Maximization Comfort of My Dream House

Daylight, Thermal and Visual

Fan Cao

Professor: Mostapha Sadeghipour Roudsari
Fall 2016| ARCH 753 Building Performance Simulation

Part 1:

Final Project For Dream House

In Seattle

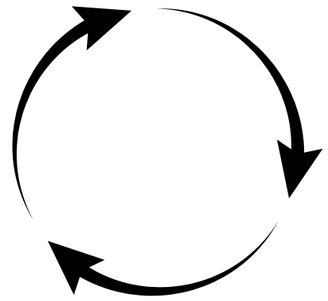
Part 2:

Previous Work For Dream House

In Philadelphia

Part 3:

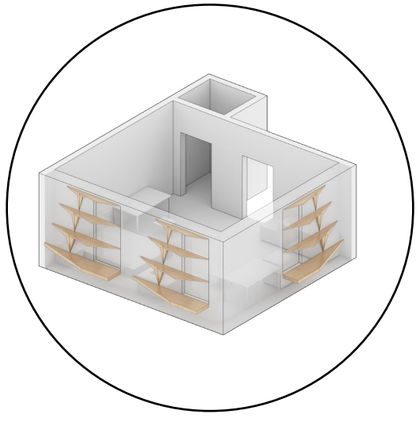
Conclusion and Analysis



Part 1:

Final Project

Site: Seattle

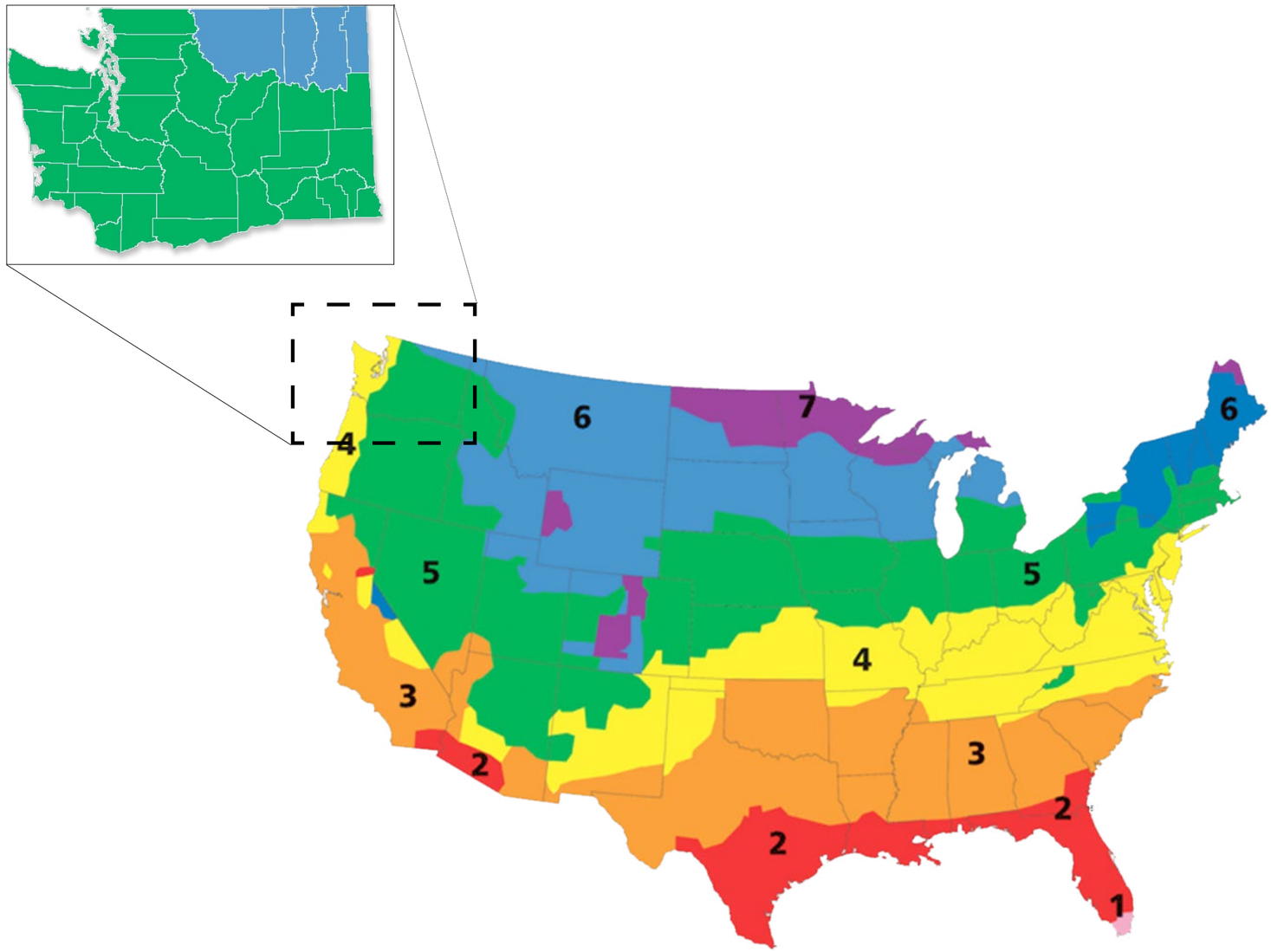


Climate Zone

Code and general condition

Residencial Code

Ceiling R-value	**38**
Wood Frame Wall R-value	**20 or 13+5[h]**
Mass Wall R-value [i]	**13/17**
Floor R-value	**30[g]**
Basement Wall R-value [c]	**10/13**
Slab R-value [d], Depth	**10, 2 ft**
Crawlspace Wall R-value [c]	**10/13**
Fenestration U-Factor [b]	**0.35**
Skylight U-Factor [b]	**0.60**
Glazed fenestration SHGC [b, e]	**NR**



Climate Zone Map

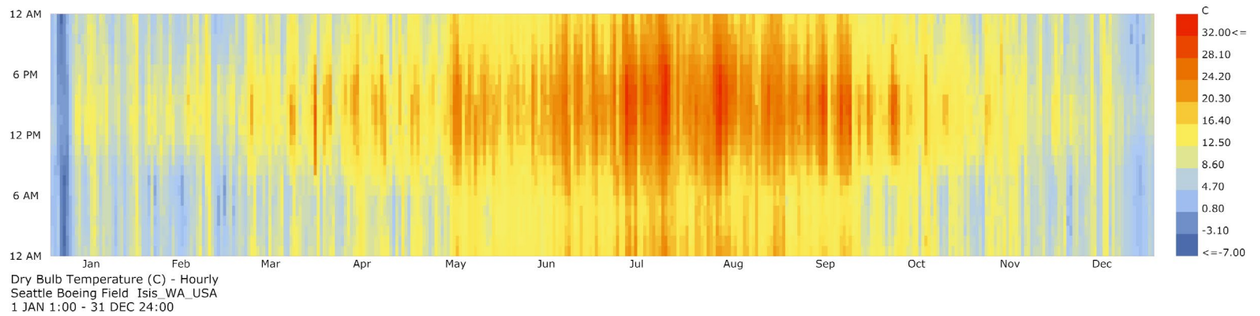
From the Climate zone, we can find that Seattle is belonging to the Zone 4 B which means that the wheather is cold and humid.

From the Residencial code, we can got some information of the construction material requirement. For the final step, it would be much easier to choose the way of how to construct.

Outdoor Data

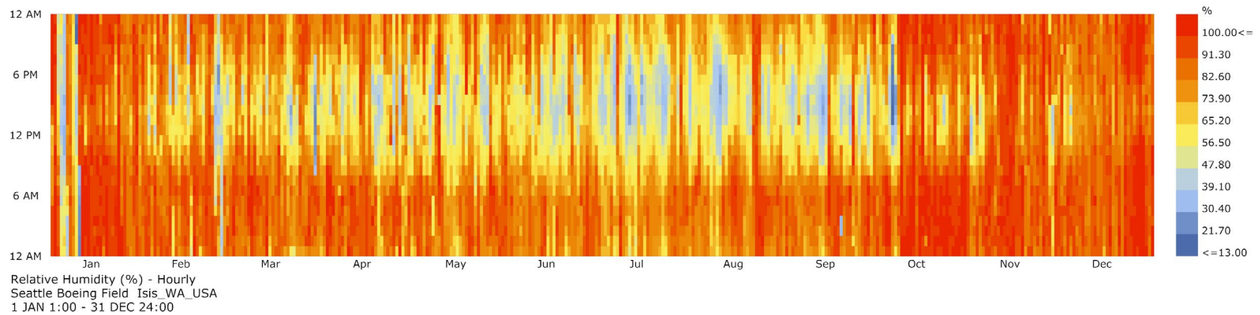
Temperature, wind speed and humidity

Using Seattle EPW file to generate the basic ourdoor weather data. From the thermal chart we can finde the weather is not that extreme. No extreme cold and no extreme hot.



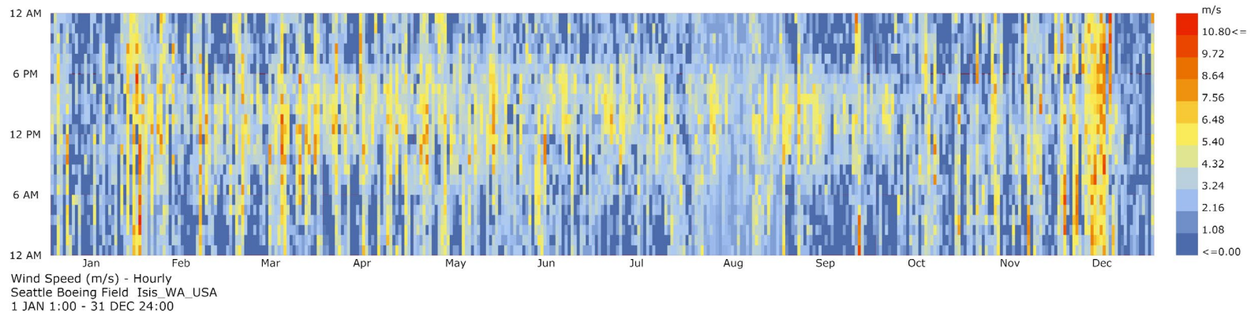
Thermal Chart

From the Humidity chart, since the seattle is surronded by the mountain and sea. So, the environment is very humid. So, the humidity would be the majot issue to deal with.



Humidity Chart

To deal with the humidity, the major way is to using the ventilation at the proper time. But, since the location of the seattle, the wind dirction and strength vary following the time.



