



Philadelphia Apartment Retrofit

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Arch 753 Final Project
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Introduction

Project Description & Approach

The intent of this project is to take the real case scenario of a recently retrofitted apartment building in the city of Philadelphia, PA. This way, there are certain parameters that will not change, just like a real life project. Such parameters are orientation, ceiling height, and room depth. This means the only changes will be done in the building envelope (facade) through shading, glazing size, and adding insulation.

The idea is to achieve maximum comfort (in different metrics) with real life constraints.

Metrics to be maximized in this project:

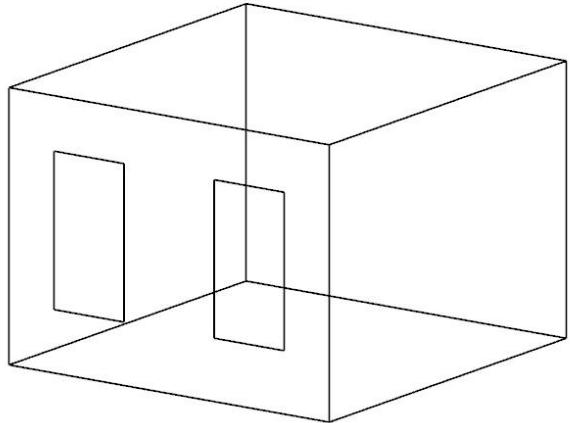
- Daylighting (through UDLI, DLA, and Lux Simulations)
- Thermal Comfort (through PMV and Adaptive Comfort,)

Metrics to be minimized in this project:

- Glare
- Heating Hours
- Cooling Hours

Additional concepts to consider:

- Maximization of views



The Latham Building

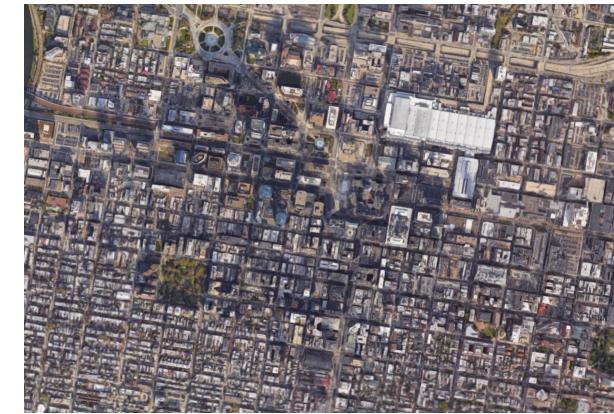
Site and Existing Conditions

This building was constructed in 1907, and acquired by Pearl Apartments in early 2015 for renovation. The unit to be analyzed is 810. Measurements are:

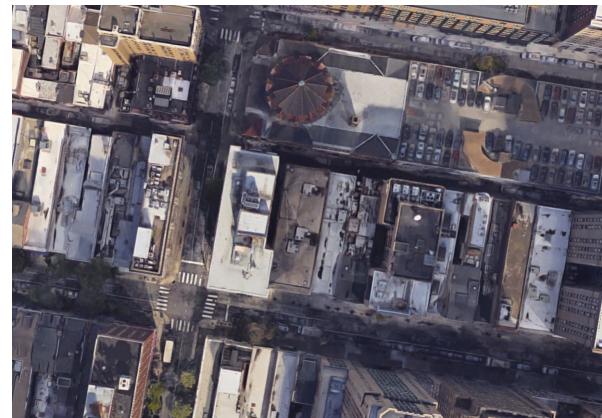
4.80m x 5.00m base x 3.50m height

- Windows face south only and are currently inoperable
- Furniture is not accounted for
- Local context such as buildings is not accounted for
- All room boundaries are treated as adiabatic except for the main facade (south side)

