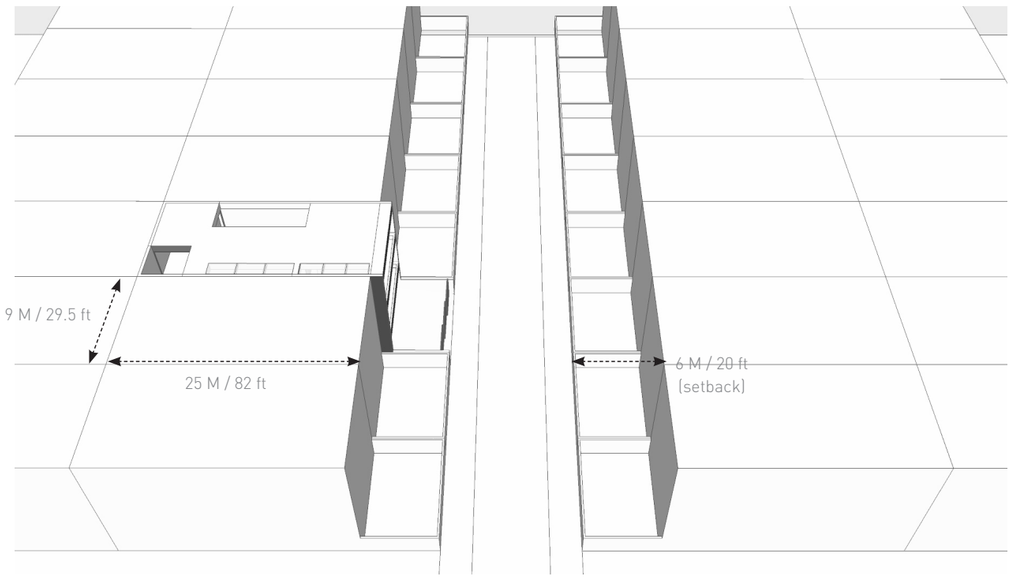
ARCHITECTURE IN THE DAYLIGHT

MANUS LEUNG
HARVARD GSD FALL 2015

Site Location

The house is located in Jl. Intern Corn Kebun Jeruk Blok U3 No.18,
Kembangan District of Jakarta 11640
Indonesia.



Site Condition and Constraints

1. Entry 2. Living Room 3. Pool 4. Bedroom 5. Void 6. Skylight

Background

The project for this daylight analysis is a three level family house situated in a suburbia neighborhood of Jakarta. The house is situated an area where the land is sub-divided into individual plots for terrace house development. Each plot of land is roughly 25M (92ft) deep, and 9M (29.5ft) wide, with a height limit of 12M (40ft). Each house is required to set back 6M (20ft) from the street elevation, that is usually used as a car porch.

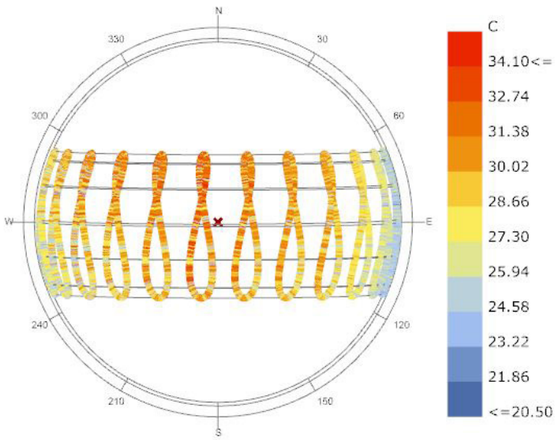
Given the constraints of a terrace house where no possible openings can be made along its side boundaries, the design adopted a series of skylights and voids as a strategy to maximize the amount of daylight entering the house.

Objectives

Apart from basic orientation studies, the daylight performance of the design is relatively unknown. The purpose of this exercise is to:

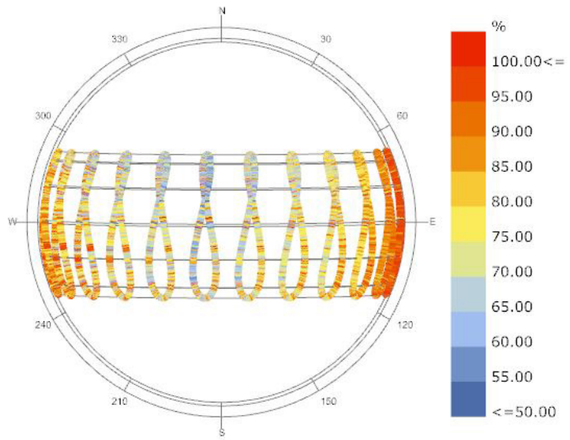
- Investigate the amount of daylight available with the current base design.
- Improve the quality of natural daylighting into the main living space of the house (level 1).
- Make adjustments to the design that integrates daylighting as part of the design narrative.

Assumptions: As there are no weather data files for Jakarta, the daylight analysis will be conducted using data collected from Kuching, Malaysia in the Southwest Pacific region, as that is the closest available weather file.



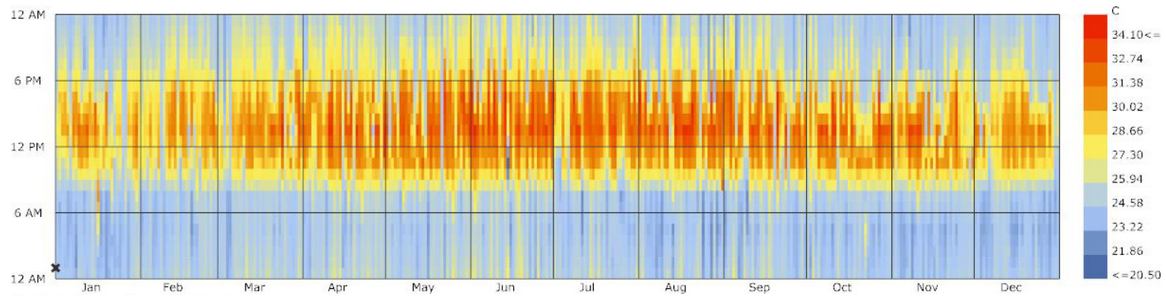
Sun-Path Diagram - Latitude: 1.48
Hourly Data: Dry Bulb Temperature (C)
KUCHING_MYS

ANNAUL DRY BULB TEMPERATURE

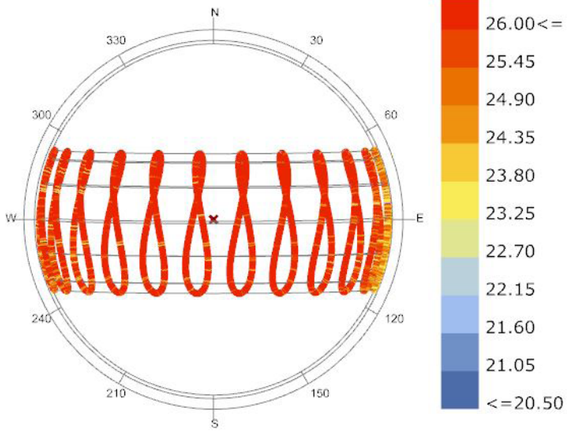


Sun-Path Diagram - Latitude: 1.48
Hourly Data: Relative Humidity (%)
KUCHING_MYS

ANNAUL RELATIVE HUMIDITY

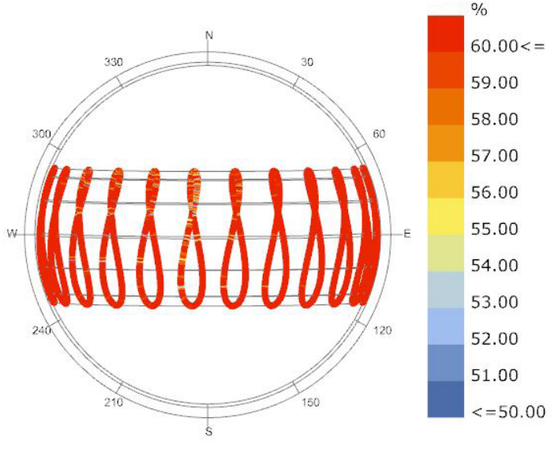


DRY BULB TEMPERATURE (C) - HOURLY
1 JAN 1:00 - 31 DEC 24:00



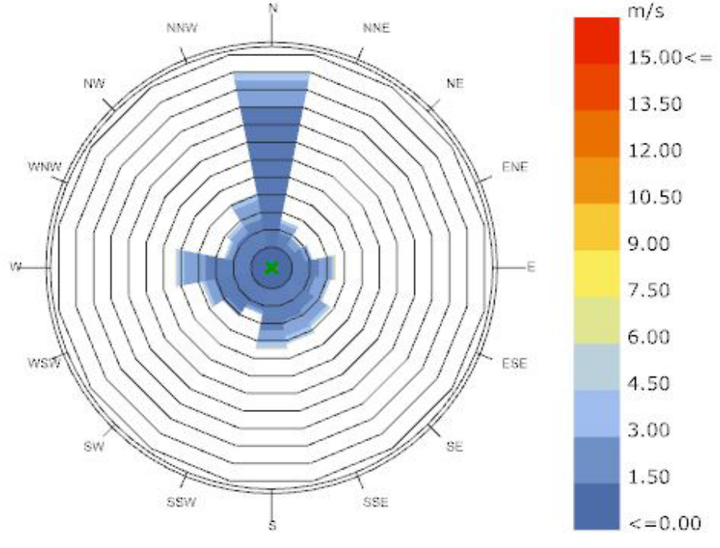
Sun-Path Diagram - Latitude: 1.48
Hourly Data: Dry Bulb Temperature (C)
KUCHING_MYS

DRY BULB TEMP WITH UPPER LIMIT SET TO 26C



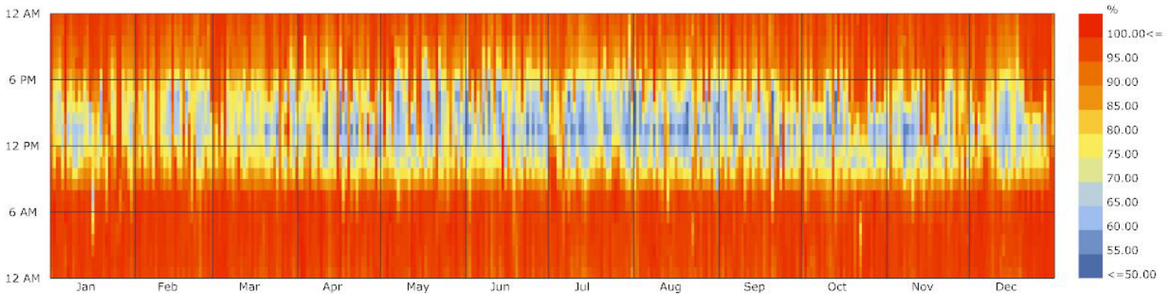
Sun-Path Diagram - Latitude: 1.48
Hourly Data: Relative Humidity (%)
KUCHING_MYS

RELATIVE HUMIDITY WITH UPPER LIMIT SET TO 60%

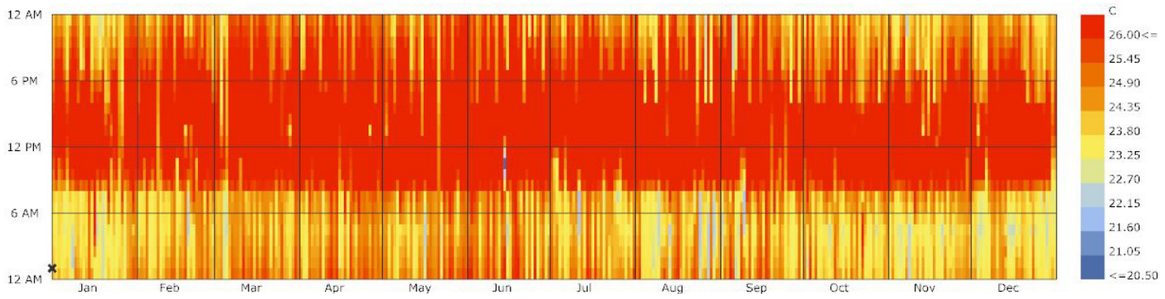


WIND-ROSE

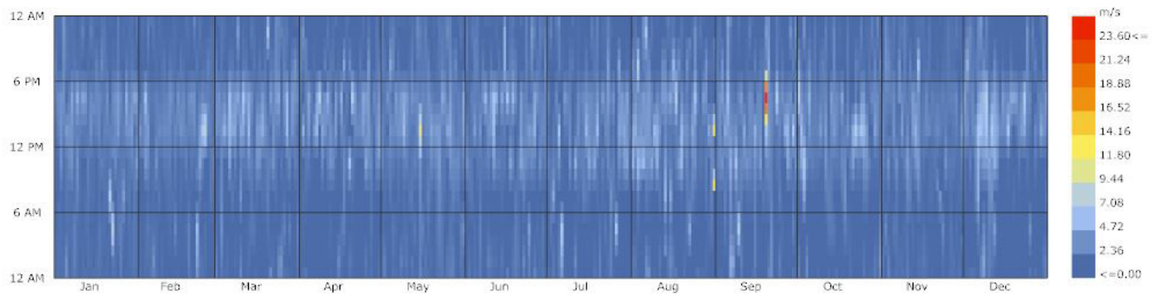
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 28.55% of the time = 2501 hours.
Each closed polyline shows frequency of 1.5% = 133 hours.



RELATIVE HUMIDITY (%) - HOURLY
1 JAN 1:00 - 31 DEC 24:00



DRY BULB TEMPERATURE (C) - HOURLY
1 JAN 1:00 - 31 DEC 24:00
* High bound set at 26.0 C



WIND SPEED (m/s) - HOURLY
1 JAN 1:00 - 31 DEC 24:00

Climate in Jakarta

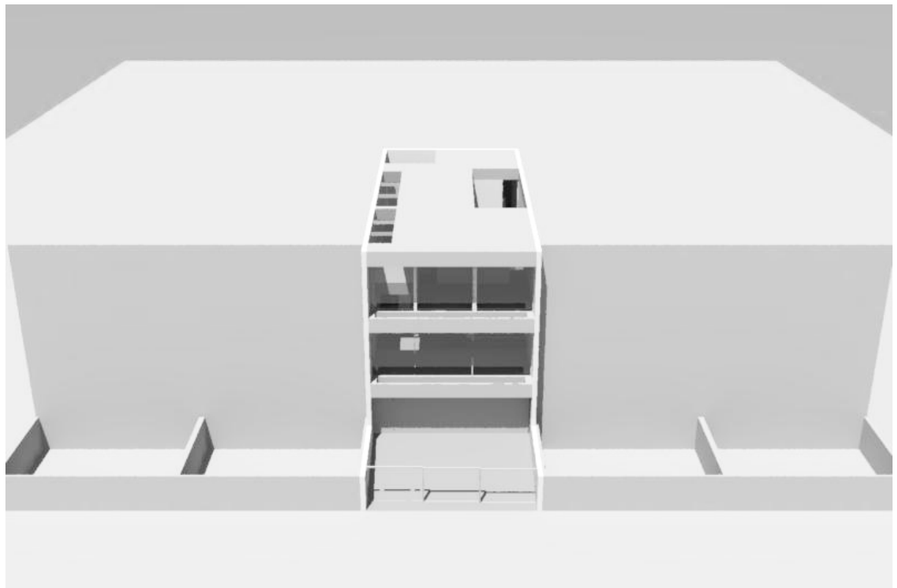
Jakarta is located relatively close to the equator with a tropical monsoon climate.

