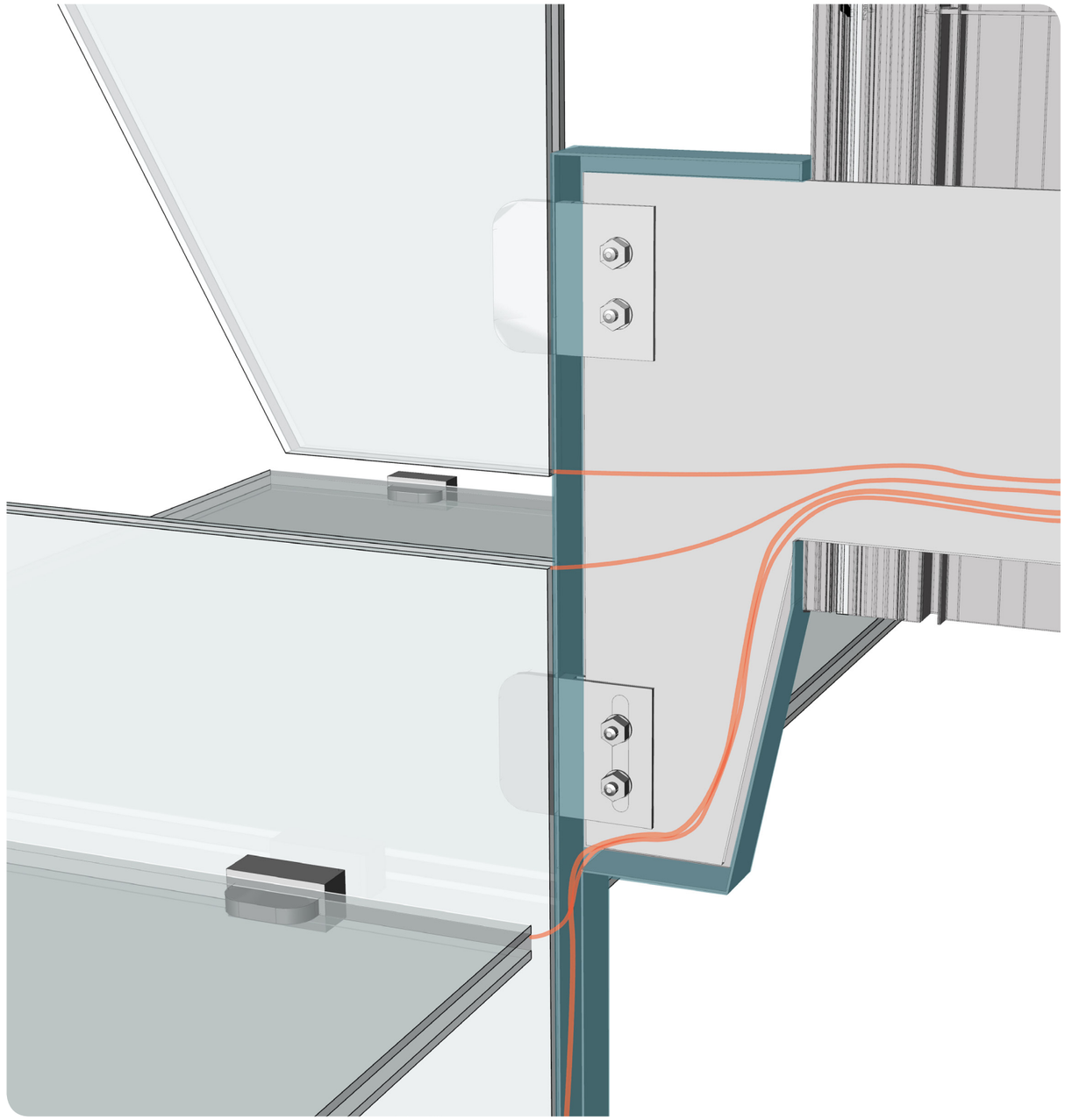


Horizontal section

Energy supply

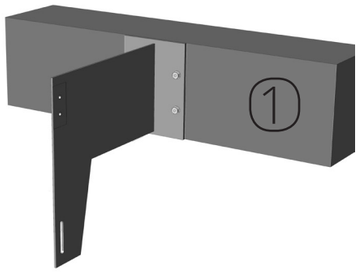


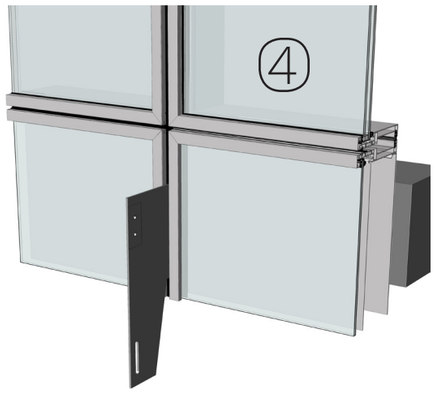
Cables position

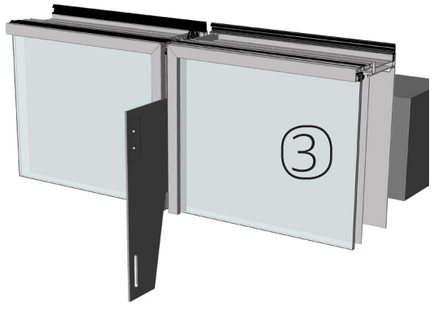


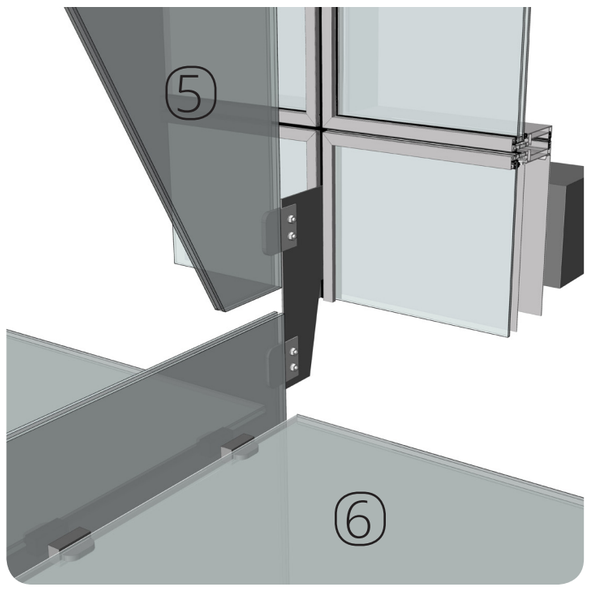
Supply cables

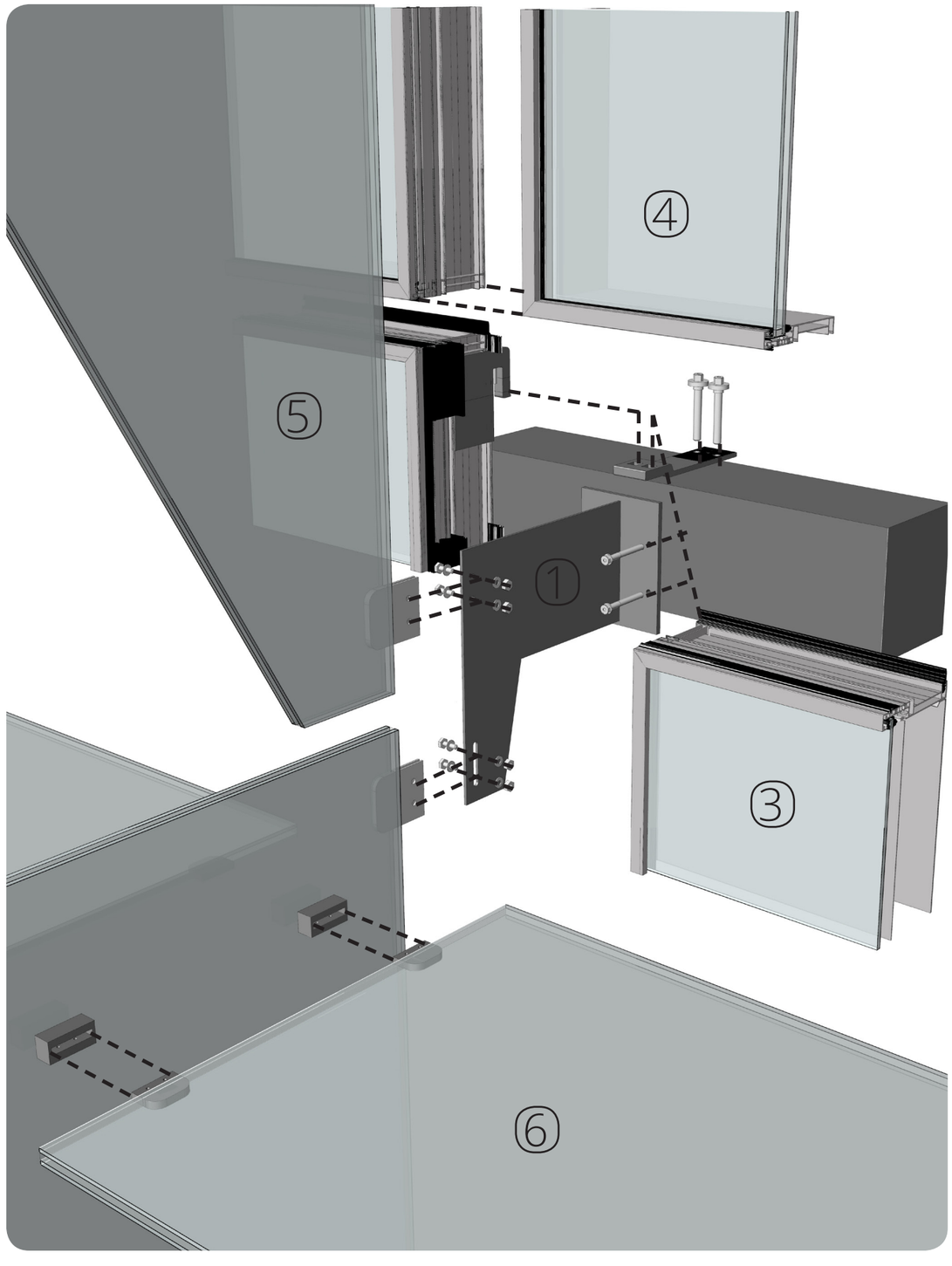
Assembling



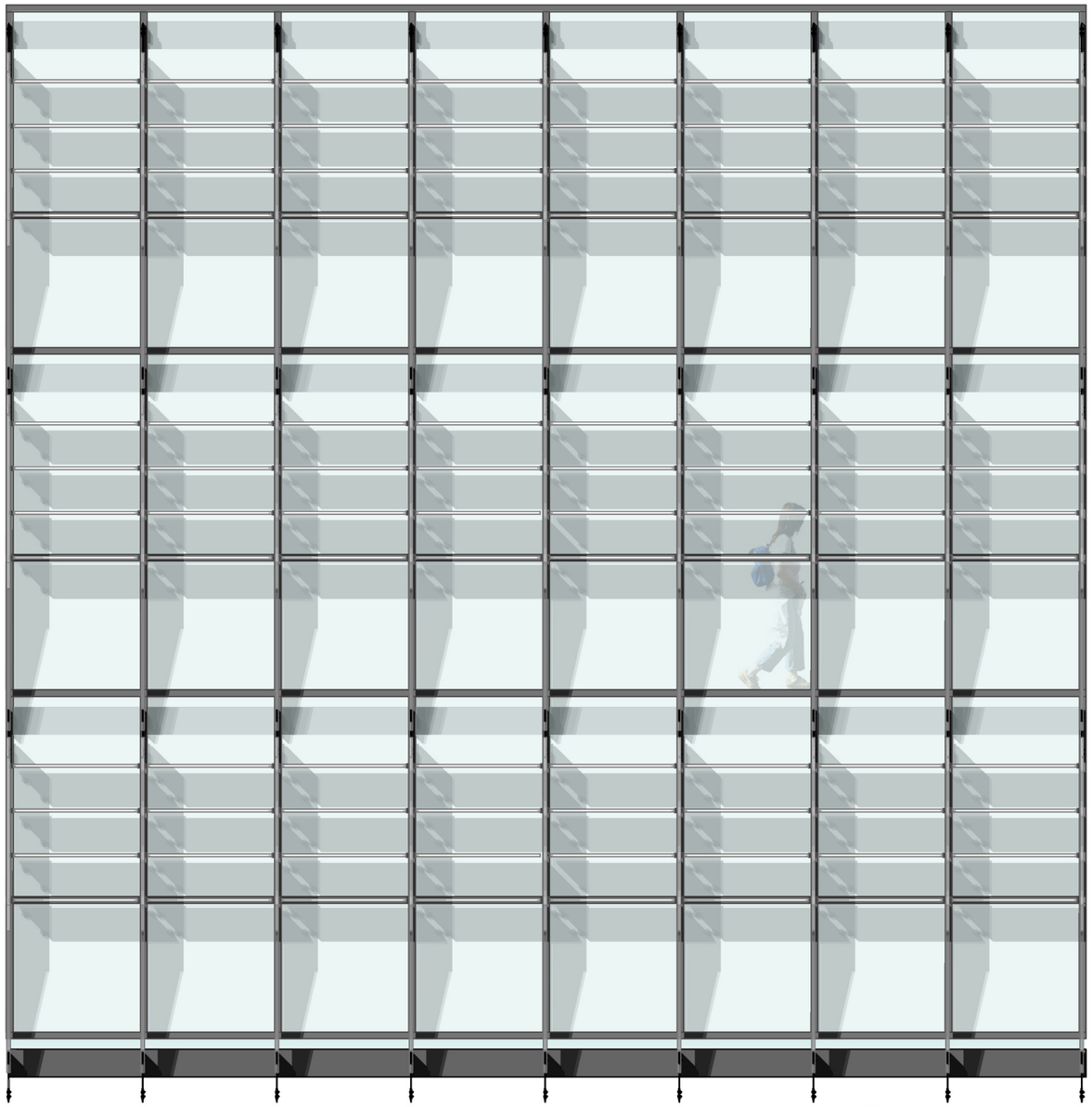




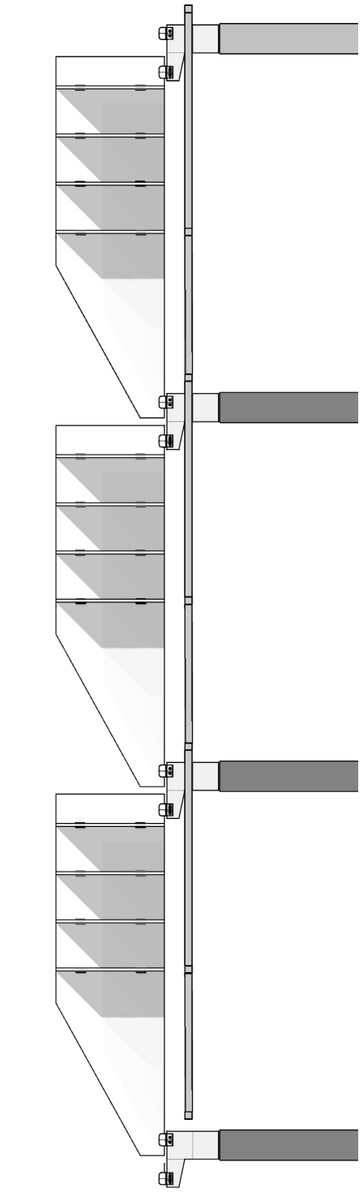




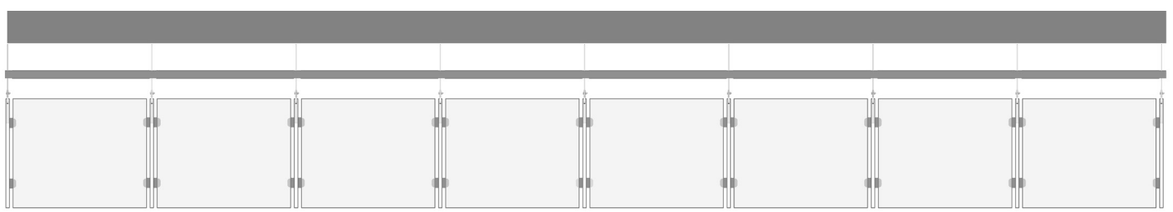
Facade section



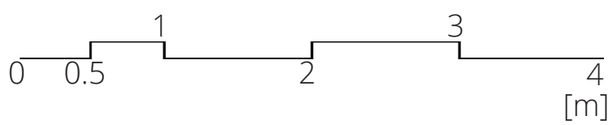
Front view

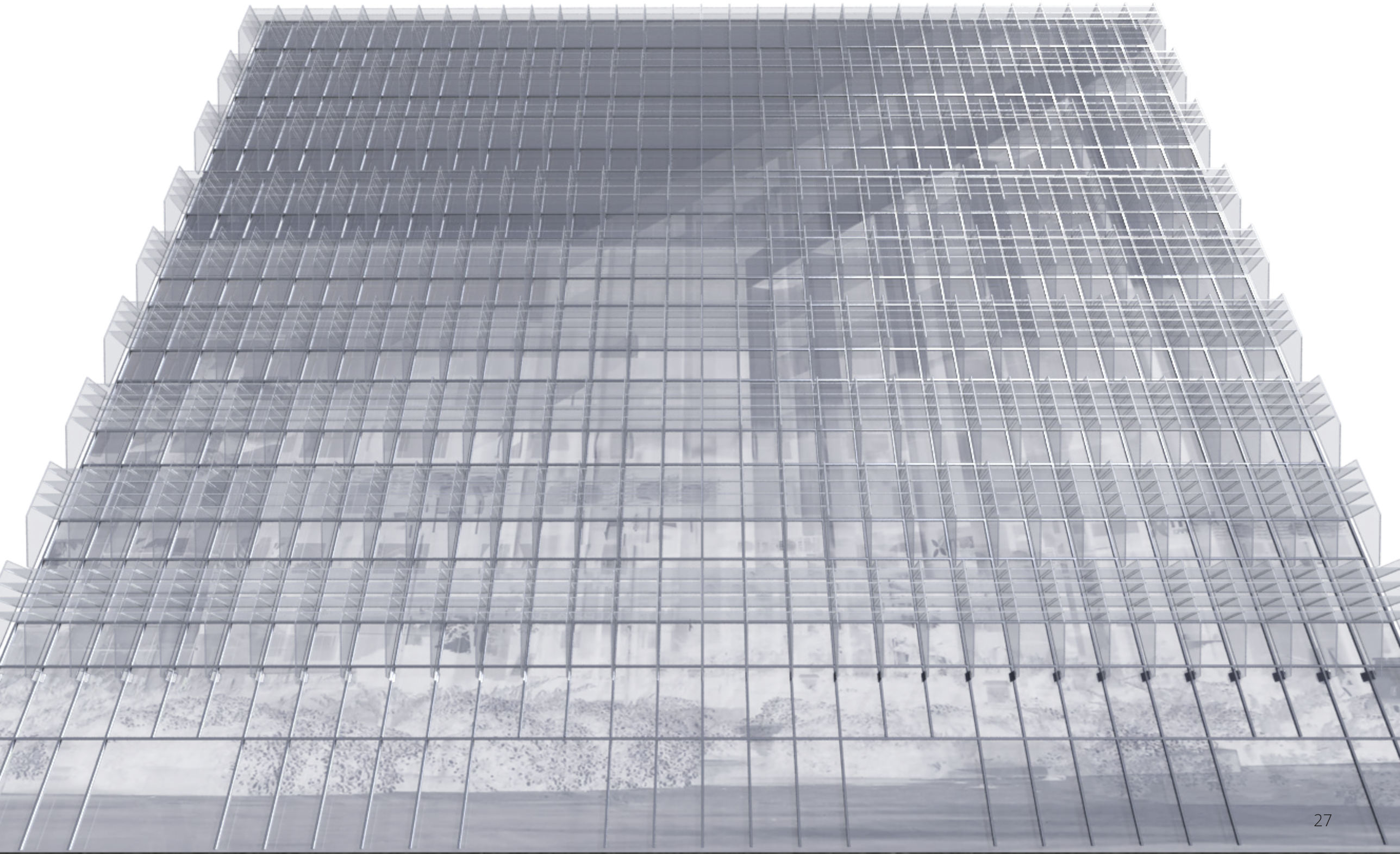


Vertical section



Top view





Daylight analysis | South oriented

Annual glare | 2 states | Transparent - translucent

Daysim report | Two shading groups

Daylit area | DA_{500lux}[50%] > 80% of floor area = 100% ✔

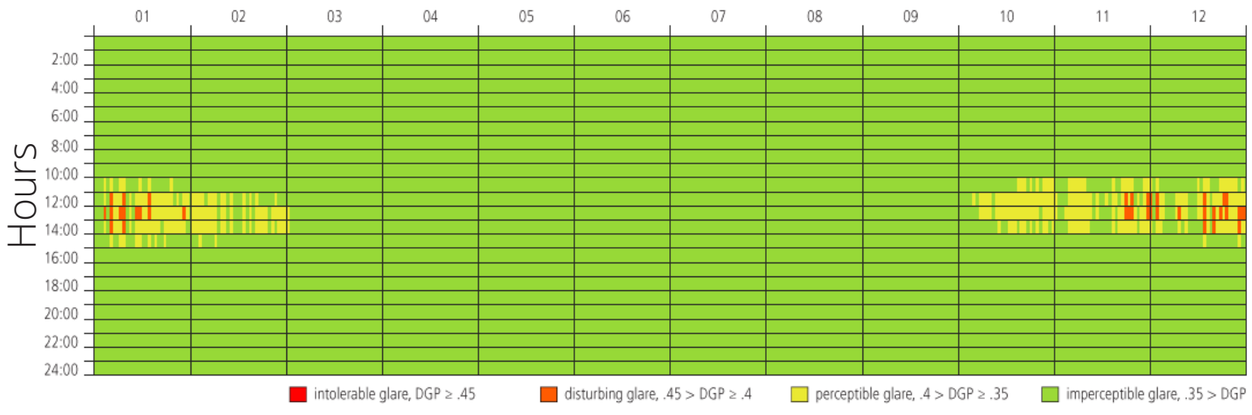
Daylight autonomy | DA > 80% for active occupant behavior = 87% ✔

Useful daylight illuminance | percentage of space with a UDI<100-2000LUX [50%] > 60% for the active occupant behavior = 47% ✖