Wind Chart

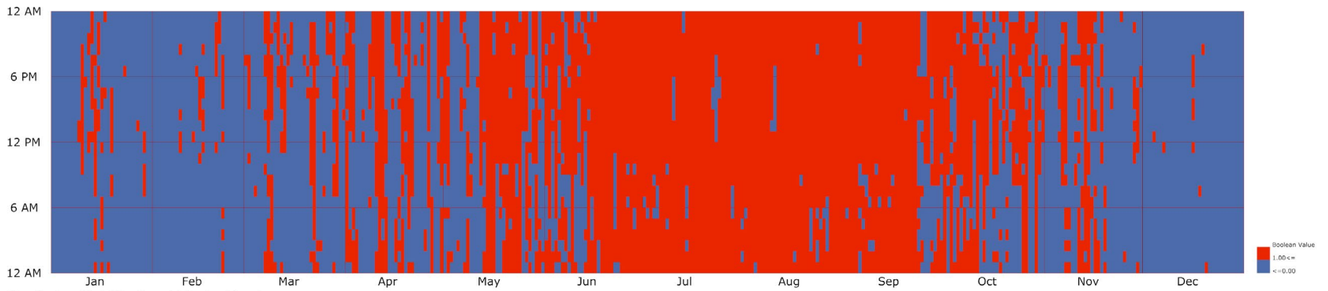
Outdoor Data

Outdoor comfort

Percent of Time Comfortable: 48.1%
Heat Stress: 0.13%
Cold Stress: 14.6%

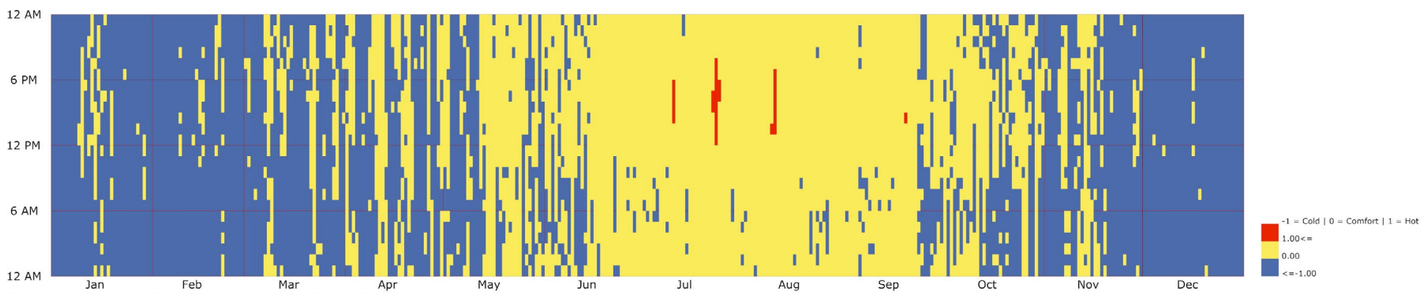
I also run the outdoor comfort for Seattle and find there is a good rate for the comfort. And even for the thermal pressure, majorly is coming for the cold weather instead of hot. So, the only issue we need to focus is to improve the indoor temperature to increase the rate of indoor comfort.

After that, I keep use the epw data to deal with the relationship between the temperature. I try to using some less strong wind to decrease the humidity indoor.



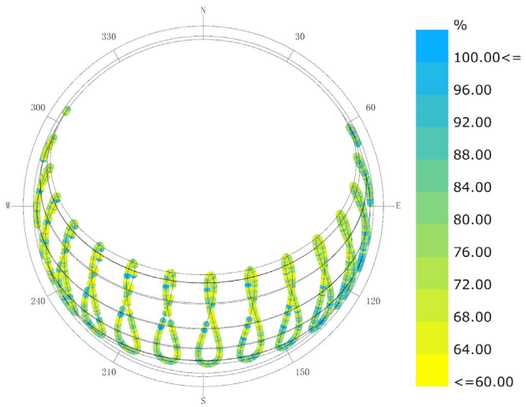
Comfort or Not (Boolean Value) - Hourly
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00

Outdoor Comfort



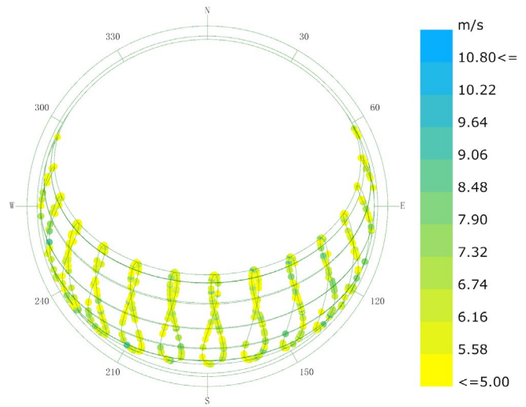
Thermal Stress (-1 = Cold | 0 = Comfort | 1 = Hot) - Hourly
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00

Outdoor Thermal Pressure



Sun-Path Diagram - Latitude: 47.68
Hourly Data: Relative Humidity (%)
Seattle Boeing Field Isis_WA_USA
... ...
Conditional Selection Applied:
Relative Humidity > 60
2809.0 hours of total 4407.0 sun up hours(63.74%).

Sun Path with Humidity



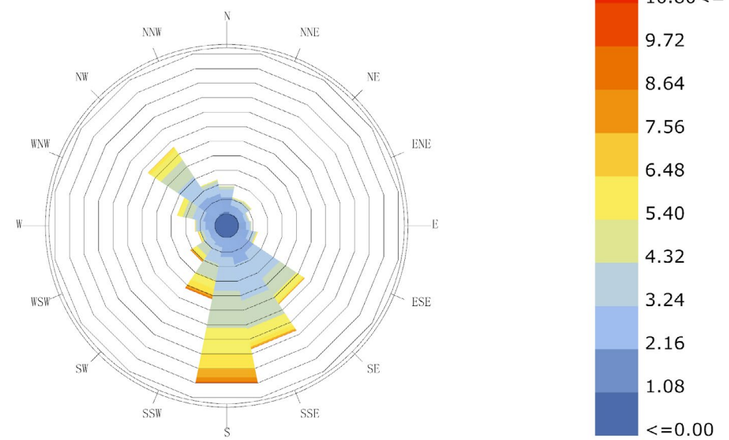
Sun-Path Diagram - Latitude: 47.68
Hourly Data: Wind Speed (m/s)
Seattle Boeing Field Isis_WA_USA
... ...
Conditional Selection Applied:
Wind Speed > 5
547.0 hours of total 4407.0 sun up hours(12.41%).

Sun Path with Wind Speed

Outdoor Data

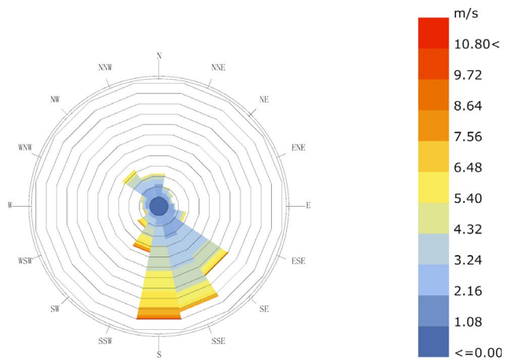
Different Season: wind distribution

I am trying to find a typcial relationship between the wind dirction and season. And find the relationship between them. But I can not deal with them. Since the building is fix. When I need the when, I can not ideally changing the room direction at that time. But, it is still an clue when I adject the dirction of the room.



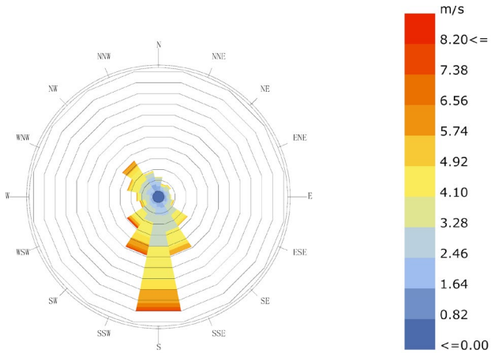
Wind-Rose
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 19.97% of the time = 1749 hours.
Each closed polyline shows frequency of 1.5%. = 135 hours.

Wind Rose



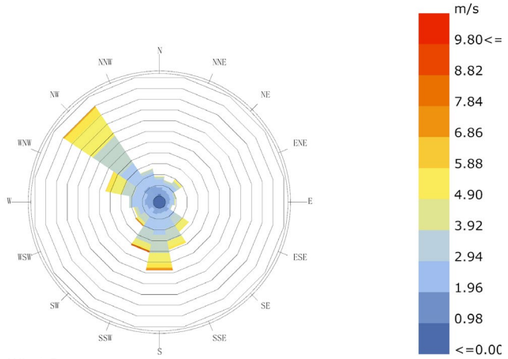
Wind-Rose
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 MAR 24:00
Hourly Data: Wind Speed (m/s)
Calm for 22.64% of the time = 489 hours.
Each closed polyline shows frequency of 1.6%. = 34 hours.

Winter - Wind Rose



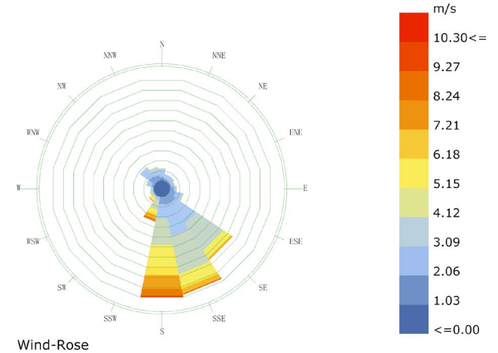
Wind-Rose
Seattle Boeing Field Isis_WA_USA
4 APR 1:00 - 30 JUN 24:00
Hourly Data: Wind Speed (m/s)
Calm for 16.67% of the time = 352 hours.
Each closed polyline shows frequency of 2.0%. = 42 hours.

Spring - Wind Rose



Wind-Rose
Seattle Boeing Field Isis_WA_USA
7 JUL 1:00 - 30 SEP 24:00
Hourly Data: Wind Speed (m/s)
Calm for 15.41% of the time = 318 hours.
Each closed polyline shows frequency of 1.7%. = 35 hours.

Summer - Wind Rose



Wind-Rose
Seattle Boeing Field Isis_WA_USA
10 OCT 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 23.19% of the time = 462 hours.
Each closed polyline shows frequency of 1.8%. = 36 hours.

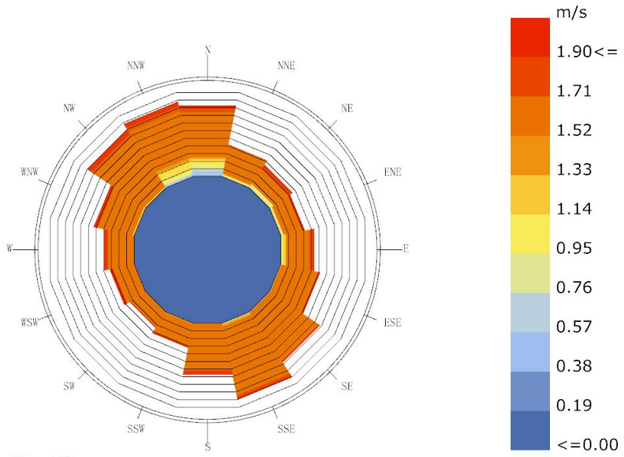
Autumn - Wind Rose

Outdoor Data

Available wind source

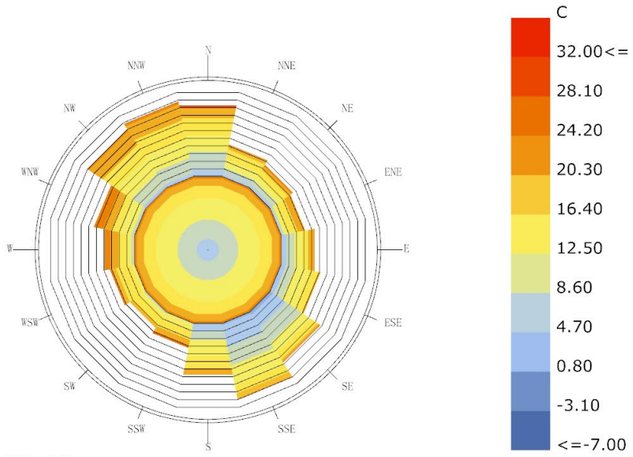
Analysisi the wind distribute when the speed is under the 2m/s. And find the relationship between temperature and humidity.

