Final proposal for dream room

ARCH-753 BUILDING PERFORMANCE SIMULATION
PENNDESIGN | UNIVERSITY OF PENNSYLVANIA

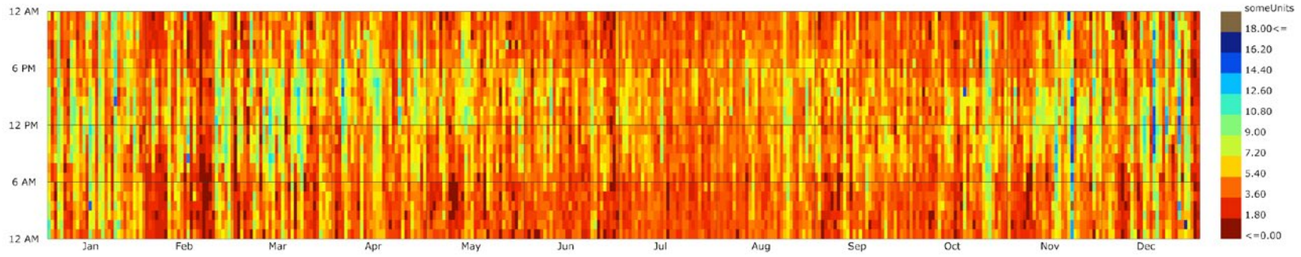
Climate Zone

weather data: USA_PA_Philadelphia.Intl.AP.724080_TMY3
lattitude: 39.87
longitude:-75.23
occupied hour: 6pm-8am

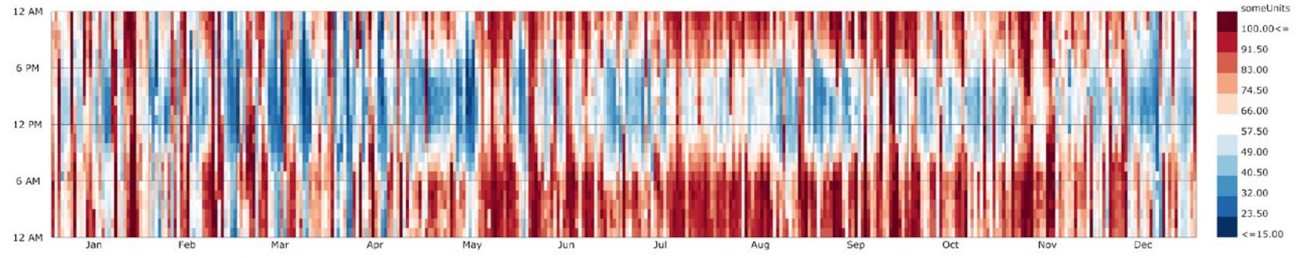
CLimate Zone: -5 zone
Characteristic:

Temperature in Philadelphia is mainly between between 12 to 20 throughout the whole year, And the average relative humidity is 65.9. However, relative humidity during daytime decreases to about 50%, which helps cooling temperature down by using evaporative strategy.

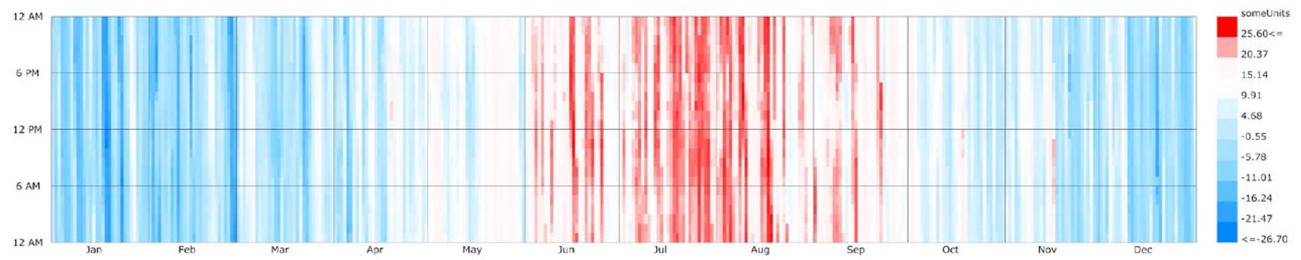
My building type of this project is 4-floor townhouse, and the occupied hour is mainly from 6pm to 8am, in which the outside temperature is not as high as daytime, but relative humidity higher than daytime might cause a problem which makes people uncomfortable.



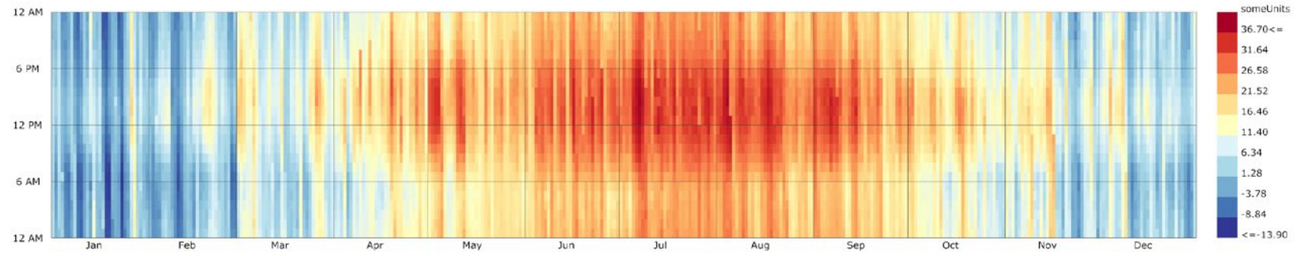
WIND SPEED m/s



RELATIVE HUMIDITY %



DEW POINT TEMPERATURE °C



DRY BULB TEMPERATURE °C

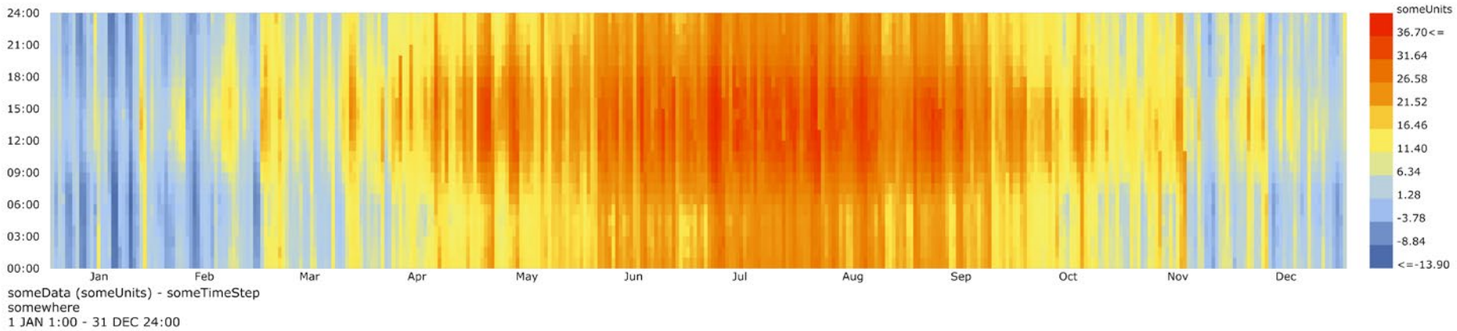
Comprehensive Climate Analysis

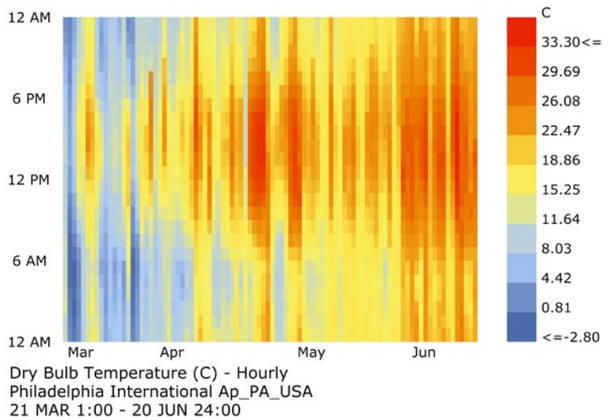
General Analysis:
Dry bulb Temperature/ Wind Speed/ Relative Humidity/Dew Point Temperature