Glare | 0.3% of occupied hours = 0% ✔

Transparent

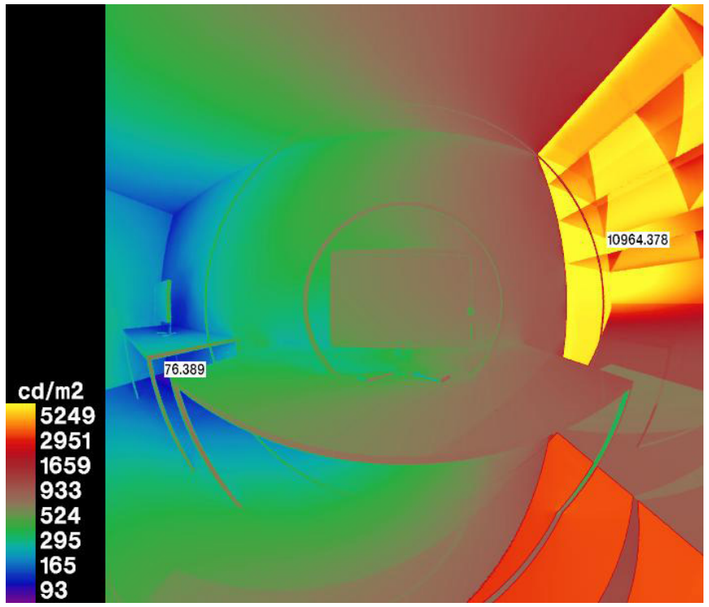
Translucent

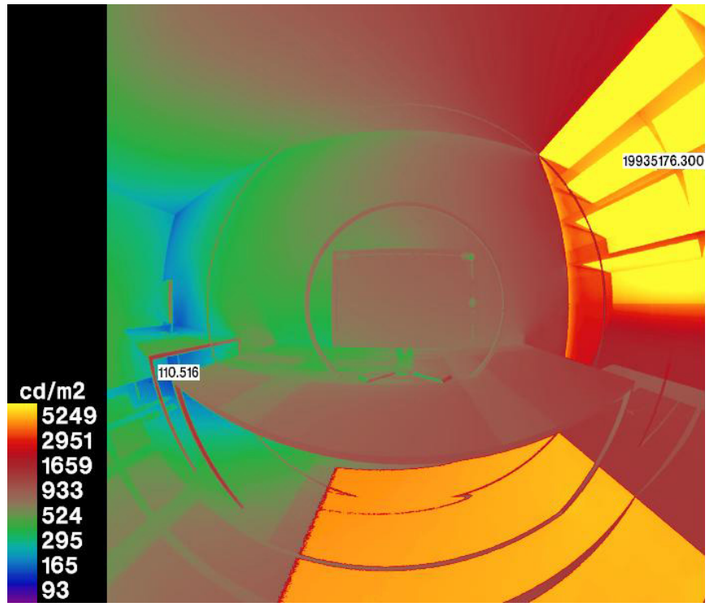


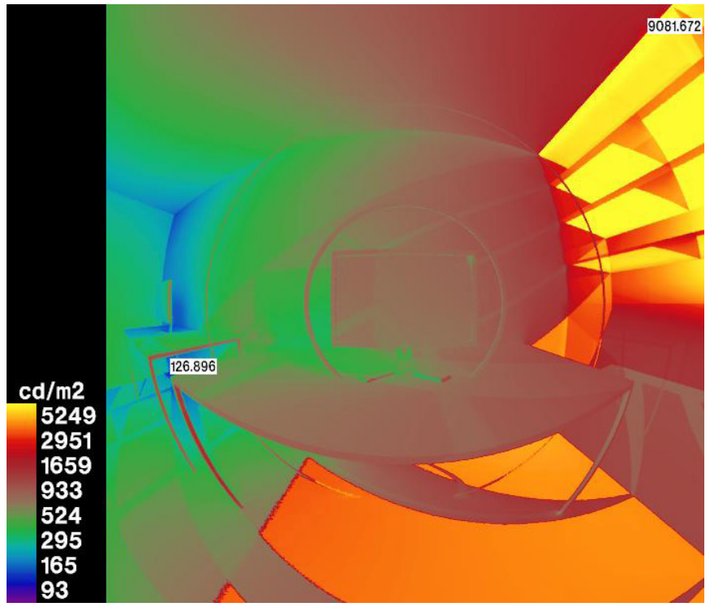
Daylight analysis | South oriented

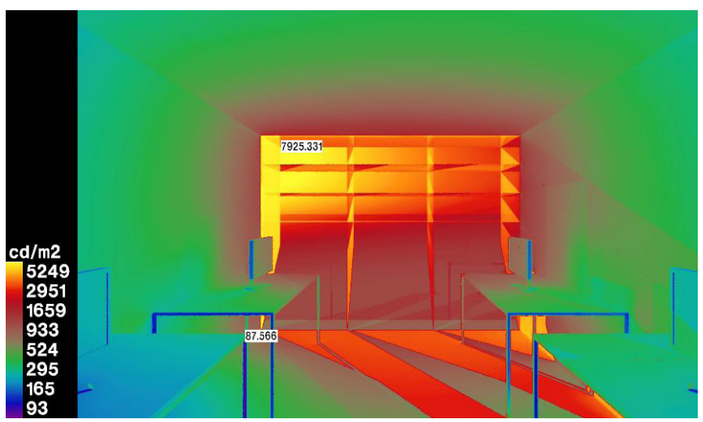
21st December

Proposed shading system - 10:00, 12:00 & 14:00

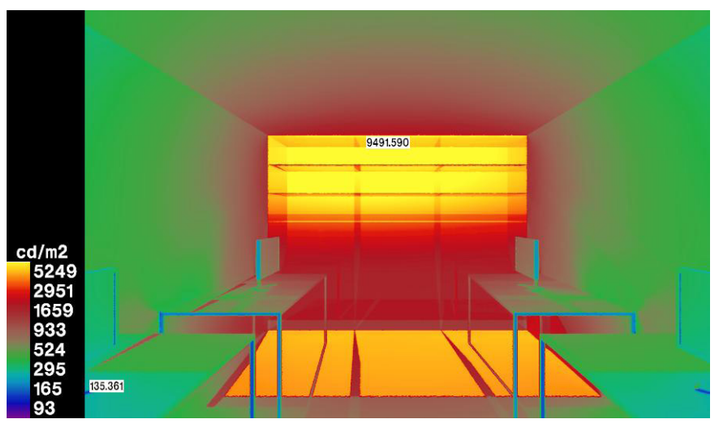




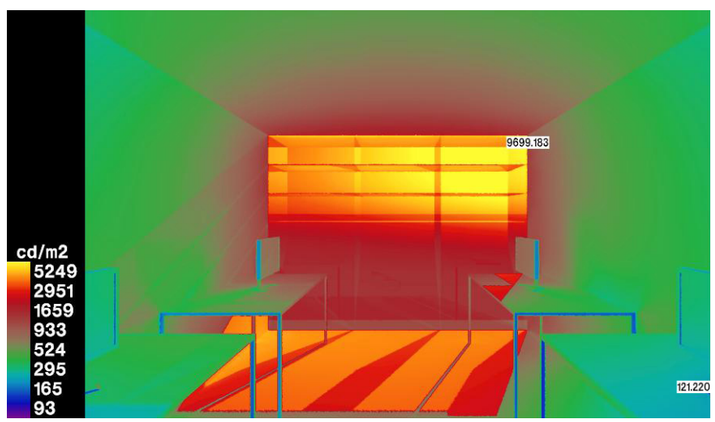




All translucent

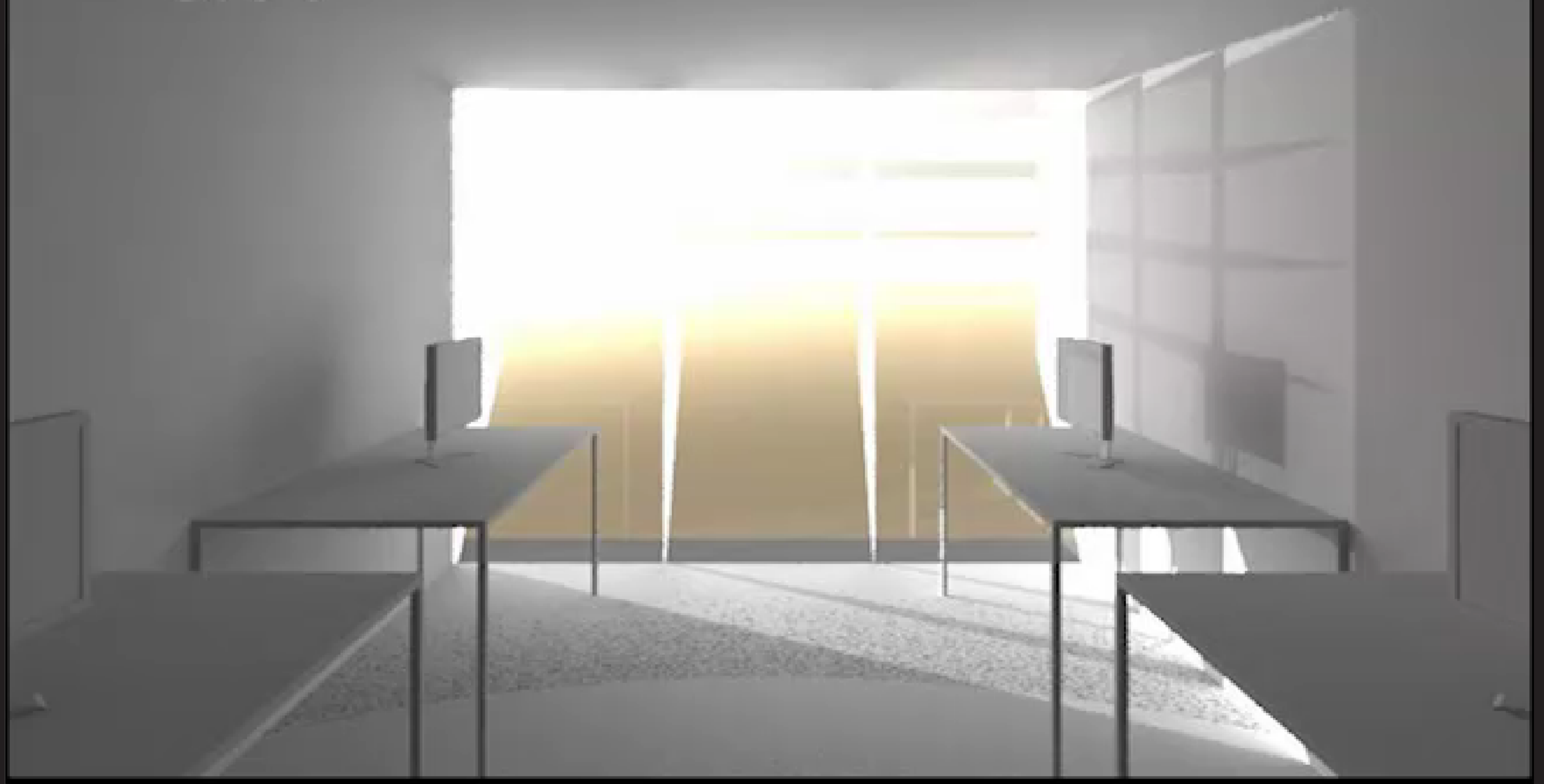


Only horizontal translucent



Only horizontal translucent

Vertical traslucent
8:00



Daylight analysis | West oriented

Annual glare | 2 states | Transparent - translucent

Daysim report | Two shading groups

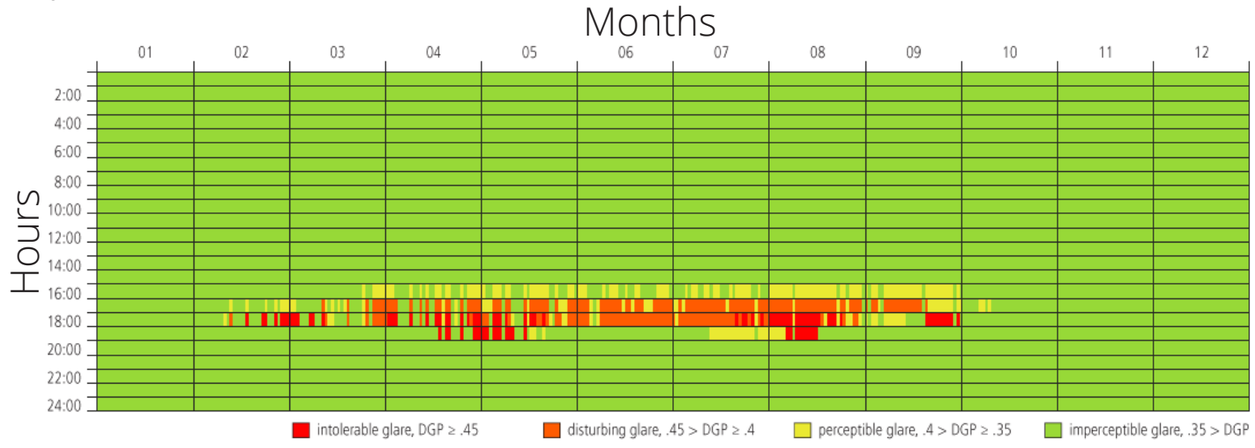
Daylit area | DA_{500lux}[50%] > 80% of floor area **=** 87% ✔

Daylight autonomy | DA > 80% for active occupant behavior = 79% ✔

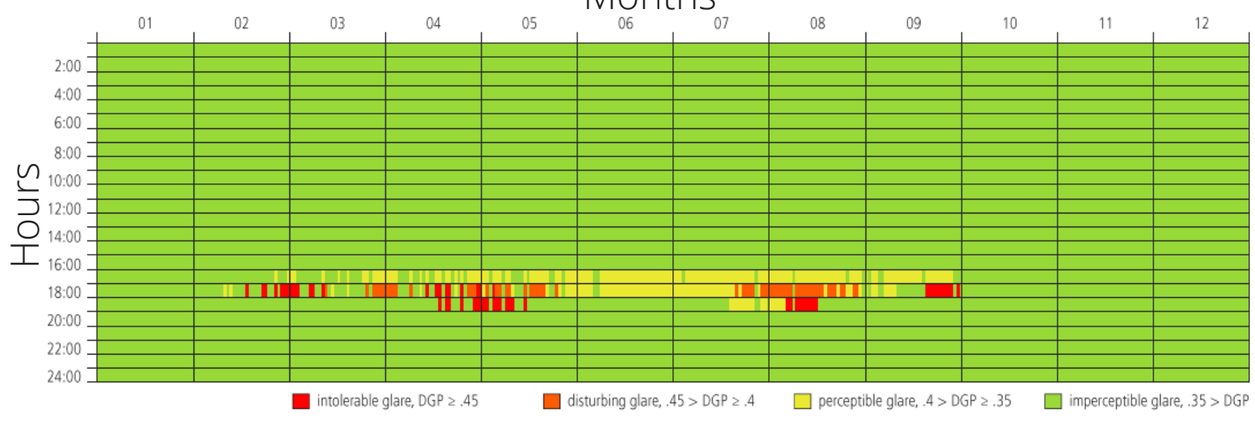
Useful daylight illuminance | percentage of space with a UDI<100-2000LUX [50%] > 60% for the active occupant behavior = 79% ✔