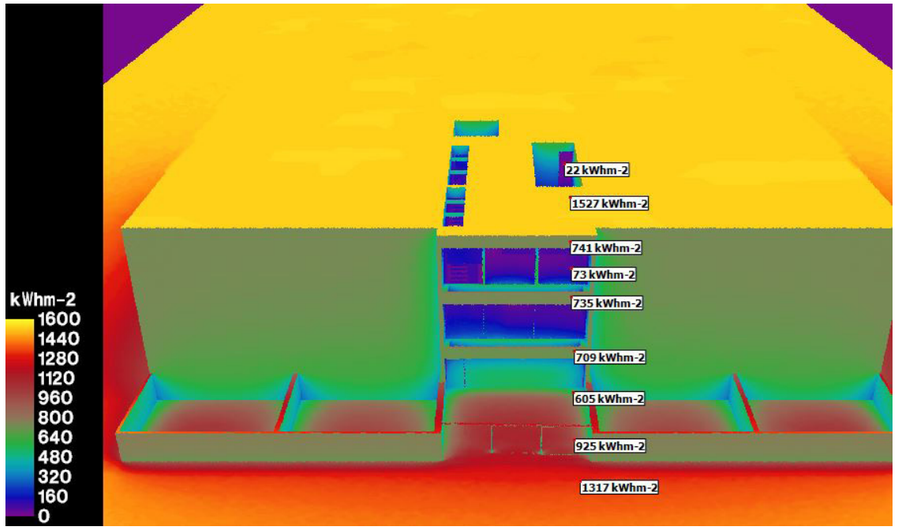
The average high temperature ranges from 29.9 °C to 32.7 °C, and the average low temperature ranges from 24.2 to 25.5 °C annually. And to compare this to its relative humidity, its average ranges from 75% to 85% all year round.

With such a high temperature and relative humidity all-year-round, the use of adaptive comfort ventilation will be an ideal strategy to maintain comfort while inside the house. The skylights and voids within the design should provide a stack effect and cross ventilation to minimize the use of mechanical cooling. However, access to wind is limited to the north orientation with relatively low wind speed of approximately 3m/s as its highest.

Objectives

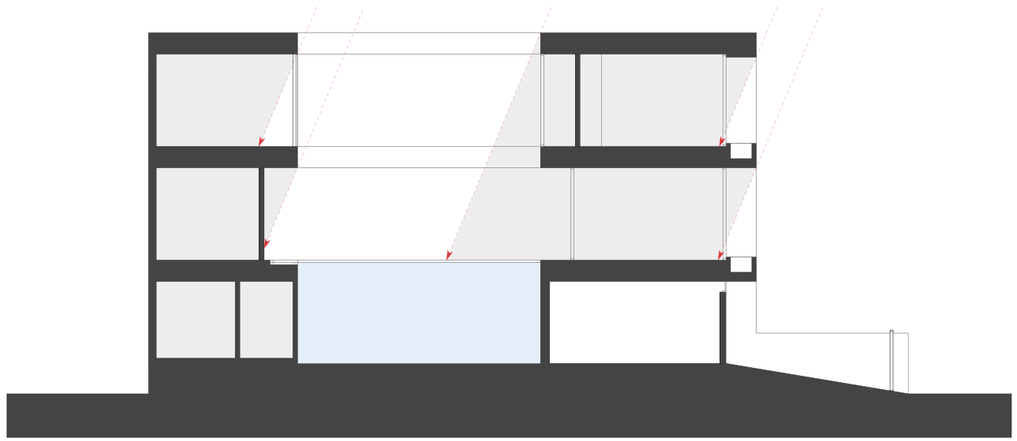
- Control the amount of daylight entering the house to minimize heat gain will be crucial to provide thermal comfort.



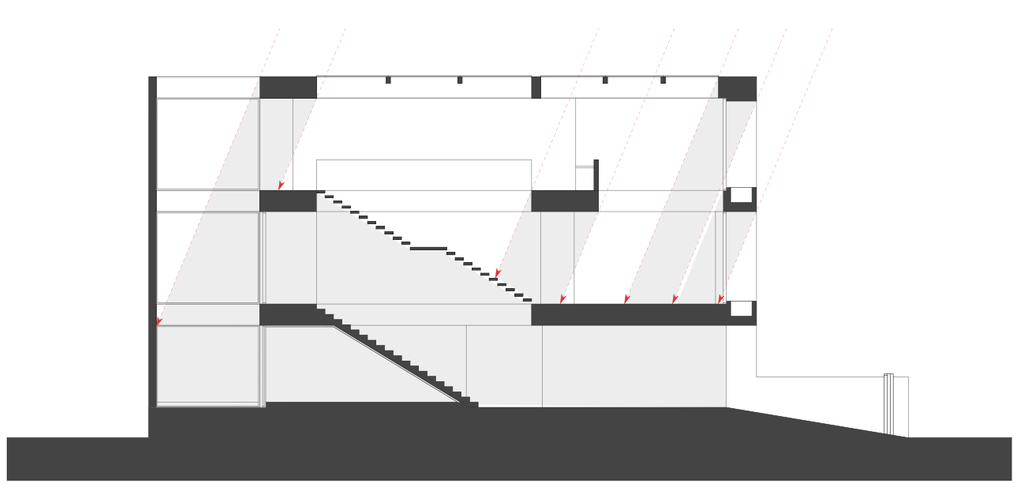


Exterior Radiation Map

The reading shows an evenly distributed high level of radiation on the roof and ground (horizontal planes) and almost a 50% decrease to all vertical planes. Being relatively close to the equator, sun angles for the summer and winter solstice are relatively high.



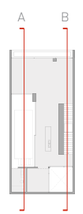
A

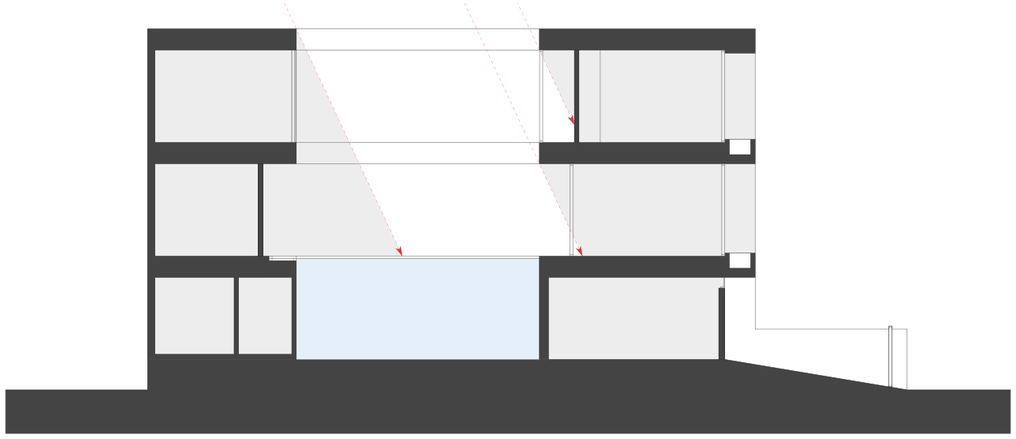


B

JUN21 12.00

Sun angle at 25°





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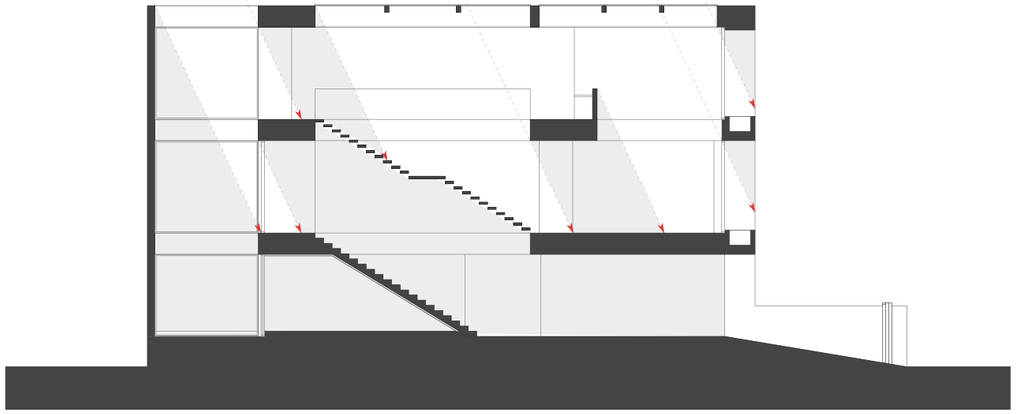
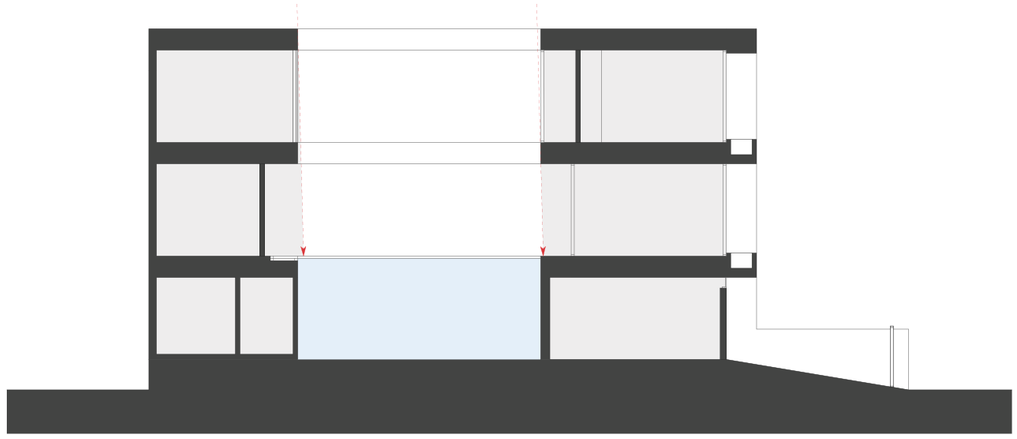


B

DEC21 12.00

Sun angle at 25°



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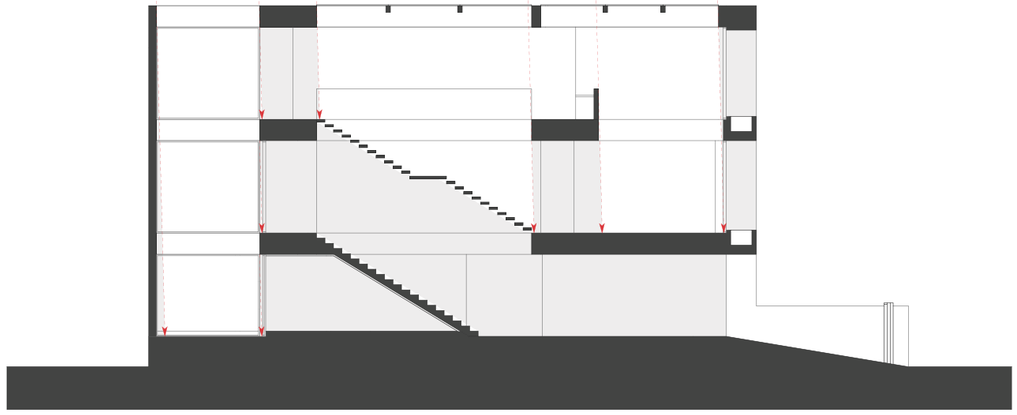
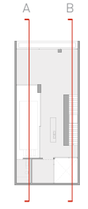


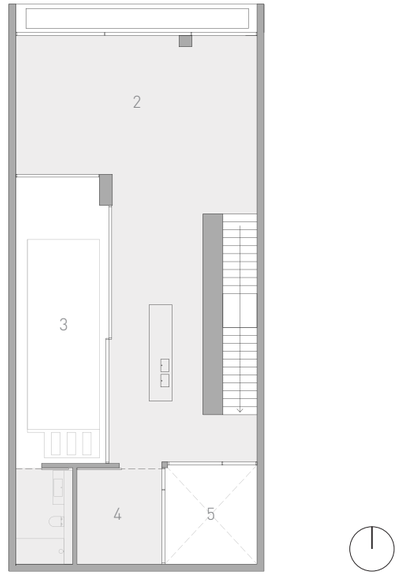
B

MAR21 12.00

Sun angle at 2°

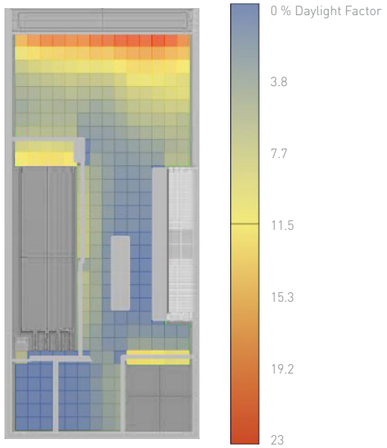


06
SOLAR INTERIOR ANALYSIS:
QUANTITATIVE & QUALITATIVE



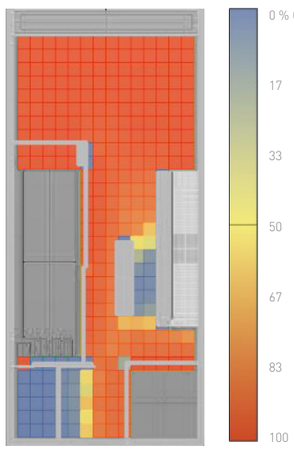
L1

1. Entry 2. Living Room 3. Pool 4. Bedroom 5. Void 6. Skylight



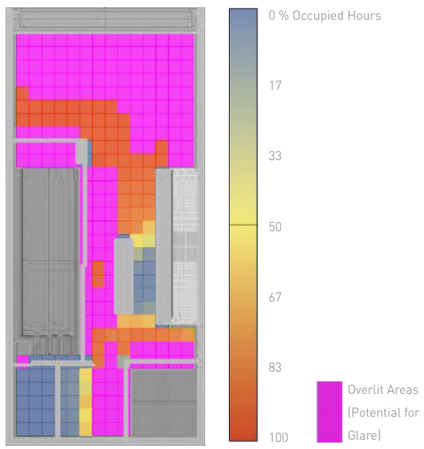
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 5.29%
100% of Area between 0 & 23
0% of Area > 23%; 0% of Area < 0%



DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 76.39%
of time occupied



DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 20.97% of
time occupied

Current Base Design

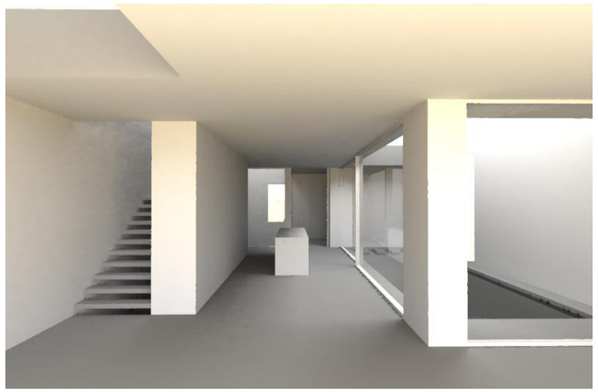
• Current Daylight Factor is 5.29%; hence there is sufficient daylight available. A majority of the light is accessible around the living room area, which is preferable.