SEASONAL DRY BULB TEMPERATURE

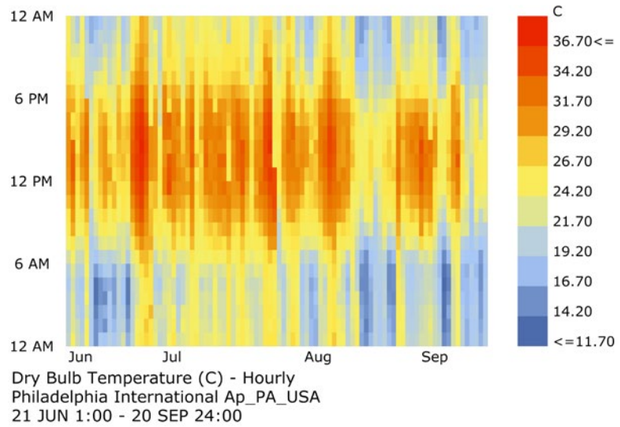
These graphics show the the average temperature of each season is 16, 24, 9.5, 1.1.

Concluded from data above, the climate of philadelphia will be cooler and uncomfortable for people during the autumn and the winter. Also, I assume at this time people would like more stay at home than going outside.

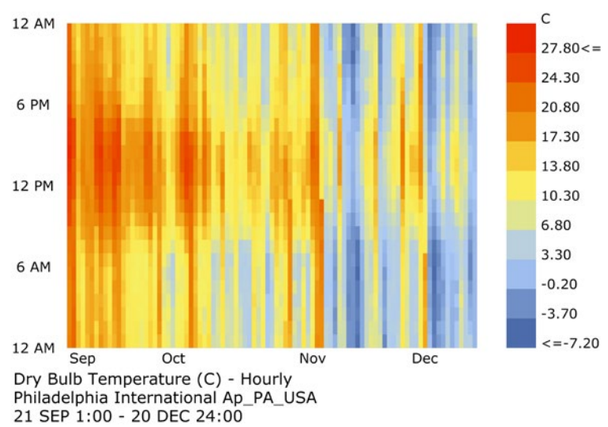




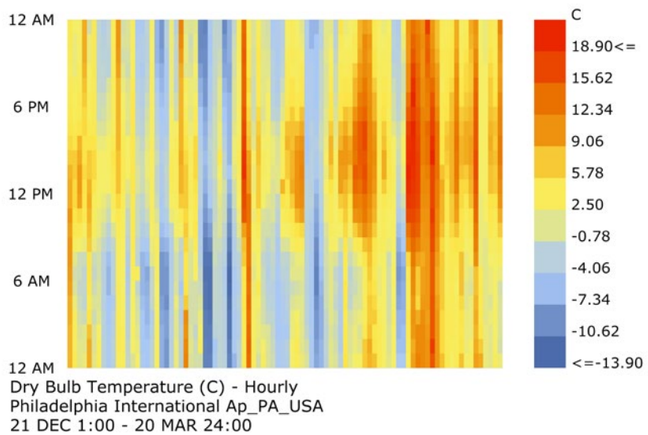
SPRING



SUMMER



AUTUMN

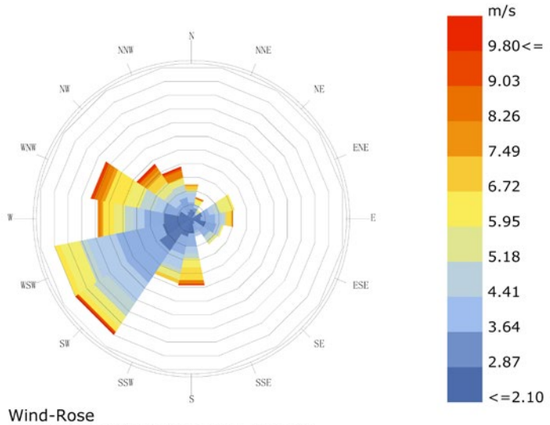


WINTER

WIND-ROSE CHARTS

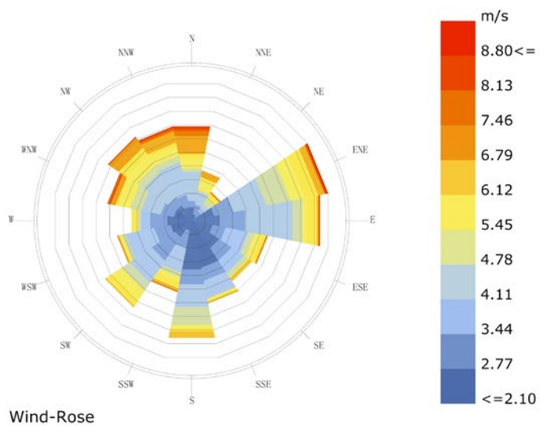
Take the standard of wind speed (2-10m/s) and Dry Bulb Temperature (18-24) as confortable references, we know that each season is totally different. There are 527 hours satisfied for Spring, 848 hours for Summer, 179 hours for Autumn, and 5 hours for Winter.

These windrose graphics are supplements to the previous page.



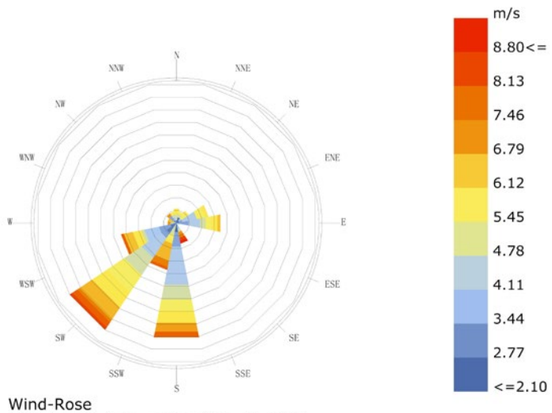
Wind-Rose
Philadelphia International Ap_PA_USA
21 MAR 1:00 - 20 JUN 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.3%. = 7 hours.
... ...
Conditional Selection Applied:
2 < Wind Speed < 10
and 18 < Dry Bulb Temperature < 24
527.0 hours of total 8760.0 hours (6.02%).
527.0 hours of analysis period 2208.0 hours (23.87%).