Glare | 0.3% of occupied hours = 0% ✔

Transparent



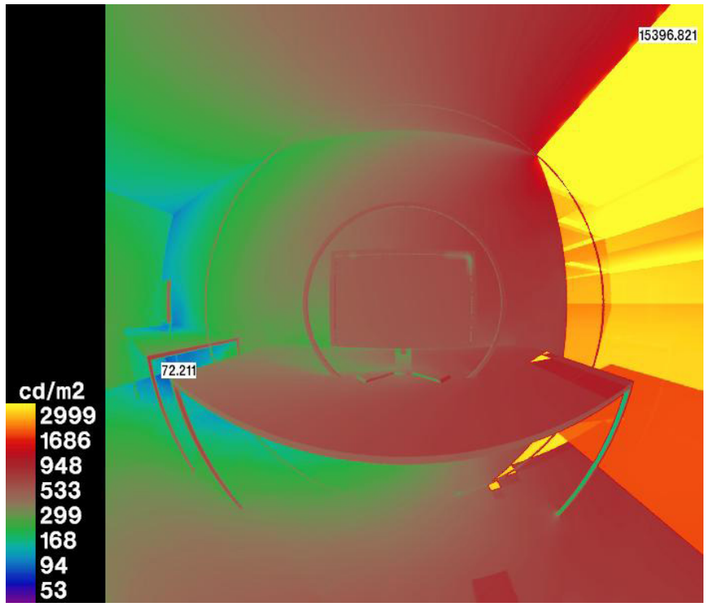
Translucent

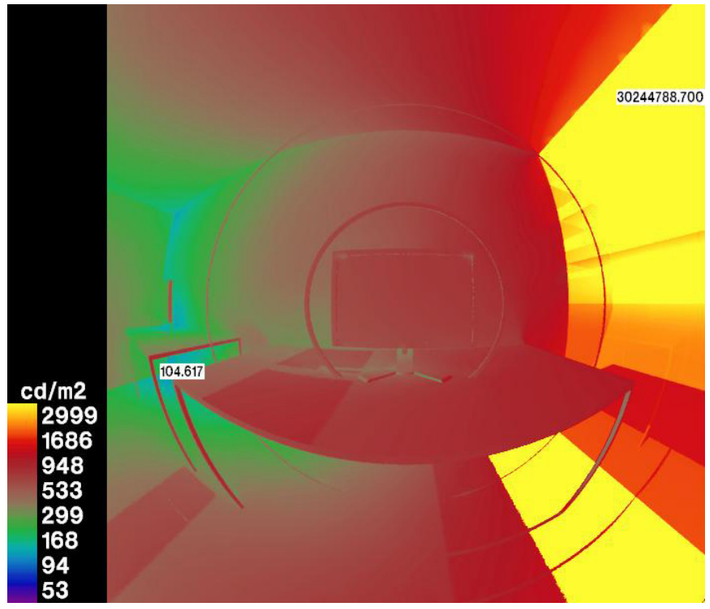


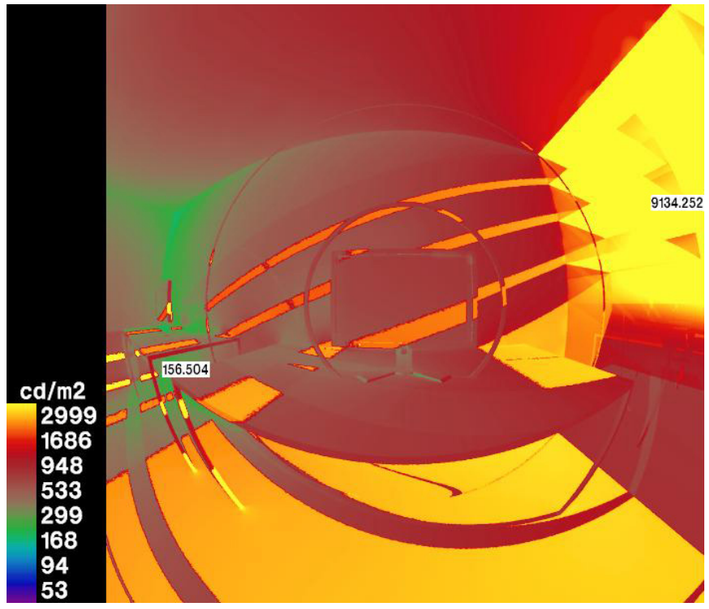
Daylight analysis | West oriented

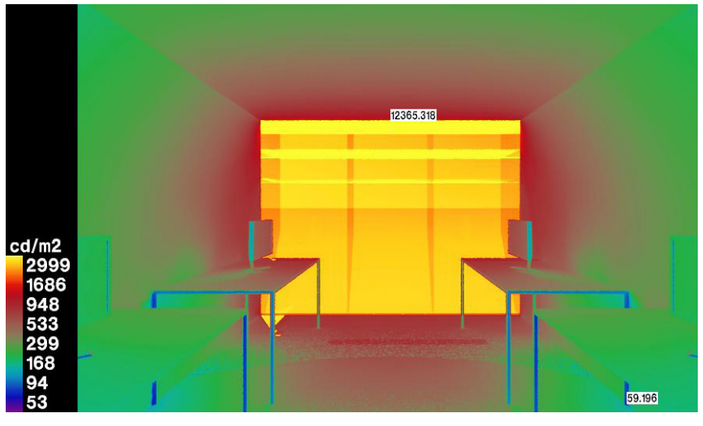
21st June

Proposed shading system - 14:00, 16:00 & 18:00

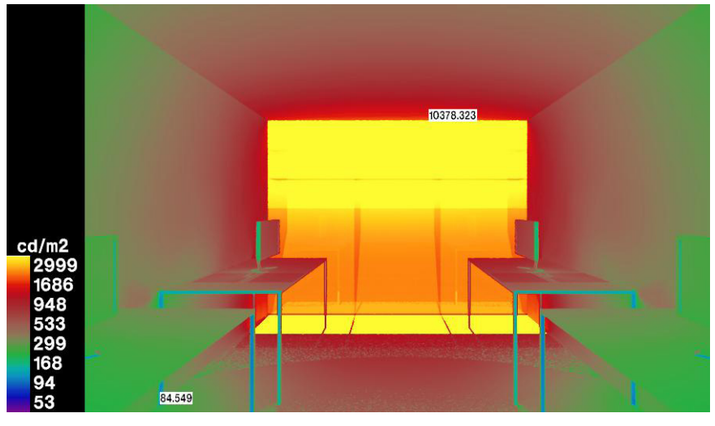




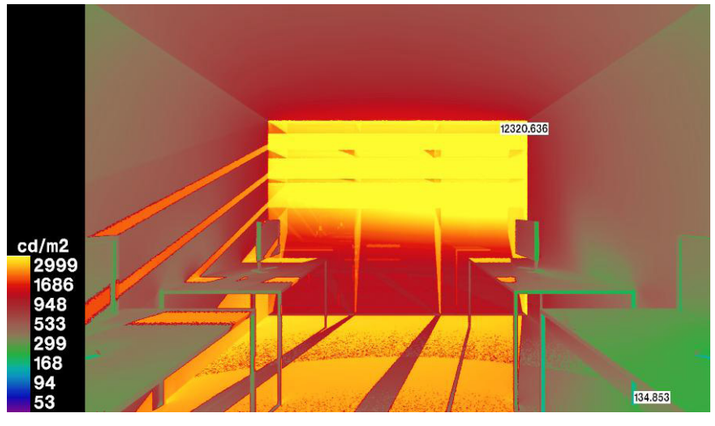




Only horizontal translucent

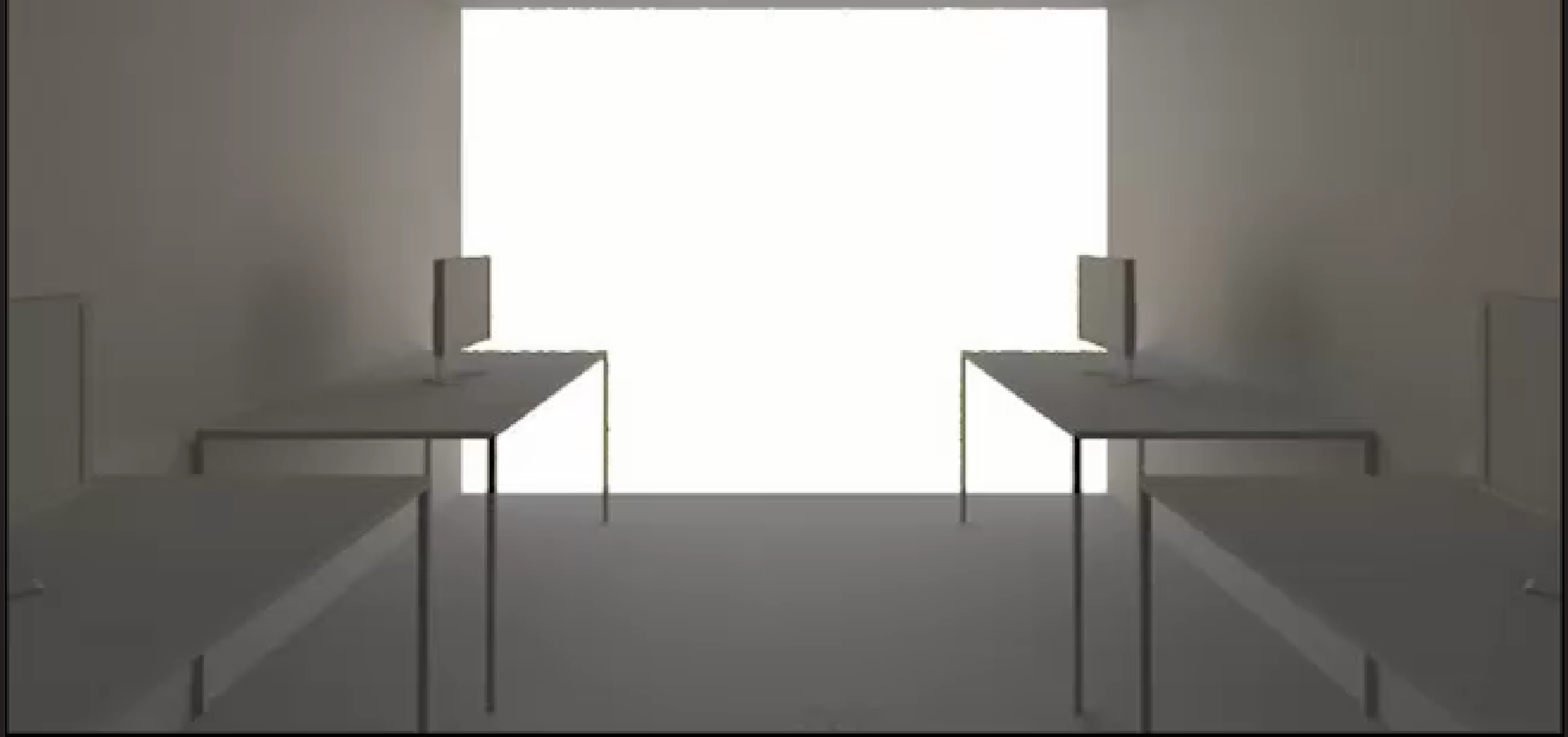


Only horizontal translucent



All translucent

All transparent
8:00



Amsterdam | Daylight analysis | South oriented

Annual glare | 2 states | Transparent - translucent

Daysim report | Two shading groups

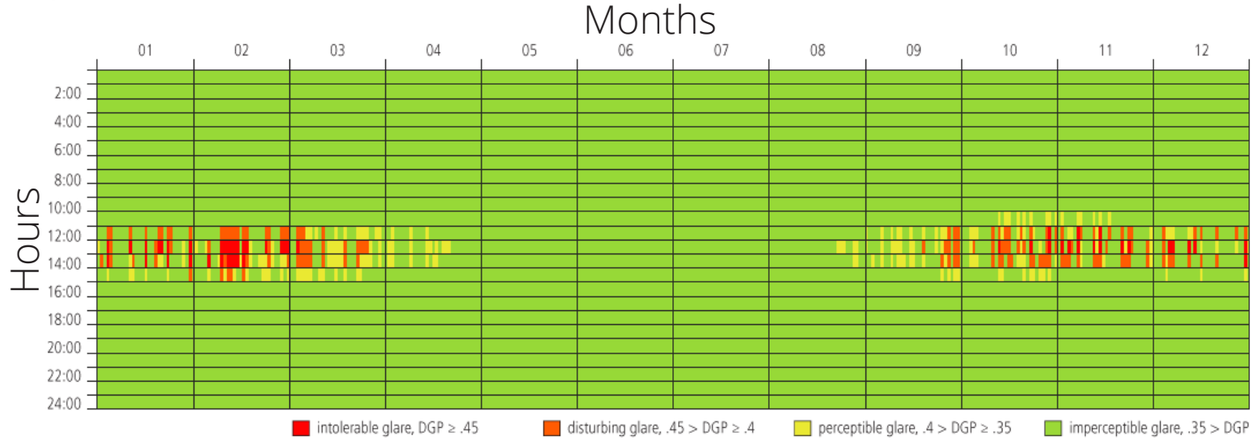
Daylit area | DA_{500lux}[50%] > 80% of floor area **=** 81% ✔

Daylight autonomy | DA > 80% for active occupant behavior = 67% ✖

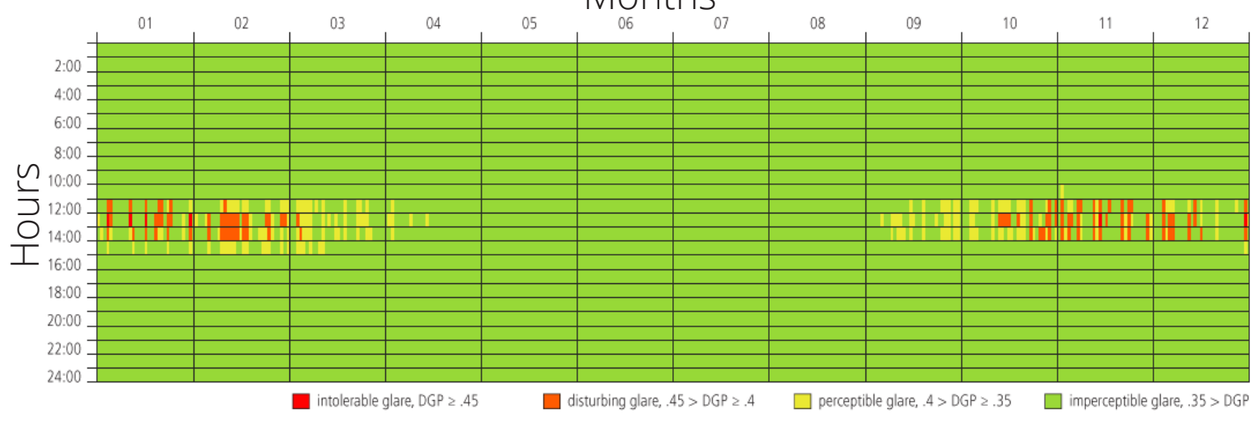
Useful daylight illuminance | percentage of space with a UDI<100-2000LUX [50%] > 60% for the active occupant behavior = 61% ✔

Glare | 0.3% of occupied hours = 0% ✔

Transparent



Translucent



Amsterdam | Daylight analysis | West oriented

Annual glare | 2 states | Transparent - translucent

Daysim report | Two shading groups

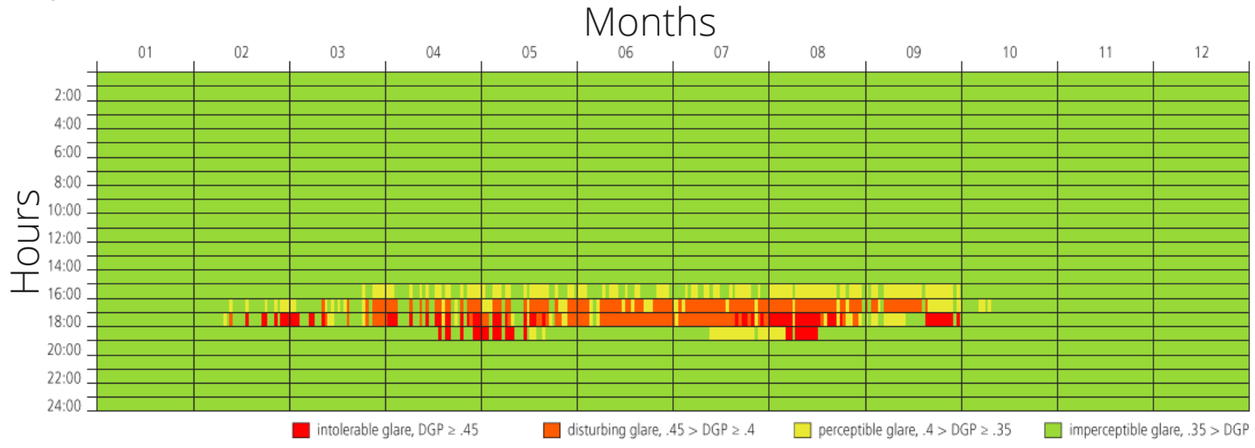
Daylit area | DA_{500lux}[50%] > 80% of floor area **=** 67% ✔

Daylight autonomy | DA > 80% for active occupant behavior = 67% ✖

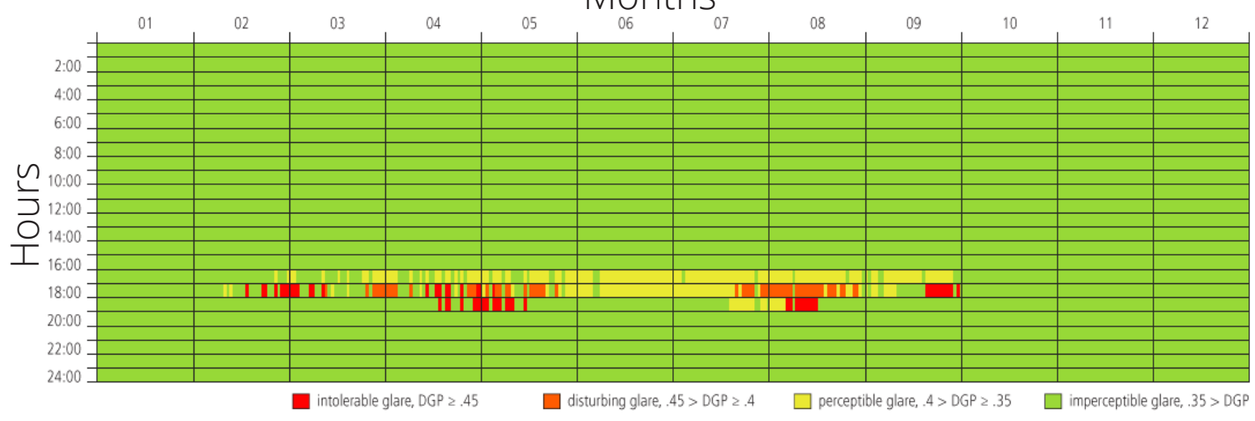
Useful daylight illuminance | percentage of space with a UDI<100-2000LUX [50%] > 60% for the active occupant behavior = 80% ✔

