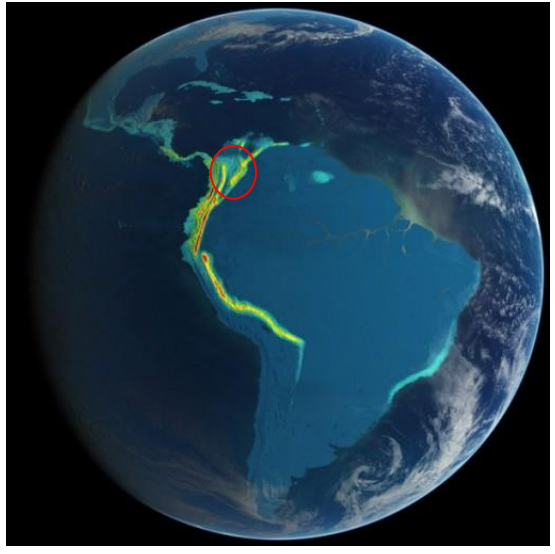


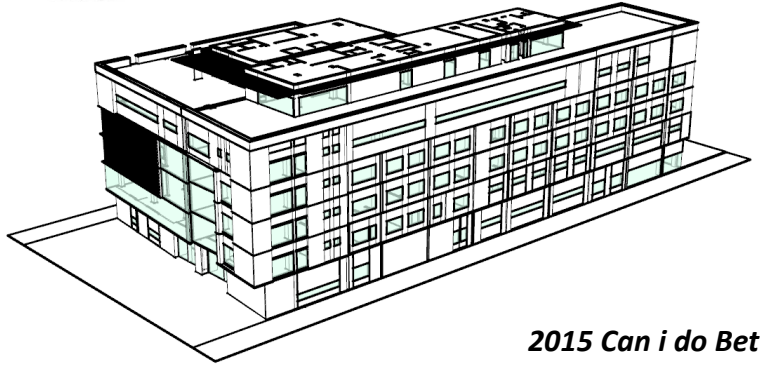
Luis Fernando Garcia Gonzalez
TRANSSOLAR ACADEMY

Passive Power Hospital

My Home,
Colombia – Cota – Cundinamarca
(Close to the capital city Bogota)

Jun 2015

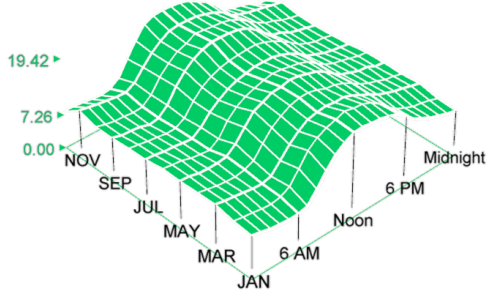
My Design 2013



Long Long time ago

2015 Can i do Better?

Summer = Winter



My HVAC Design 2013, my concern 2015 can I do better, can return to the basics

Jun 2015

Individual Project Agenda

- Project Selection - done
- Project Analysis of „design as is“ – done
- Development of Saving Strategies – done
- Compliance of Strategies with Code – done
- Verification of Strategies by Simulation – done
- Economical Calculation of Paybacktime – done
- Verify, review and generate final report - Current Work

Passive Power Hospital (PPH)

Daylight Status

Improve surface reflectivity

Geometry adjustment

DIN Handled Design

Hybrid

Passive

Mechanical

HVAC Options

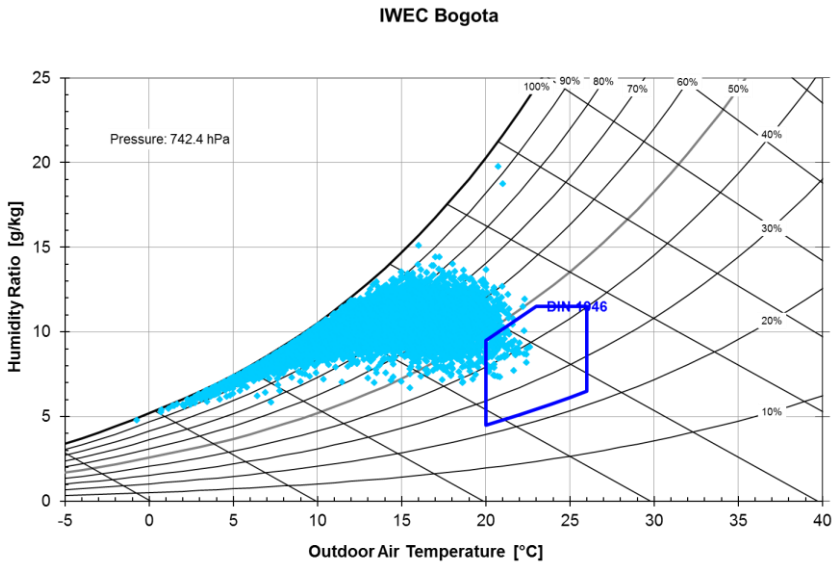
ASHRAE Handled Design

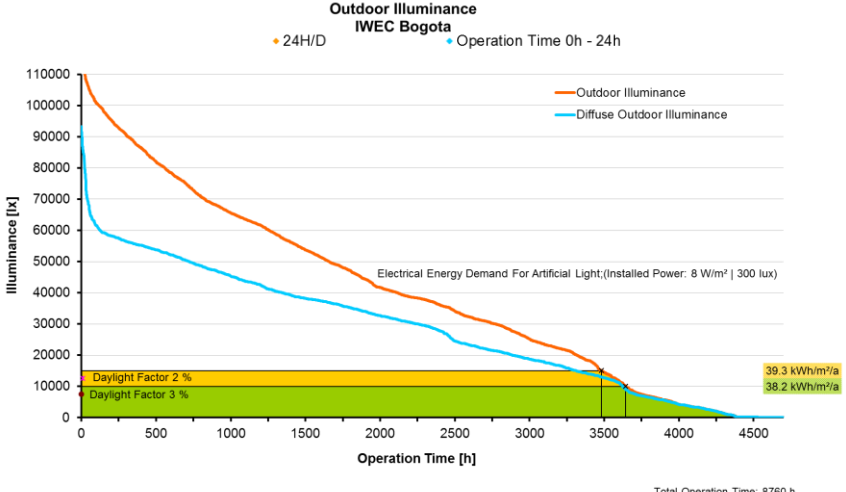
Transsolar Green Box

- ✓ 100 % Outside Air
- ✓ 100% Dayligth
- ✓ 100% Hybrid HVAC

Goals Patient Rooms

This is the work flow of the project, I start with daylight status of the project, and in parallel make the building physics analysis, to compare with the ASHRAE and DIN standards, after that, i continue making a proposal to change the geometry of the building, to achieve the goals of the, DIN Hybrid design.

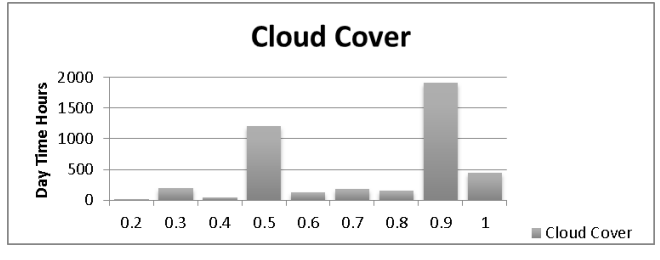




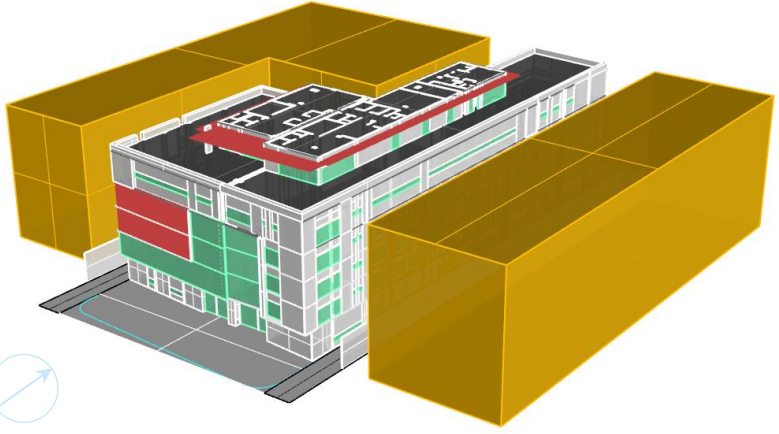
BOGOTA, COLOMBIA
2600 meters above sea level
LATITUDE: 4,7 N
LONGITUDE: 74,13W
DAILY RANGE: 13° C