SPRING



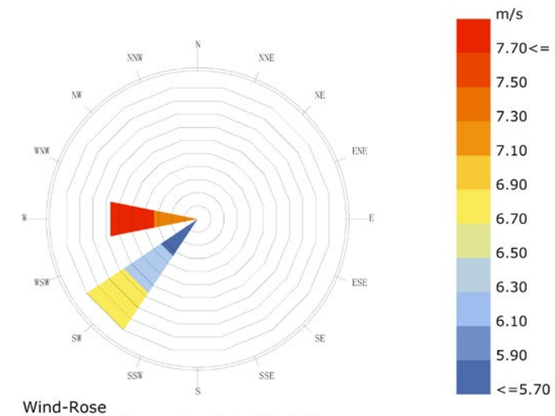
Wind-Rose
Philadelphia International Ap_PA_USA
21 JUN 1:00 - 20 SEP 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.4%. = 8 hours.
... ...
Conditional Selection Applied:
2 < Wind Speed < 10
and 18 < Dry Bulb Temperature <24
848.0 hours of total 8760.0 hours (9.68%).
848.0 hours of analysis period 2208.0 hours (38.41%).

SUMMER



Wind-Rose
Philadelphia International Ap_PA_USA
21 SEP 1:00 - 20 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.2%. = 4 hours.
... ...
Conditional Selection Applied:
2 < Wind Speed < 10
and 18 < Dry Bulb Temperature <24
179.0 hours of total 8760.0 hours (2.04%).
179.0 hours of analysis period 2184.0 hours (8.20%).

AUTUMN



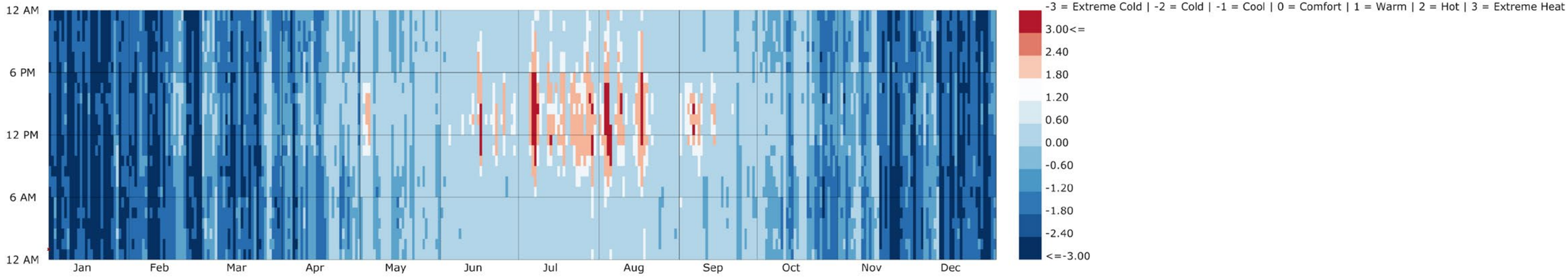
Wind-Rose
Philadelphia International Ap_PA_USA
21 DEC 1:00 - 20 MAR 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.0%. = 0 hours.
... ...
Conditional Selection Applied:
2 < Wind Speed < 10
and 18 < Dry Bulb Temperature < 24
5.0 hours of total 8760.0 hours (0.06%).
5.0 hours of analysis period 2160.0 hours (0.23%).

WINTER

“UTCI, is Universial Thermal Climate Index, including parameters of dry bulb temperature relative humidity, wind speed, and it uses them in a human energy balance model to give a temperature value that is indicative of the heat stress or cold stress felt by the human body.

From the UTCI graphic, the main issue is in summer during daytime, it is in strong heat stress range, and from October to December and January to April, it is in the cold stress.

Heat Stress(-13<UTCI<9)=3.14%
Comfortable(9<UTCI<26)=41.28%
Cold Stress(26<UTCI<32)=34.3%

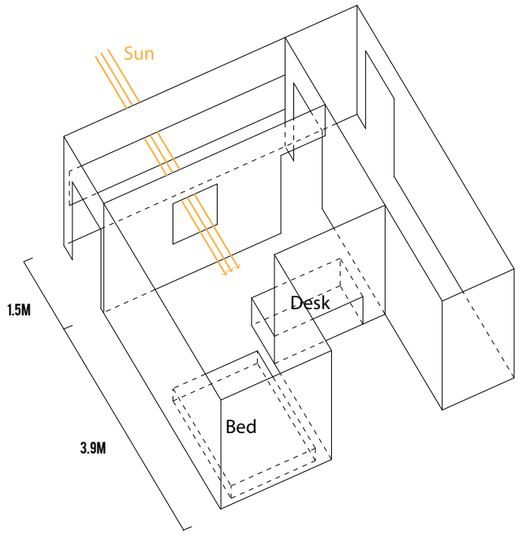


-3 - Strong Cold Stress - potential public health hazard with higher-than-normal mortality rates (UTCI < -13C).
-2 - Moderate Cold Stress - cold but no public health hazard (-13C < UTCI < 0C).
-1 - Slight Cold Stress - cool but comfortable for short periods of time (0C < UTCI < 9C)
0 - No Thermal Stress - comfortable conditions (9C < UTCI < 26C).
+1 - Slight Heat Stress - warm but comfortable for short periods of time (26C < UTCI < 28C).
+2 - Moderate Heat Stress - hot but no public health hazard (28C < UTCI < 32C).
+3 - Strong Heat Stress - potential public health hazard with higher-than-normal mortality rates (UTCI > 32C).

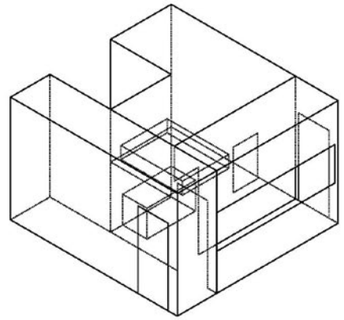
TEST ROOM MODEL FOR DAYLIGHT SIMULATION

My room has a corridor in front of it. This daylight simulation is the test that how I could use shading to reduce the radiance of sunlight.

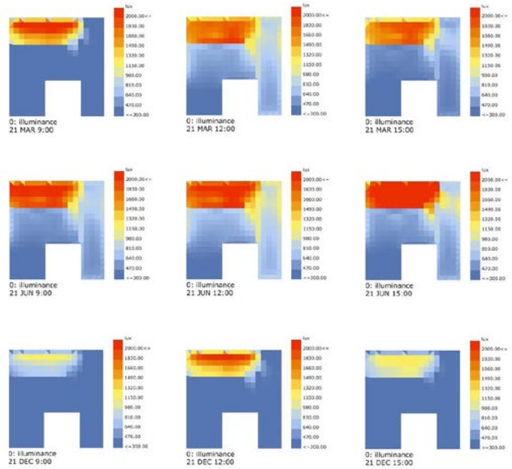
Run 9 grid-based daylight analysis for 21 of March, June, and December at 9, 12 and 15