Since the humidity is really high, so anytime the wind can be a useful source. As for the temperature, only the Northwest wind can be use. Since only from that direction the temperature is much higher thanthe other.



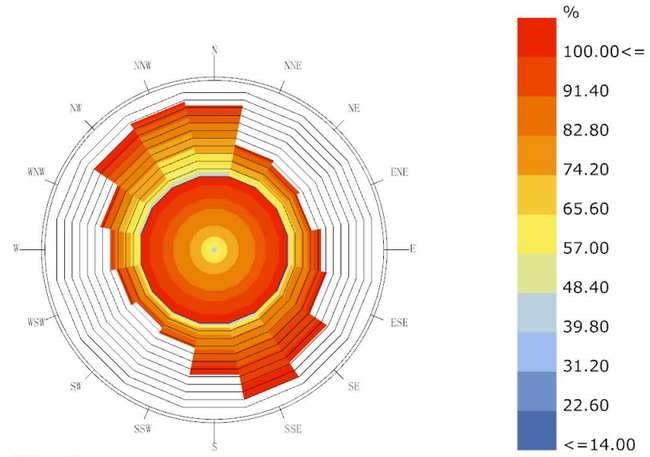
Wind-Rose
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 19.97% of the time = 1749 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
2792.0 hours of total 8760.0 hours (31.87%).

Wind Speed - Wind Rose



Wind-Rose
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 19.97% of the time = 1749 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
2792.0 hours of total 8760.0 hours (31.87%).

Temperature - Wind Rose



Wind-Rose
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Relative Humidity (%)
Calm for 19.97% of the time = 1749 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
2792.0 hours of total 8760.0 hours (31.87%).

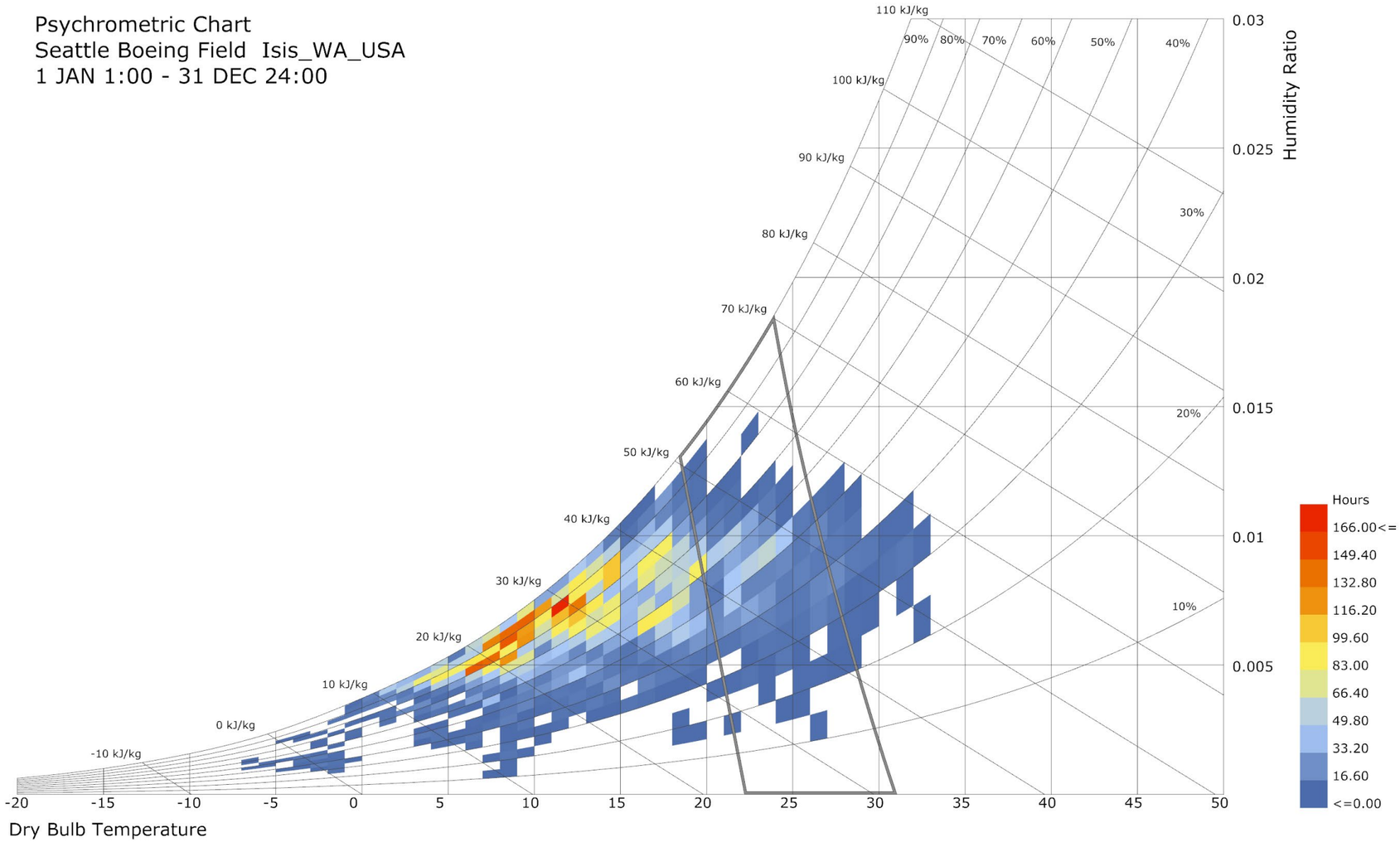
Humidity- Wind Rose

Outdoor Data

Psychromatic Chart

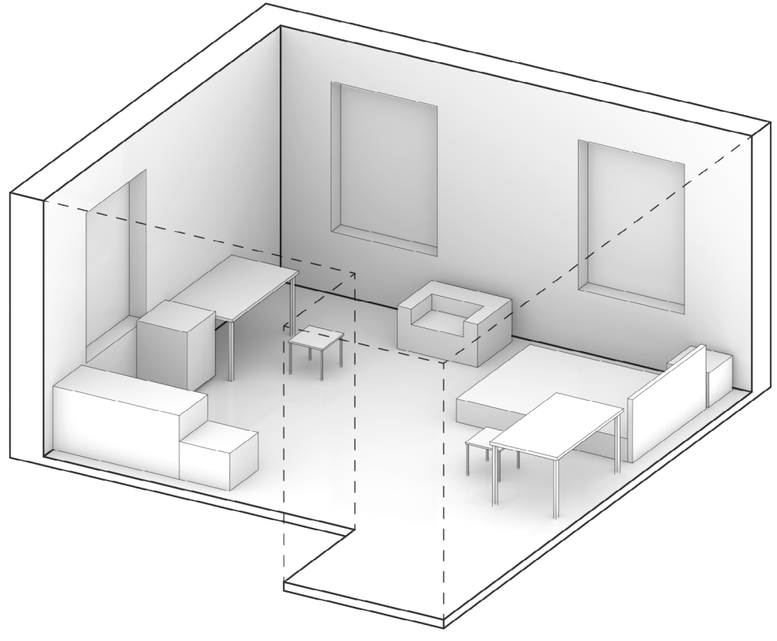
From this chart, the major problem is two. The first one, is how to increase the temperature that below the comfort area. The second one is how to decrease the humidity to let more time belongs to the comfort area.