Glare | 0.3% of occupied hours = 1% ✖

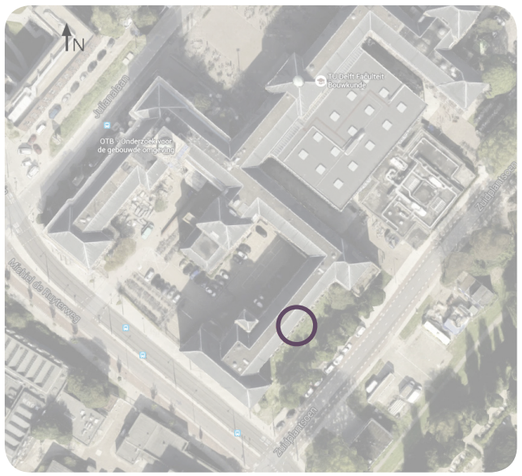
Transparent



Translucent

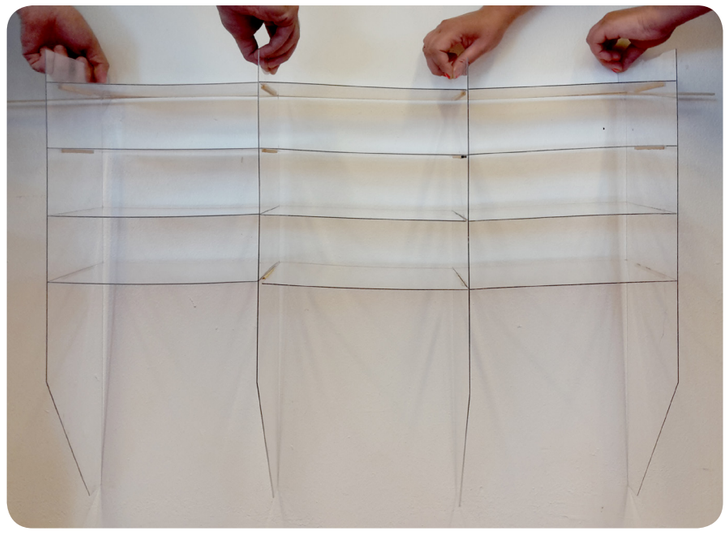


Real-time measurements



26 May | East-south orientation

11:00

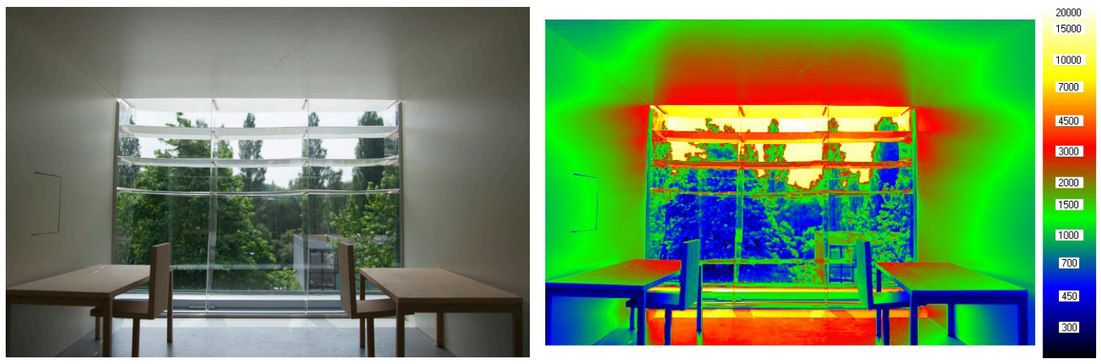


Real-time measurements

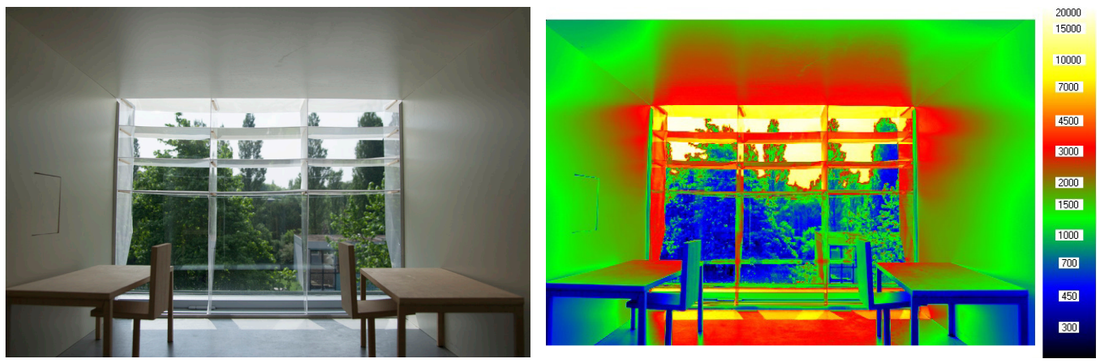
All transparent

Vertical translucent

Horizontal translucent



All translucent

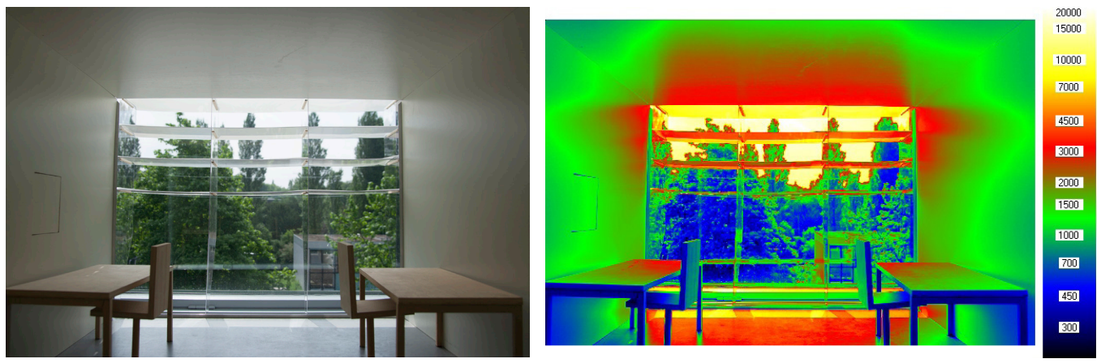


Real-time measurements

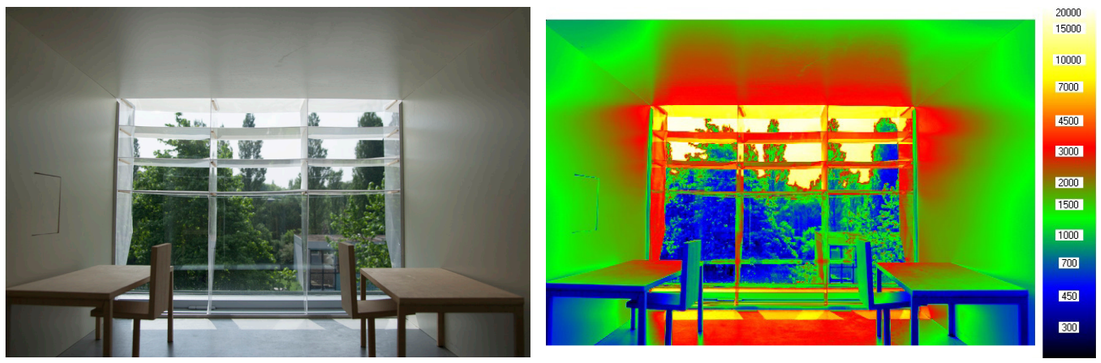
All transparent

Vertical translucent

Horizontal translucent

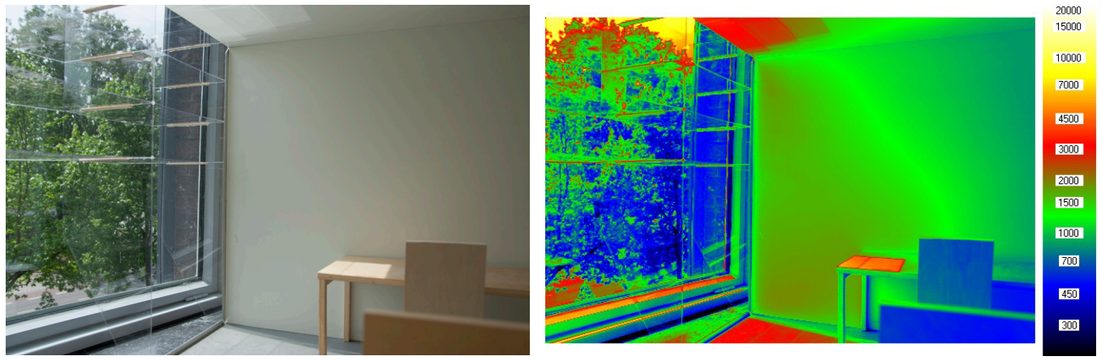


All translucent

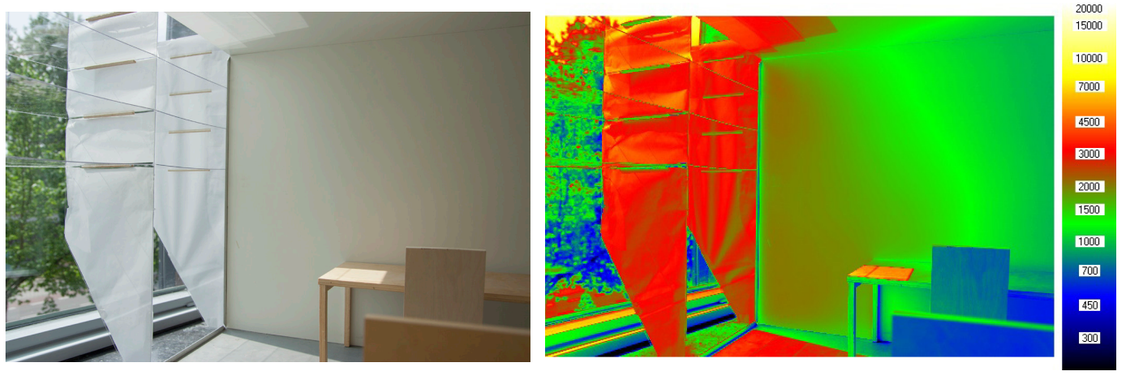


Real-time measurements

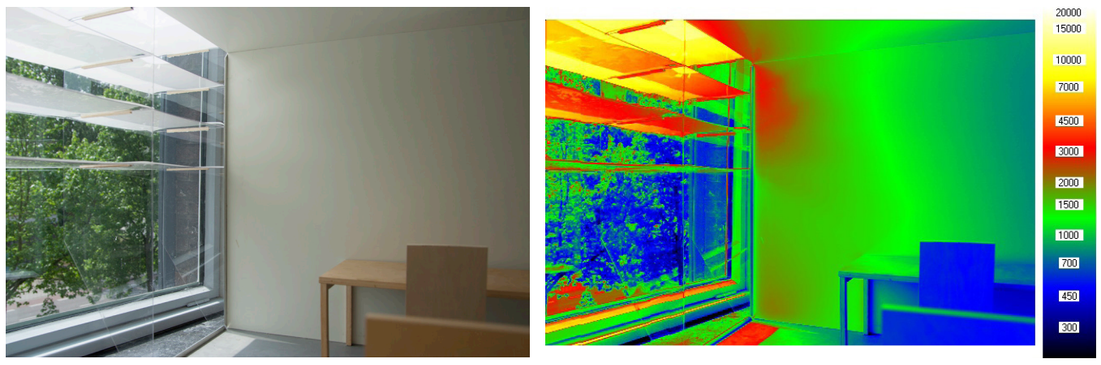
All transparent



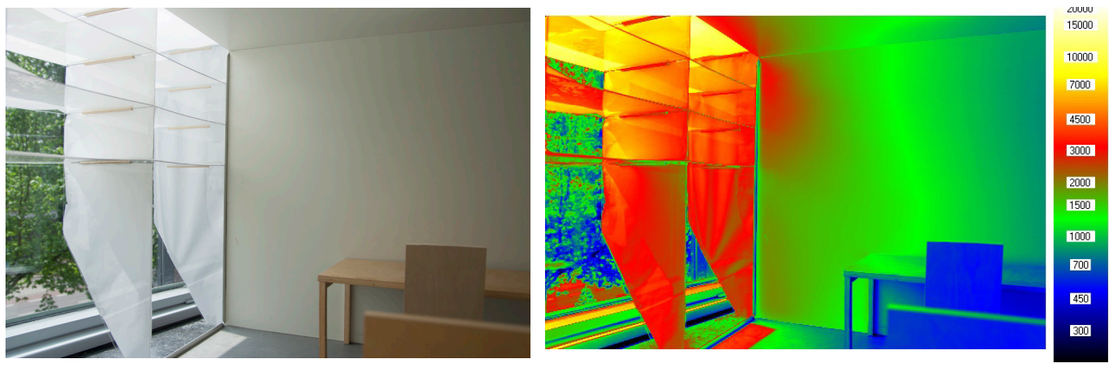
Vertical translucent



Horizontal translucent



All translucent



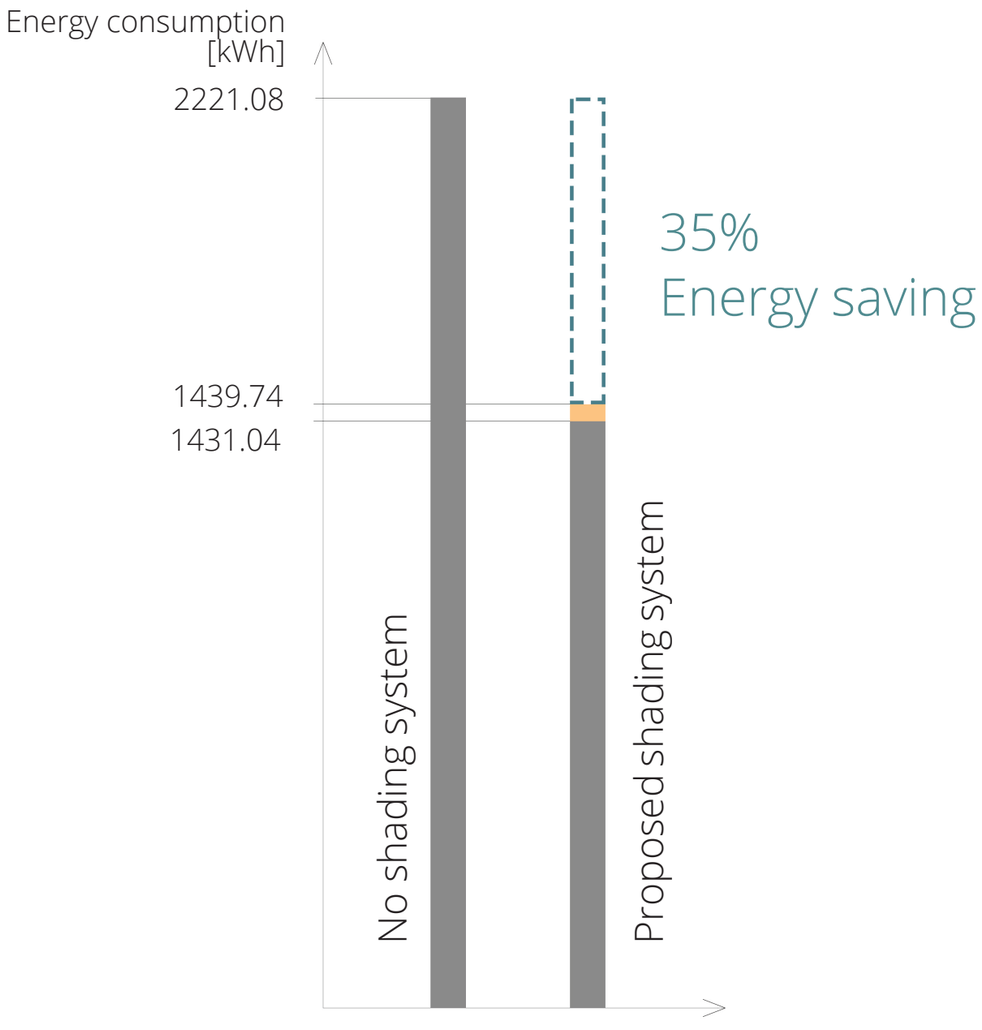
Cost analysis

	Materials	System price per façade surface [€/m^2]
1	Glass sheets - PDLC film	1400
2	Acrylic sheets - PDLC film	1300
3	Horizontal | Glass sheets - PDLC film Vertical | Satin glass sheets	1250
4	Satin glass sheets	850