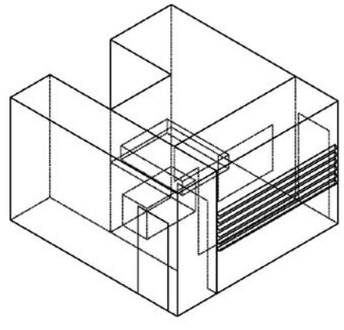
without shading



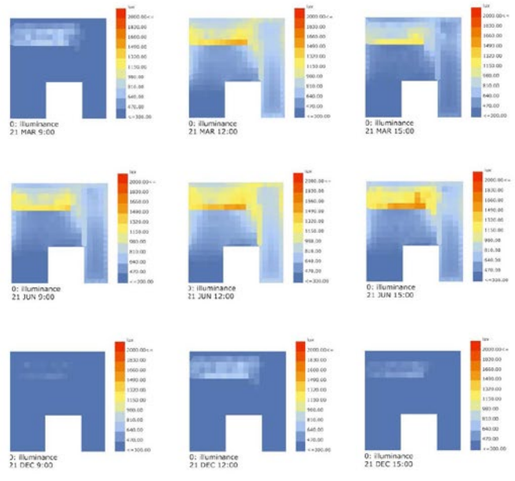
Dream Room without Shading



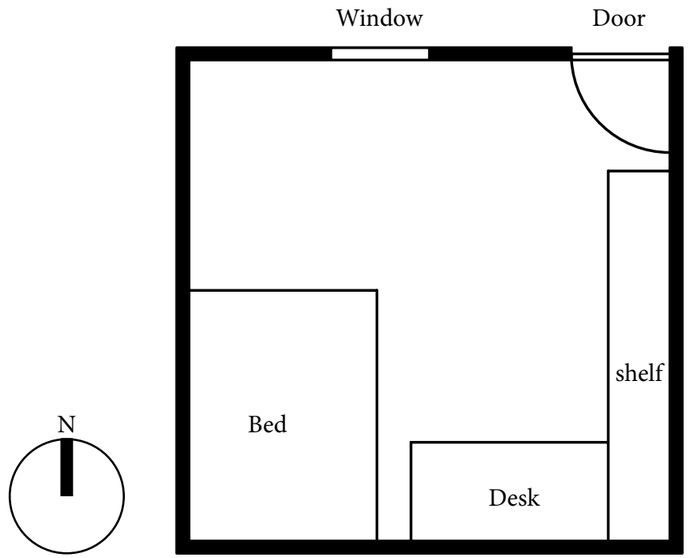
with shading

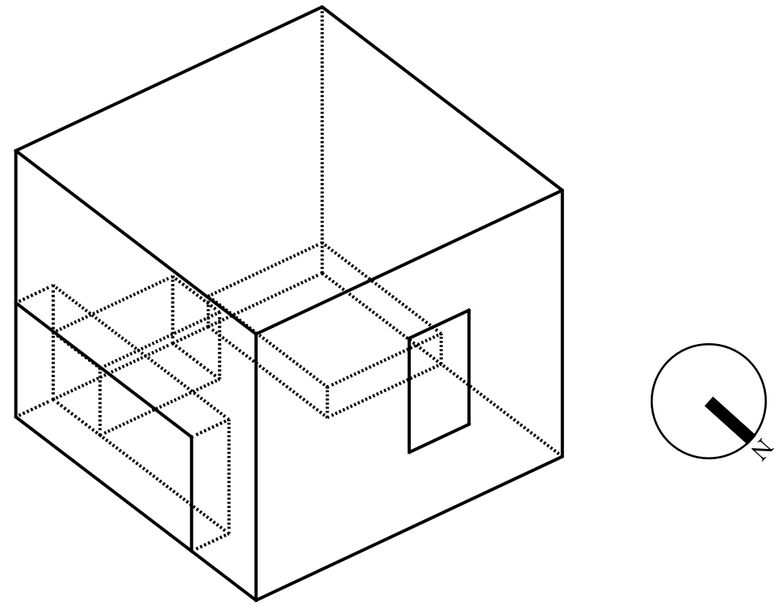


Dream Room with Shading



BASE-CASE MODEL
Annual Daylight Analysis

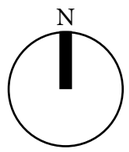


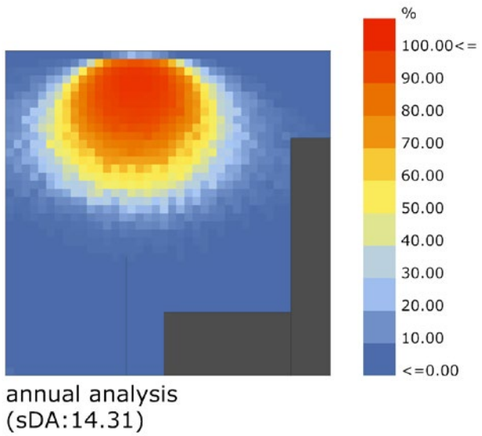


*in order to make results more accurate, I remove the corridor.