• Daylight Autonomy (set at 300 Lux) is 76.39%. This reading is also preferable.

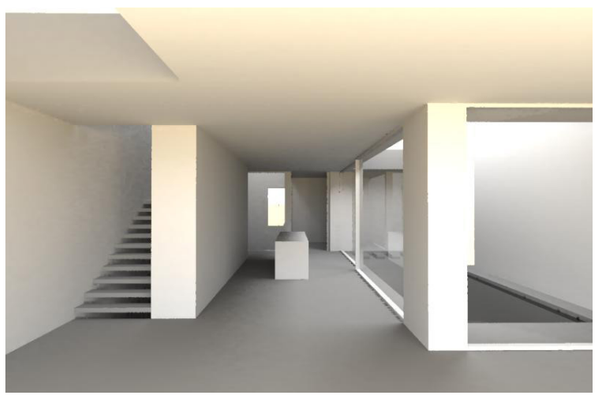
• Daylight Autonomy (set at 300 Lux) is 20.97%. There is a large amount of over lit area, with potential glare. There is an opportunity to control, minimize and redirect some of the daylight available to create a holistic design and improve the overall experience and comfort of the living space.

A series of design investigation will be carried out aiming to: improve the daylight availability %, without compromising too much of the daylight factor and daylight autonomy currently available.

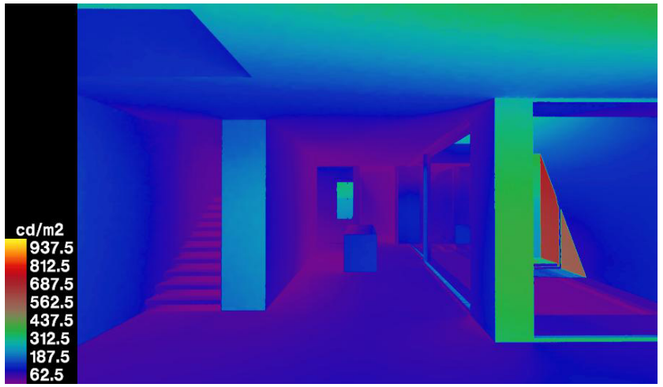
JUN21 09.00

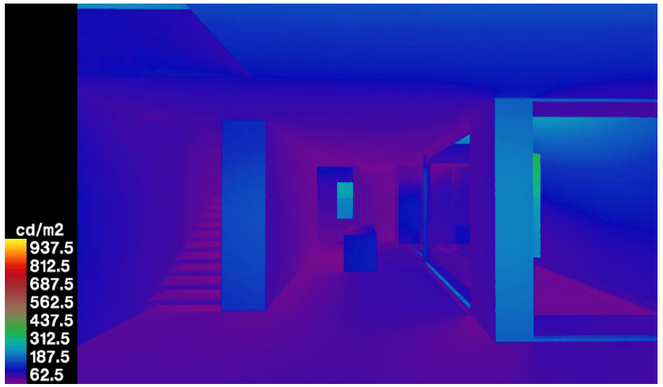


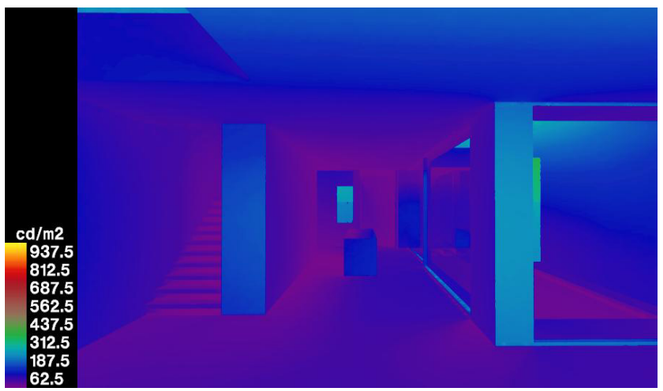
DEC21 09.00



MAR21 09.00



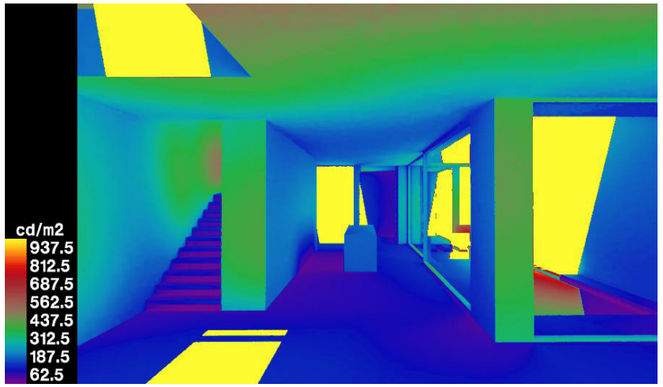


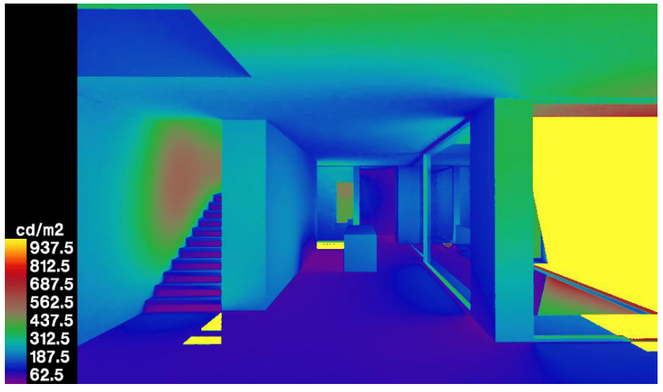


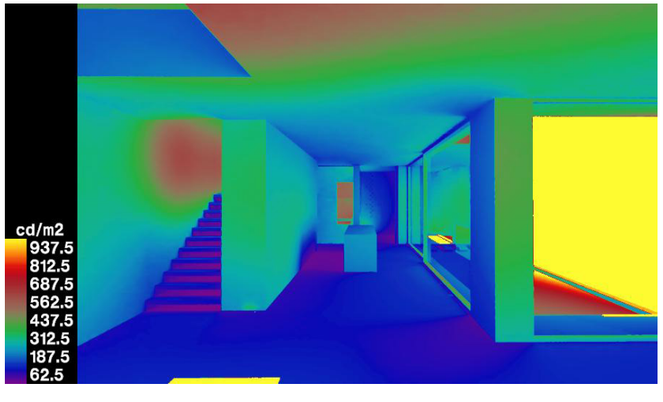
JUN21 12.00

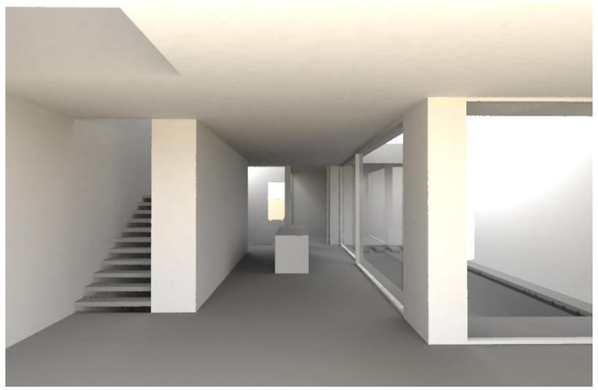
DEC21 12.00

MAR21 12.00

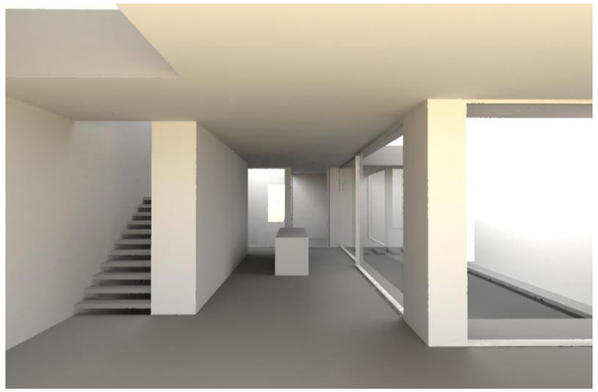




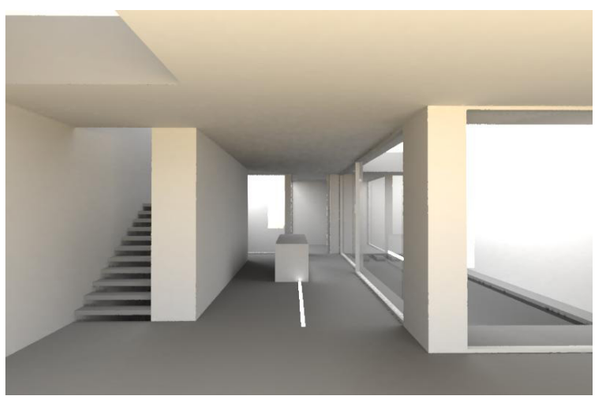




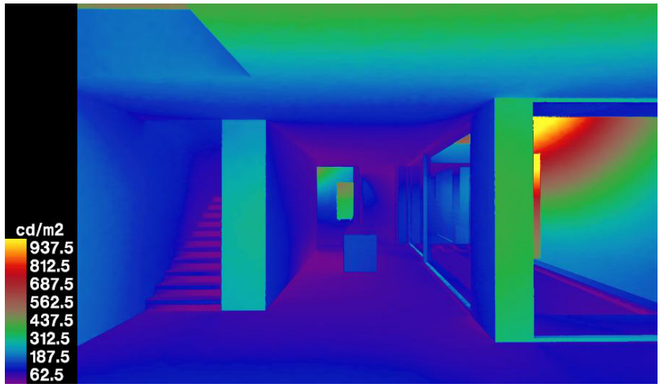
JUN21 15.00

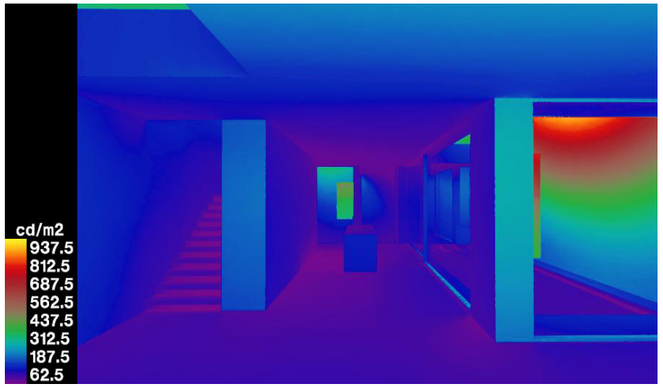


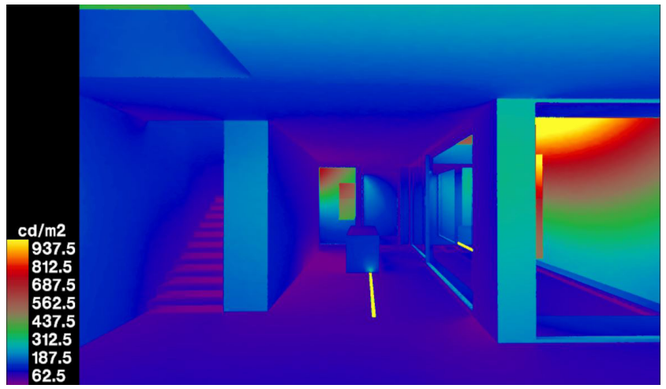
DEC21 15.00

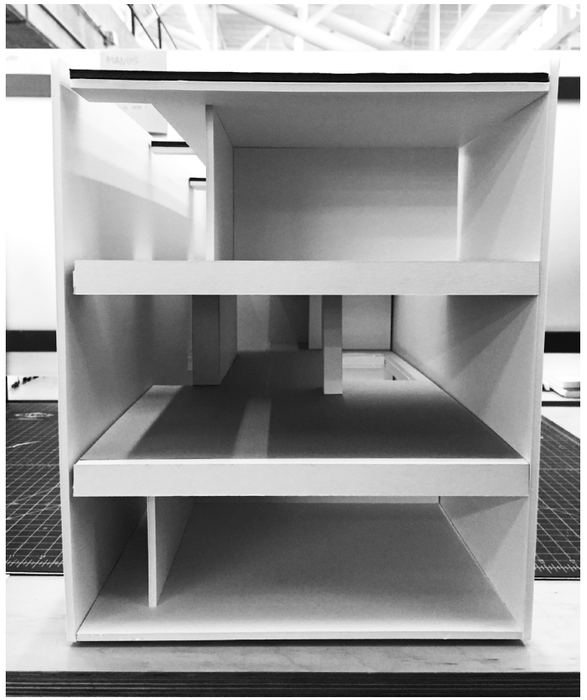


MAR21 15.00







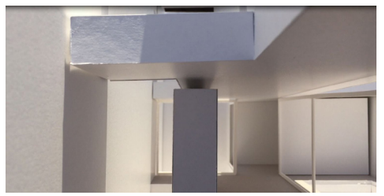


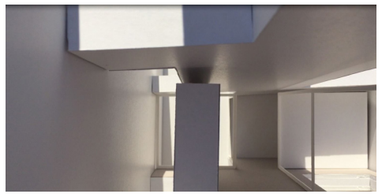
Physical model was also used to study the solar interior analysis.