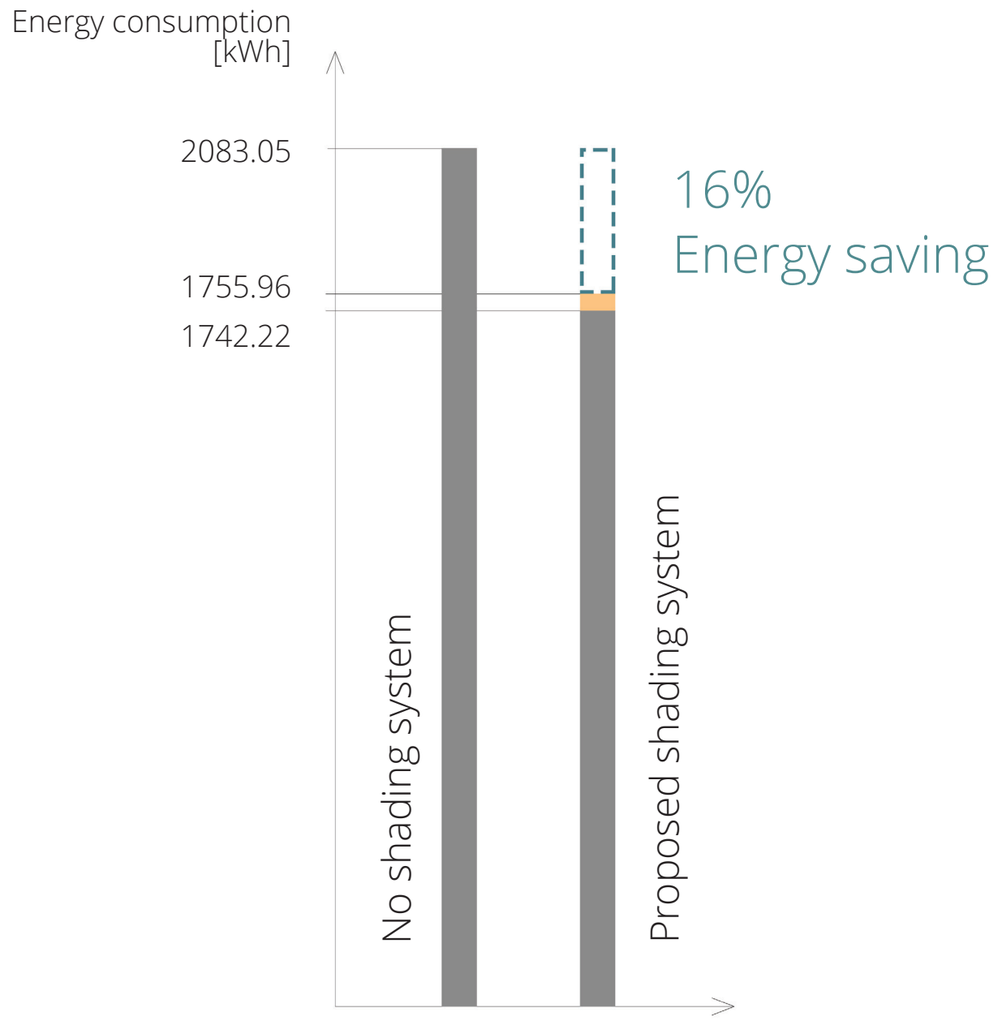
Energy consumption

System’s energy use | 0.4 Watt/m^2

South orientation

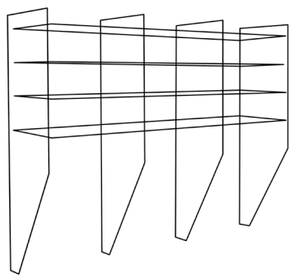


West orientation

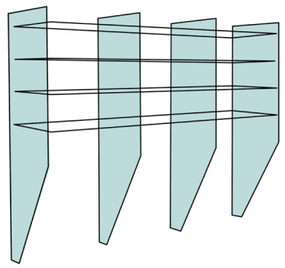


Conclusions

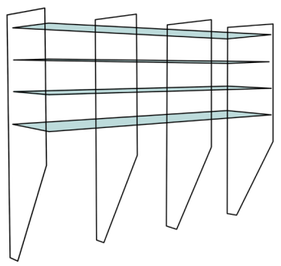
No shading needed
Transparent - Invisible