Rittenhouse Square
City Hall

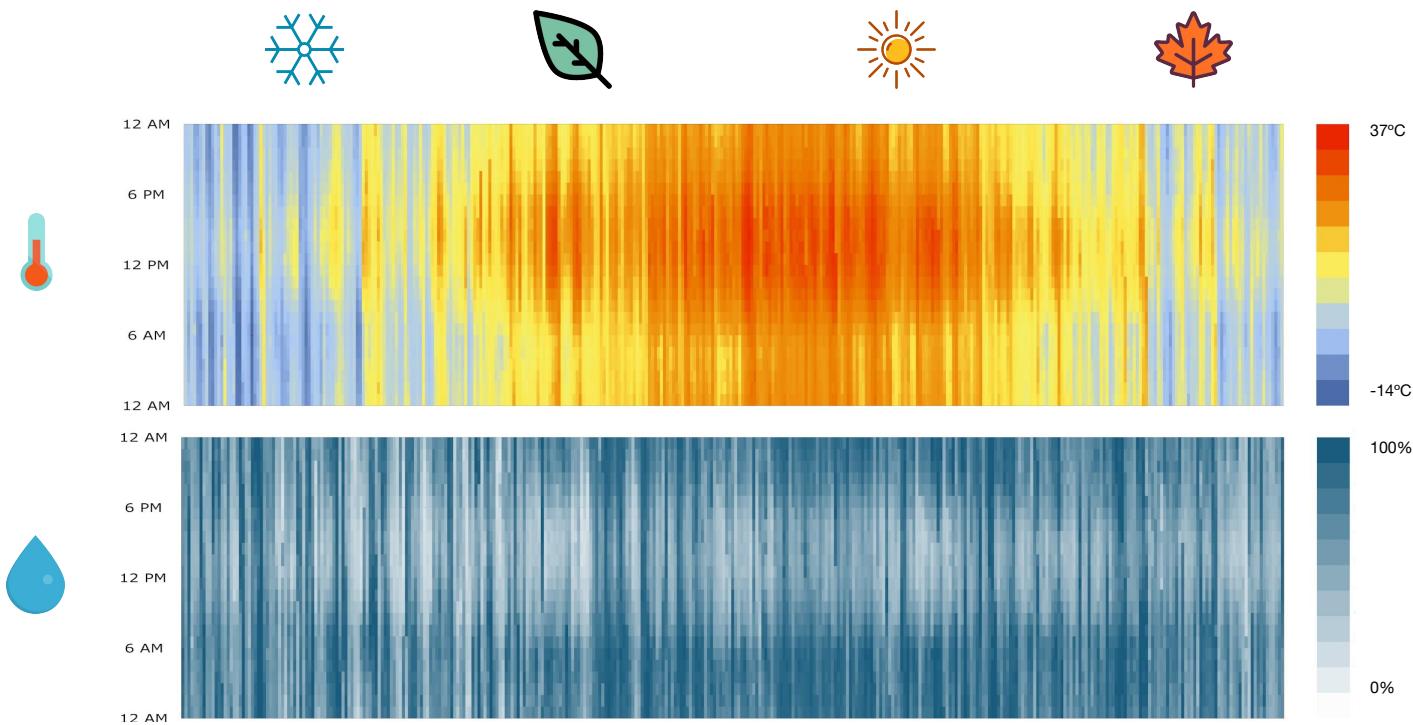


17th Street
Walnut Street
The Latham Building



The Latham Building
Perspective (2016)