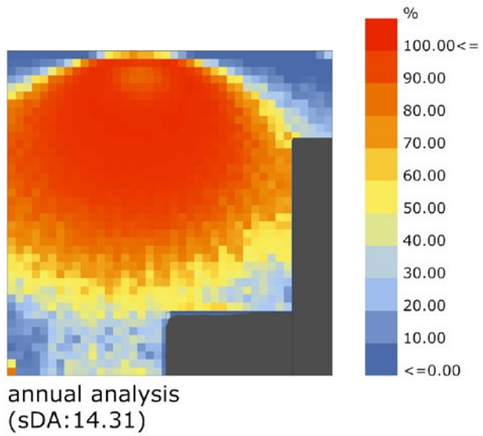
BASE-CASE MODEL ASSESSMENT

annual daylight analysis and thermal comfort analysis

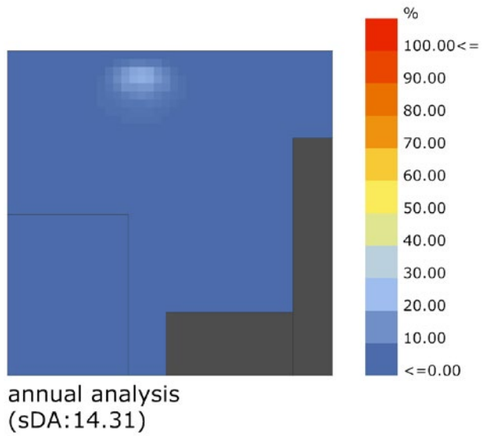




DAYLIGHT AUTONOMY(DLA)
300 LUX



USEFUL DAYLIGHT(UDLI)
100-2000z LUX



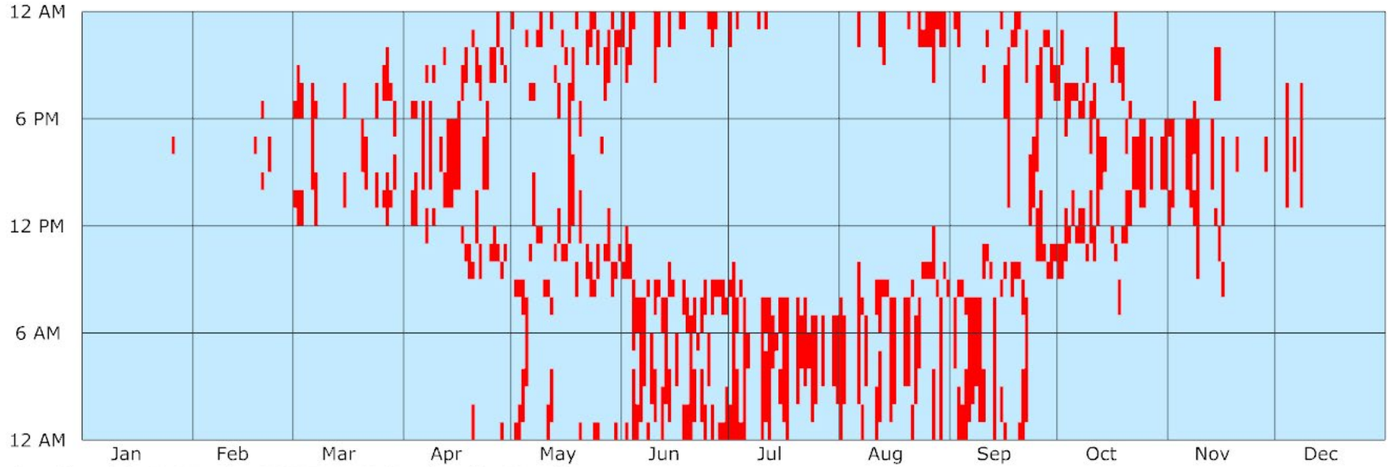
USEFUL DAYLIGHT(UDLI)
>2000 LUX

sDA:14.31%

INDOOR COMFORT
Adaptive comfort

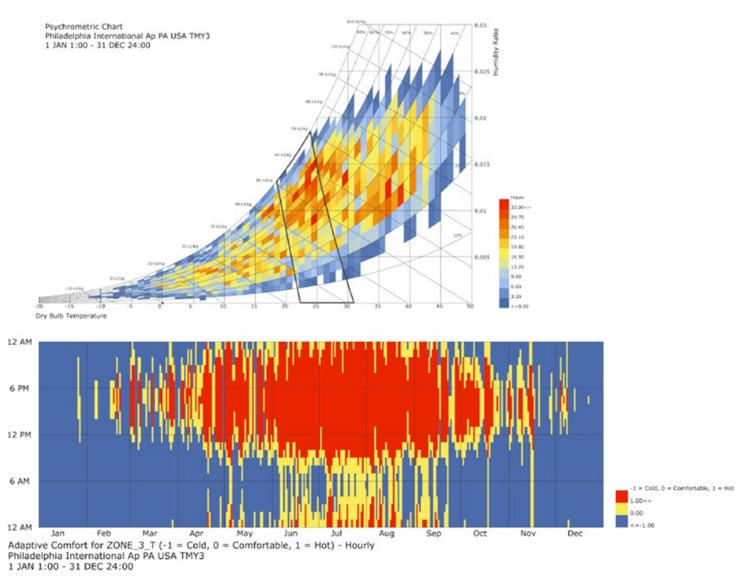
first run of energy simulation to caculate the indoor comfort.
Indoor comfort analysis for baseline shows only about 10% PMV comfort and 17% adaptive comfort of entire year hours. Comparing to outdoor UTCI comfort, there is 20 – 30 % reduction in both PMV and adaptive comfort of indoor environment.
By looking at comfort condition chart, the major reason caused un-comfortable is cold issue in winter and hot issue in summer.

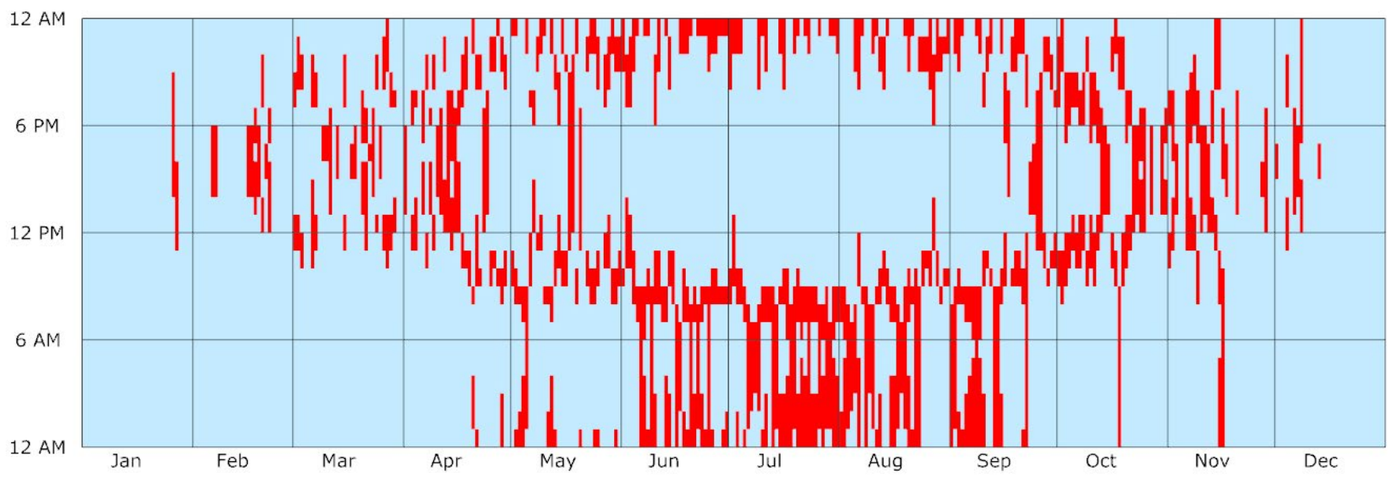
Adaptive comfort(%)=17.8
hot(%)=27.1
cold(%)=55



PMV COMFORT OR NOT

10.75%
comfortable





ADAPTIVE COMFORT OR NOT

17%
comfortable

Issue1:
Cold Stress in Winter&low Adaptive Comfortable
Issue2:
low sDA means the room cannot get enough sunlight

Proposal:
comfortable hours could be modified by several reasons
1. change room orientation
2. change the size of windows
3. change construction materials
4. add shading

Orientation Change

When the wndow to wall ratio is 0.1 same with the situation of the dream room, there is no obvious comfortable time modification through the orientation change.

0°

Adaptive comfort (%)17.02
PMV comfort(%)10.75
Cold Stress(%)57.69

45°

Adaptive comfort (%)16.50
PMV comfort(%)10.65
Cold Stress(%)57.41

90°

Adaptive comfort (%)16.64
PMV comfort(%)10.71
Cold Stress(%)56.52

135°

Adaptive comfort (%)16.68
PMV comfort(%)10.8
Cold Stress(%)55.53

180°

Adaptive comfort (%)17.05
PMV comfort(%)10.97
Cold Stress(%)55.03

Orientation Change& Window Size Change

When the wndow to wall ratio is 0.3 and north window orient to South(180°), the cold issue is modified, and the confortable time become better.

0°

Adaptive comfort (%)16.39
PMV comfort(%)10.71
Cold Stress(%)57.32

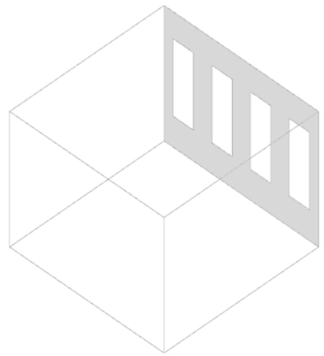
45°

Adaptive comfort (%)16.0
PMV comfort(%)10.38
Cold Stress(%)56.46

90°

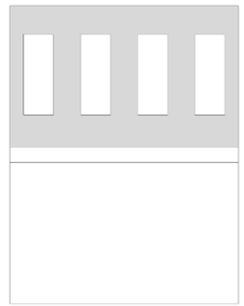
Adaptive comfort (%)15.8
PMV comfort(%)10.38
Cold Stress(%)54.2