MAR 21

JUN 21

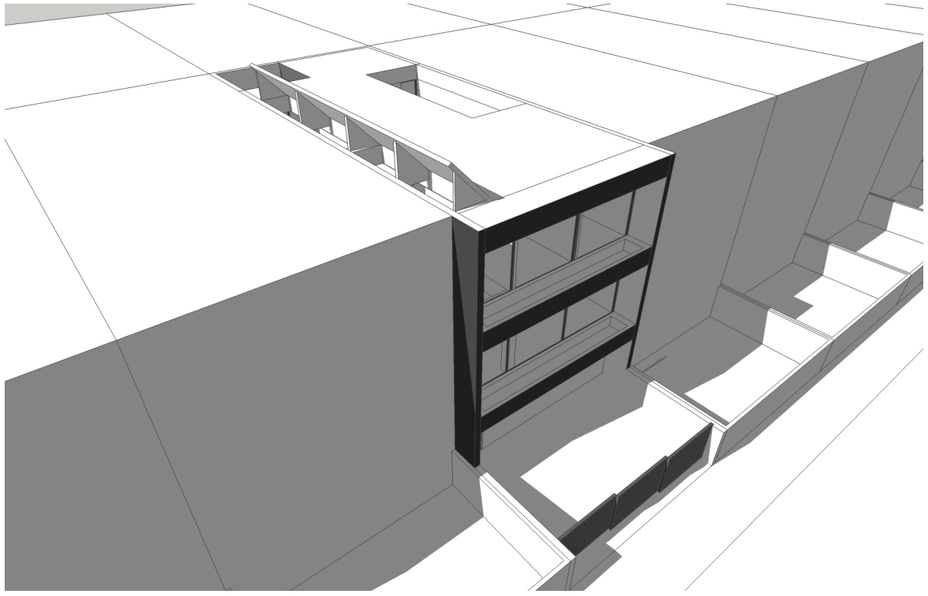
DEC 21

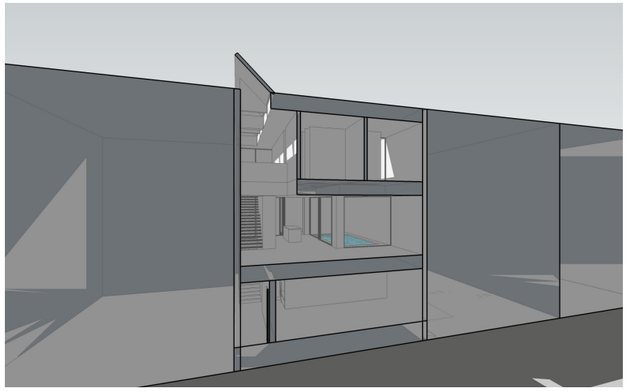



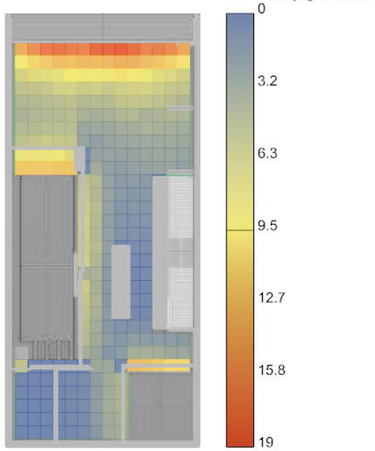





09:00 12:00 15:00

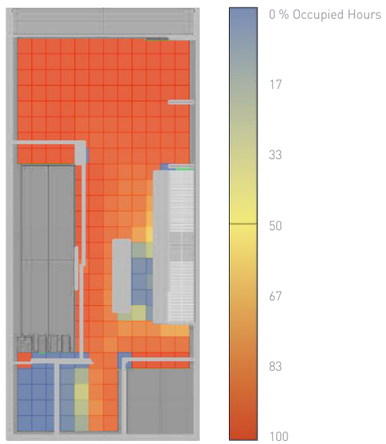






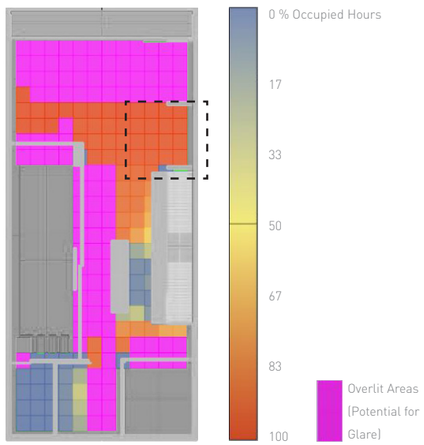
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 4.53%
100% of Area between 0 & 19
0% of Area > 19%; 0% of Area < 0%



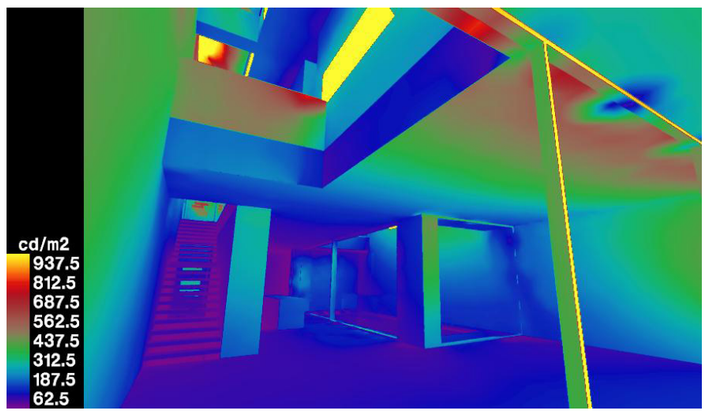
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 74.52%
of time occupied

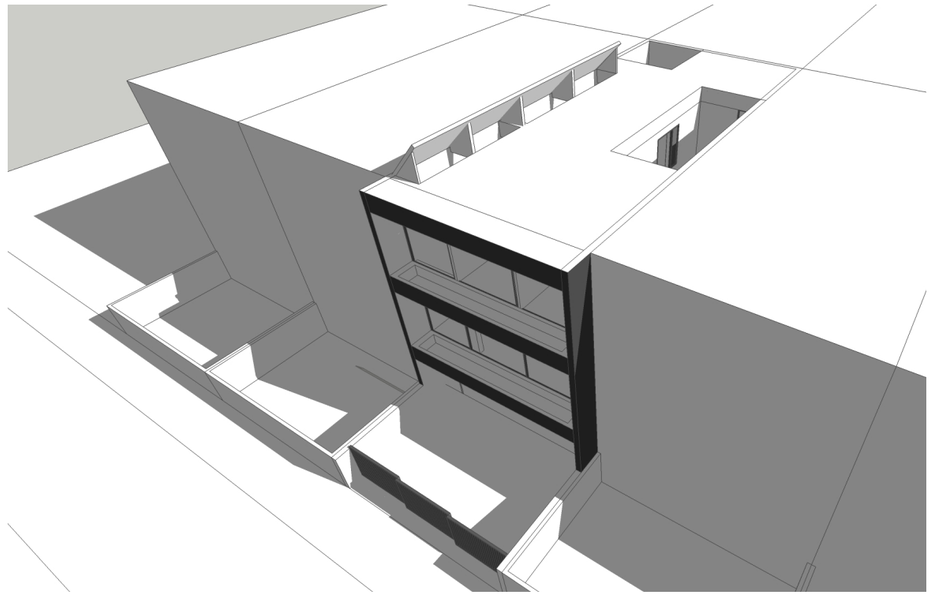


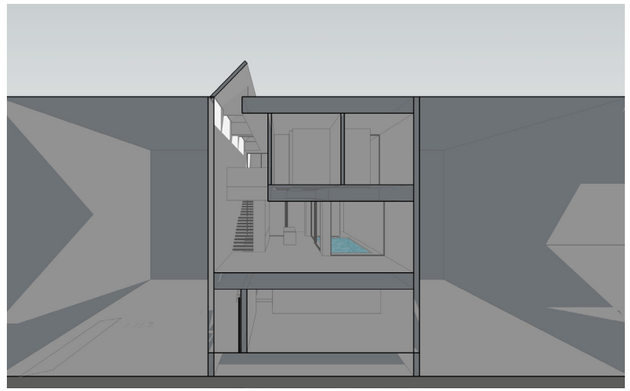
DAYLIGHT AVAILABILITY

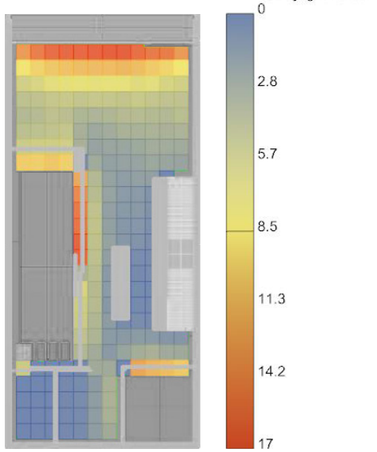
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 27% of
time occupied



DEC21 13:00

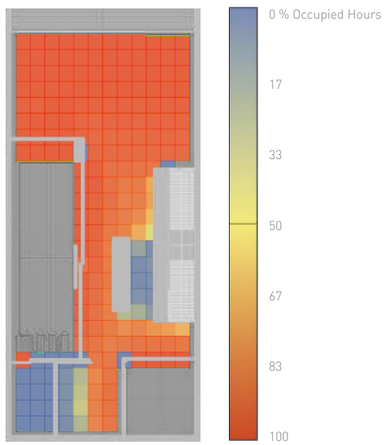






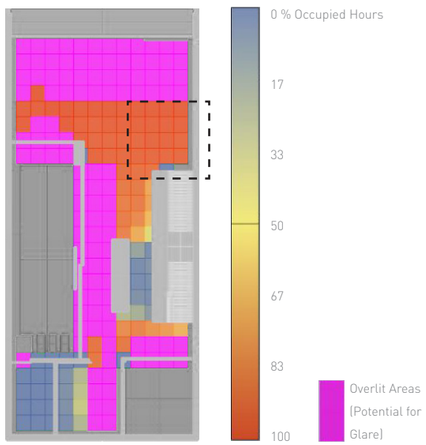
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 4.53%
99.1% of Area between 0 & 17
0.9% of Area > 17%; 0% of Area < 0%



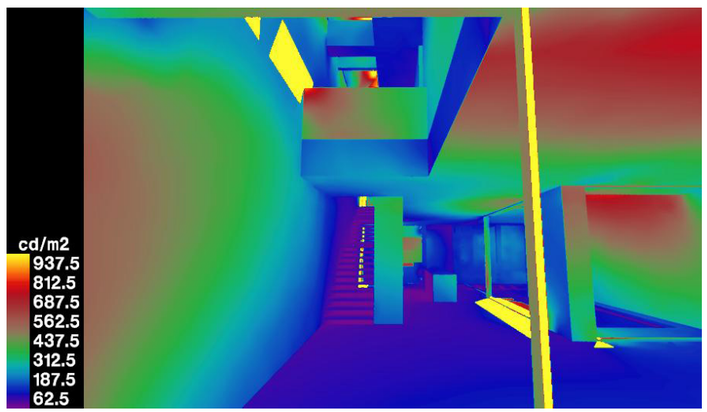
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 74.65% of time occupied

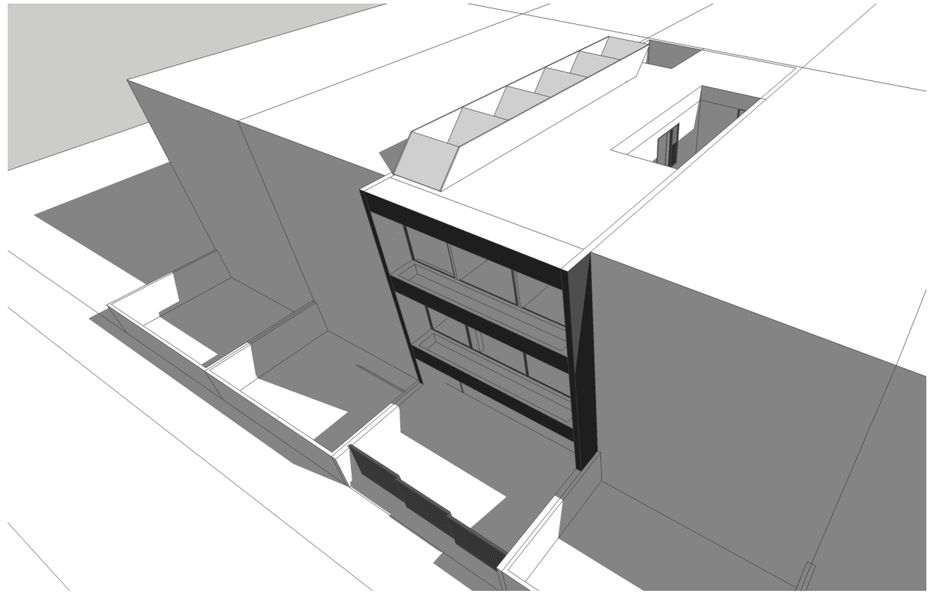


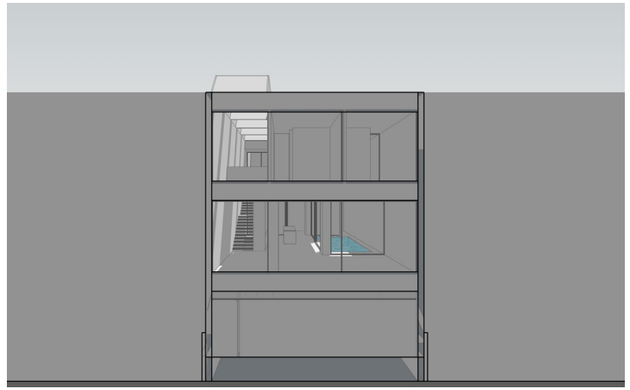
DAYLIGHT AVAILABILITY

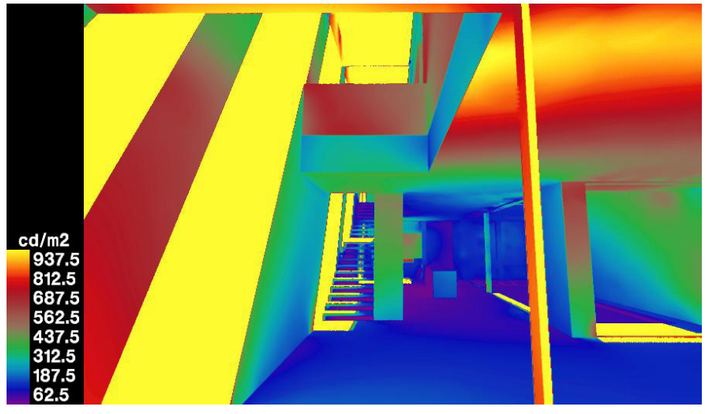
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 26.25% of time occupied