Weather Context

Climate Zone, Temperature and Precipitation

Location: Philadelphia, Pennsylvania, USA

Latitude: 39.87°

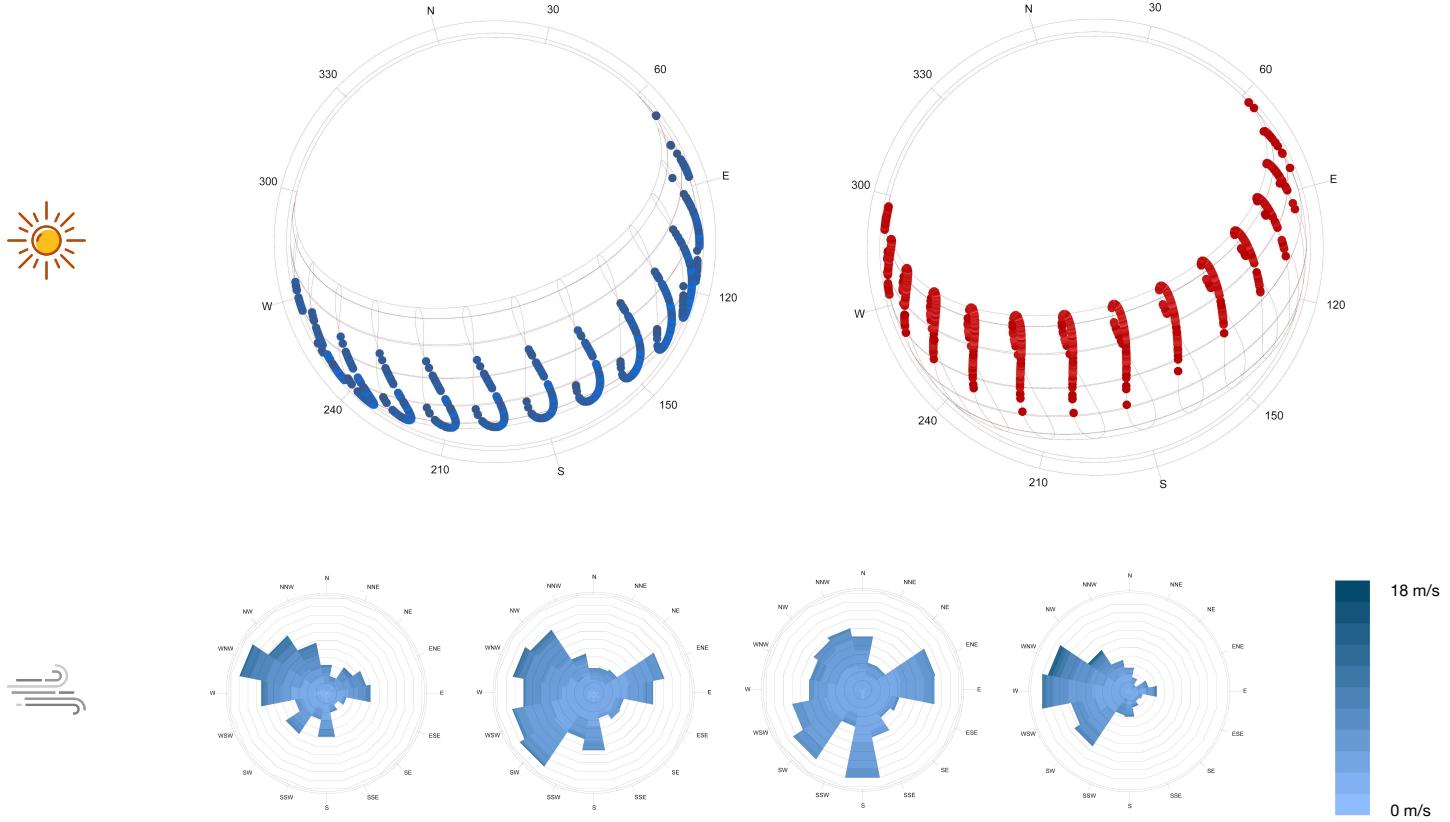
Longitude: -75.23°

Time Zone: -5.0

Climate Zone: Zone 3 (Mixed-Humid)

Air temperature in Philadelphia typically fluctuates between 5°C and 30°C, predominantly on the cold side (under 18°C).

Humidity is relatively acceptable throughout the year.