135°



Adaptive comfort (%)16.03
PMV comfort(%)10.08
Cold Stress(%)51.75

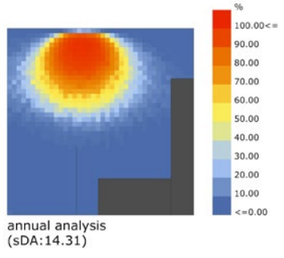
180°



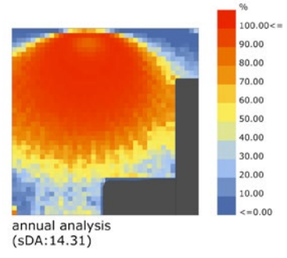
Adaptive comfort (%)16.24
PMV comfort(%)10.8
Cold Stress(%)50.55

Comparison of the SDA
when the north window(0°) orient to south(180°)

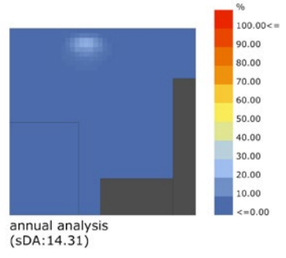
WWR 0.1



DAYLIGHT AUTONOMY(DLA)
300 LUX



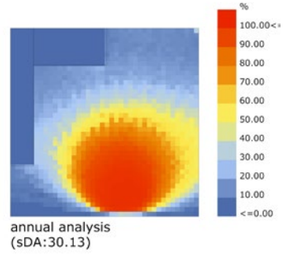
USEFUL DAYLIGHT(UDLI)
100-2000z LUX



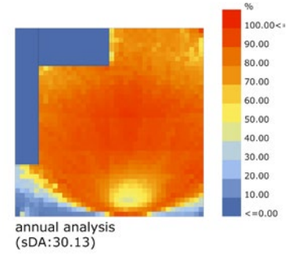
USEFUL DAYLIGHT(UDLI)
>2000 LUX

sDA:14.31%

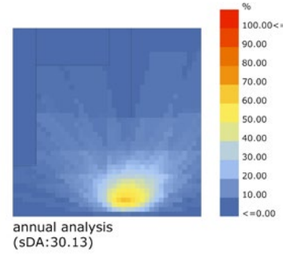
WWR 0.1



DAYLIGHT AUTONOMY(DLA)
300 LUX



USEFUL DAYLIGHT(UDLI)
100-2000z LUX

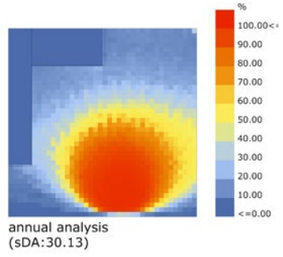


USEFUL DAYLIGHT(UDLI)
>2000 LUX

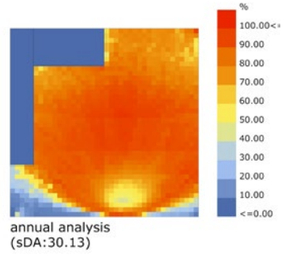
sDA:30.13%

Comparison of the SDA
The south window(180°) become triple large

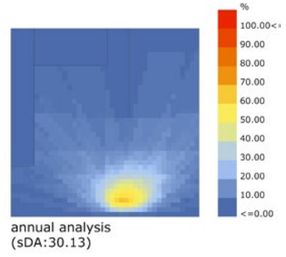
WWR 0.1



DAYLIGHT AUTONOMY(DLA)
300 LUX



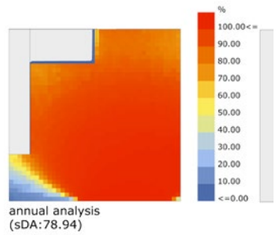
USEFUL DAYLIGHT(UDLI)
100-2000z LUX



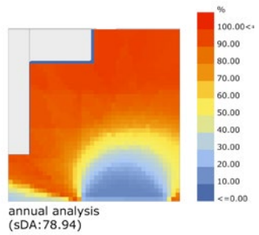
USEFUL DAYLIGHT(UDLI)
>2000 LUX

sDA:30.13%

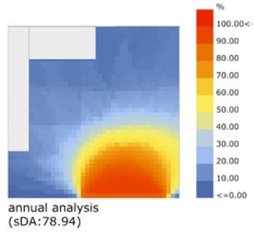
WWR 0.3



DAYLIGHT AUTONOMY(DLA)
300 LUX



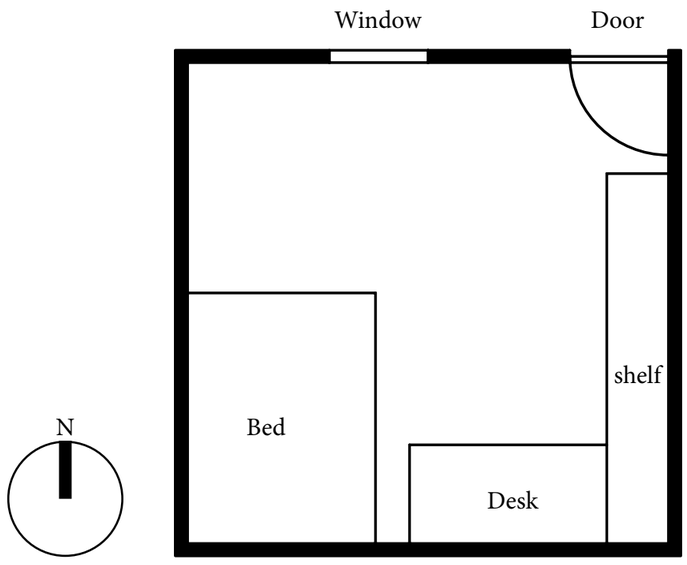
USEFUL DAYLIGHT(UDLI)
100-2000z LUX



USEFUL DAYLIGHT(UDLI)
>2000 LUX

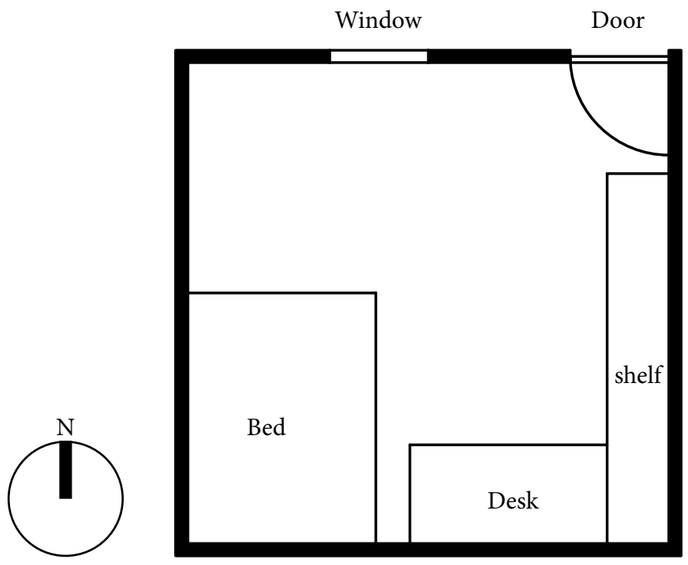
sDA:78.94%

Strategies:
Orientation&Window Ratio



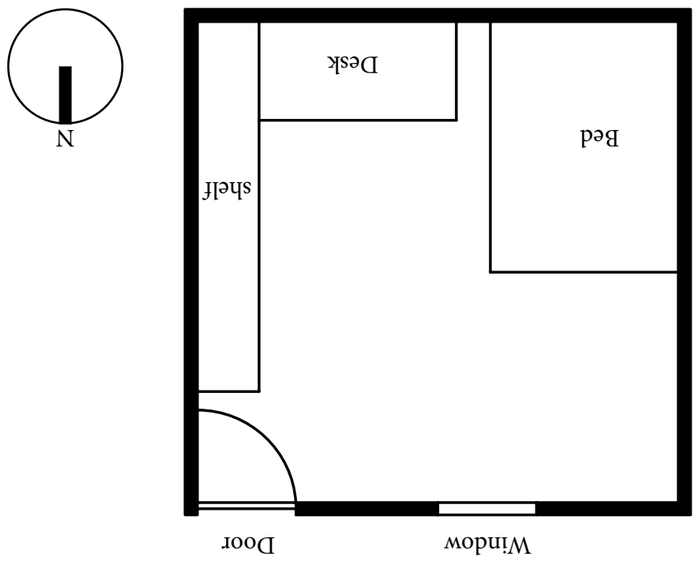
sDA:14.31%

Adaptive comfort(%)=17.8
hot(%)=27.1
cold(%)=55