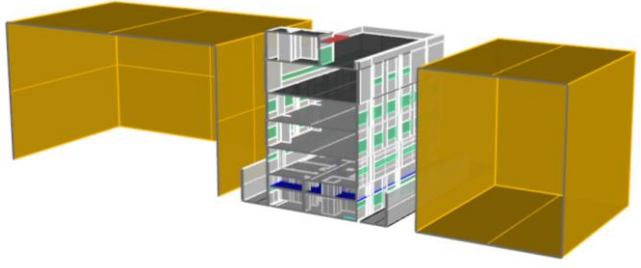
DESIGN CONDITION (0,4%)
COOLING:
21,2 ° C DB , 13,6° C MCWB
CDH23,3 3 HOURS
HEATING:
2,8° C DB
HDD18,3 1752 HOURS
2009 ASHRAE HANDBOOK – FUNDAMENTALS

DIURNAL NOISE LEVELS: 75-80 Db
NIGTH NOISE LEVEL: 70-75 Db



DAYLIGHT ANALISIS

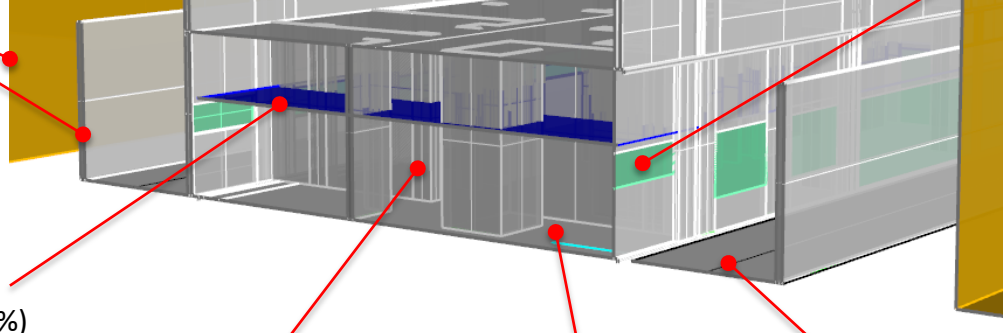




Building Daylight, materials setup.

Wall Exterior
(Reflection 35%)

Glass Transparent
(Transmission 79%)



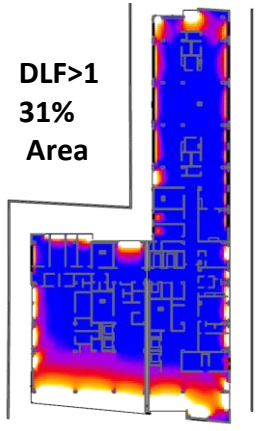
Ceiling
(Reflection 70%)

Wall Interior
(Reflection 50%)

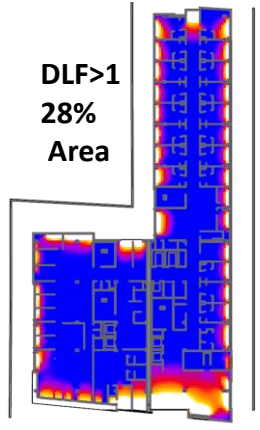
Floor
(Reflection 30%)

Ground
(Reflection 30%)

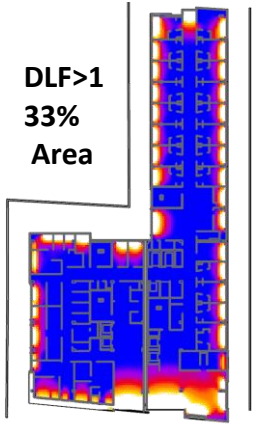
Gr Level



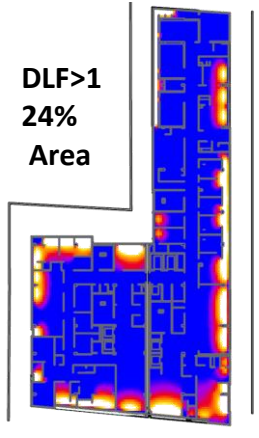
1-Level



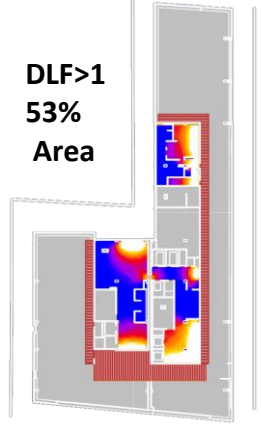
2 - Level



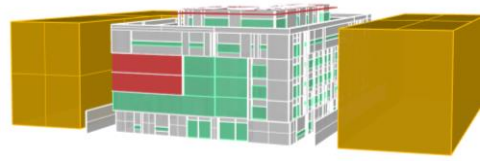
3 - Level



4 - Level

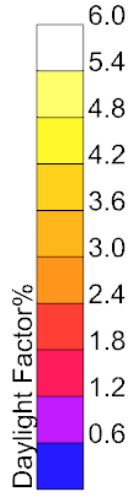


5 - Level



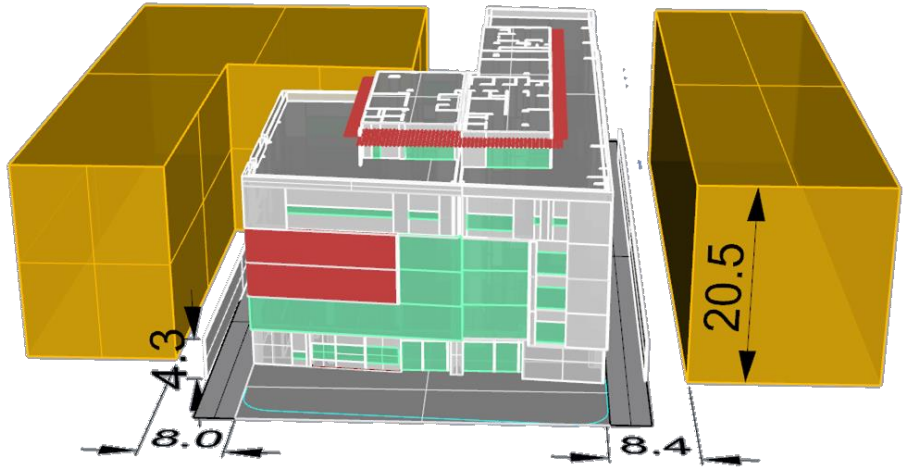
Model design as is

Gross Area with DLF>1, 29%



Daylight Factor, analysis grid 85 cm from Floor, model with internal partitions.

Target
1≤DLF≤5
19≤UGR≤22



Alternatives for improving performance

REFLECTIVITY

Building Daylight, materials setup with improving performance.