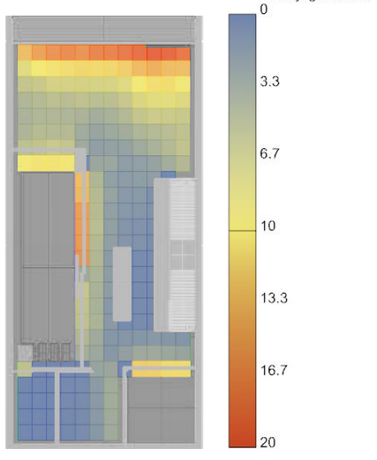


DEC21 13:00



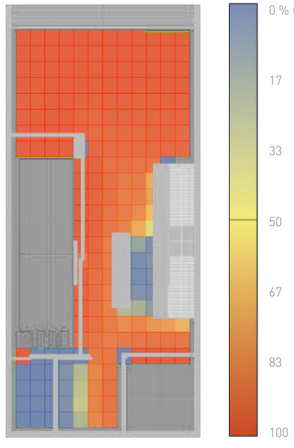






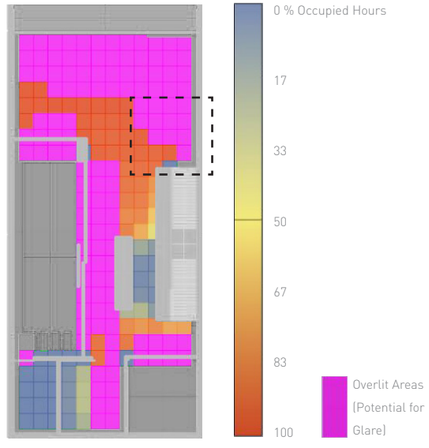
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 4.93%
100% of Area between 0 & 20
0% of Area > 17%; 0% of Area < 0%



DAYLIGHT AUTONOMY

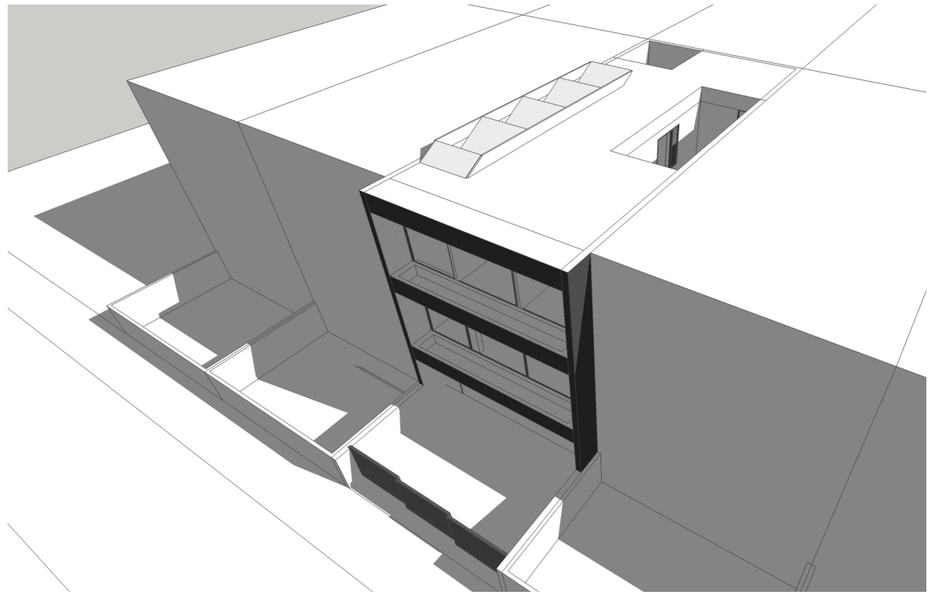
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 74.7% of time occupied

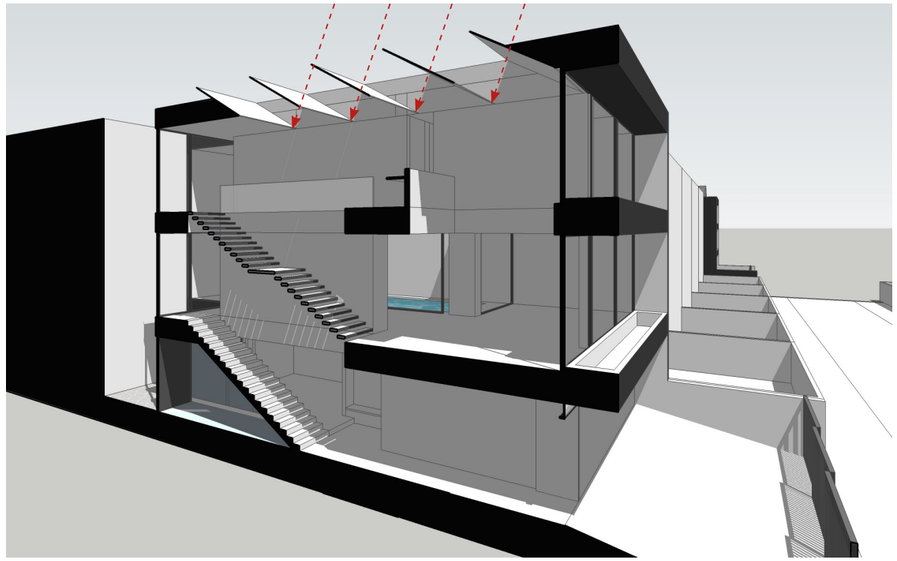


DAYLIGHT AVAILABILiTY

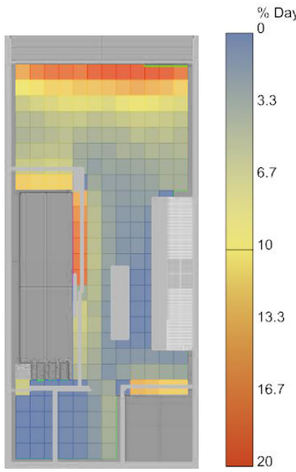
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 21% of time occupied

DEC21 13:00



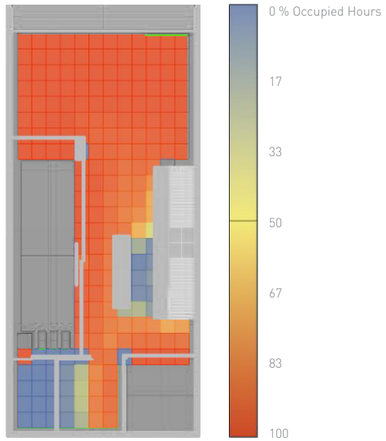


JUN21 12:00



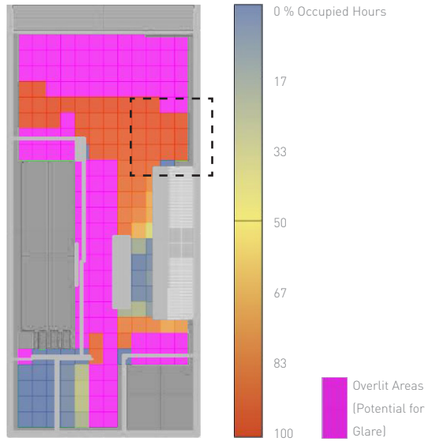
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 4.69%
100% of Area between 0 & 18
0% of Area > 17%; 0% of Area < 0%



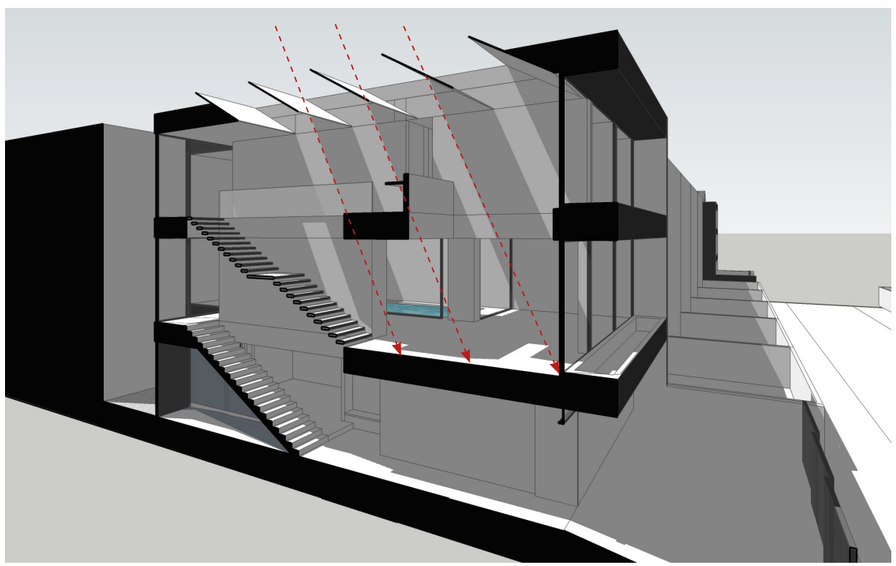
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 74.78% of time occupied



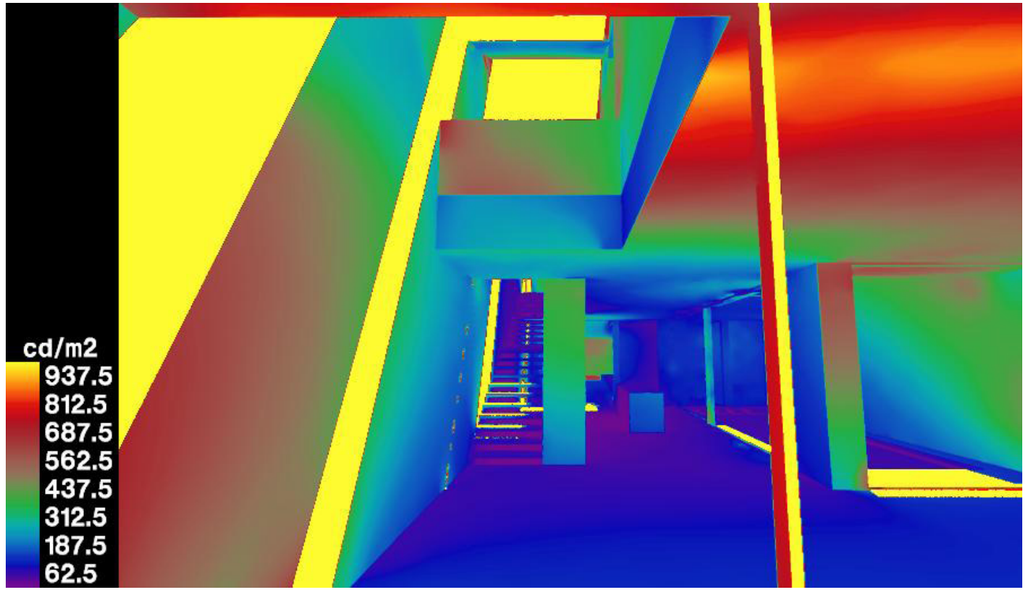
DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 26.38% of time occupied



DEC21 12:00

This design option provides a desired lighting atmosphere that enhances the spatial quality of the staircase / circulation space, while keeping direct sun out during the summer solstice . Keeping out the direct sun from the north during the summer solstice is ideal as there is a study area on the second floor that faces north.

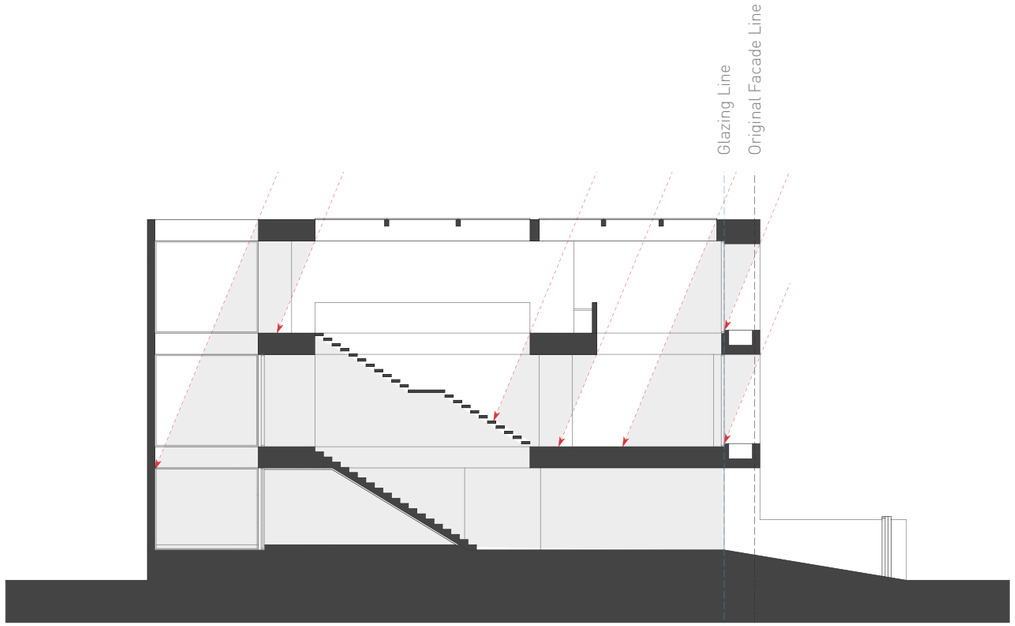


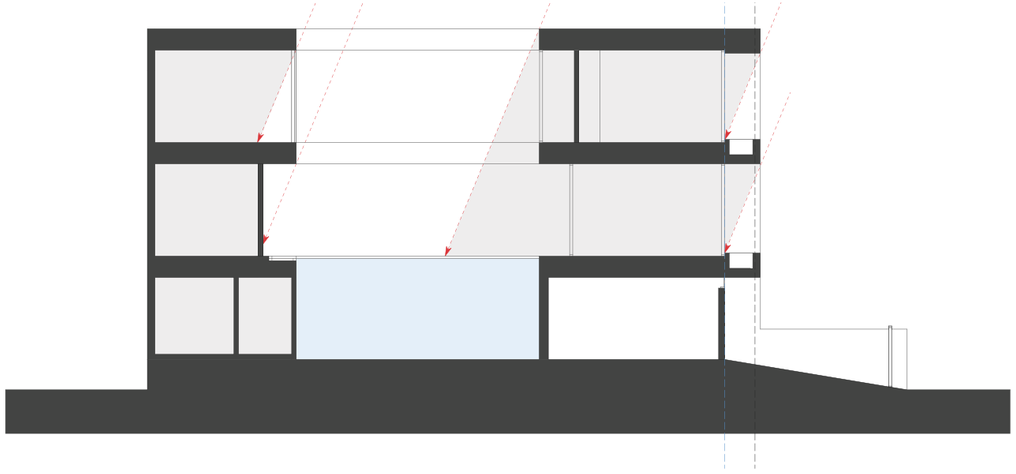
DEC21 13:00

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 74.78%
of time occupied

DEC21 13:00

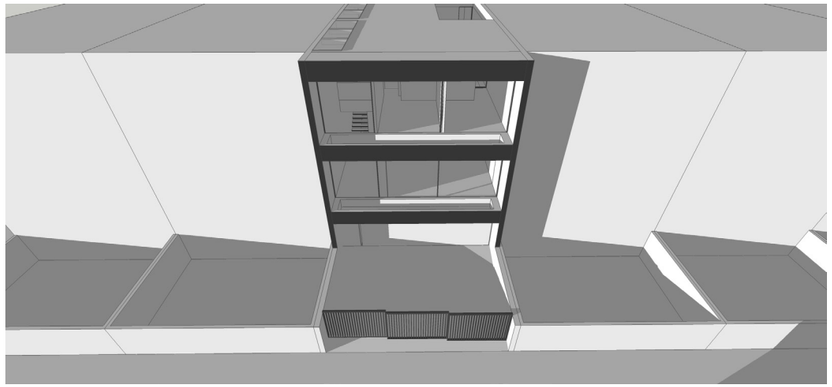
The light from the skylight creates a special moment that draws attention to the double height void and the space beyond. As one progress to the level above, the angled planes obstructs views to the sky and frames the north facing window to the views outside.