Psychrometric Chart
Seattle Boeing Field Isis_WA_USA
1 JAN 1:00 - 31 DEC 24:00



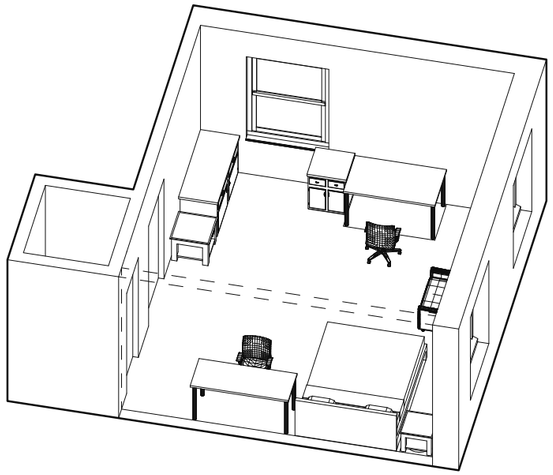
Base-case Model Analysis

Energy analysis and Major Issues

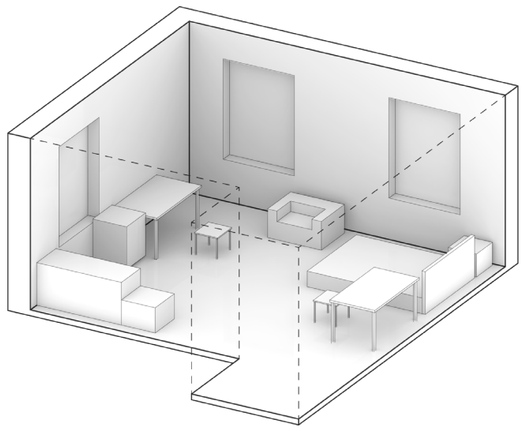


Current Condition

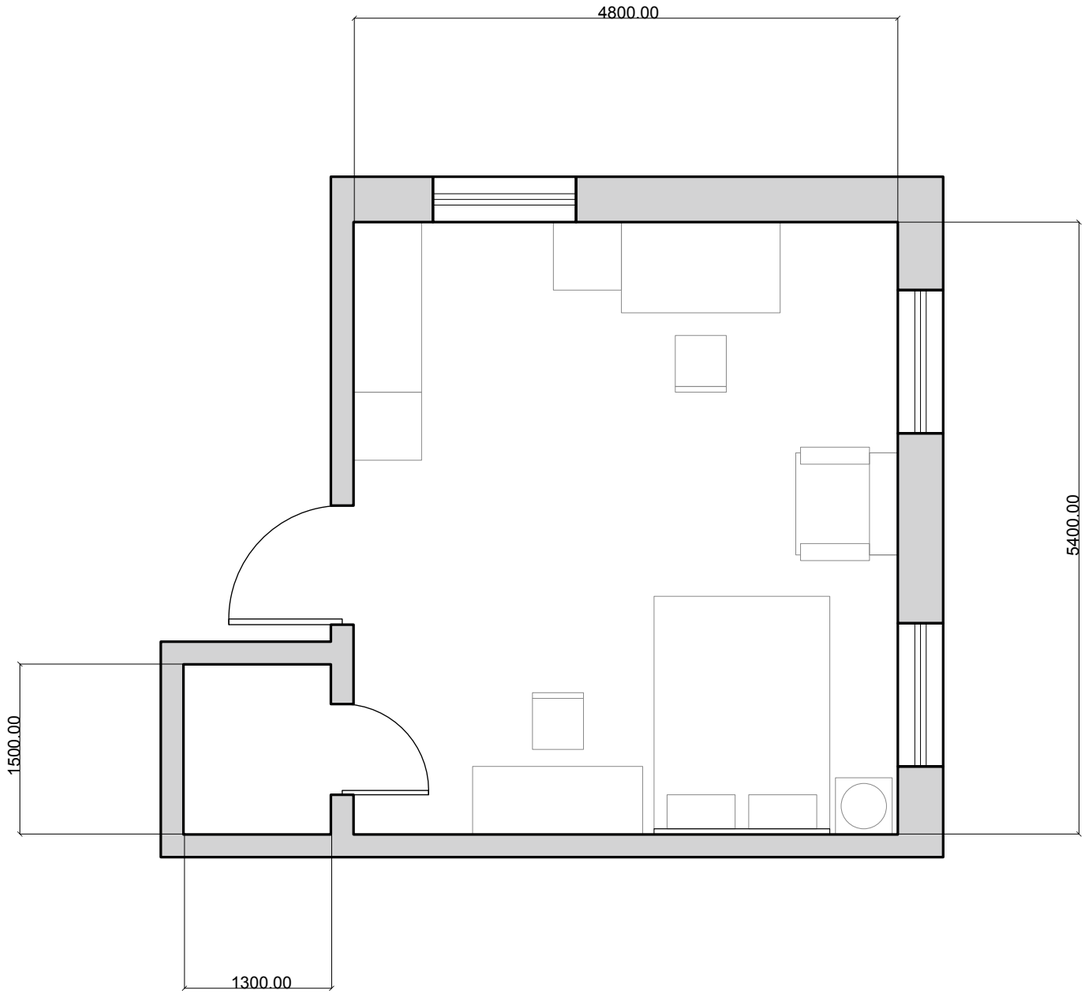
My room



Isometric View



Isometric View



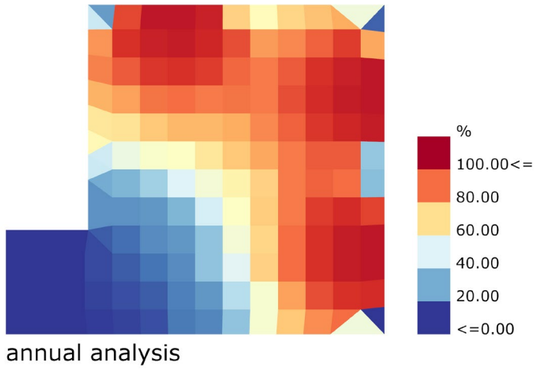
Plan

Daylight Analysis

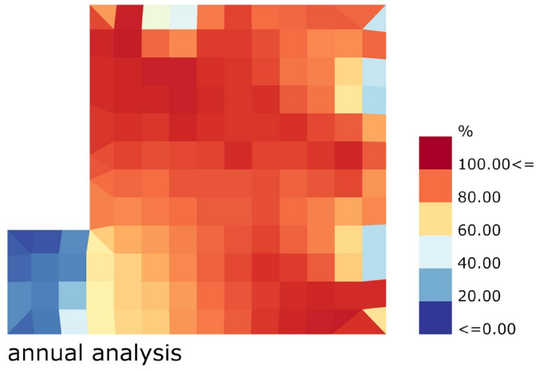
Daylight Autonomy, 100 - 2000, >2000

First of all, I analysis the daylight condition. And find the the condition is ok. Since Seattle is not a city that sunshine as Florida, so we should open more windows to get more daylight hours. But we should also think about the thermal pressure. The more openning we made, the more thermal we lost.

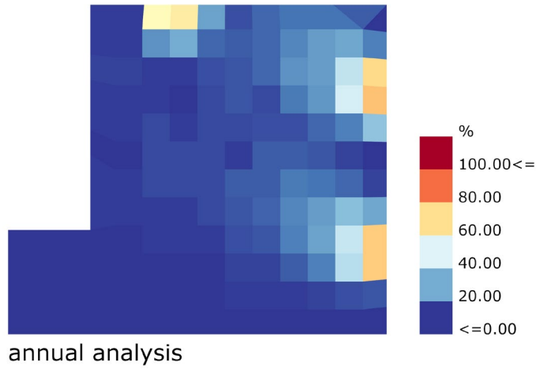
sDA:58.2%



Daylight Autonomy



100 -2000



>2000

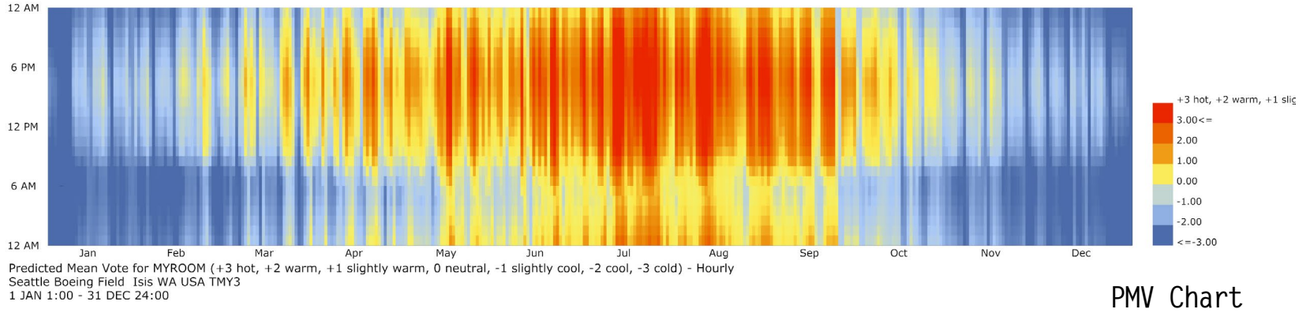
Thermal Comfort Analysis

PMV Comfort and Adaptive Comfort

PMV Comfort:16.9%

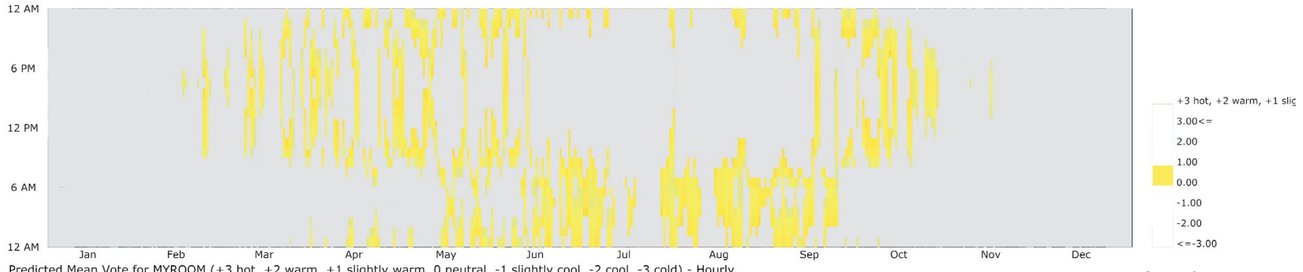
Adaptive Comfort: 17.9%

I test the existing conditon of the PMV and Adaptive comfort. Since the problem, I am dealing with is the related with the humidity and the Adaptive comfort is not considering the humidity, So, I will using the PMV comfort as my major standard to adjust the building.



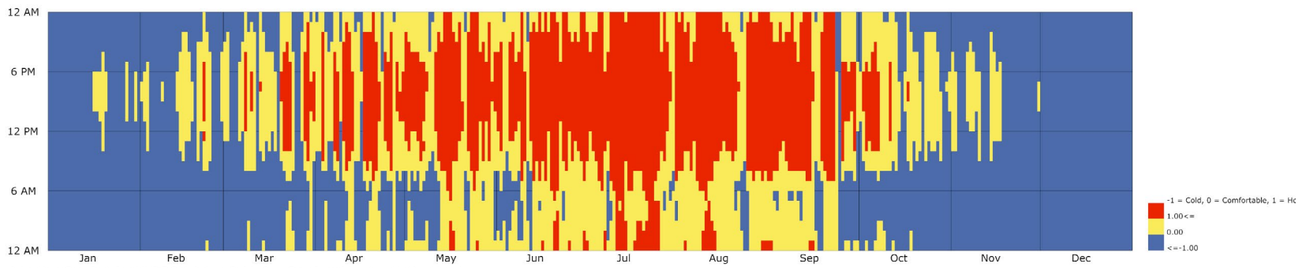
Predicted Mean Vote for MYROOM (+3 hot, +2 warm, +1 slightly warm, 0 neutral, -1 slightly cool, -2 cool, -3 cold) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

PMV Chart



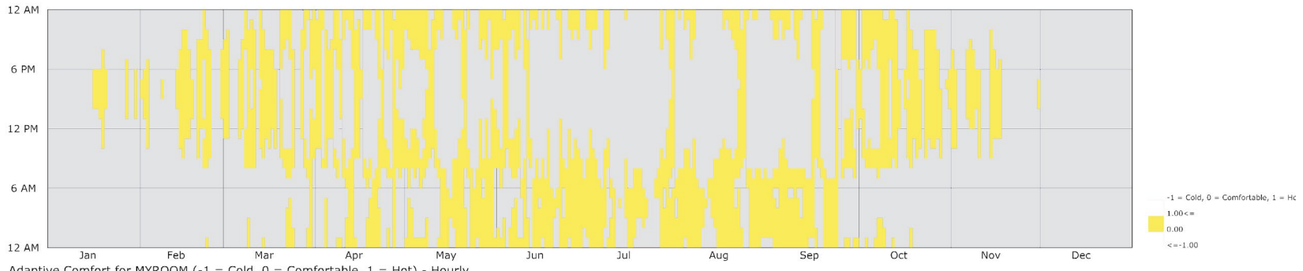
Predicted Mean Vote for MYROOM (+3 hot, +2 warm, +1 slightly warm, 0 neutral, -1 slightly cool, -2 cool, -3 cold) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

PMV Comfort



Adaptive Comfort for MYROOM (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