Wall Exterior Neighbor
(Reflection 50%)

Wall Exterior
(Reflection 65%)

Ceiling
(Reflection 70%)

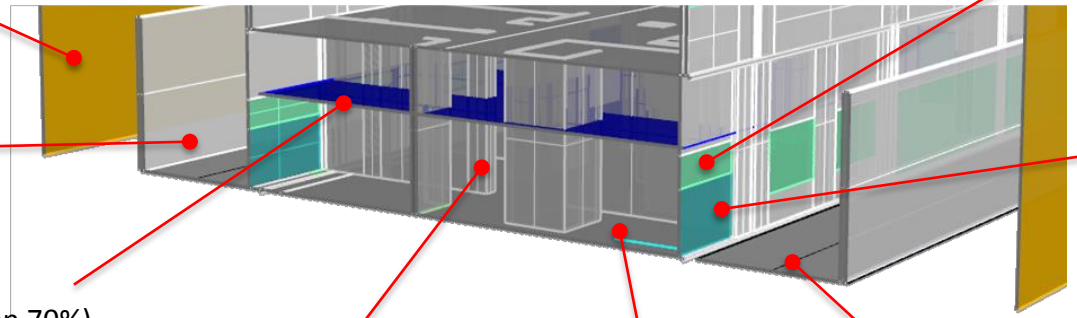
Wall Interior
(Reflection 65%)

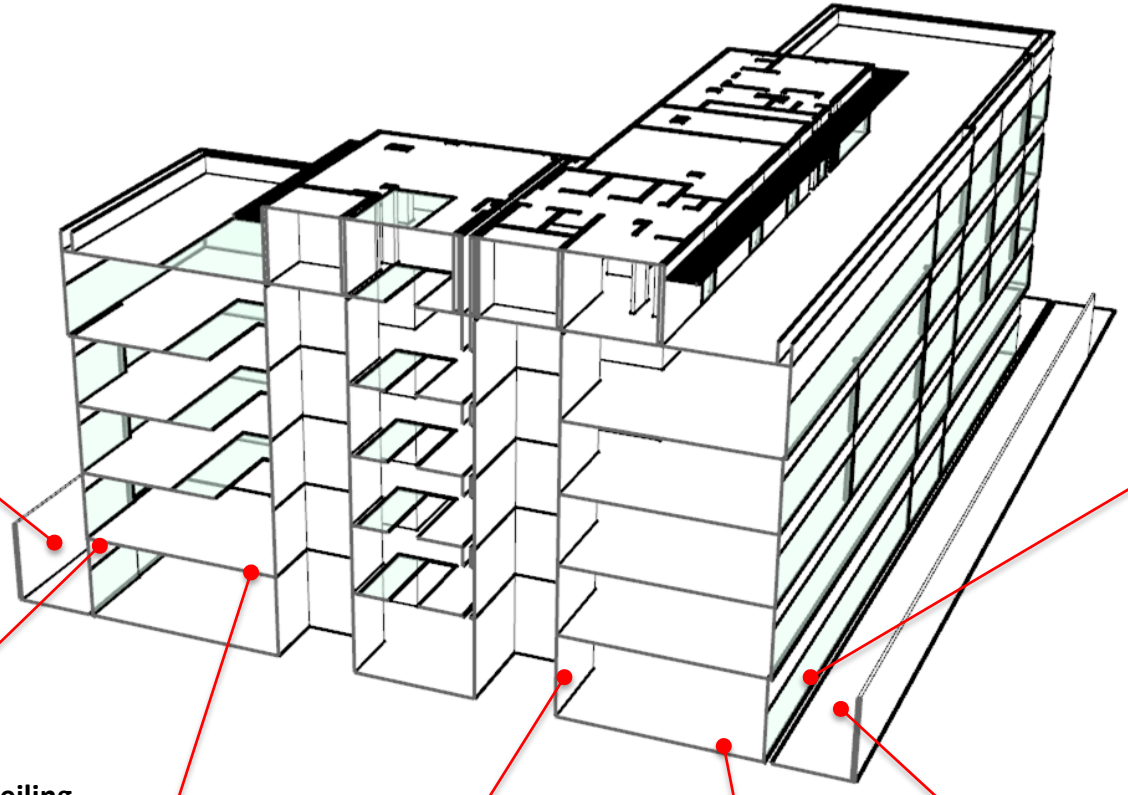
Floor
(Reflection 40%)

Ground
(Reflection 30%)

Glass Transparent
(Transmission 79%)

Glass Trasnparent
(Transmission 50%)





REFLECTIVITY

Nort

Wall Exterior Neighbor
(Reflection 50%)

Wall Exterior
(Reflection 65%)

Ceiling
(Reflection 70%)

Wall Interior
(Reflection 65%)

Floor
(Reflection 40%)

Ground
(Reflection 30%)

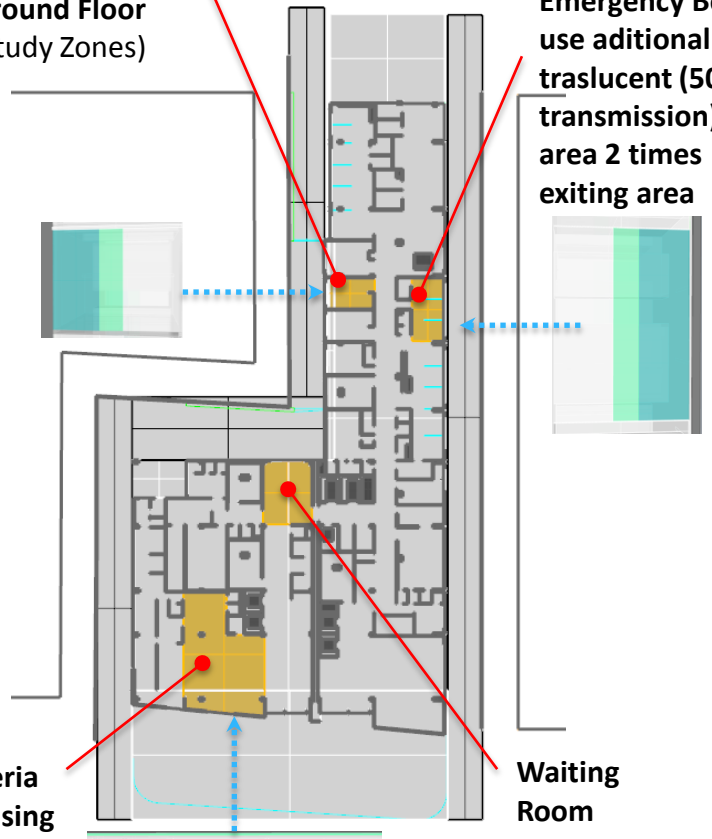
Glass Transparent
(Transmission 79%)

Building Daylight, materials setup with improving performance.

Healing Room use aditional traslucent (50% transmission) area 2 times exiting area

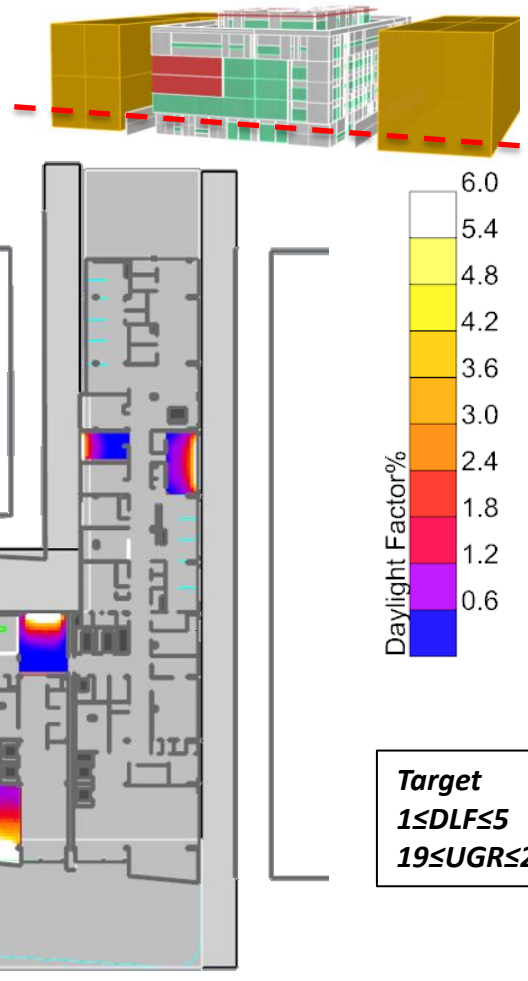
Ground Floor
(Study Zones)

Emergency Box use aditional traslucent (50% transmission) area 2 times exiting area



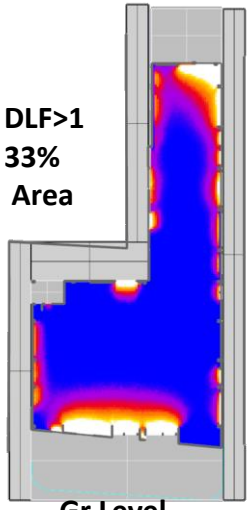
Cafeteria Increasing window area in 270%

Waiting Room

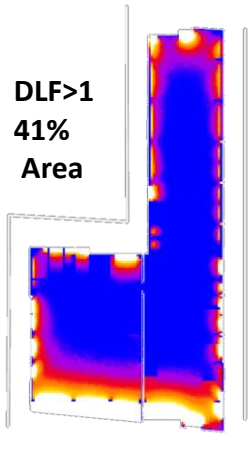


Daylight Factor, analysis grid 85 cm from Floor, first floor key zones study.