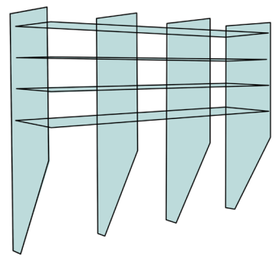
Vertical translucent



Horizontal translucent

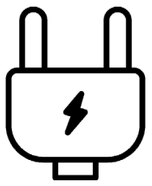


Fully shaded
Translucent



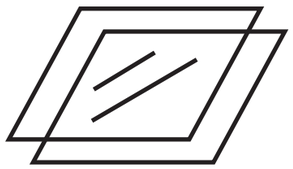
Simple design &
construction method

Adequate daylight &
glare protection



Reduction of energy
consumption

Further research



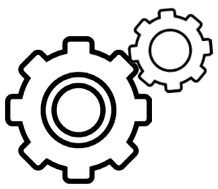
Transparent

Lightweight

Stiff & high-strength

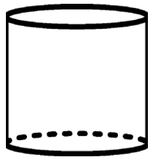
Durable & scratch-proof

Depth and spacing

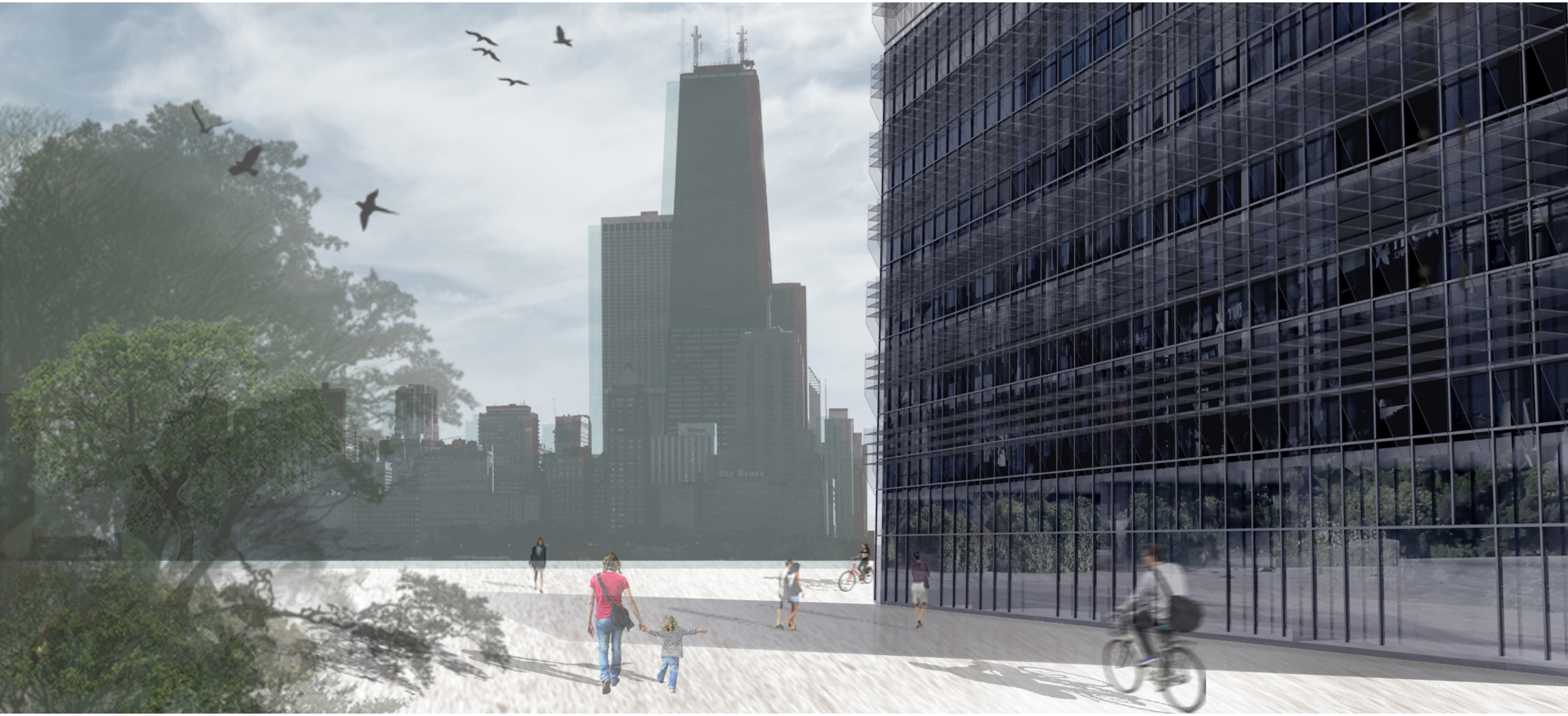


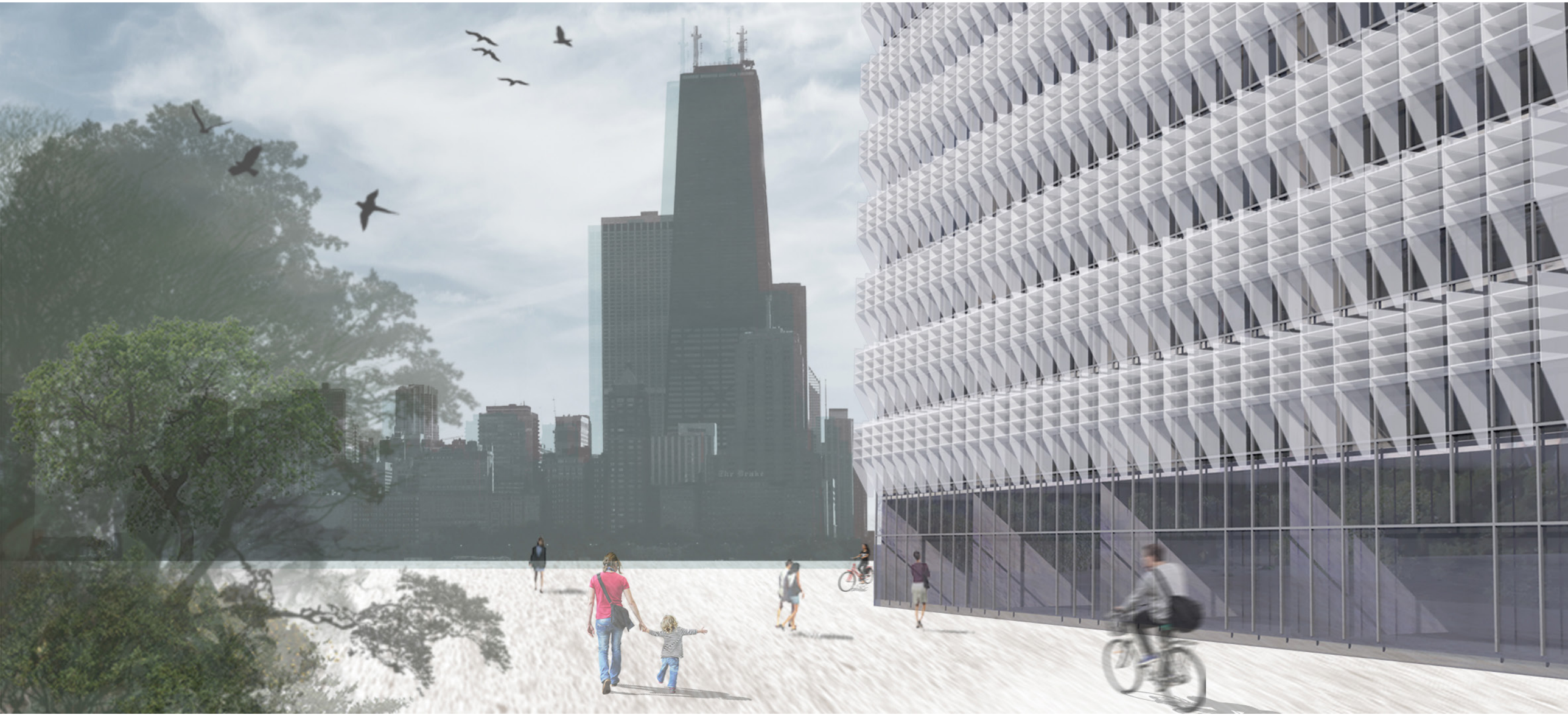
Connections dimensioning

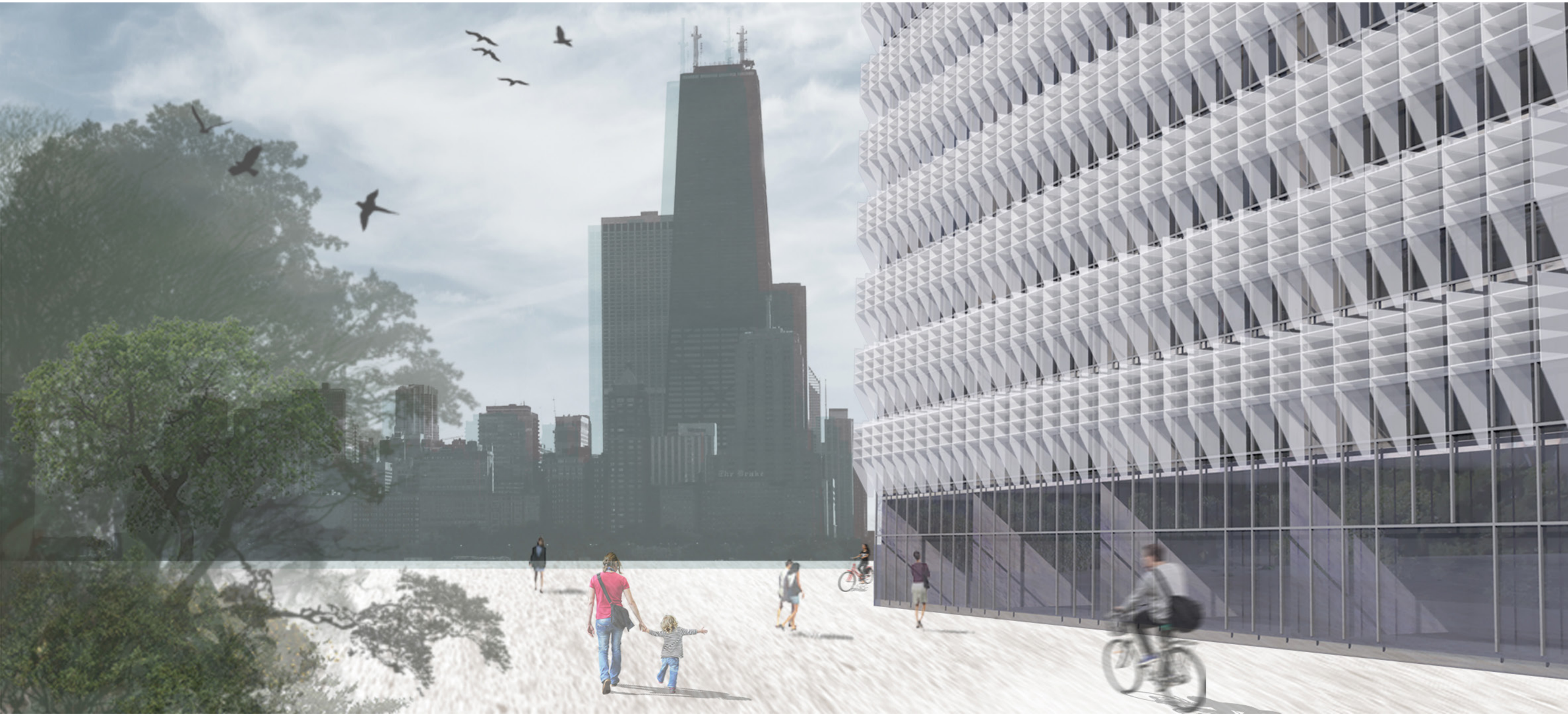
Component thickness



Cylindrical building shape







Thank you

P1 - 10/11/15 | P2 - 15/01/16 | P3 - 4/03/16 | P4 - 20/05/16 | P5

November | December | January | February | March | April | May | June

Study on the importance of sunlight
Daylight in architecture
Need for solar control
Need for adaptation
Daylight as a factor influencing arch. design
Basic sun shading designs
Adaptive designs

Bucky lab projects
Analysis
Qualitative categorization

Study cases
Analysis
Qualitative categorization
Daylight simulations
Comparison

Design research

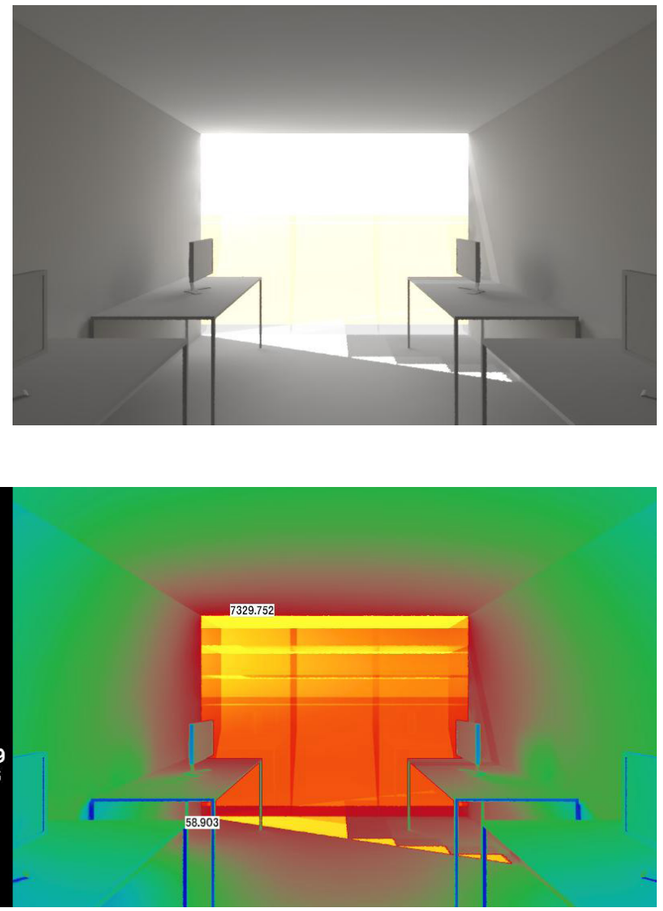
Proposed solar shading system
Material & geometry research
Simulations
Design Optimization
Daylight simulations

Connections
Facade construction analysis
Technical details
Assembling
Maintenance
Visualizations
Real-time measurements
Discussion