Adaptive Chart

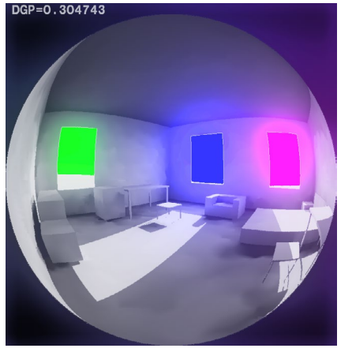
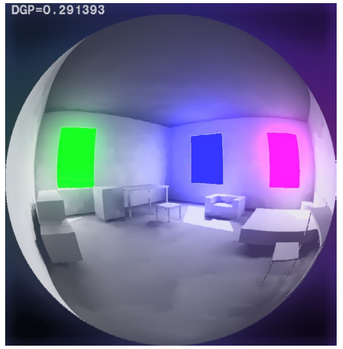
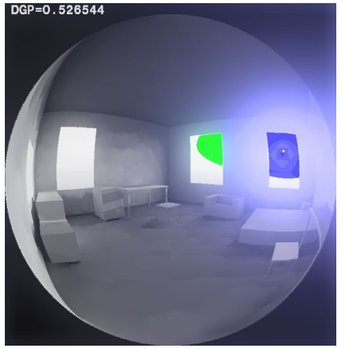
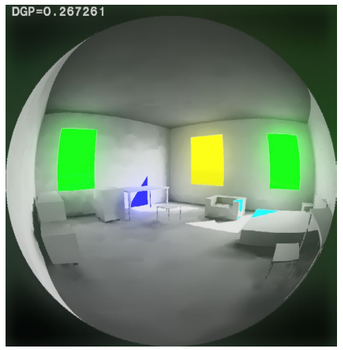
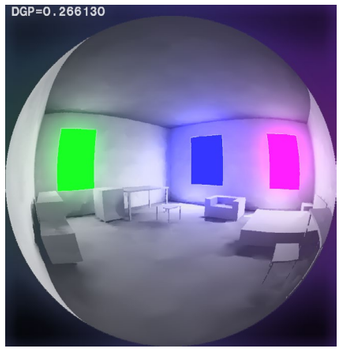
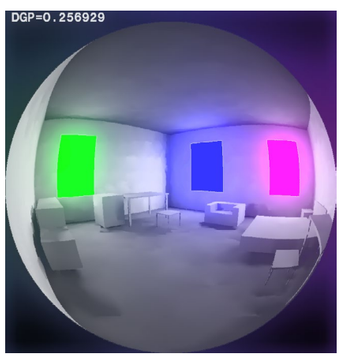
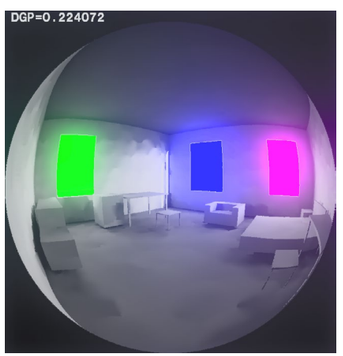


Adaptive Comfort for MYROOM (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

Adaptive Comfort

Glare Analysis

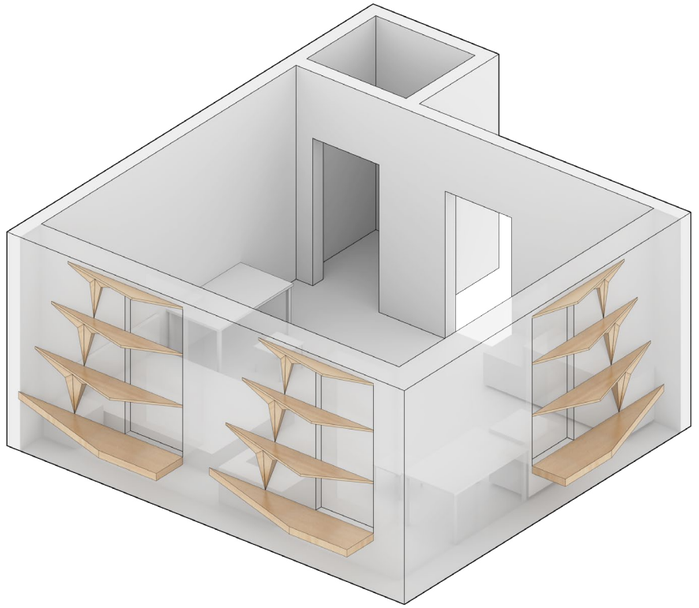
Point Time Glare Analysis

	MAR	JUN	DEC
9:00			
12:00			
15:00			

Since, the problem of Seattle is cannot get enough sun hour. So, what I am trying to do is making sure that after the adjustment, the glare will also not happened.

Design Proposals Comparison

The improvement of different aspects

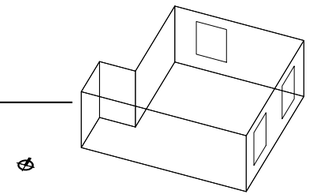


First Step - Adjust the Direction

Try different direction to maximum the PMV and Minimum the Humidity

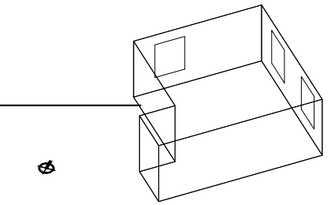
0 °

Year Average Humidity : 59.06%
PMV Indoor Comfort: 16.97%



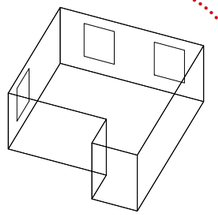
45 °

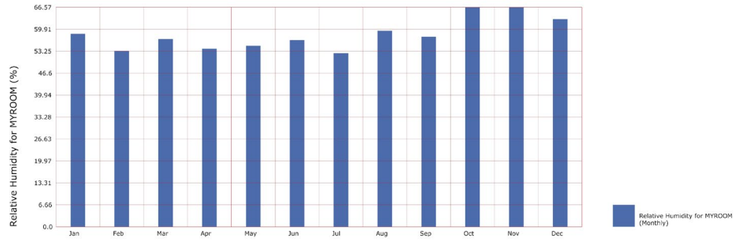
Year Average Humidity : 58.94%
PMV Indoor Comfort: 17.29%



90 °

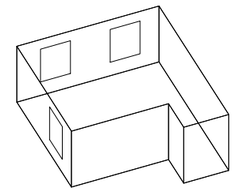
Year Average Humidity : 58.35%
PMV Indoor Comfort: 17.42%

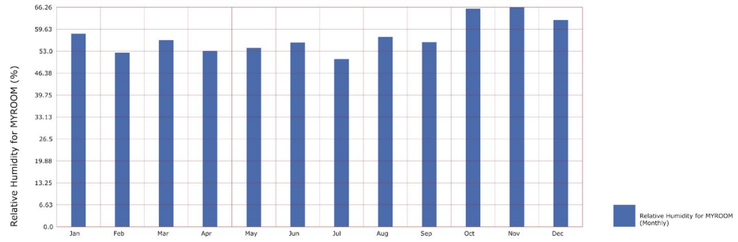




135 °

Year Average Humidity : 57.34%
PMV Indoor Comfort: 16.71%





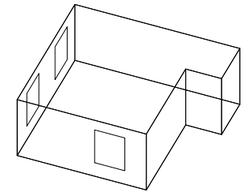
From the PMV comfort and average humidity, I found the rotate 90° is the best. But, I found there is no sourth side windows. So, Iit could not be used.

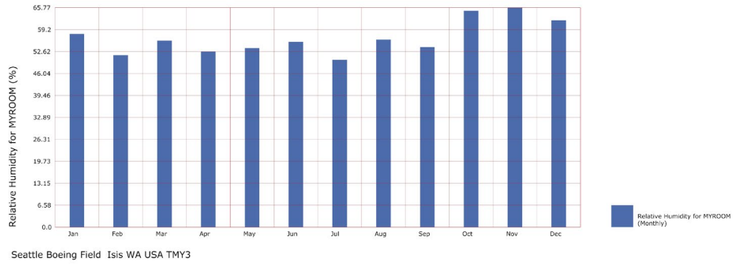
First Step - Adjust the Direction

Try different direction to maximum the PMV and Minimum the Humidity

180 °

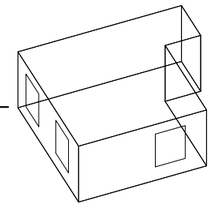
Year Average Humidity : 56.66%
PMV Indoor Comfort: 16.41%

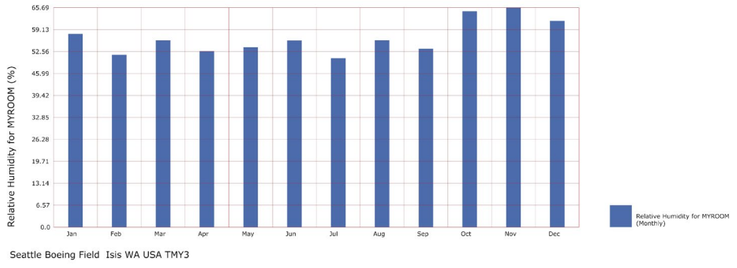




225 °

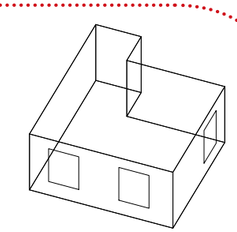
Year Average Humidity : 56.64%
PMV Indoor Comfort: 16.25%

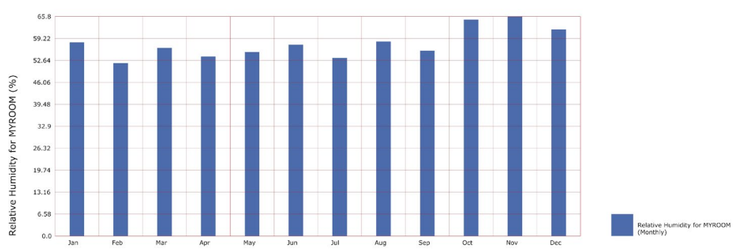




270 °

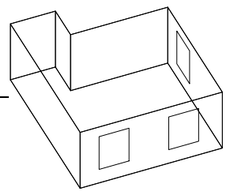
Year Average Humidity : 58.56%
PMV Indoor Comfort: 16.60%

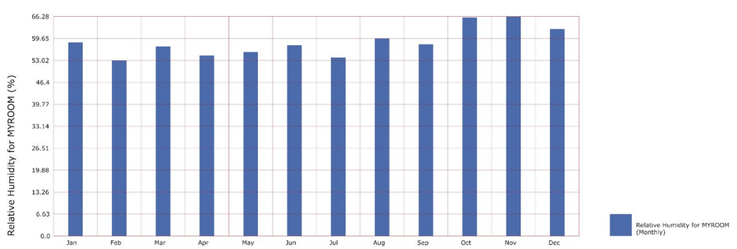




315 °

Year Average Humidity : 58.56%
PMV Indoor Comfort: 16.60%





The second best one is rotate 270 degree. The PMV is the second best one. And the humidity is lower than before.

Step Two - Changing the size of Window

For Seattle :*Common Seattle Residential Code Requirements*
Window area for natural light must be 8 percent
of floor area (exception for artificially
lighted rooms).