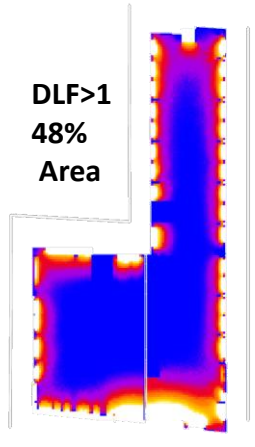
Target
1≤DLF≤5
19≤UGR≤22



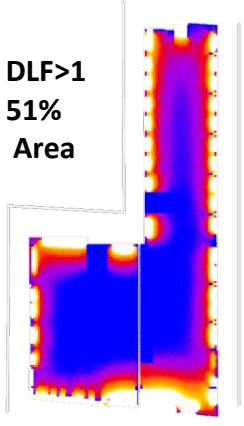
Gr Level



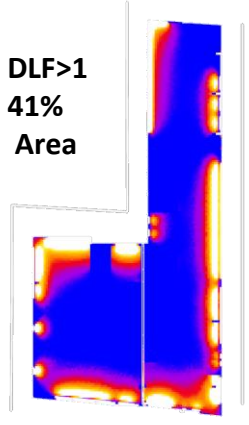
1-Level



2 - Level

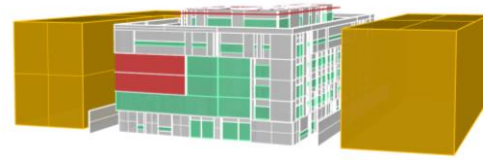


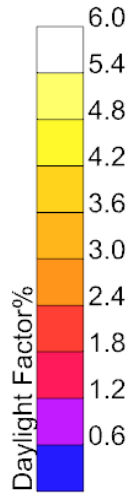
3 - Level



4 - Level

5 - Level





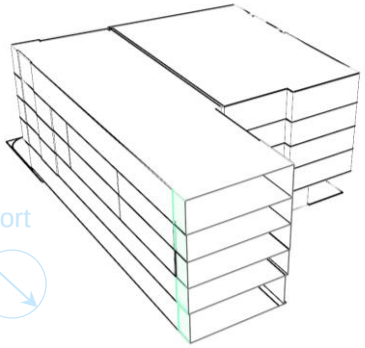
Model without internal partitions

Gross Area with DLF>1, 48%

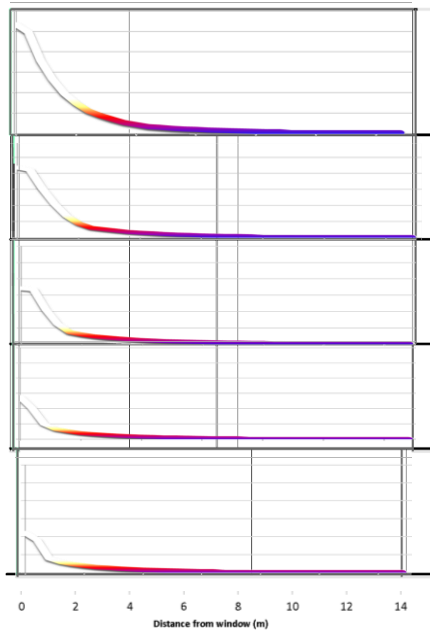
Daylight Factor, analysis grid 85 cm from Floor, model without partitions and materials with reflection improvement.

Target
1≤DLF≤5
19≤UGR≤22

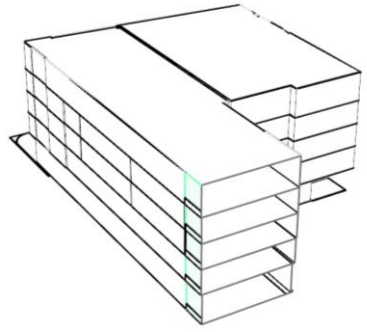
DAYLIGHT IMPROVEMENT



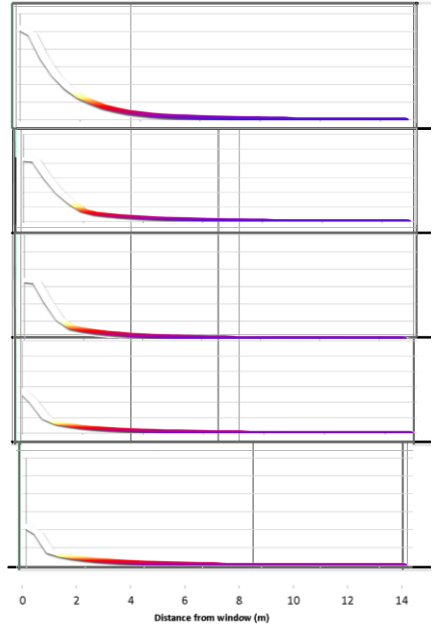
100 % glass facade



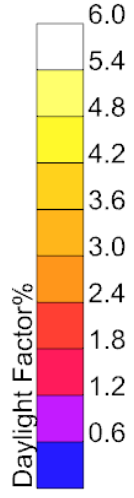
Distance from window with DLF>1



85 cm Balustrade



Distance from window with DLF>1



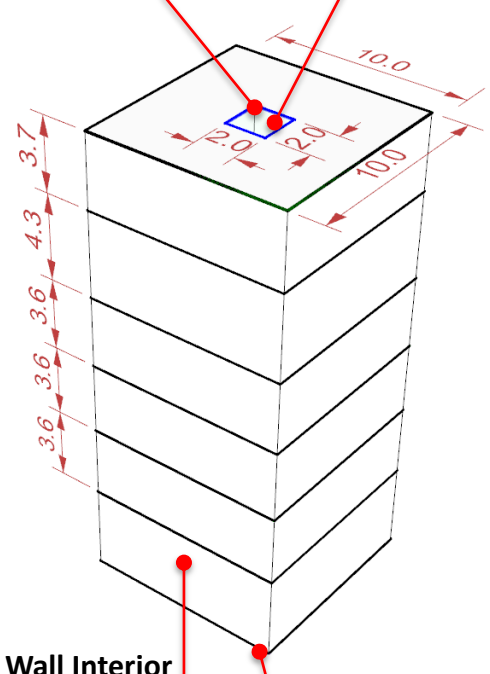
Options for improvement: increase the Window Wall Ratio (WWR)