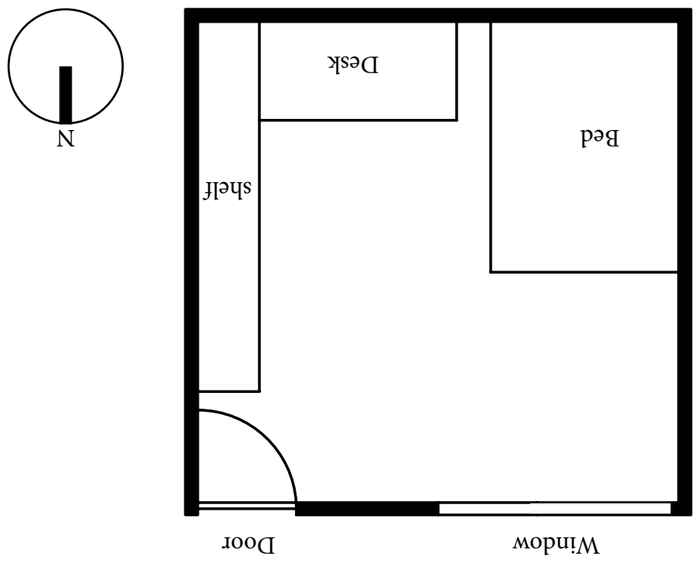
sDA:14.31%

Adaptive comfort(%)=17.8
hot(%)=27.1
cold(%)=55



sDA:30.13%

Adaptive comfort (%)17.05
PMV comfort(%)10.97
Cold Stress(%)55.03



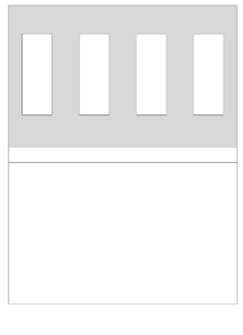
sDA:78.94%

Adaptive comfort (%)16.24
PMV comfort(%)10.8
Cold Stress(%)50.55

Further Strategies

Change construction material

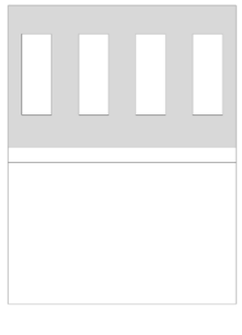
WWR 0.3



Adaptive comfort (%)17.05
PMV comfort(%)10.97
Cold Stress(%)55.03

Exterior Wall (R5.5)
Exterior Window(R1.0, SHGC0.7)
Exterior Roof(R9.2)
Air change hour(2)

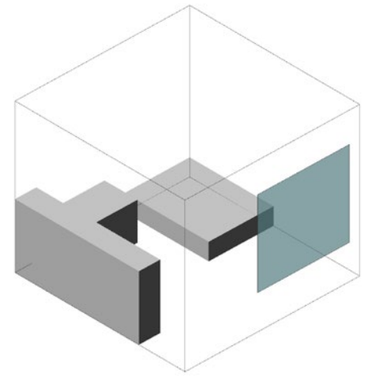
WWR 0.3



Adaptive comfort (%)21.86
Cold Stress(%)43.26

Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

WWR 0.3



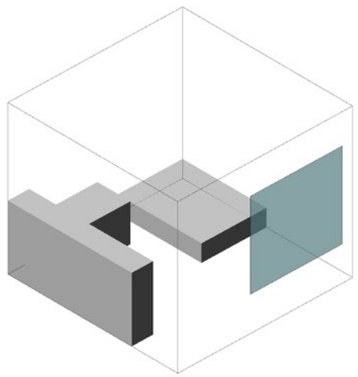
Adaptive comfort (%)20
Cold Stress(%)34

Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

Further Strategies

Add shading shelter

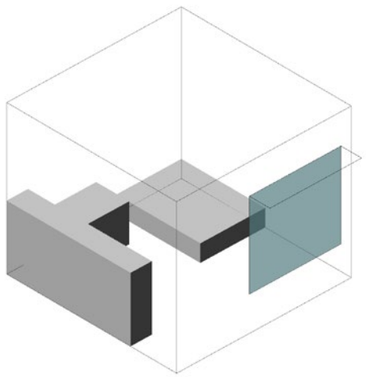
window to wall ratio 0.3 same to what I get from before



Adaptive comfort (%)21.72
Hot Stress(%)45.70
Cold Stress(%)32.58

Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

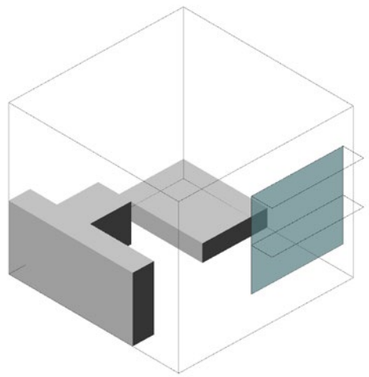
shelter number 1



Adaptive comfort (%)23.87
Hot Stress(%)39.24
Cold Stress(%)36.89

Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

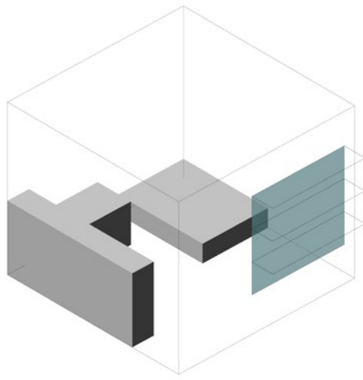
shelter number 2



Adaptive comfort (%)24.20
Hot Stress(%)34.21
Cold Stress(%)41.59

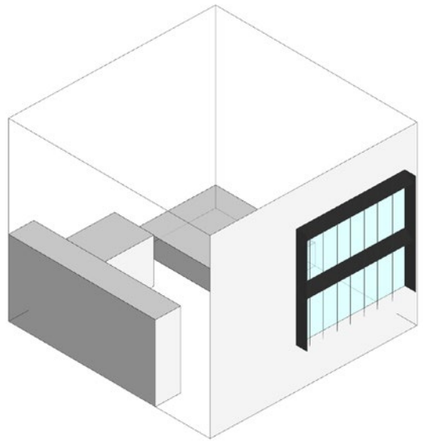
Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