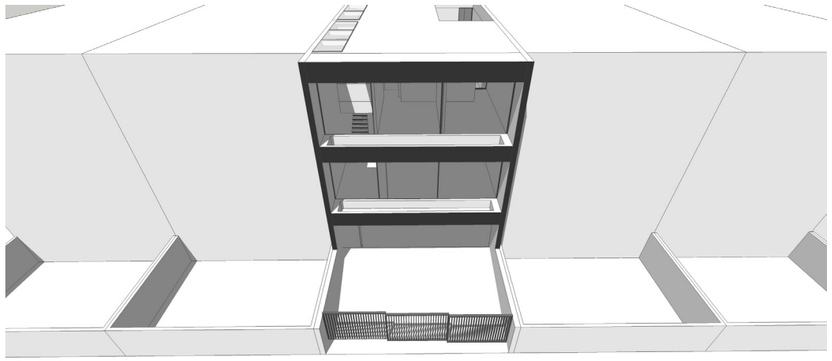


JUN21 12.00

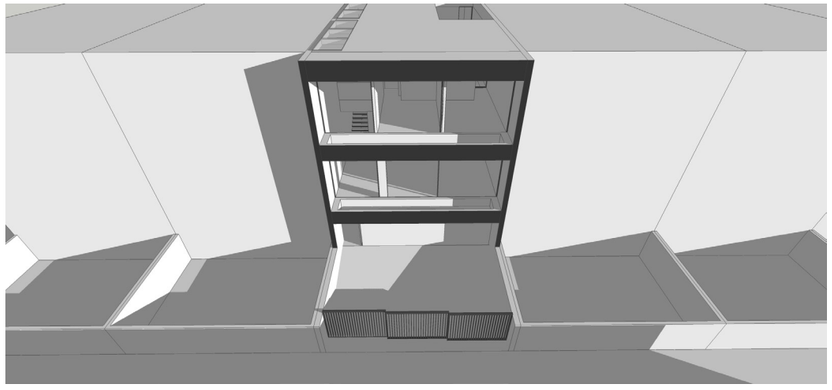
An increase in the overhang on the north facade helps to reduce direct sun during the summer solstice.



JUN21 07.10

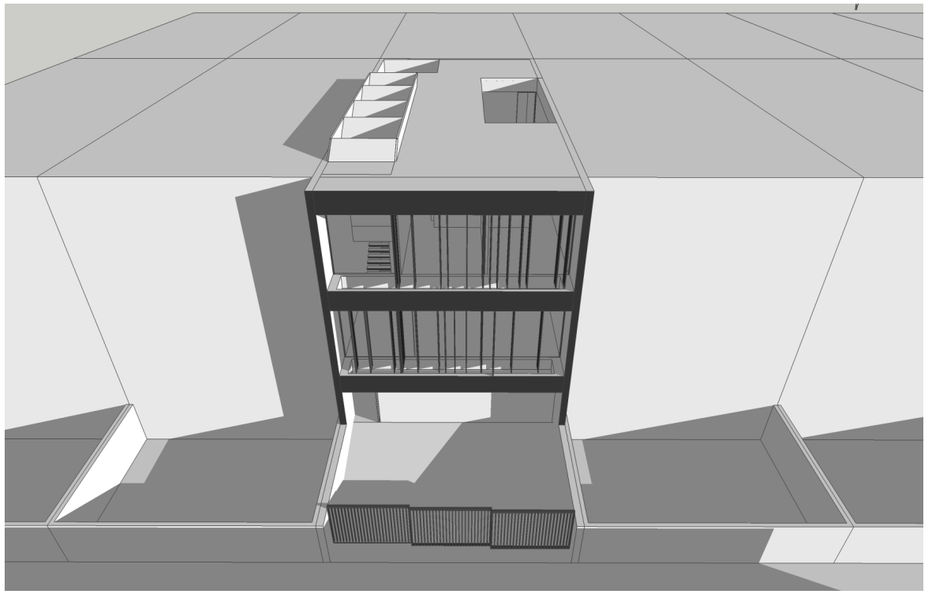


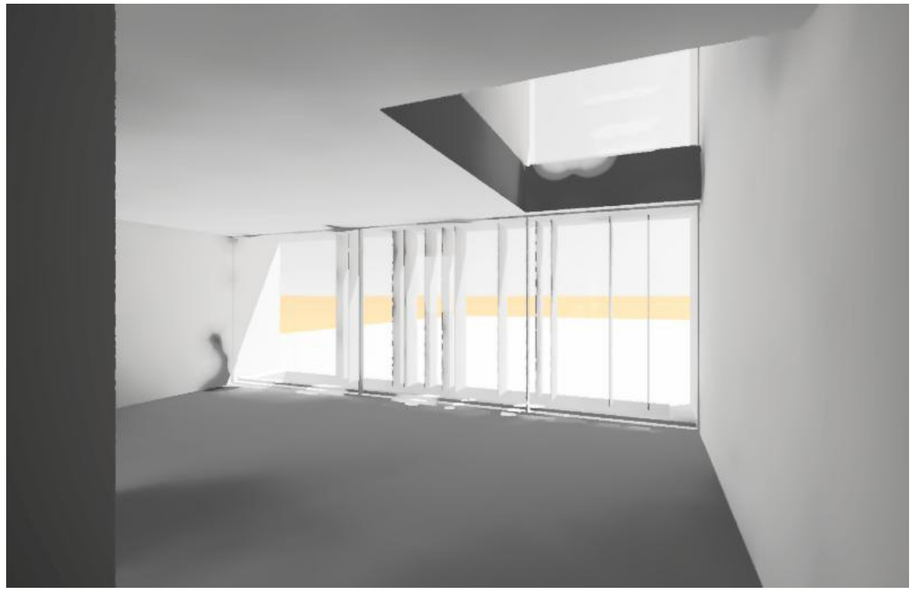
JUN21 12.00

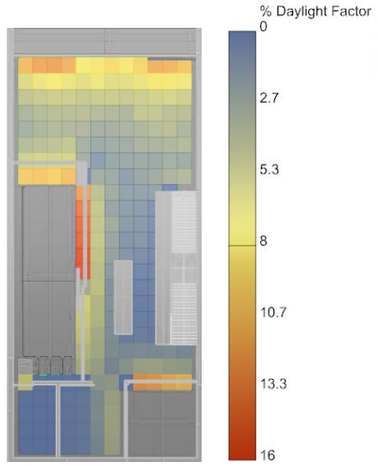


JUN21 17.45

Direct sun is still available during other times in the summer solstice, from the east and west orientation. Vertical louvers could potential help to control any potential glare.

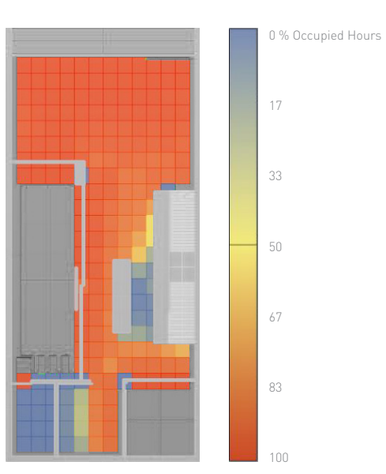






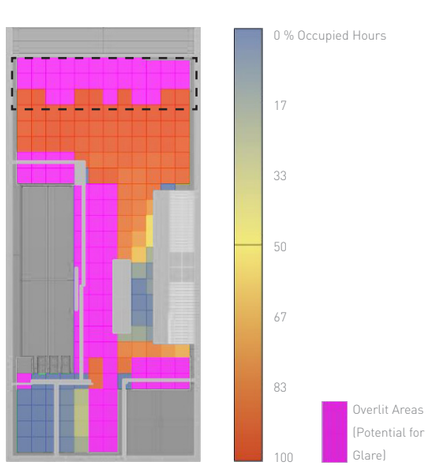
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 3.74%
99.6% of Area between 0 & 16
0.4% of Area > 16%; 0% of Area < 0%



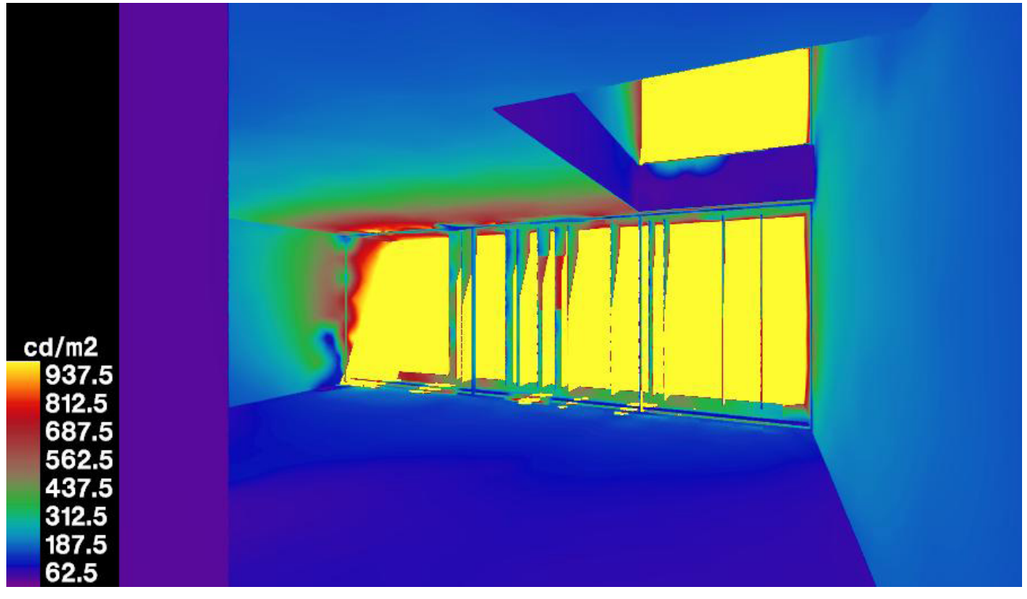
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 73.7% of time occupied

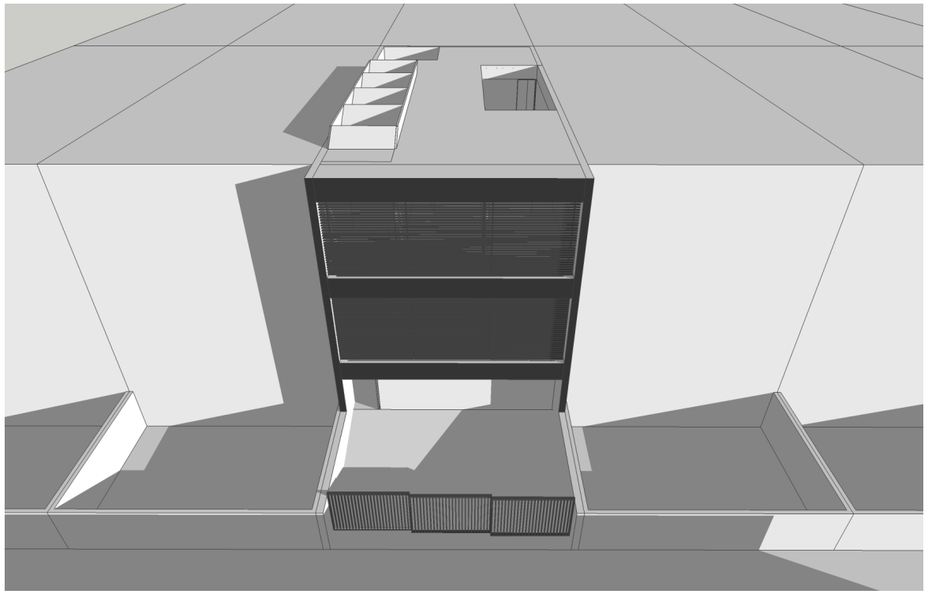


DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 34.33% of time occupied

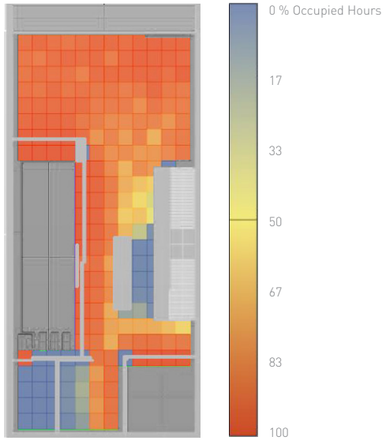


JUN21 13:00



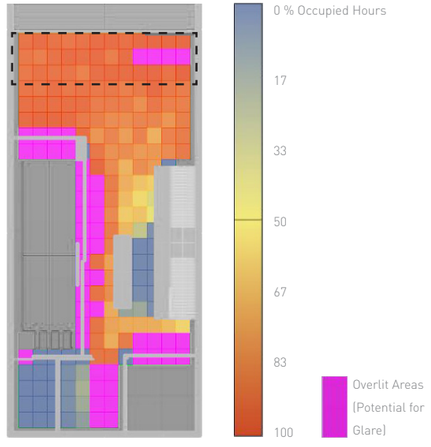
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 2.42%
100% of Area between 0 & 16
0% of Area > 16%; 0% of Area < 0%