Target
1≤DLF≤5
19≤UGR≤22

DLA-Minimun 300 lux,
8-18 Hours

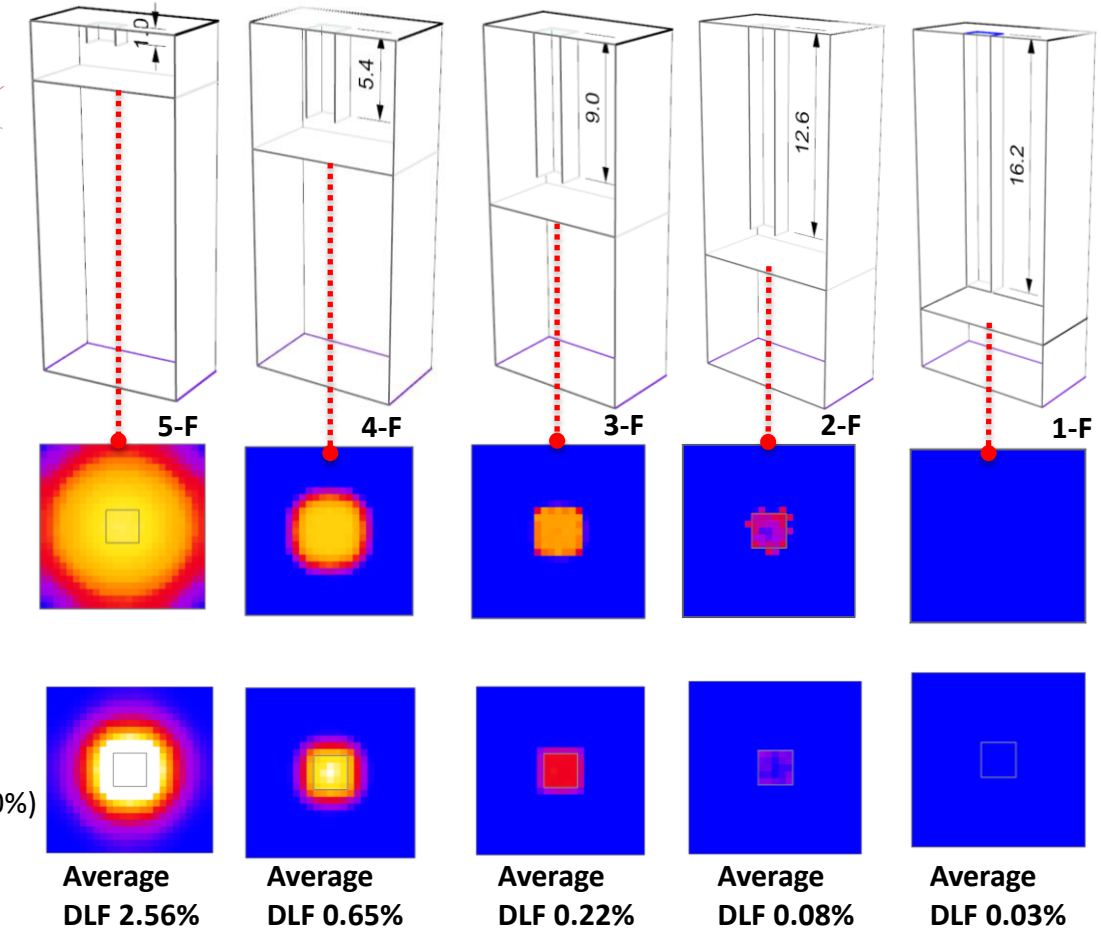
Wall Interior
(Reflection 90%)

Glass Transparent
(Transmission 81%)



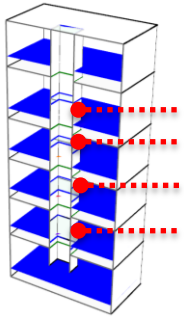
Wall Interior
(Reflection 65%)

Floor
(Reflection 40%)



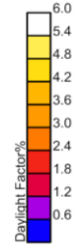
Options for improvement: Use a light duct

Light Duct

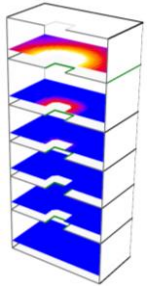


20%Glass
40%Glass
60%Glass
80%Glass

5-F	4-F	3-F	2-F	1-F	G-F
Average DLF 0.01%	Average DLF 0.01%	Average DLF 0.01%	Average DLF 0.01%	Average DLF 0.01%	Average DLF 0.00%

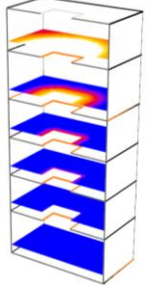


Light Opening 2x2 m



Average DLF 4.58%	Average DLF 1.93%	Average DLF 1.14%	Average DLF 0.57%	Average DLF 0.01%	Average DLF 0.00%

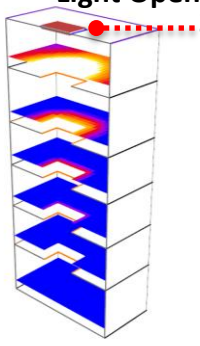
Light Opening 3x3 m



Average DLF 6.02%	Average DLF 1.20%	Average DLF 0.23%	Average DLF 0.09%	Average DLF 0.04%	Average DLF 0.05%

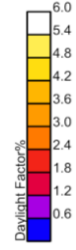
Options for improvement: Use a light duct with different configurations.

Light Opening 3x3 m

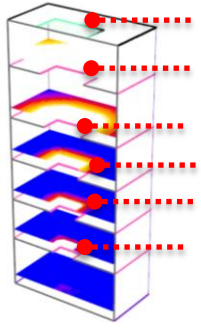


20 cm height louver

5-F	4-F	3-F	2-F	1-F	G-F
Average DLF 4.27%	Average DLF 1.00%	Average DLF 0.21%	Average DLF 0.08%	Average DLF 0.03%	Average DLF 0.04%

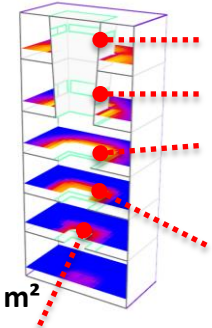


Light Opening



20.5m²
16.0m²
12.25m²
9.0m²
6.25m²
4.0m²

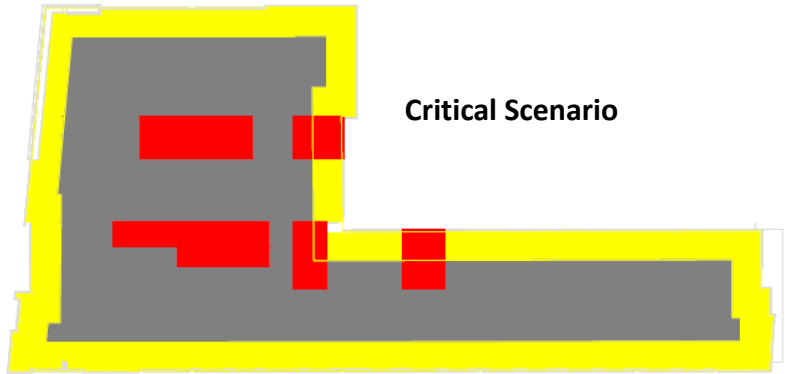
Average DLF 12.69%	Average DLF 4.11%	Average DLF 0.82%	Average DLF 0.31%	Average DLF 0.12%	Average DLF 0.05%

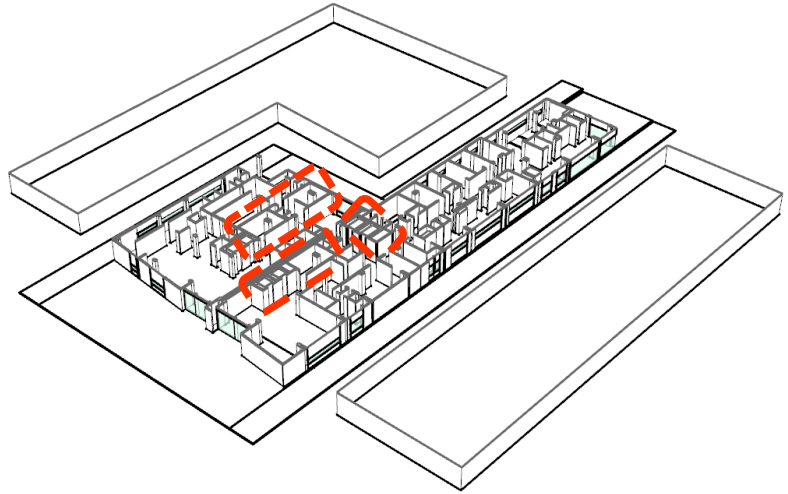


20%Glass
40%Glass
7.4 m² Floor Glass
10 m² Floor Glass
12.1 m² Floor Glass

Average DLF 2.74%	Average DLF 2.80%	Average DLF 2.05%	Average DLF 0.86%	Average DLF 0.35%	Average DLF 0.2%

Options for improvement: Use a light duct with different configurations.





Critical scenario Daylight status.