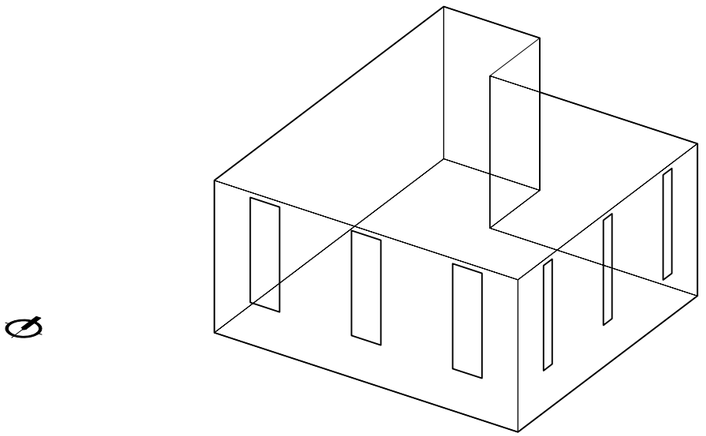
Area: 35.25㎡

Required Windows Area: 2.82㎡

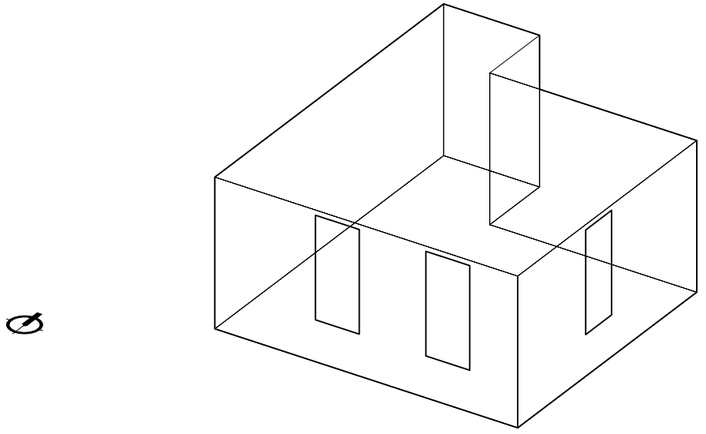
Actual Window Area: 5.04㎡

Sourthside Ratio : 20%

Eastside Ratio : 20%



Test Model



Combine Window Area

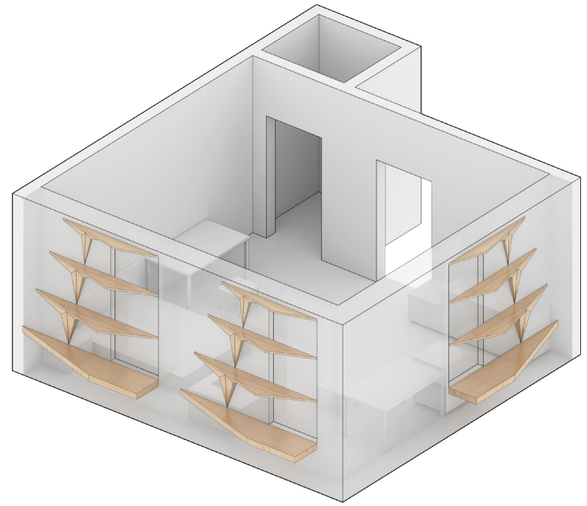
Since all the simulation is based on the ratio of the wall,
after my test. The best resule is ratio of both side 10%.
So, I means less is better. But, I thought the room need
lights. So, I intentionally add some window area.

Step Two - Changing the size of Window

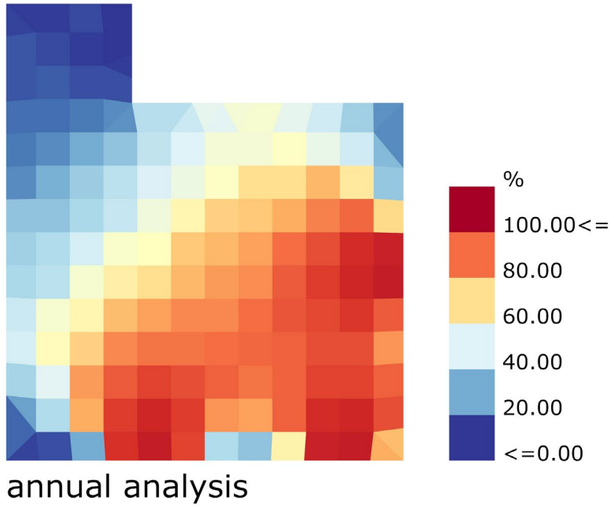
Test the daylight condition & Add Shading

Since I combine the separated window into one or two. So I do need to relocated them. And I try to make them ditribute evenly. So, the daylight autonomy will be better. But the sDA indeed decreased a little bit.

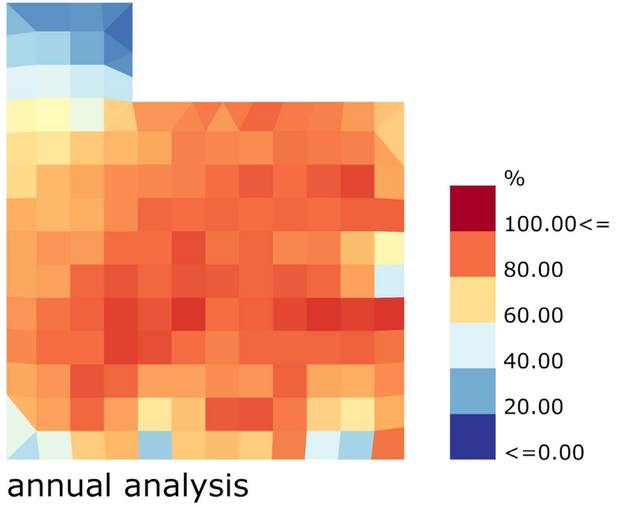
sDA:50.6% - From 58.2%



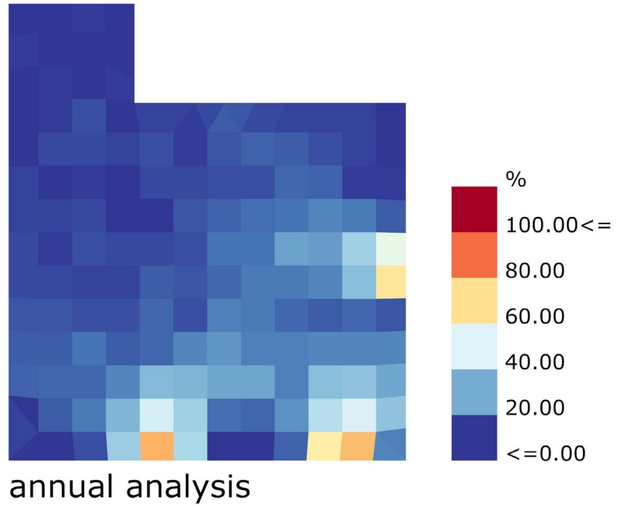
With Shading System



Daylight Autonomy



100 -2000



>2000

Step Three - Changing the Construction

Test different construction PMV comfort

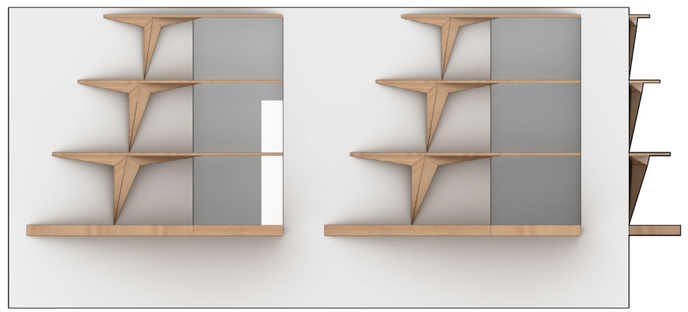
After test several different construction, I found the best way to increase PMV rate is to make the value of R for each component larger. So, I basicly change them into the maximum for the climate zone 4.

Windows Rate:
N: 0%
S: 20%
E: 20%
W: 0%

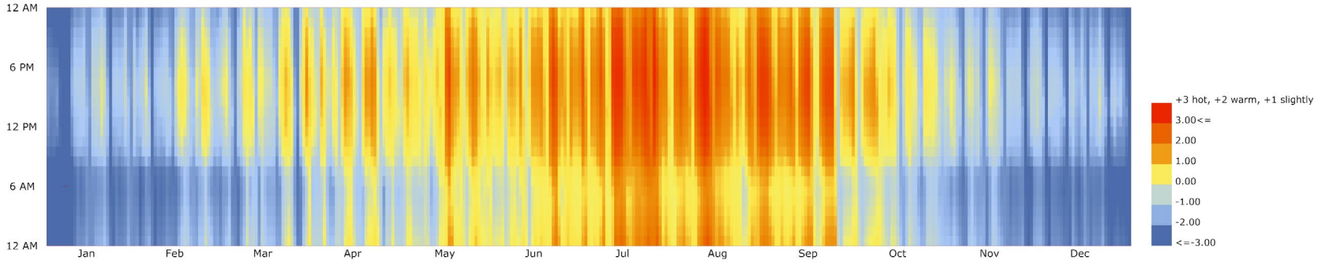
Exterior Wall: R34.4
Exterior Windows: R1.7 SHGC 0.39
Exterior Roof: R34.4

Shading: Yes

PMV Comfort:29.235% - From 16.7%

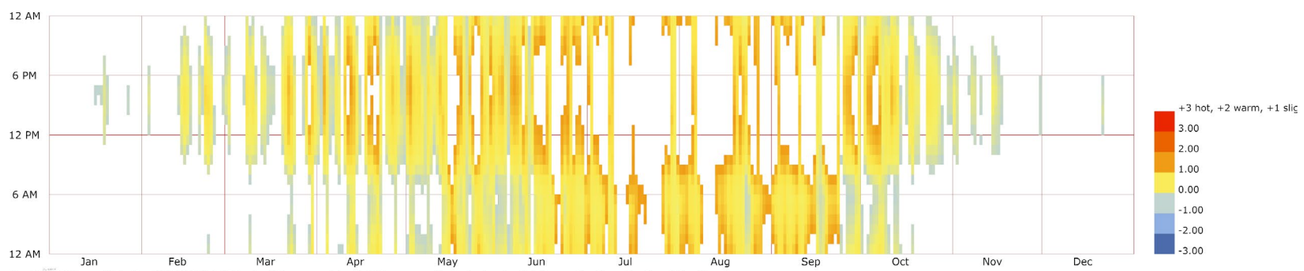


Elevation - With Shading System



Predicted Mean Vote for MYROOM (+3 hot, +2 warm, +1 slightly warm, 0 neutral, -1 slightly cool, -2 cool, -3 cold) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