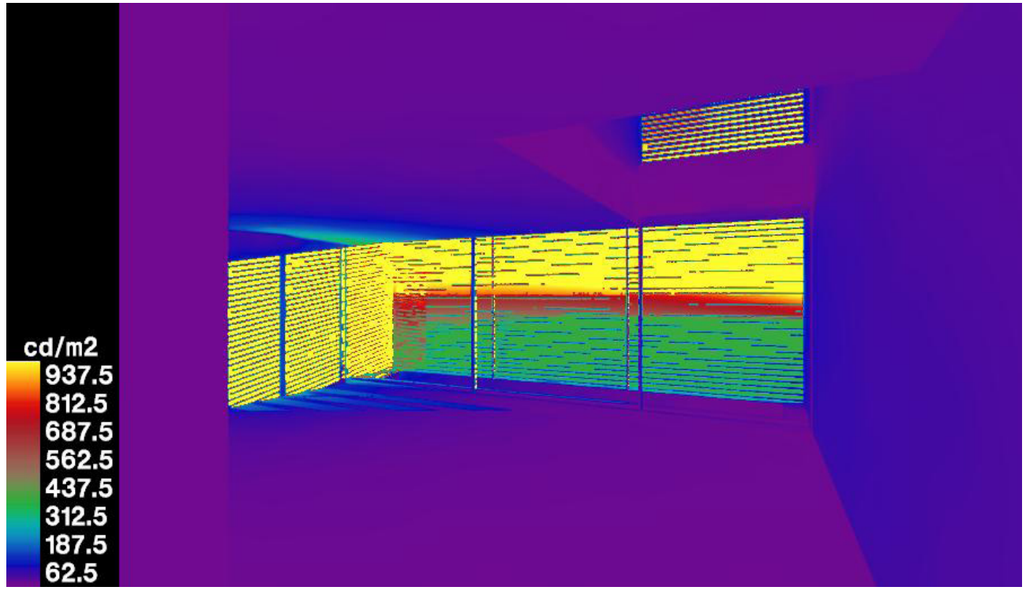
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 68.69%
of time occupied

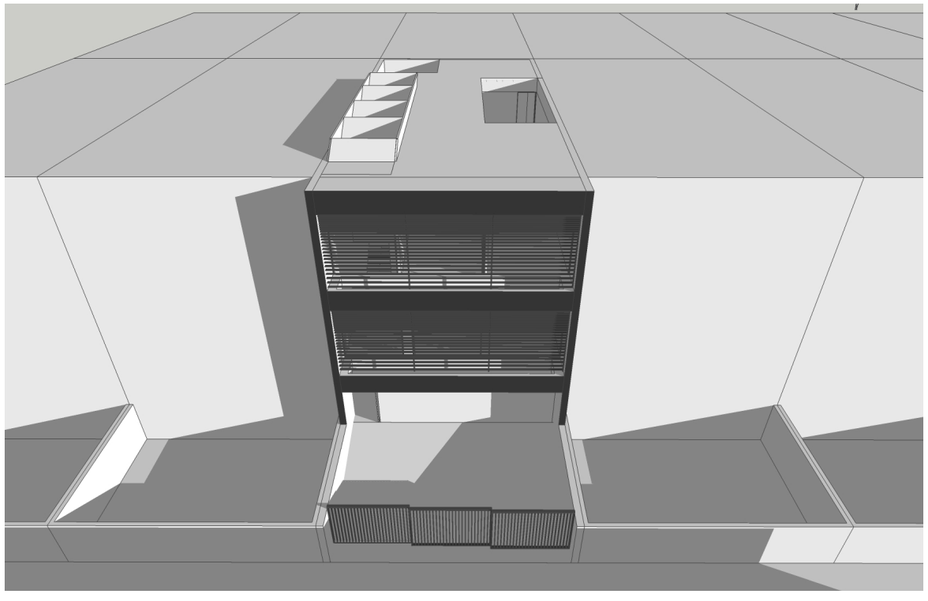


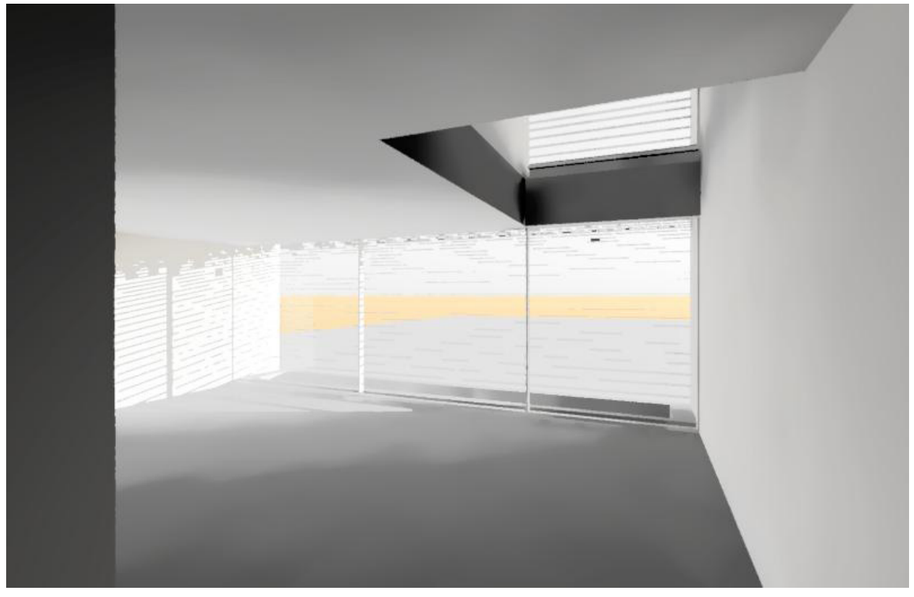
DAYLIGHT AVAILABILiTY

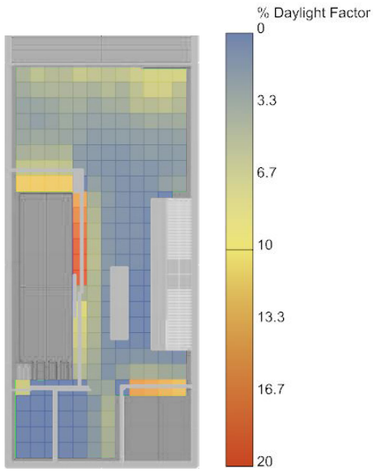
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 47.72% of
time occupied



JUN21 07:00

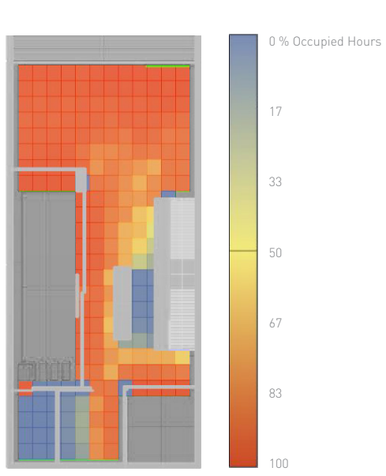






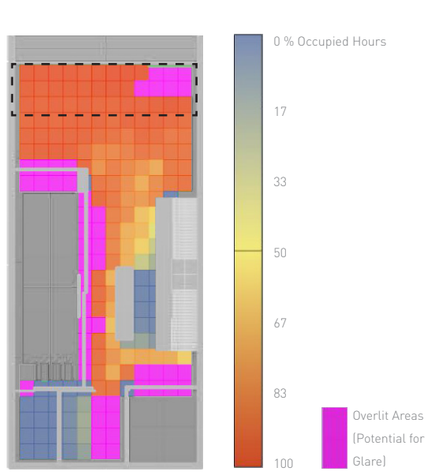
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 2.69%
100% of Area between 0 & 16
0% of Area > 16%; 0% of Area < 0%



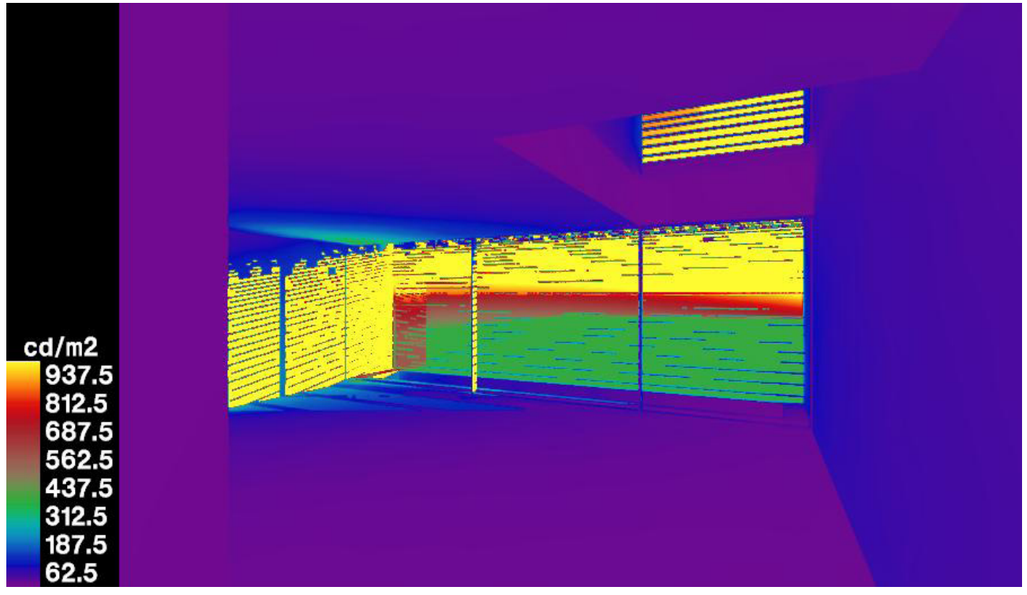
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 69.84%
of time occupied

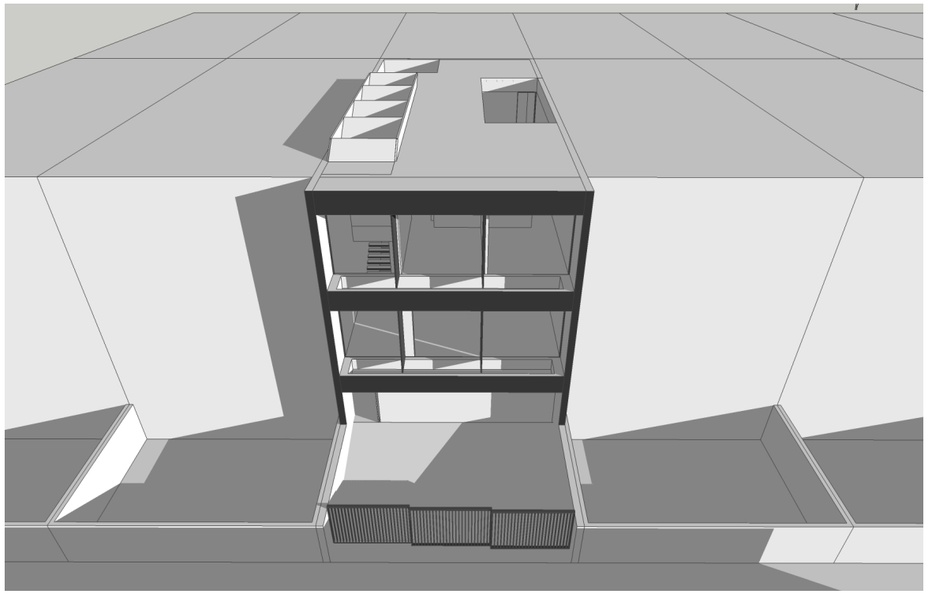


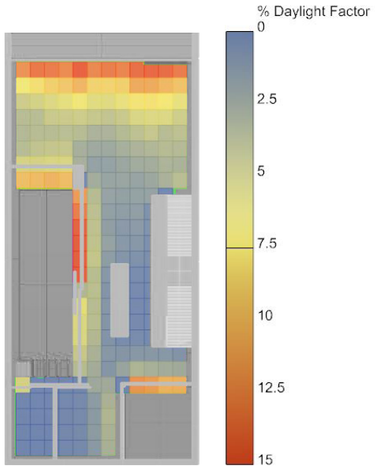
DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 48.29% of
time occupied



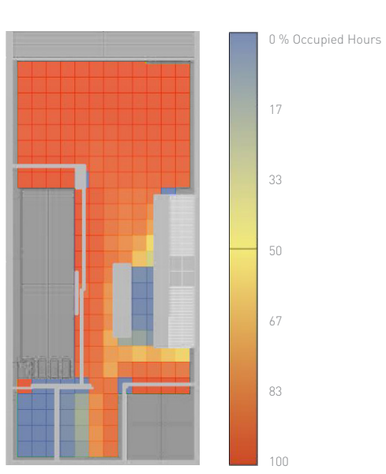
JUN21 07:00





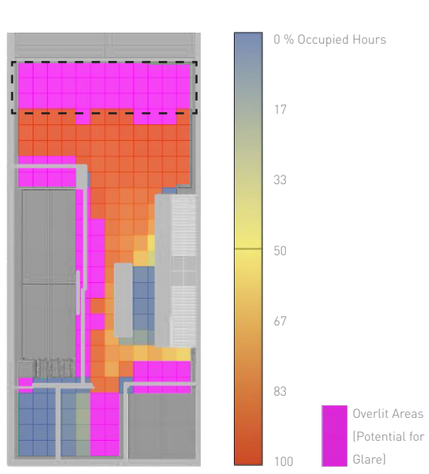
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 4.14%
98.7% of Area between 0 & 15
1.3 of Area > 15%; 0% of Area < 0%



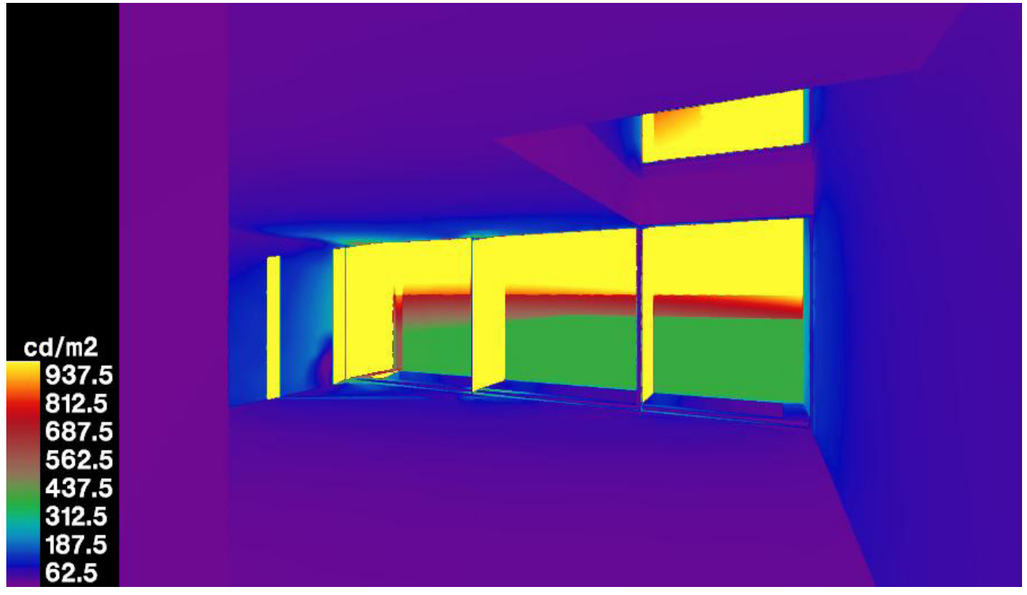
DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 73.09%
of time occupied