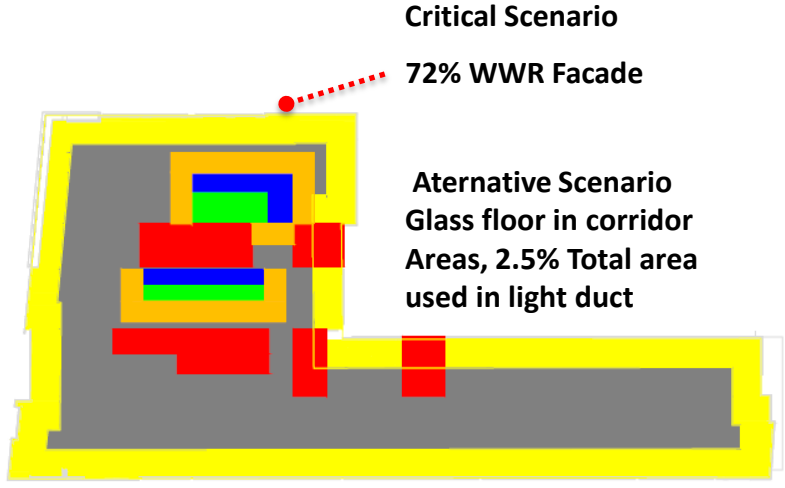
building zones fixed

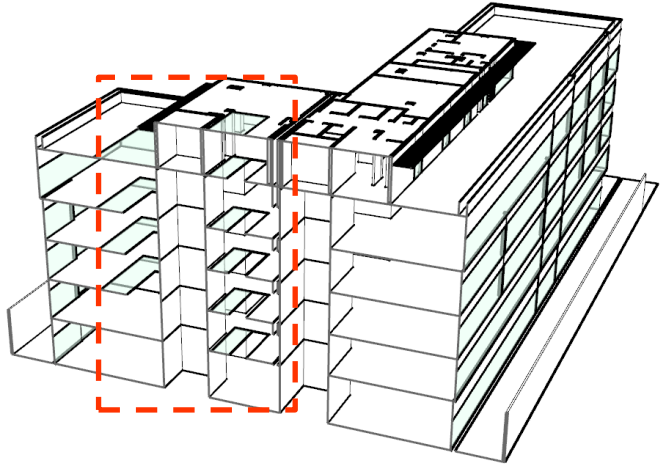
Services: EmergencyStaircases, elevator.

Intention Reduce Dark Area

Total Floor Area: 1637m²
Services Area: 163m² (10% Total)
Dark Area: 920m² (56%Total)
WWR: 30%

Services | **Glass Floor** | **Dark Area** | **Light Opening** | **Acual DayLight** | **Projected DayLight**

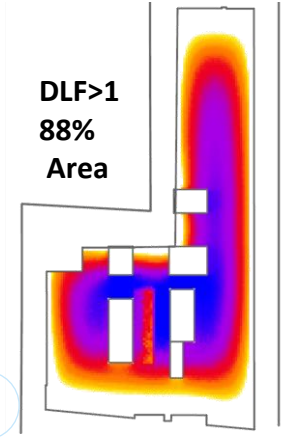




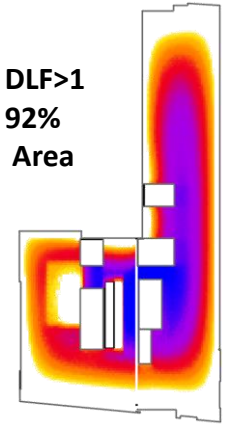
Alternative
Total Floor Area: 1637m²
Services Area: 163m² (10% Total)
Light Duct: 41m² (2.5% Total)
Glass Floor: 44m² (2.7%Total)
Projected Dark Area: 735m² (45%Total)

Propose for improvement: light ducts, glass floor, conserving the services zones and increasing the WWR.

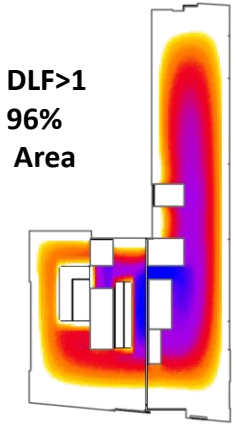
Services | **Glass Floor** | **Dark Area** | **Light Opening** | **Acual DayLight** | **Projected DayLight**



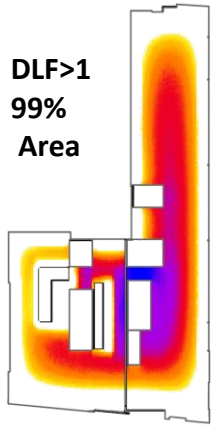
Gr Level



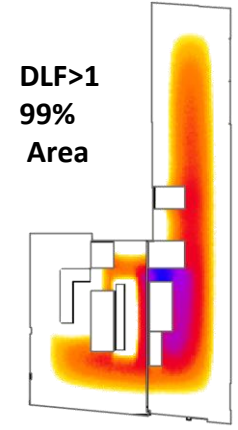
1-Level



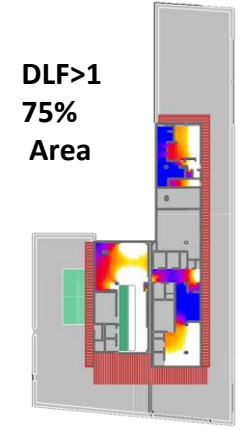
2 - Level



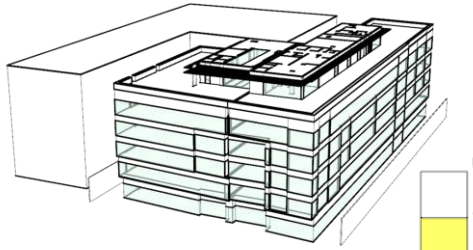
3 - Level



4 - Level

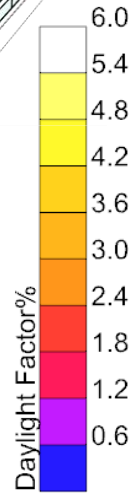


5 - Level



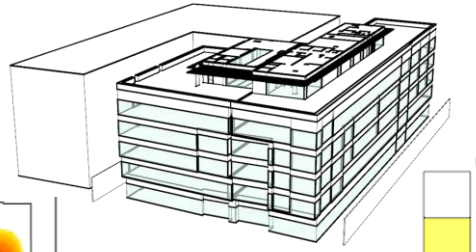
Model without internal partitions

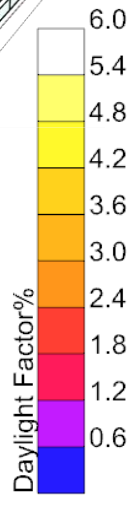
Gross Area with DLF>1, 95%



Target
1≤DLF≤5
19≤UGR≤22

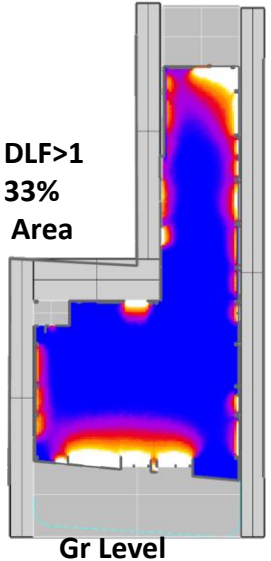
Daylight Factor, analysis grid 85 cm from Floor, model without partitions and materials with reflection improvement and geometry adjustment.



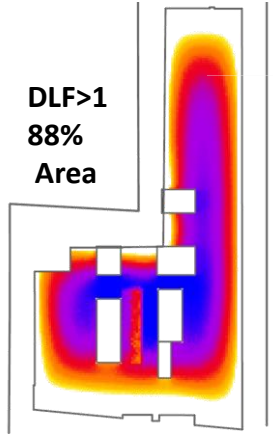


Comparison between each stage of study.