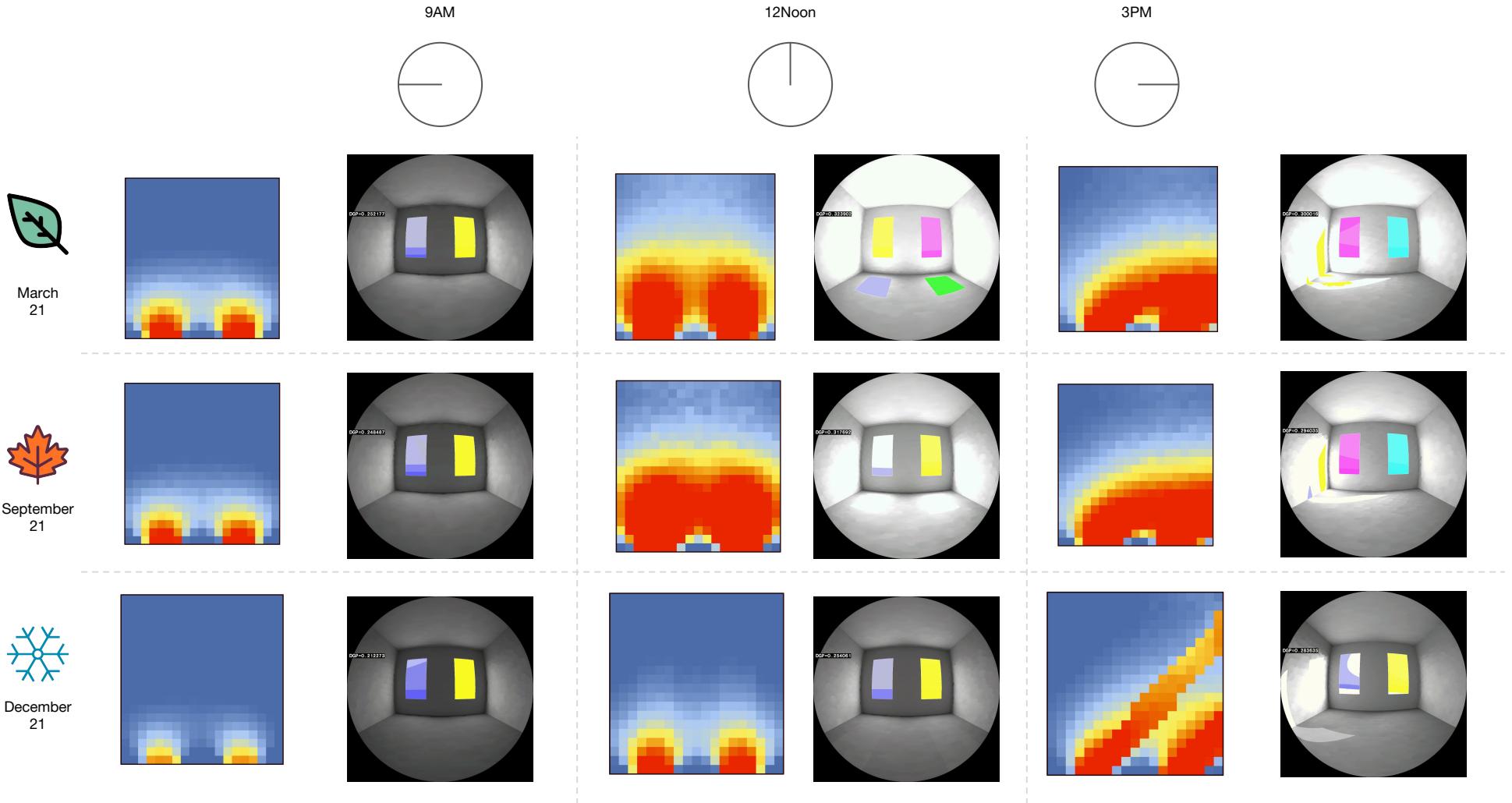
Weather Analysis

Sun Positions and Prevalent Winds

Sun positions during the hotter hours of the year (above 26°C) indicate there should be longer overhangs (since there are none currently) and they should probably be longer or more pronounced on the south - southwest side. This will cover harmful sunlight more effectively.

Sun positions during the colder hours of the year (below 9°C) indicate windows should be drawn as low as possible, to expose most of the floor thermal mass to sunlight.

Precipitation data for the area shows a significant amount of rain in the winter months, which may affect outdoor activities and water management systems. The data also shows some variation in precipitation throughout the year, with higher amounts in the winter and lower amounts in the summer.

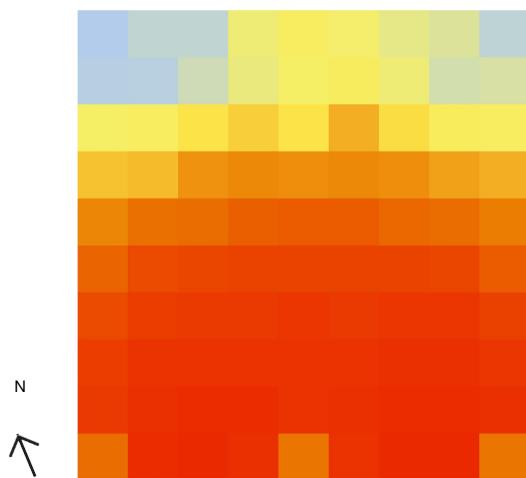


Base Case Daylighting

Lux, Glare

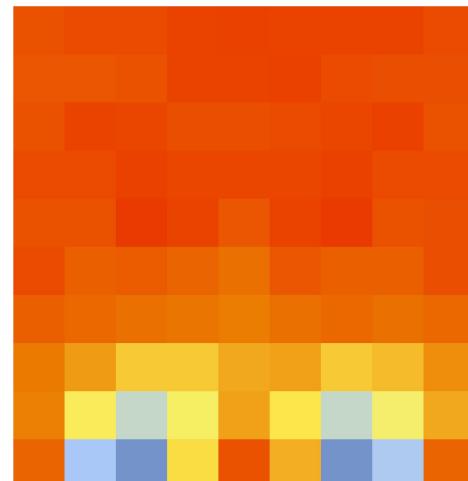
This set of simulations for the critical sun angles throughout the year shows us that there is both poor lux levels during the morning, high glare probability during the afternoons, and somewhat non-uniform light distribution throughout.

Strategies to improve distribution would be light shelves and reflective surfaces, and overhangs to protect the windows from excessive glare.