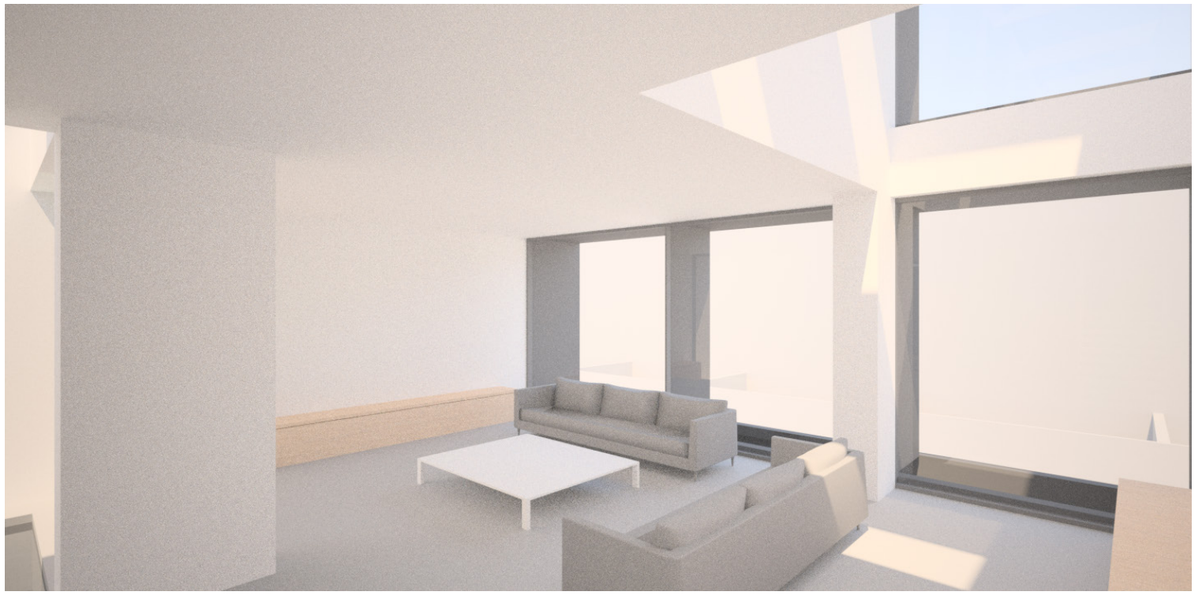


DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 36.28% of
time occupied

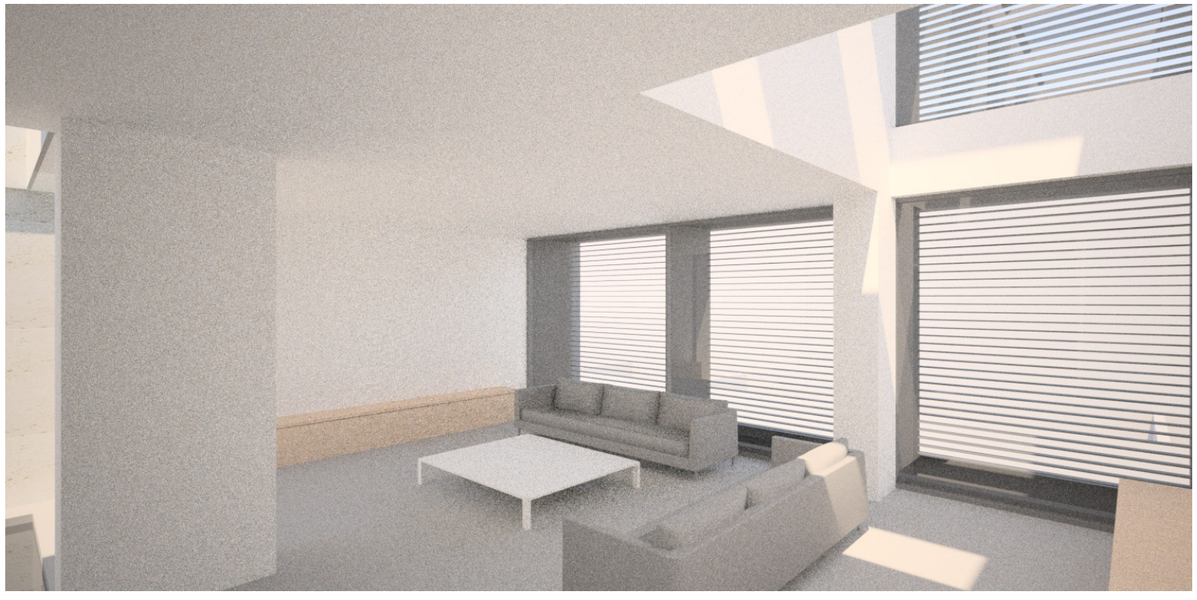


JUN21 07:00



DEC21 13:00

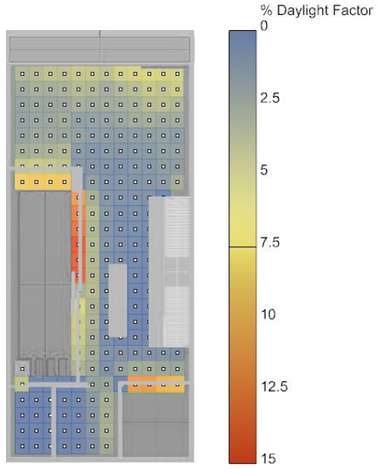
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 68.69%
of time occupied



DEC21 13:00

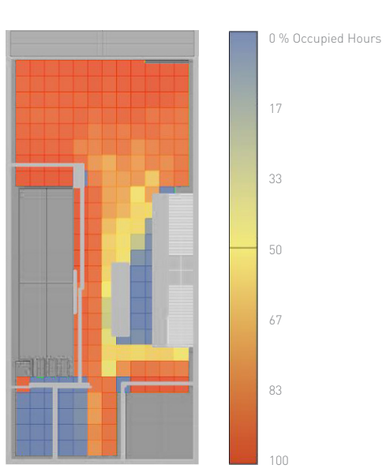
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 47.72% of
time occupied

MATRIX DESIGN PROCESS : HONE MATERIAL FINISH FOR INTERNAL WALLS AROUND VOIDS / LIGHTWELLS



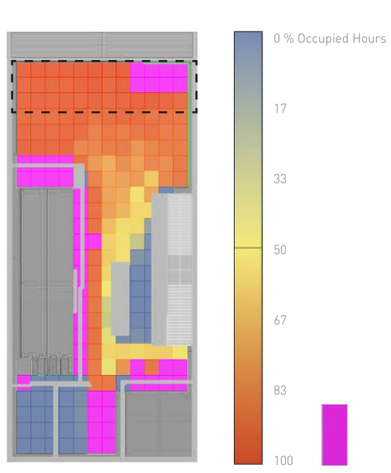
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 2.51%
98.7% of Area between 0 & 15
1.3 of Area > 15%; 0% of Area < 0%



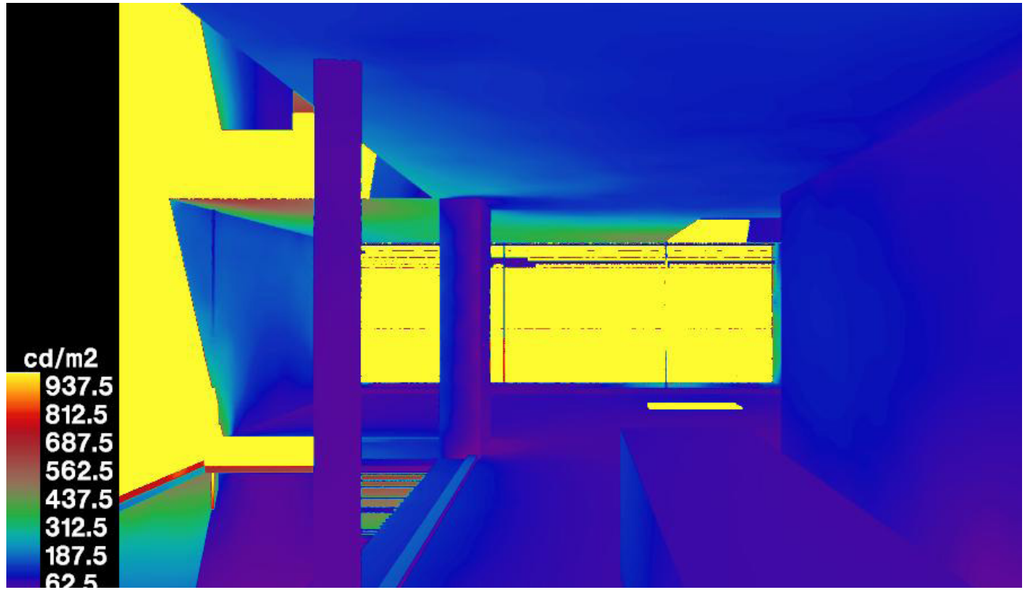
DAYLIGHT AUTONOMY

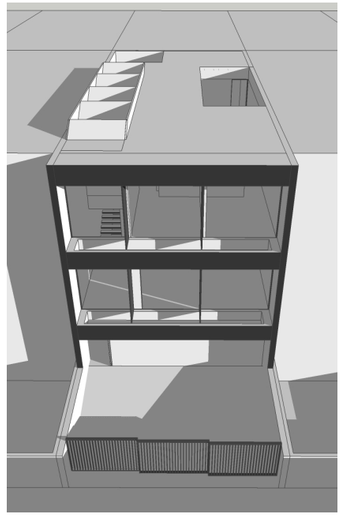
Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 65.76%
of time occupied



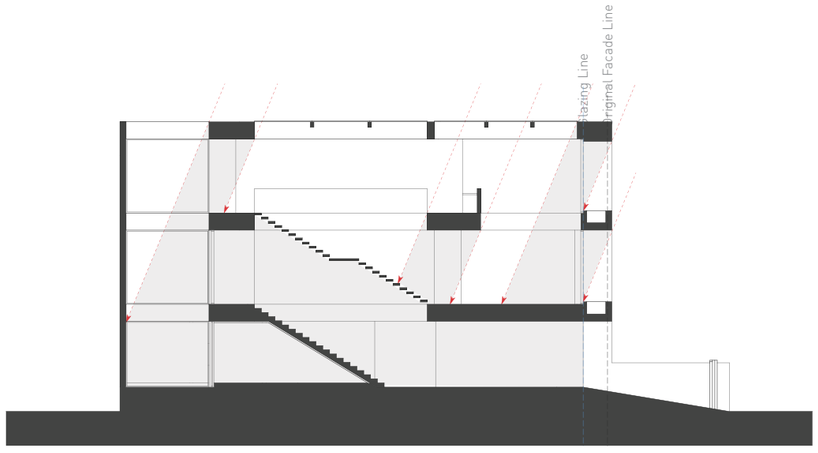
DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 49.12% of
time occupied

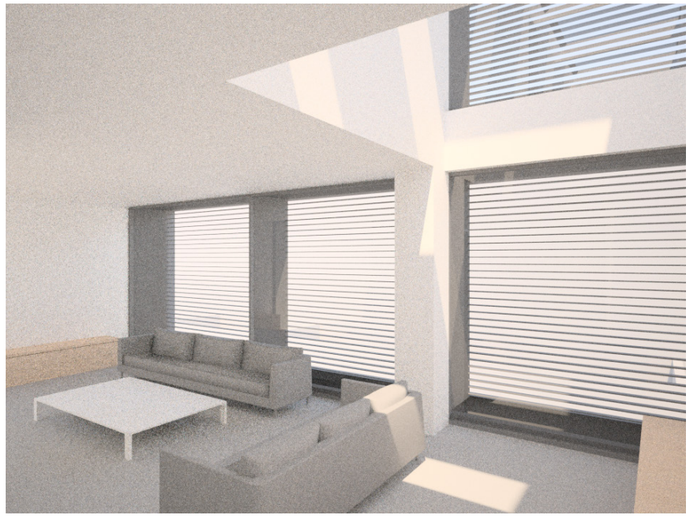




MODIFICATION 1

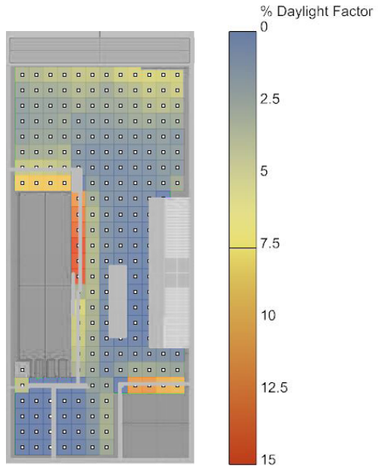


MODIFICATION 2



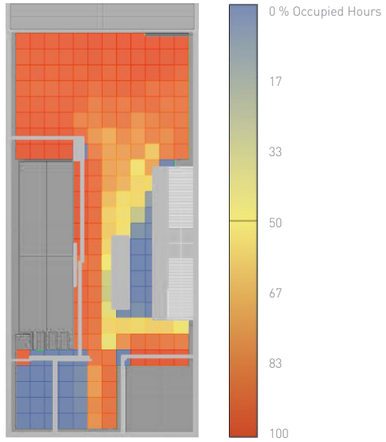
MODIFICATION 3

MODIFICATION 4



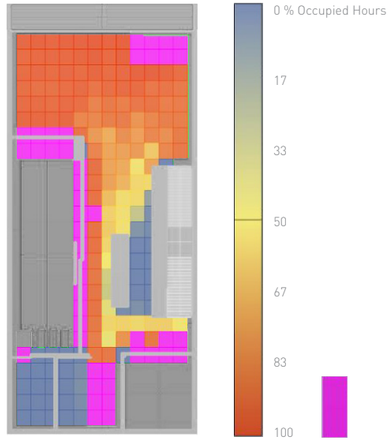
DAYLIGHT FACTOR

Daylight Factor Nodes Analysis
Mean Daylight Factor = 2.51%
98.7% of Area between 0 & 15
1.3 of Area > 15%; 0% of Area < 0%



DAYLIGHT AUTONOMY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 65.76%
of time occupied



DAYLIGHT AVAILABILiTY

Daylight Autonomy (300 lux)
Mean Daylight Autonomy = 49.12% of
time occupied

Current Base Design

- Modification 1: A new skylight design that controls the direct sun and reduces the overal over lit areas in the living space.

- Modification 2: An increase in the overhang on the north facade helps to reduce direct sun during the summer solstice.

- Modification 3: Introduced vertical and horizontal shading devices on the north facade to allow flexible solar control depending on user comfort.

- Modification 4: Introduced hone material finish for internal walls of light wells to reduce glare.