shelter number 3

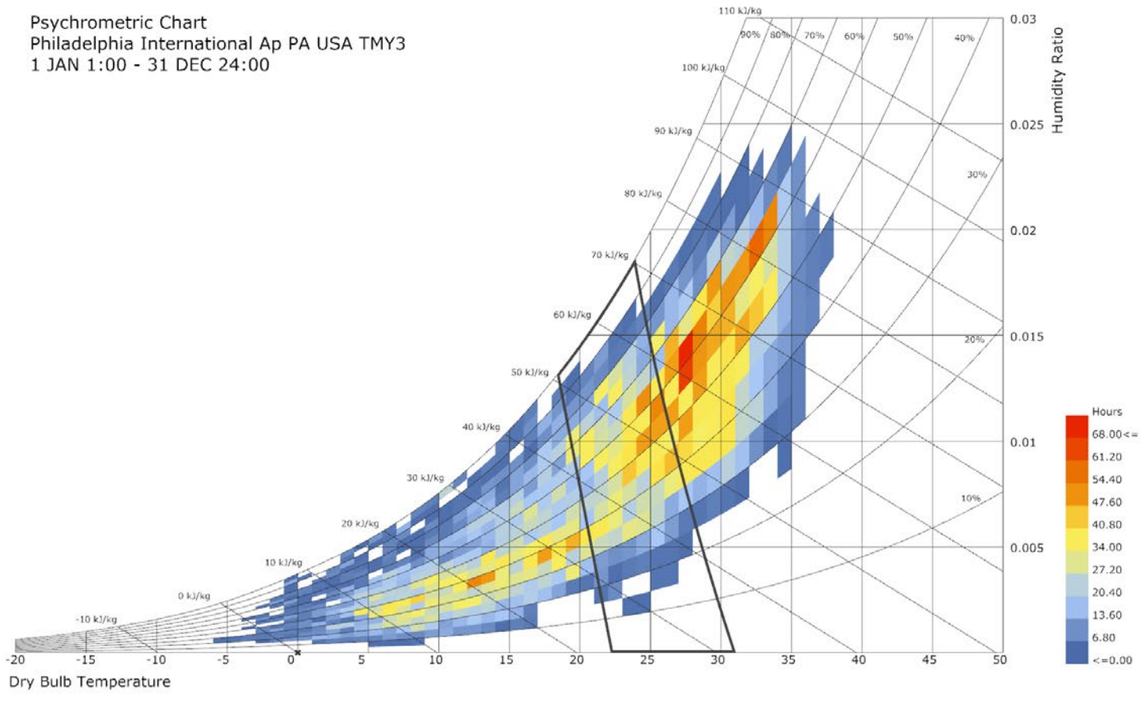


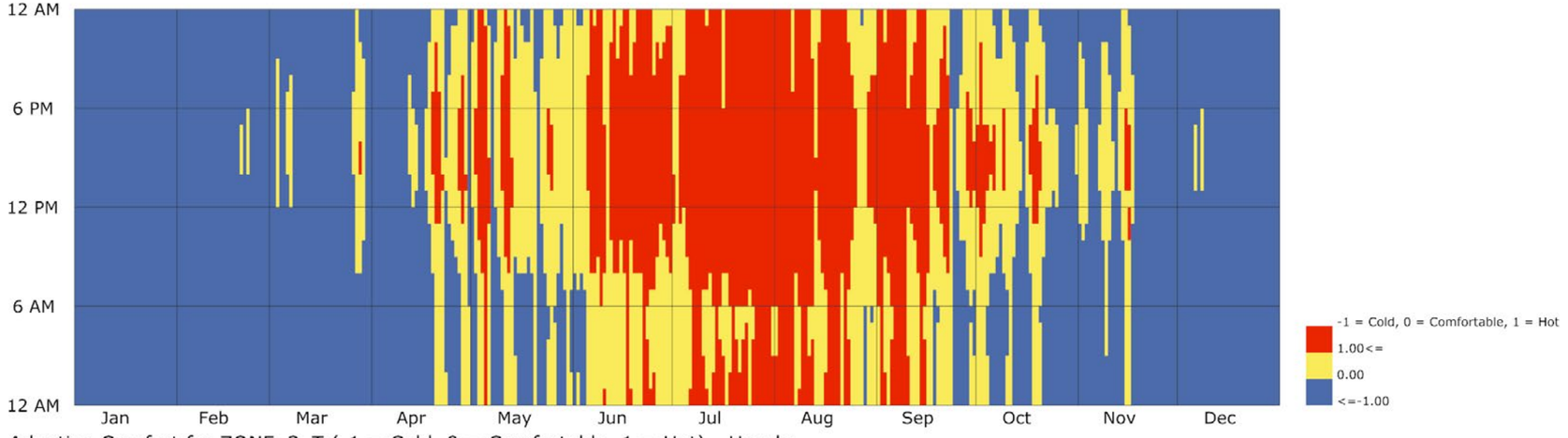
Adaptive comfort (%)23.85
Hot Stress(%)30.25
Cold Stress(%)45.9

Exterior Wall (R34.4)
Exterior Window(R0.7, SHGC0.65)
Exterior Roof(R34.4)
Air change hour(2)

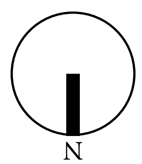


Adaptive comfort (%)24.10
Hot Stress(%)23.26
Cold Stress(%)52.64

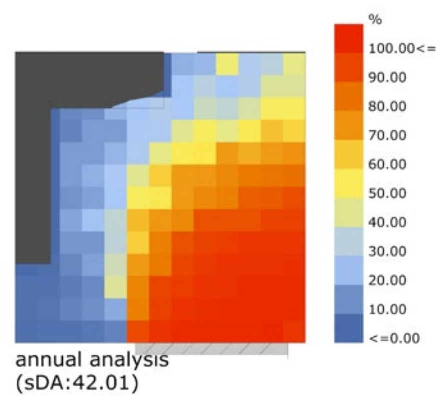




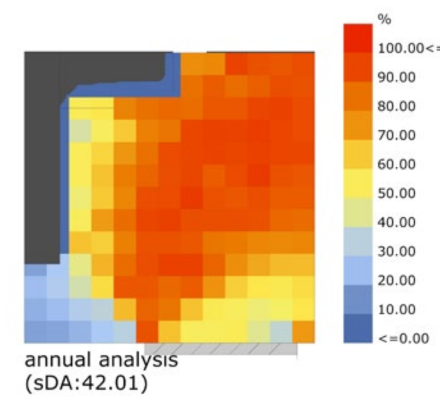
Adaptive Comfort for ZONE_3_T (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



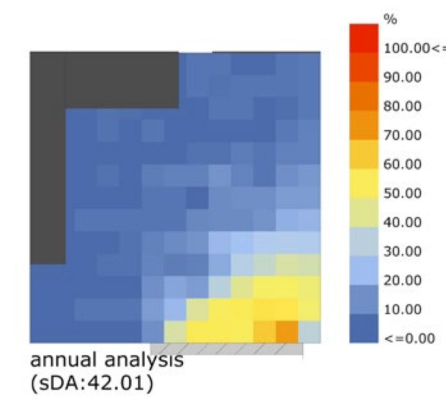
WWR 0.3



DAYLIGHT AUTONOMY(DLA)
300 LUX



USEFUL DAYLIGHT(UDLI)
100-2000z LUX



USEFUL DAYLIGHT(UDLI)
>2000 LUX

sDA:42.01%