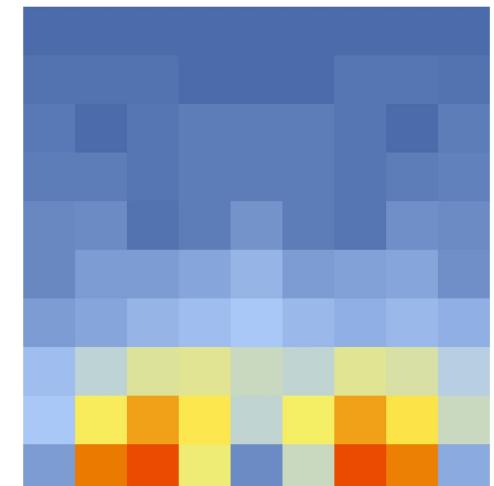


DLA
% time with 300+ Lux

SDA - 75.56%



UDLI
% time with 100-2000 Lux

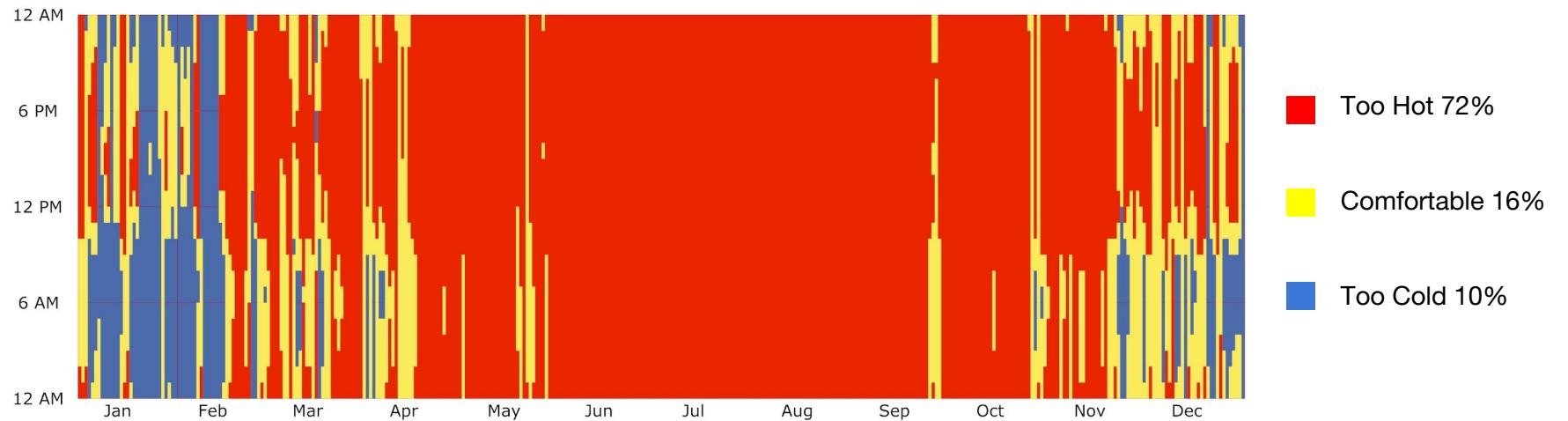


UDLI
% time with 2000+ Lux

Base Case Daylighting

Lux, UDLI, DLA

This kind of analysis shows us a more global picture of the amount of lux that the room receives. From this point of view the room receives enough daylight throughout the entire year (75% of the time 300+ lux).

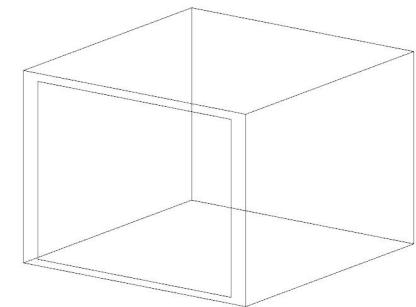
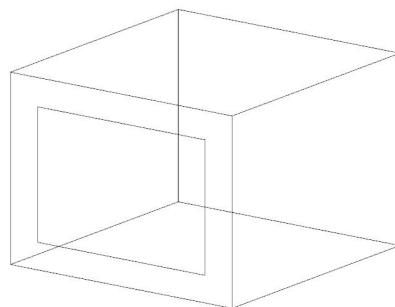
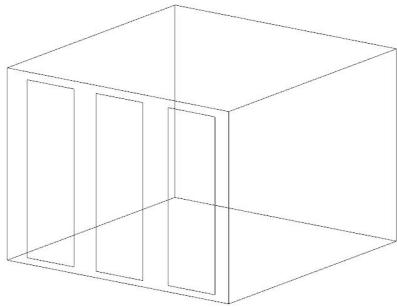


Base Case Thermal Comfort

Adaptive Comfort Metrics

With this analysis we can clearly see the room is too hot throughout the year. To improve this, we must add ventilation, and protecting the windows from high sun angles (when the surrounding temperature is higher).

Daylighting
Oriented

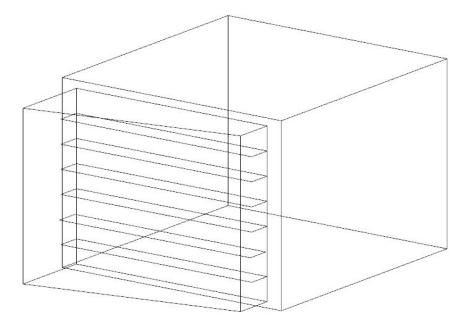
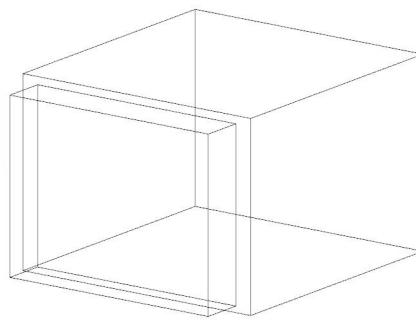
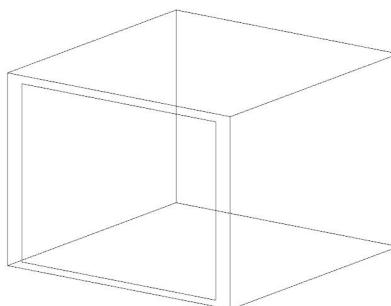