Gr Level



Gr Level



Gr Level

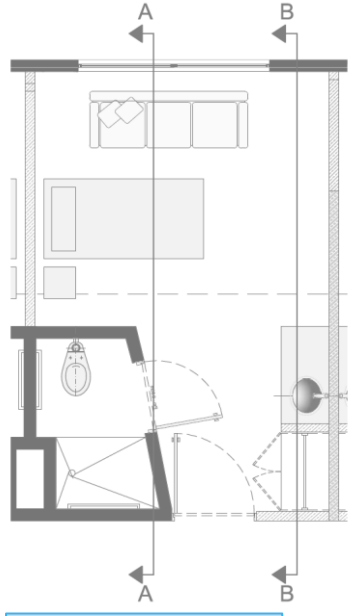
Model without internal partitions

Target
1≤DLF≤5
19≤UGR≤22

THERMAL ANALISIS

Third Floor Patient Room – Standard HVAC Design

COMMON PRACTICE CONSTRUCTION



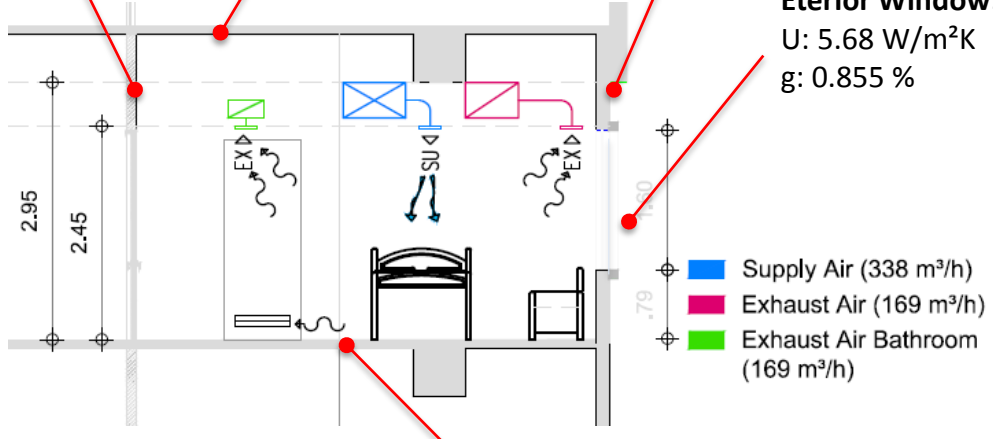
Area: 18.6 m²

Partition Wall:
Thickness: 0.15 m
U: 1.57 W/m²K

Ceiling:
Thickness: 0.16 m
U: 1.871 W/m²K

Eterior Wall:
Thickness: 0.15 m
U: 1.57 W/m²K

Eterior Window:
U: 5.68 W/m²K
g: 0.855 %



Artificial Lighting:
10 W/m²

Floor:
Thickness: 0.16 m
U: 1.871 W/m²K

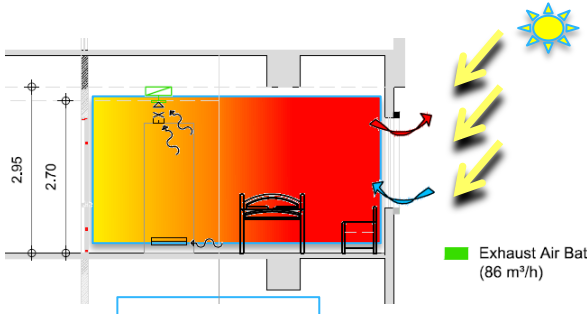
Standard hvac system, in typical patient room with common construction materials.

Third Floor Patient Room – Hybrid Design

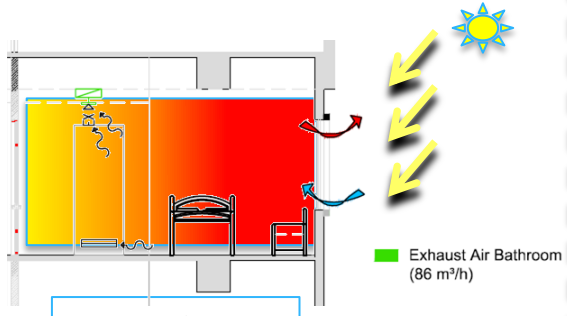
Bogota, Improve standard envelope construction

Bucaramanga, Improve standard envelope construction

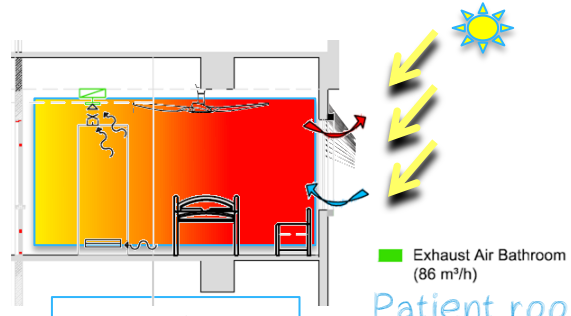
Cartagena, Rammed earth Walls, high reflective glass



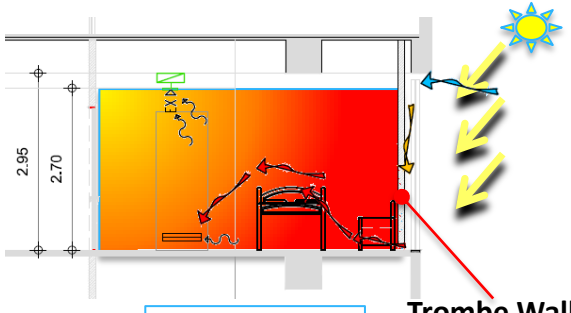
A-A Section



A-A Section



A-A Section



B-B Section

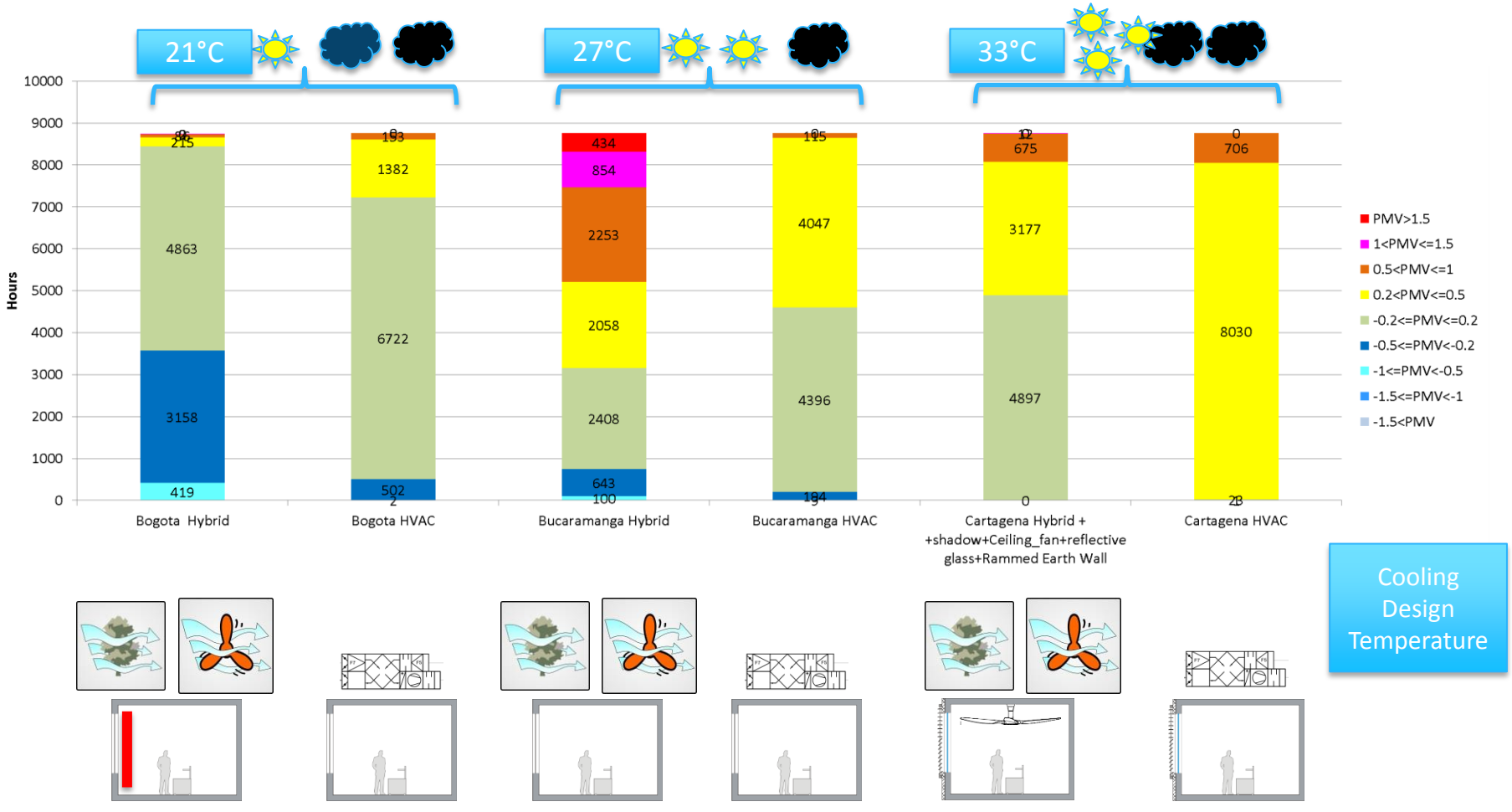
Trombe Wall:
Air chamber: 0.1m
One single glass
Brick Wall