PMV Chart

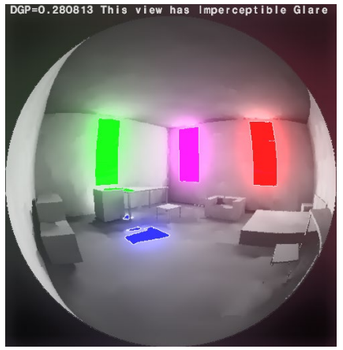
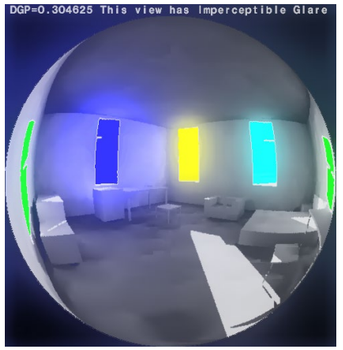
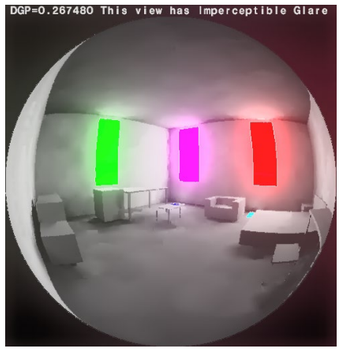
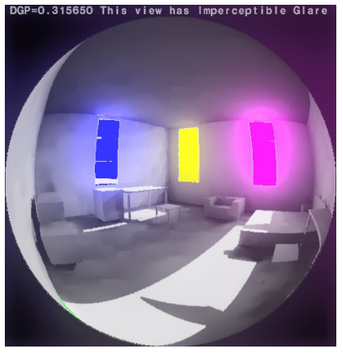
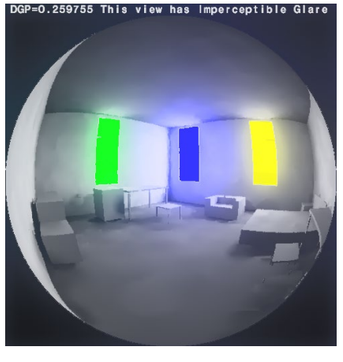
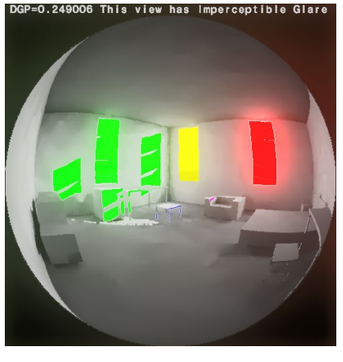


Predicted Mean Vote for MYROOM (+3 hot, +2 warm, +1 slightly warm, 0 neutral, -1 slightly cool, -2 cool, -3 cold) - Hourly
Seattle Boeing Field Isis WA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

PMV Comfort

Step Three - Changing the Construction

Test point time glare

	MAR	JUN	DEC
9:00			
12:00			
15:00			

Since the direction of this room has been changed. So the light condition for each time change drasticlly. But, after the test there is still no percepible glare.

Part 2:

Previous Work

Site: Philadelphia

Local Climate Analysis

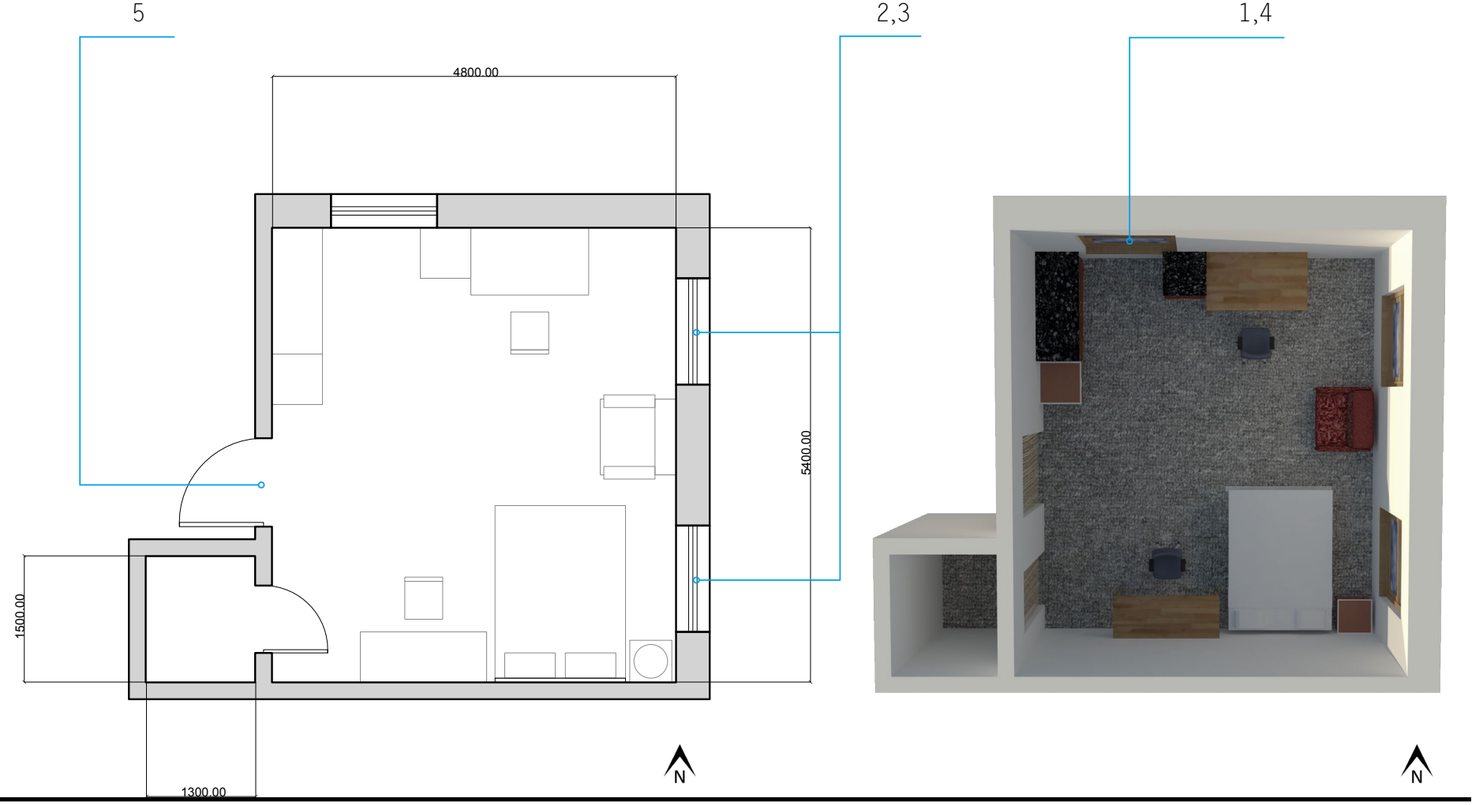
Site: Philadelphia

Analysis My Room

Disadvantage & Advantage

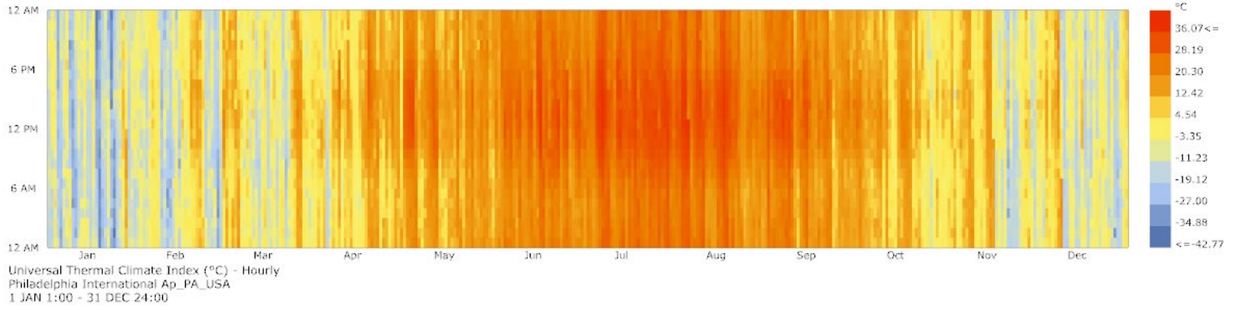
Disadvantage:

1. The windows on the north side cannot open. Next building is to close to my room.
2. The east side window is two big which makes me cannot open the windows in the morning.
3. On the east side of my house is the 40th street, and is kind of noisy.
4. There is not heater on the north side. Sometimes may feel cold.
5. The entrance of my room is directly connect to the hallway, so there is not visual block to my room.

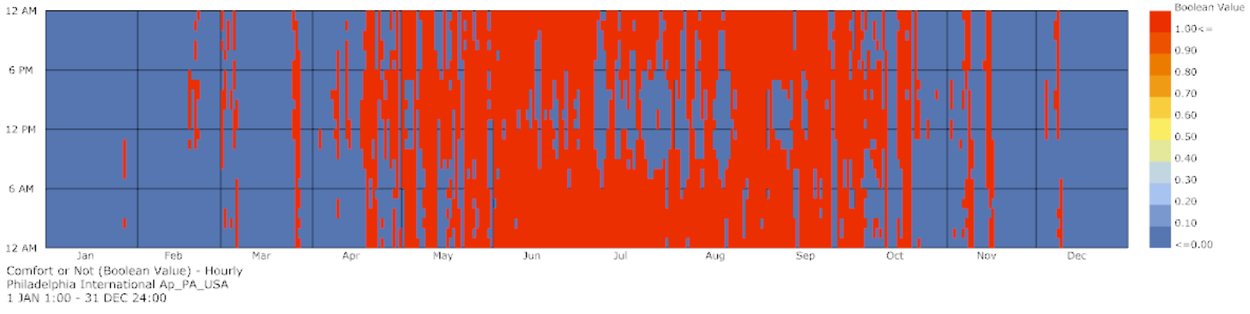


Outdoor Data

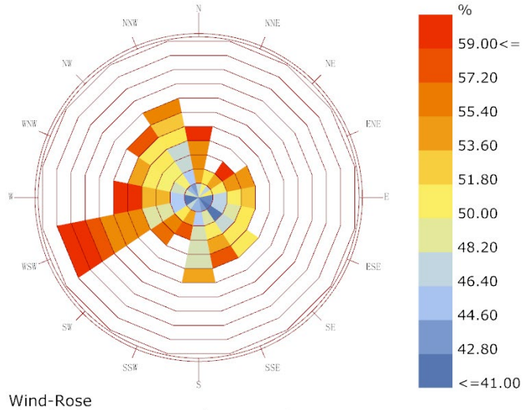
Temperature, wind speed and humidity



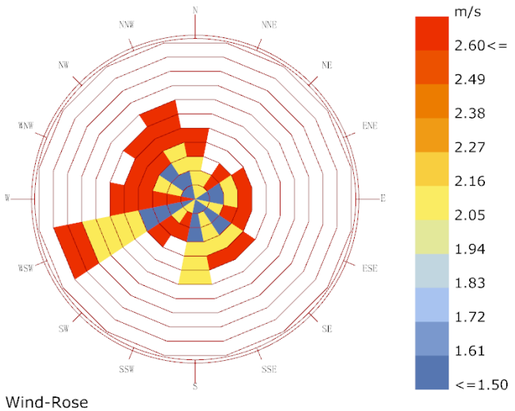
Universal Thermal Climate Index (°C) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



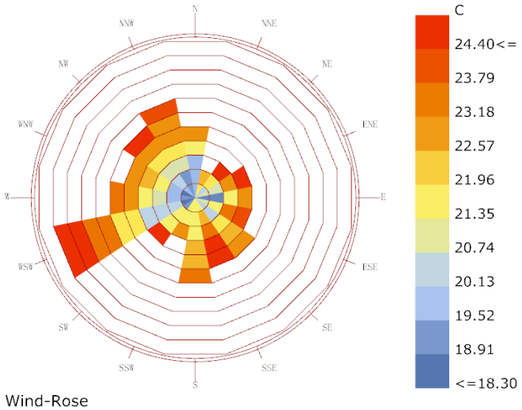
Comfort or Not (Boolean Value) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Relative Humidity (%)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.0%. = 1 hours.
... ...
Conditional Selection Applied:
18 < Dry Bulb Temperature < 25
and 40 < Relative Humidity <60
and 1 < Wind Speed < 3
79.0 hours of total 8760.0 hours (0.90%).