Split Glazing (70%)
SDA - 88%

Single Window (95%)
SDA - 100%

Single Window (95%)
SDA - 100%

Thermal
Comfort
Oriented



Maximized Glazing
No Shading
■ 9%
■ 96%
■ 1%

Maximized glazing
Box shading
■ 3%
■ 95%
■ 1%

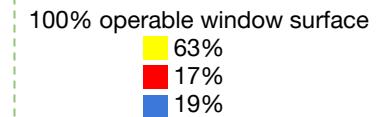
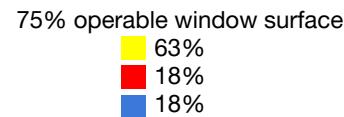
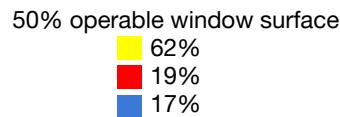
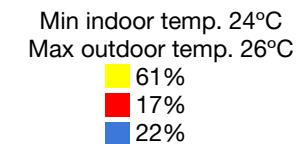
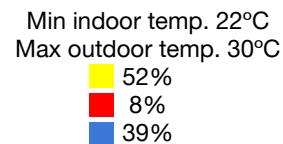
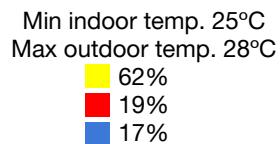
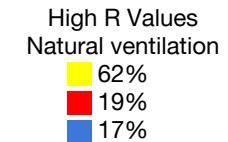
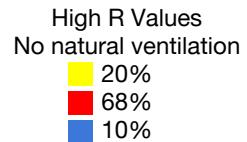
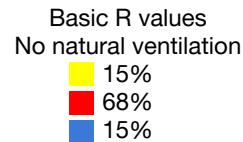
Maximized glazing
Shading + blinds
■ 4%
■ 95%
■ 1%

Glazing + Shade Design Process

UDLI + Adaptive Comfort

For the glazing design process there was not much to improve beyond the base case scenario. However, maximization of views was a defining factor, and 100% SDA was achieved by opening the windows to the maximum available surface.

For the Shading process, thermal comfort and reduction of glare probability were priorities. Final shaded case proved to help with thermal comfort much less, however glare is expected to reduce as well as proper light distribution.



Additional Parameters

Natural Ventilation + R Values

For this iterative process, R values, ventilation rates and limiting temperatures for natural ventilation were tested.

Basic R. Values were the following:

Wall: 5.5 R
Window: 1.0 R / 0.7 SHGC

High R. Values were the following:

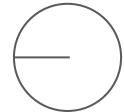
Wall: 34.5 R
Window: 1.9 R / 0.39 SHGC

Natural ventilation is the single parameter that improves thermal comfort the most, both by defining a smaller thermal gap (25-28 °C) and having a higher operable window surface (they must be foldable).



March
21

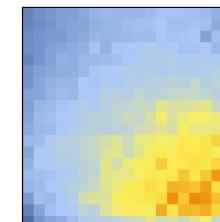
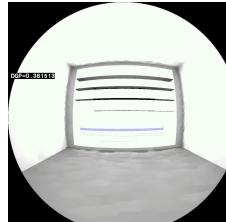
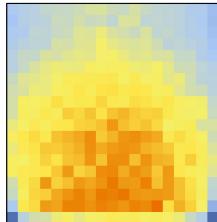
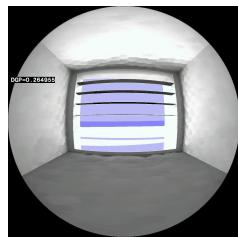
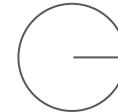
9AM



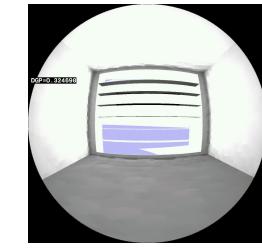
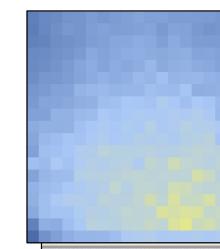
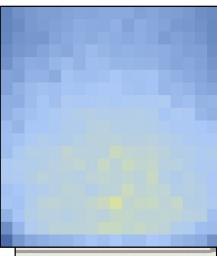
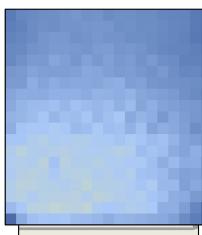
12Noon