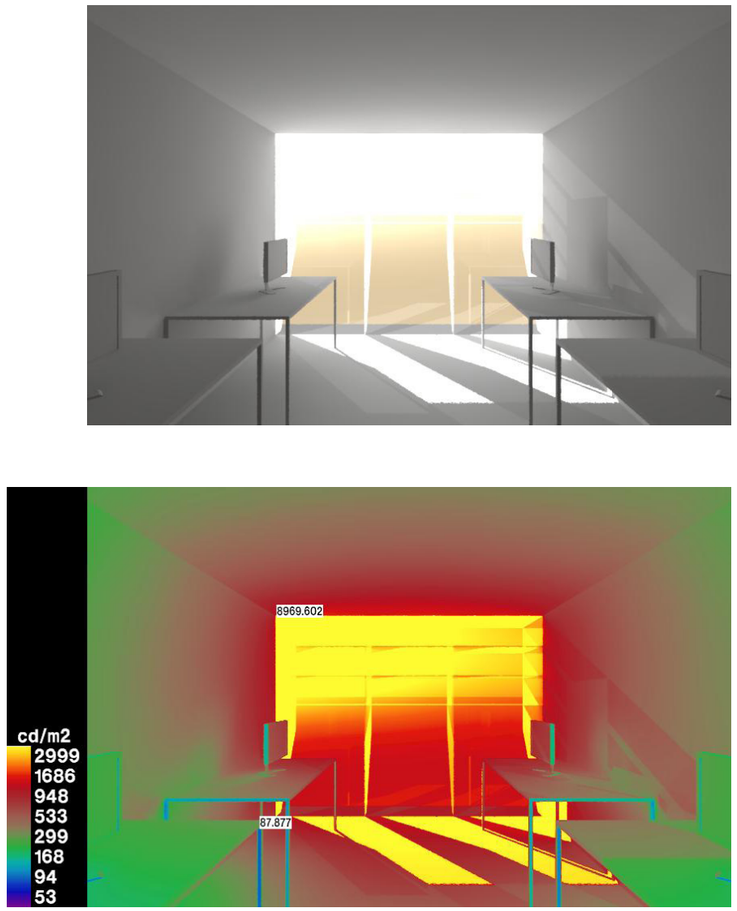
Conclusions

South
21st March

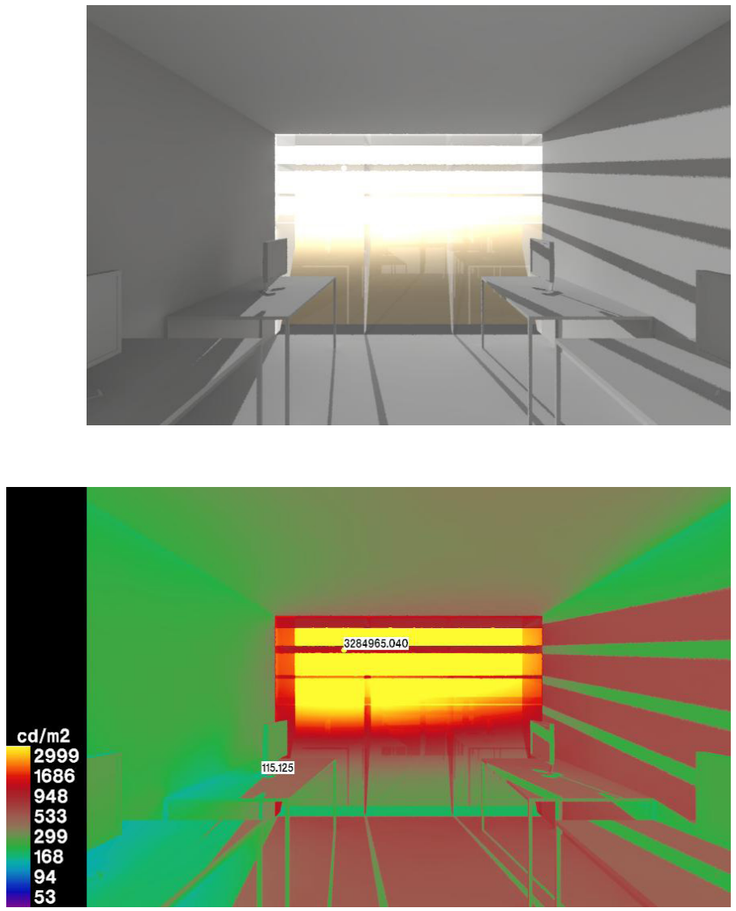
14:00



16:00

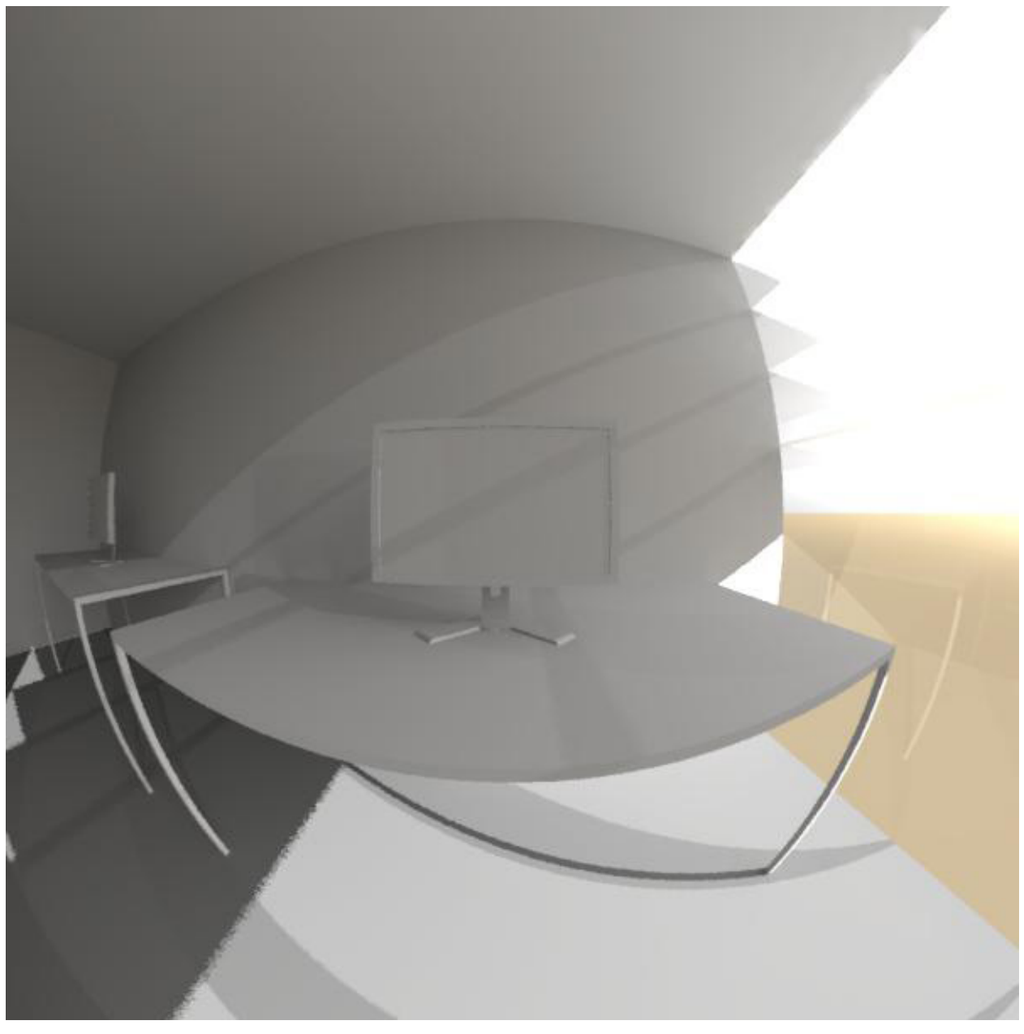


18:00



50th floor

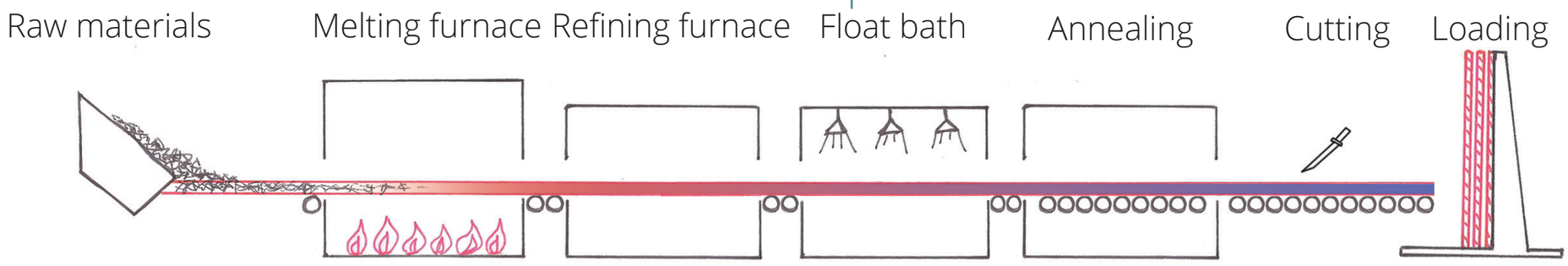
South
21st December
14:00



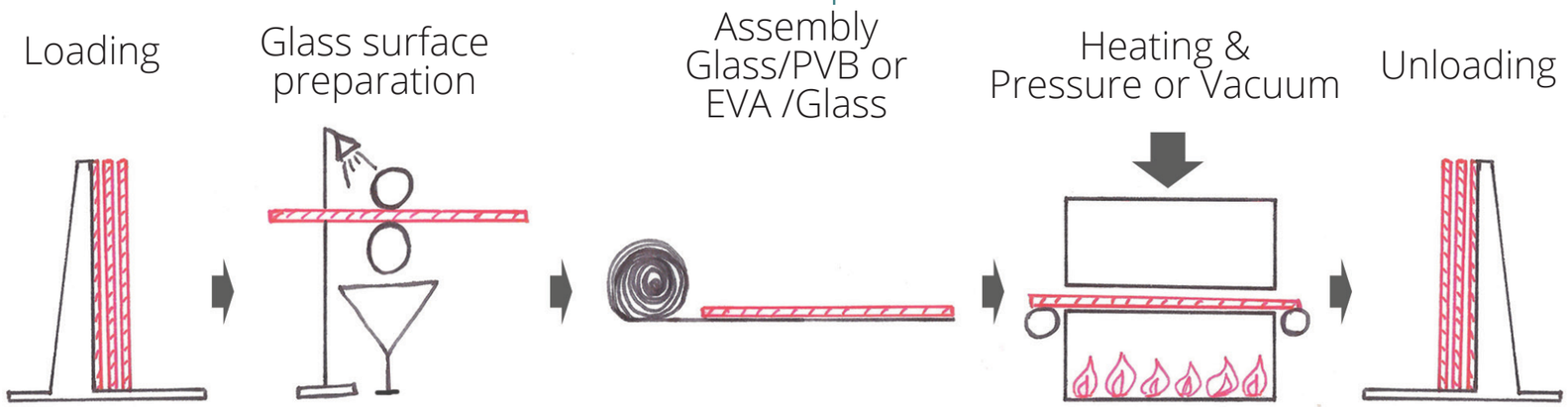
West
21st June
16:00

Feasibility

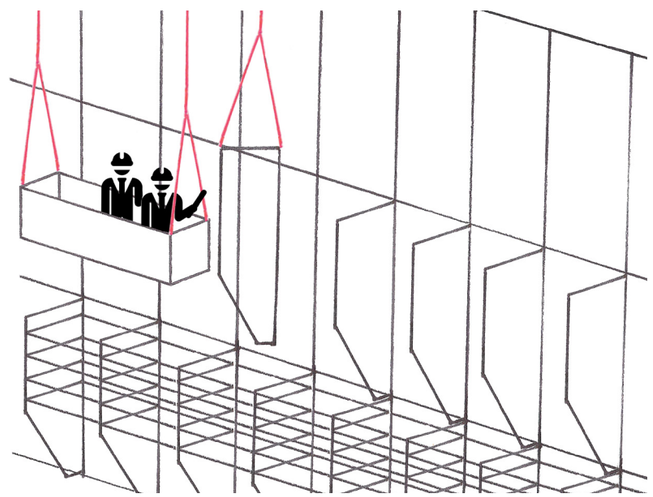
Manufacture process



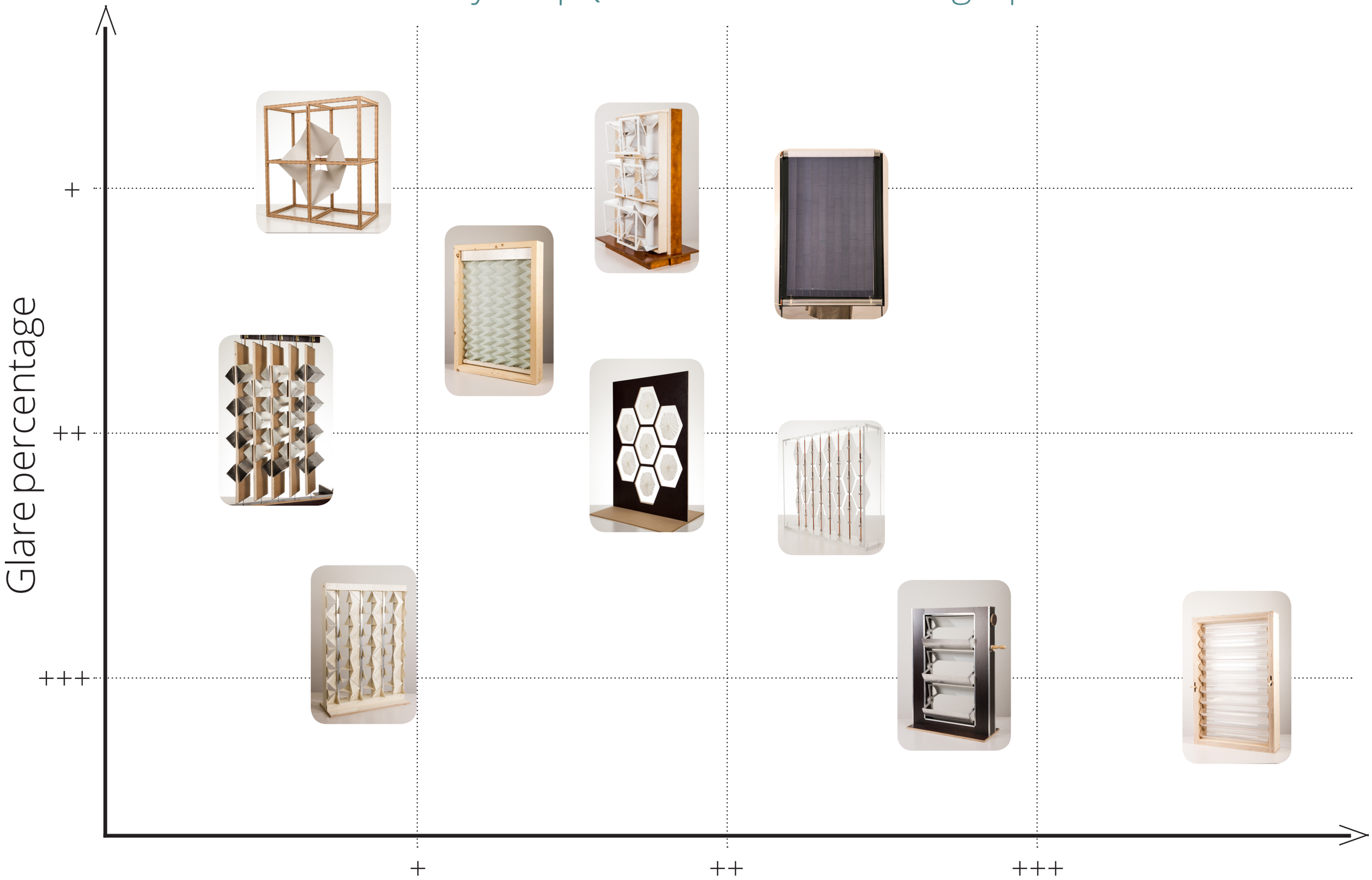
Lamination process



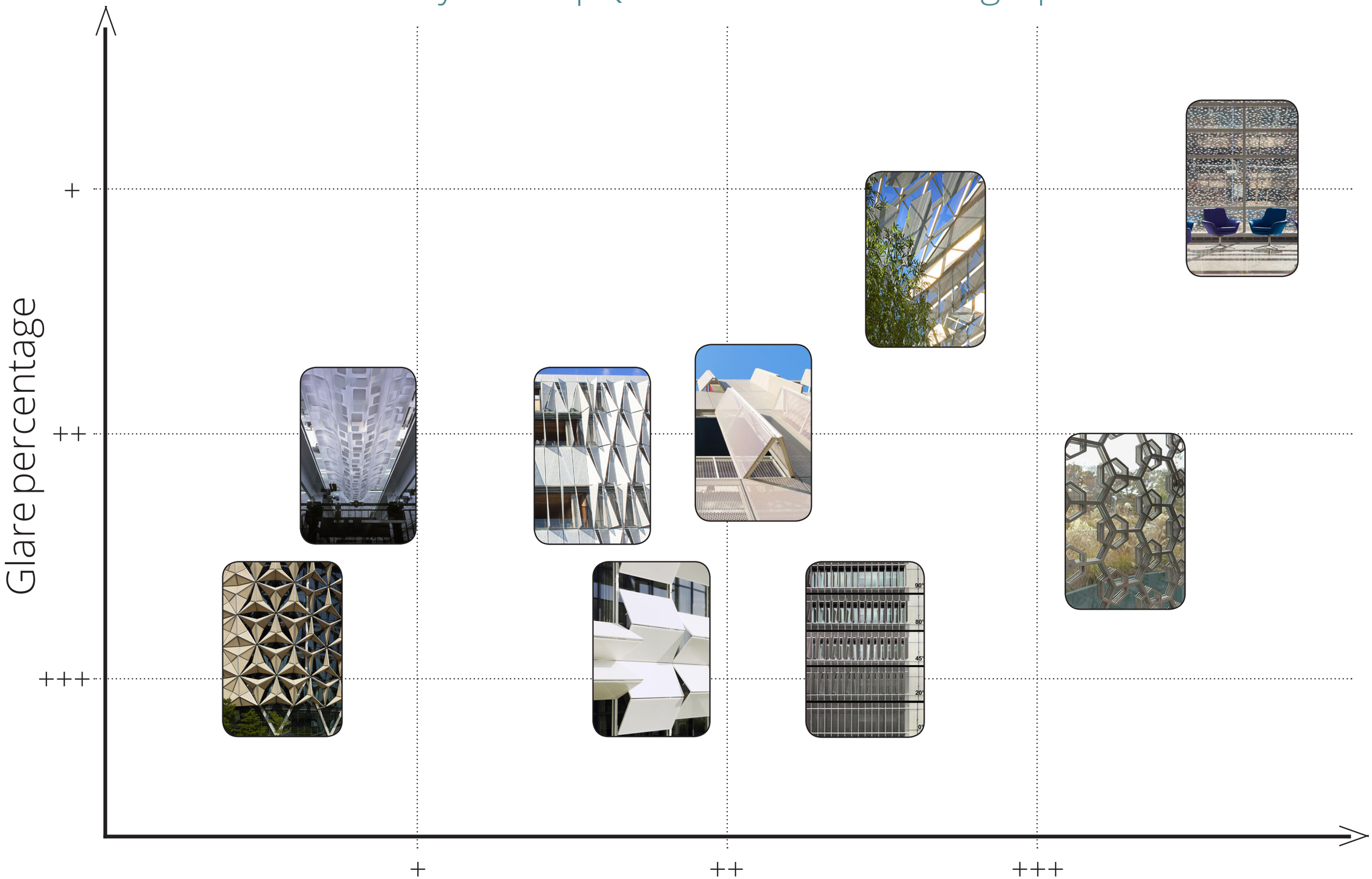
Installation process



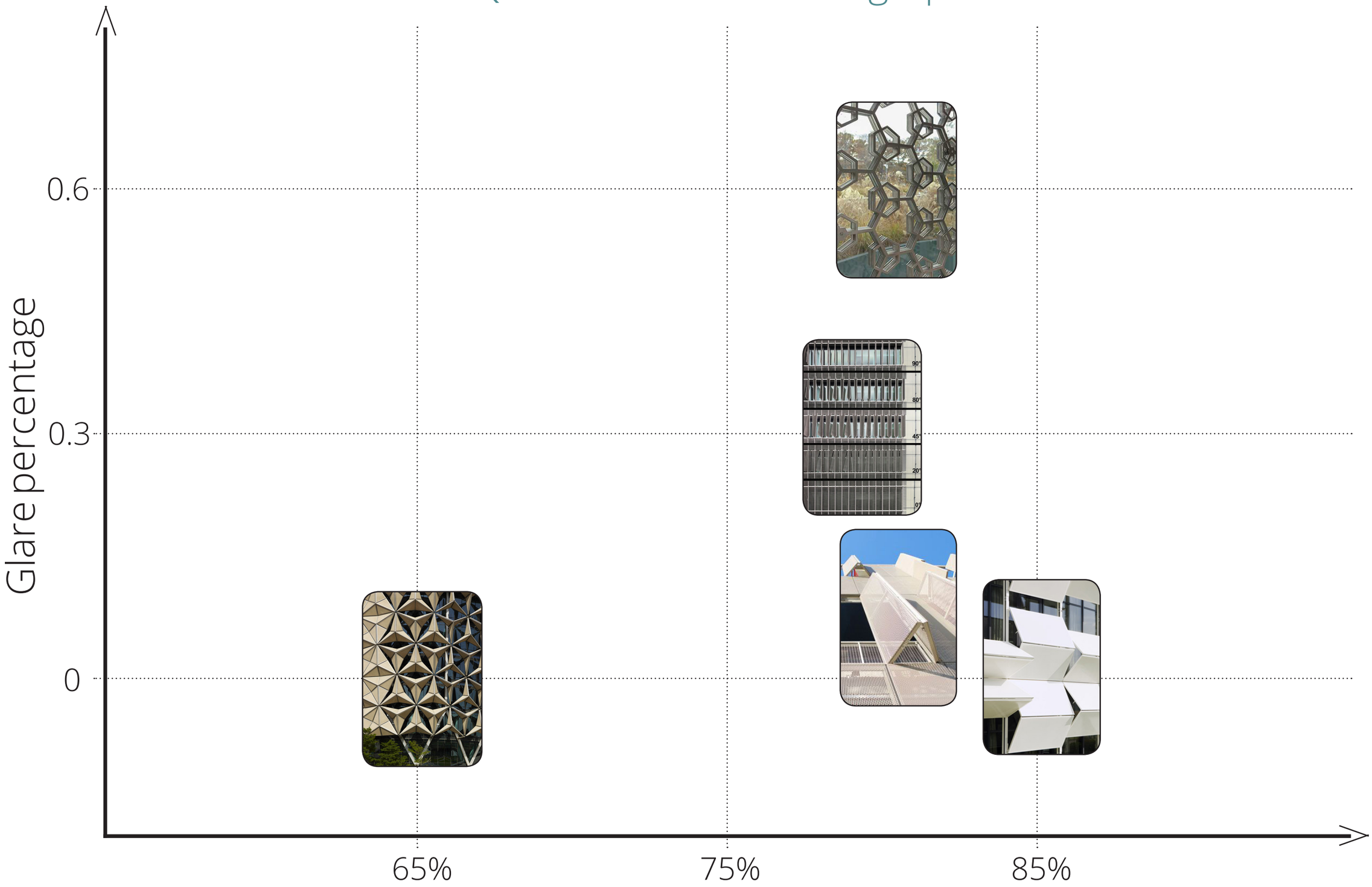
Bucky lab | Qualitative evaluation graph



Study cases | Qualitative evaluation graph



Quantitave evaluation graph



Energy consumption

Energy use | 0.4 Watt/m^2

South orientation

Energy consumptions	No shading system [kWh]	Proposed shading system [kWh]
Energy consumed	2221.08	1431.04
System's energy consumption	-	8.43
Total energy consumption	**2221.08**	**1439.74**

Energy saving

35%

West orientation

Energy consumptions	No shading system [kWh]	Proposed shading system [kWh]
Energy consumed	2083.05	1742.11
System's energy consumption	-	13.85
Total energy consumption	**2083.05**	**1755.96**

16%