~~**Trombe Wall**~~

~~**Trombe Wall**~~

Patient room hybrid design, in three different cities.
Bogota: Improve standard envelope construction (lowest U values) with trombe wall
Bucaramanga: Improve standard envelope construction (lowest U values) without trombe wall
Cartagena: Improve standard envelope construction (lowest U values), high thermal mass without trombe wall

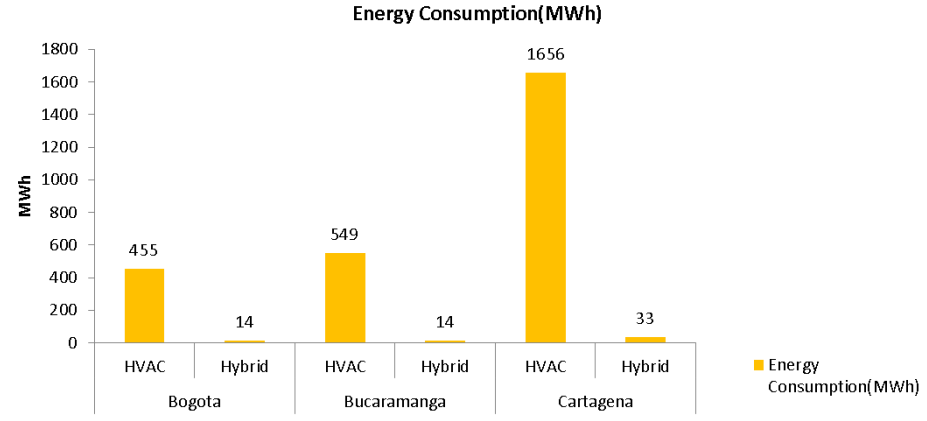
Patient Room – Thermal Scenarios – Diferent Locations

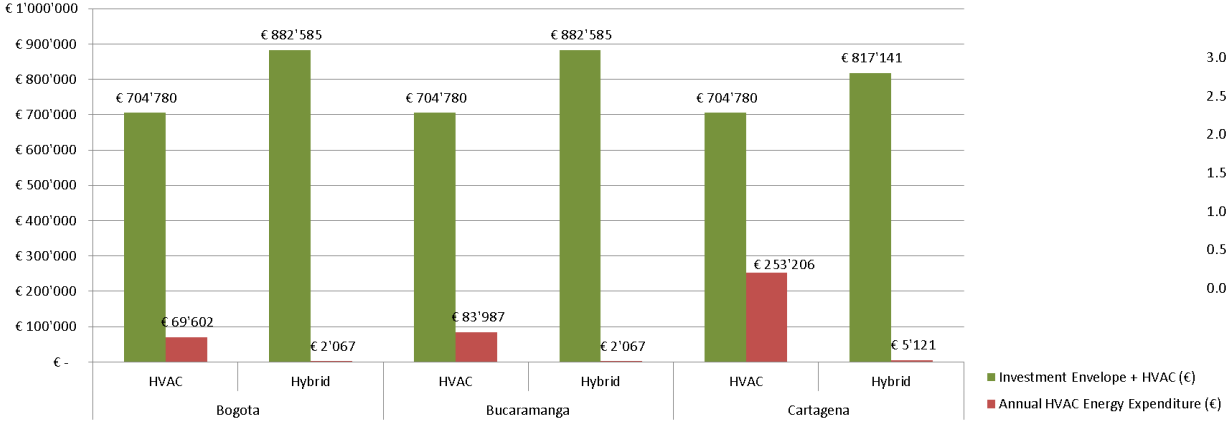


Cooling Design Temperature

Predicted mean vote for Patient room hybrid design, in three different cities.
Bogota: Improve standard envelope construction (lowest U values) with trombe wall
Bucaramanga: Improve standard envelope construction (lowest U values) without trombe wall
Cartagena: Improve standard envelope construction (lowest U values), high thermal mass without trombe wall, window shading and ceiling fan

Patient Room – Energy Economic Scenarios





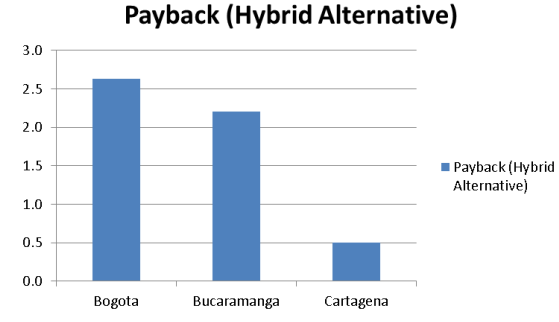
Estimated Mechanical Ventilation System Installation Cost:
3919 € / 1000 [m³/h]

Number of patient Rooms: 38

Energy Cost:
0.15291[€/kWh]

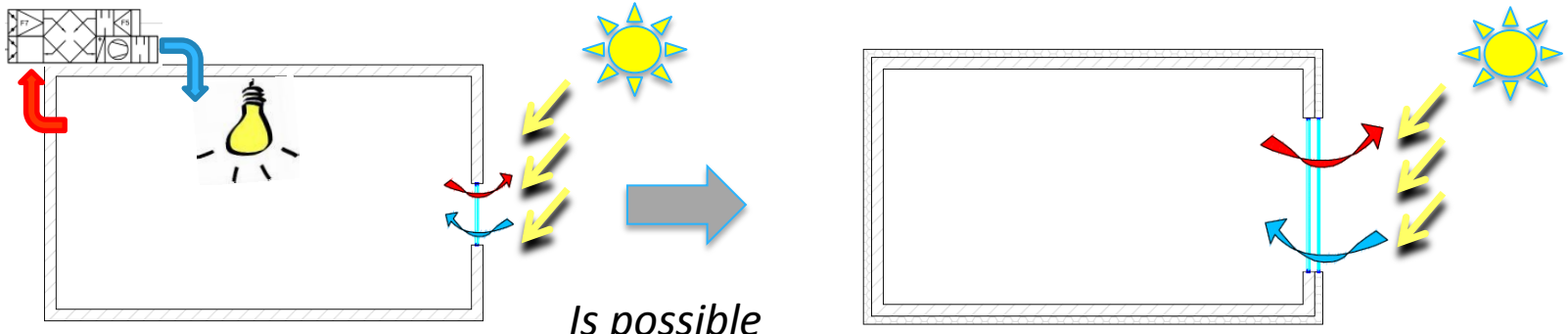
Fan Power [kW] :
L/s * 0.0017

Acoustic Louver: 500[€/each]



38 Patient room Economic Scenarios, in three different cities.
Bogota: cost analysis including envelope materials, and hybrid system.
Bucaramanga: cost analysis including envelope materials, and hybrid system.
Cartagena: cost analysis including envelope materials, and hybrid system ceiling fan.

Conclusion



Is possible
YES