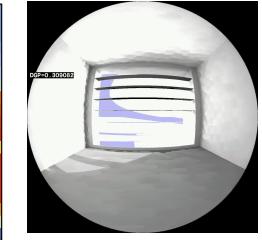
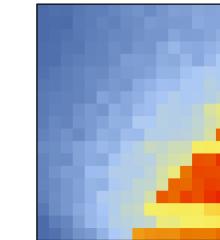
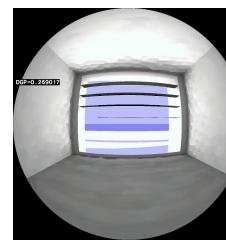
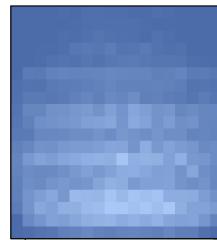
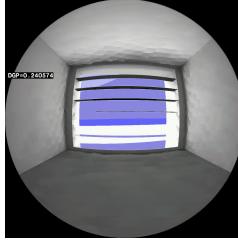
3PM



September
21



December
21

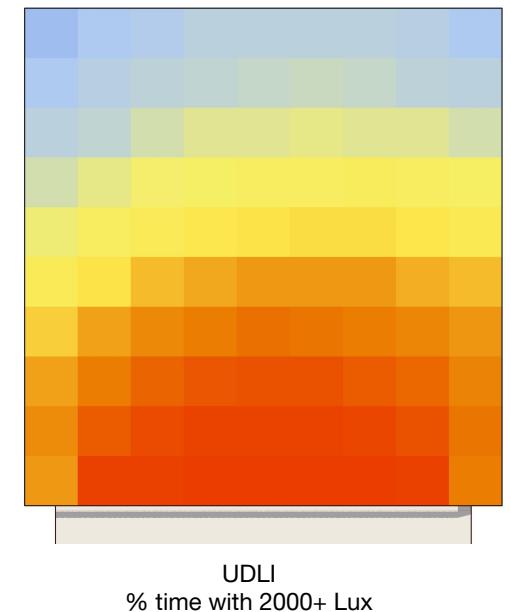
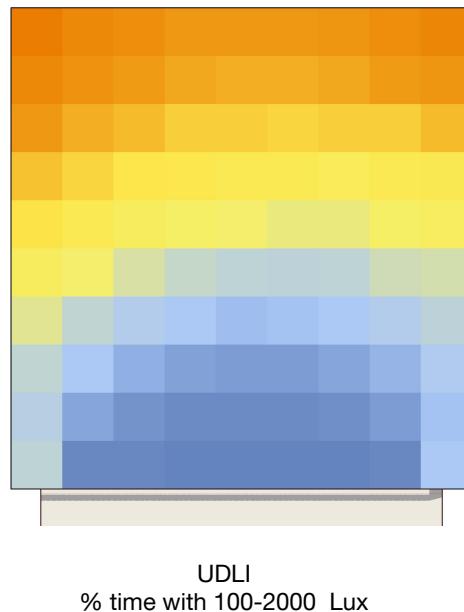
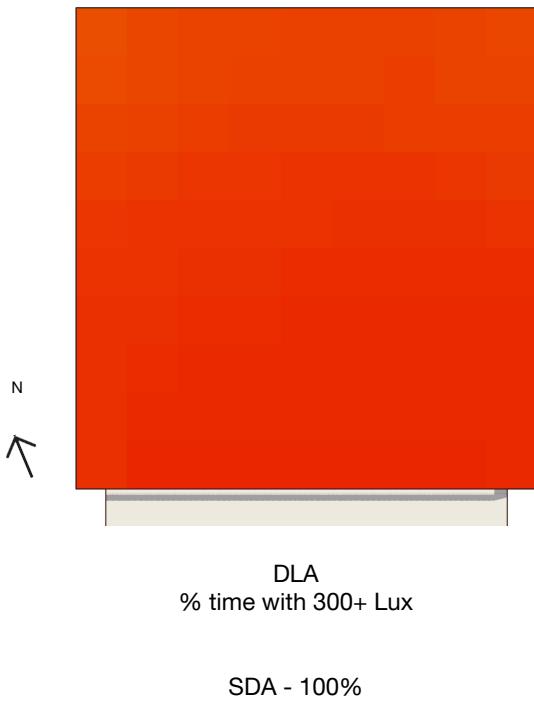


Design Case Daylighting

Lux, Glare

Compared to the base case, glare increased greatly. However it is still within the comfortable limits and should not be a problem. On the other hand, there is much better lux distribution throughout the room surface.

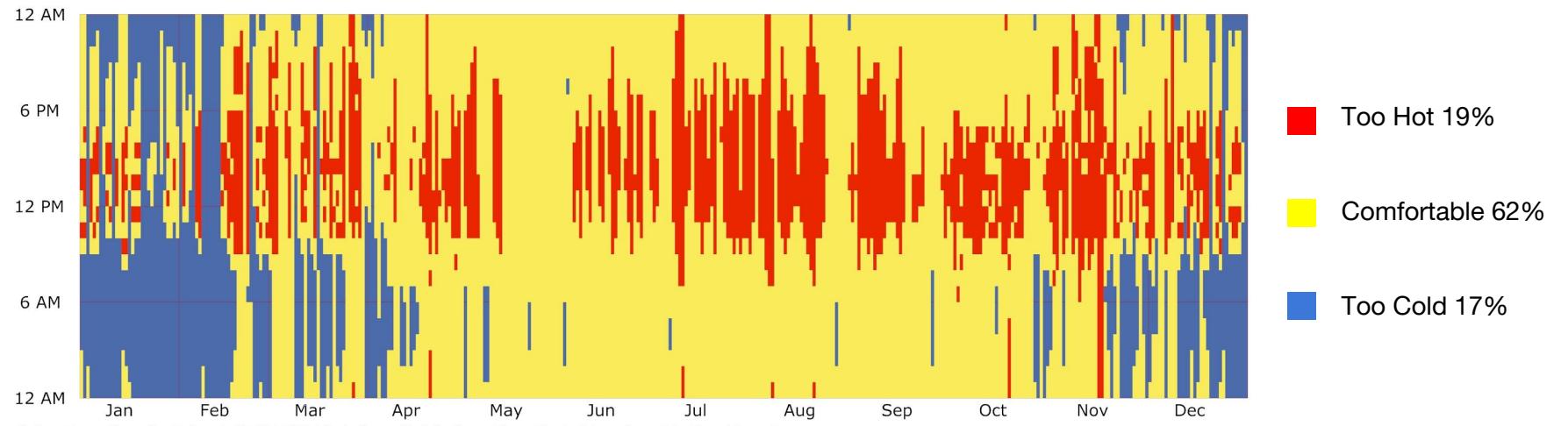
Surface for outside views was greatly maximized while maintaining glare levels within acceptable boundaries.



Design Case Daylighting

Lux, UDLI, DLA

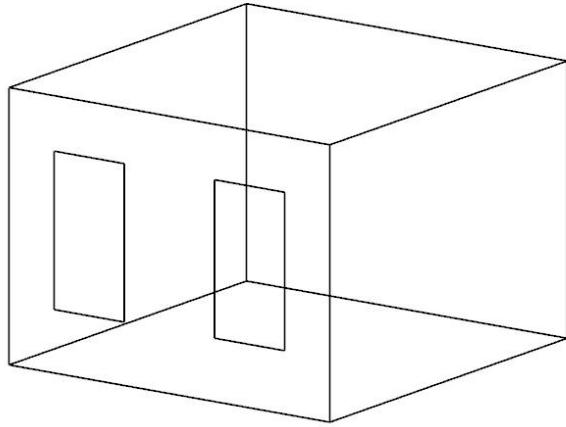
SDA was increased to 100%, making it a truly passively daylit space. UDLI above 2000 lux seems to be quite high close to the windows, but glare analysis shows acceptable levels.



Design Case Thermal Comfort

Adaptive Comfort Metrics

Thermal comfort has greatly improved, and half of the time the space can be passively cooled or heated, partly independent of mechanical systems. This reduces electrical loads greatly.



Daylighting

SDA: 75%

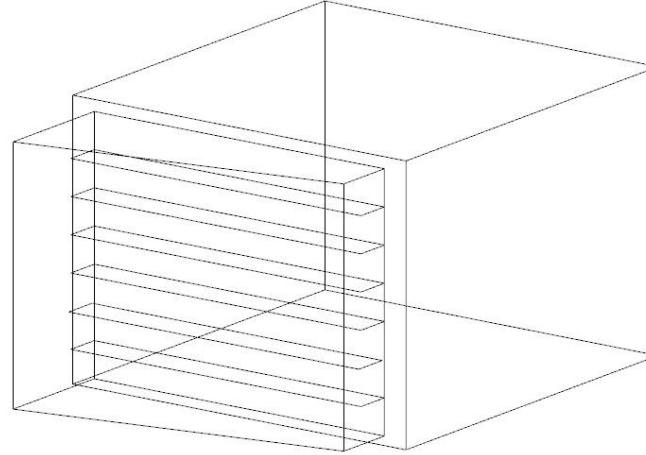
Glare Probability: 20-30%

Thermal Comfort

Too Hot 72%

Comfortable 16%

Too Cold 10%



Daylighting

SDA: 100% (+25%)

Glare Probability: 30 - 35% (+10%)

Thermal Comfort

Too Hot 19% (-53%)

Comfortable 62% (+46%)

Too Cold 17% (+7%)

Conclusions

Comparative Analysis

Although increased glazing surface reduces thermal comfort levels (due to higher exposure to heat, and glazing being a surface that easily lose/adds heat), there are ways to maximize glazing to improve views without losing thermal comfort.

Also, due to the fact that natural ventilation is now part of the equation, higher glazing surface means there is better thermal exchange when needed. Other parameters such as increased R values for the envelope and added shading are all possible in a real world retrofit project case, proving high levels of comfort can be met through passive solutions.