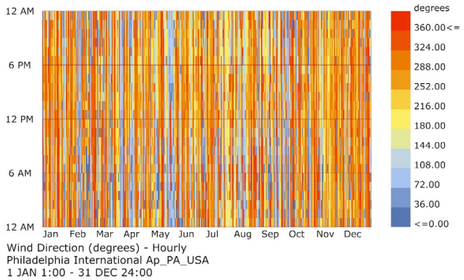
Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.0%. = 1 hours.
... ...
Conditional Selection Applied:
18 < Dry Bulb Temperature < 25
and 40 < Relative Humidity <60
and 1 < Wind Speed < 3
79.0 hours of total 8760.0 hours (0.90%).



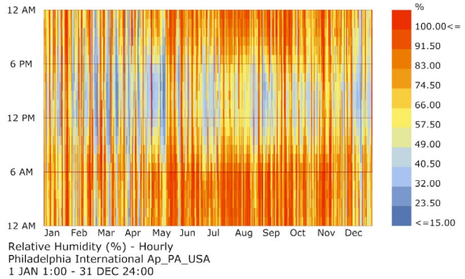
Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.0%. = 1 hours.
... ...
Conditional Selection Applied:
18 < Dry Bulb Temperature < 25
and 40 < Relative Humidity <60
and 1 < Wind Speed < 3
79.0 hours of total 8760.0 hours (0.90%).

Outdoor Data

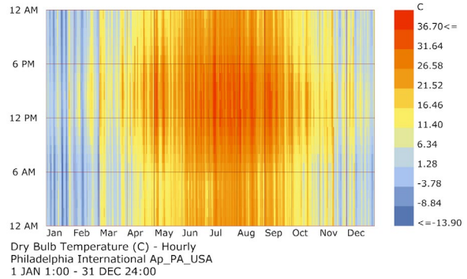
Temperature, wind speed and humidity



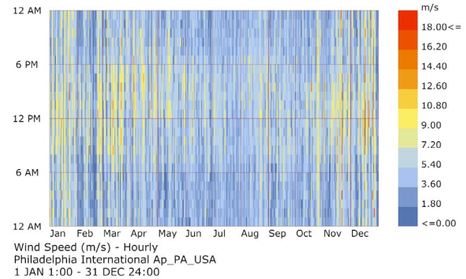
Wind Direction (degrees) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



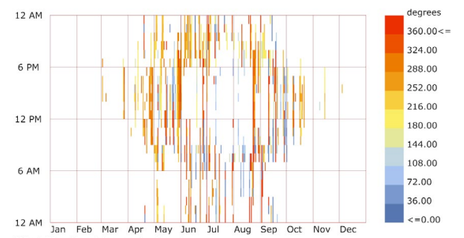
Relative Humidity (%) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



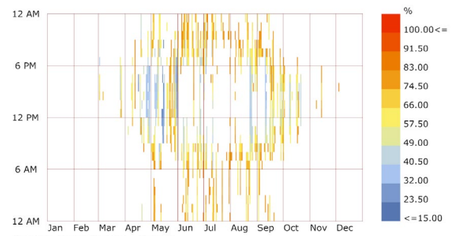
Dry Bulb Temperature (C) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



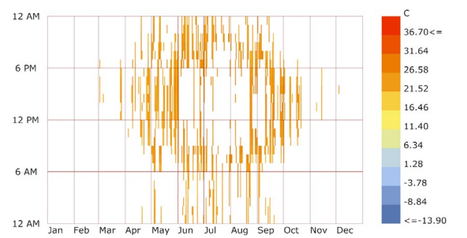
Wind Speed (m/s) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



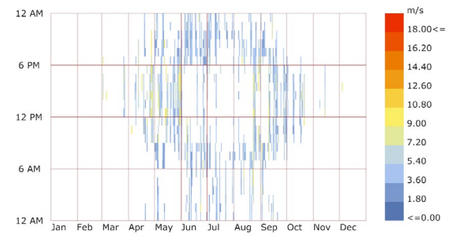
Wind Direction (degrees) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



Relative Humidity (%) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00



Dry Bulb Temperature (C) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

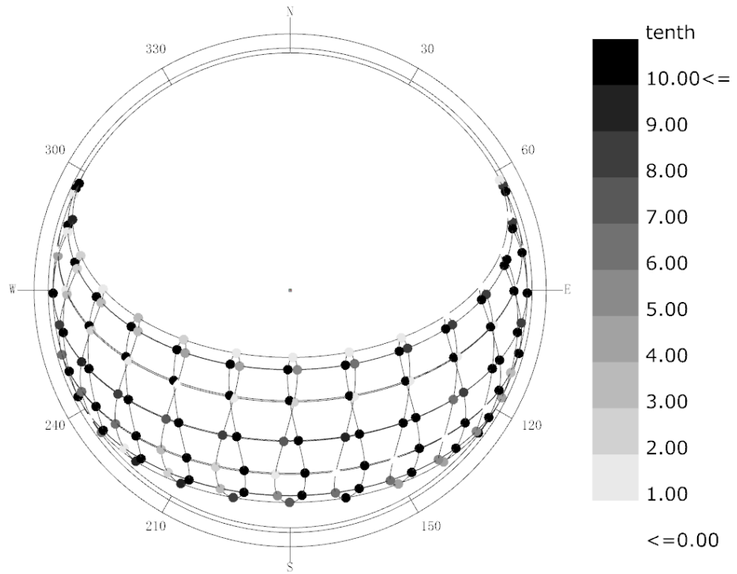


Wind Speed (m/s) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

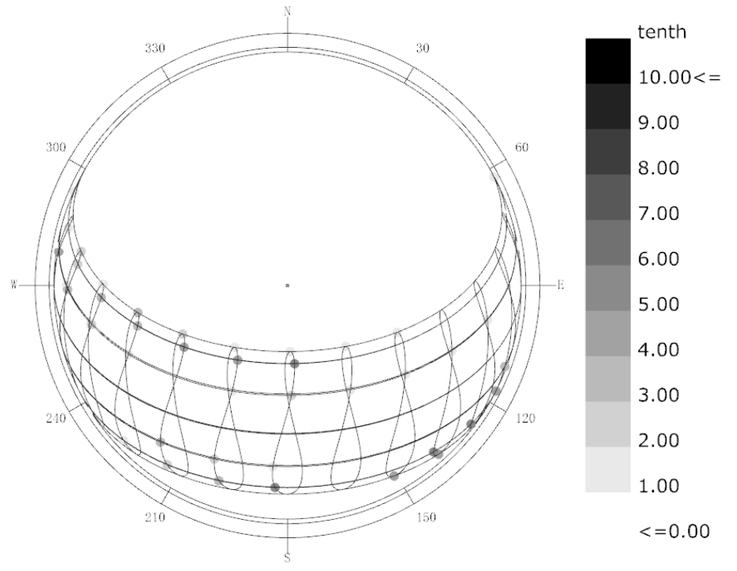
This is another way to illustrate the environment conditon, using the same parameters but did not combine with wind-rose. Using this way is much easier to understanding the relationship between the date and each parameter. So,most of the comfortable time will be from the end of spring to the end of summer. But through these chart, I thought the wind direction in this series is not that useful.

Outdoor Data

Sun Path & Cloud Cover



Sun-Path Diagram - Latitude: 39.87
Hourly Data: Total Cloud Cover (tenth)
Philadelphia International Ap_PA_USA

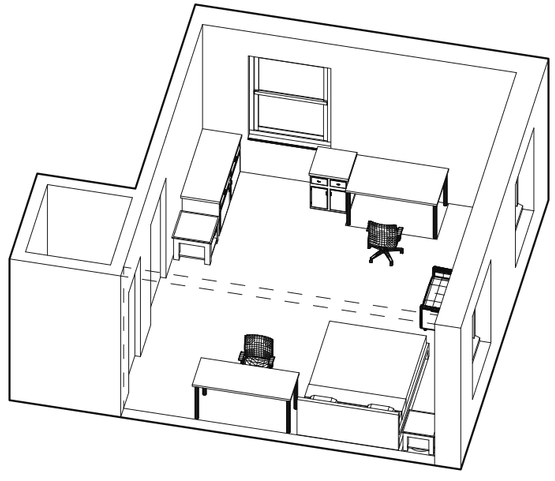


Sun-Path Diagram - Latitude: 39.87
Hourly Data: Total Cloud Cover (tenth)
Philadelphia International Ap_PA_USA
... ...
Conditional Selection Applied:
Total Cloud Cover < 6
54.0 hours of total 146.0 sun up hours(36.99%).

Cloud cover should be thought with sun path. Since when the altitude is not high, the cloud cover as high as better. So the cloud will block the sun ray and it would not influence the interior activities. But when the altitude is high, the sun ray would influence the interior activities. So, we should consider the season condition. If it is in the winter, the cloud cover should be low, vise versa. So, my room should add an additional operable shading system, so in the summer the room would be too hot. Since, there are two big windows in the east side.

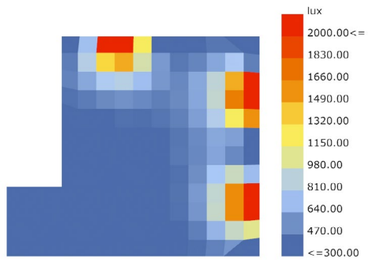
Base-case Model Analysis

Energy analysis and Major Issues

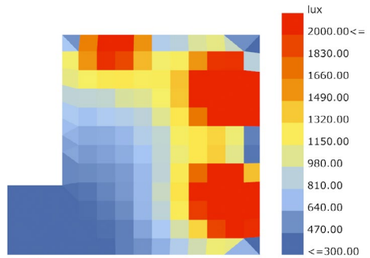


Daylight Analysis

Point in Time Analysis



0: illuminance
21 MAR 9:00



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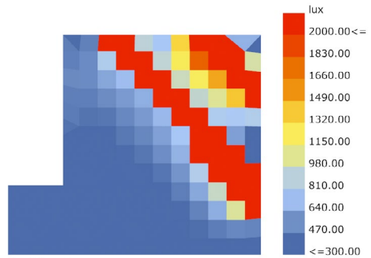
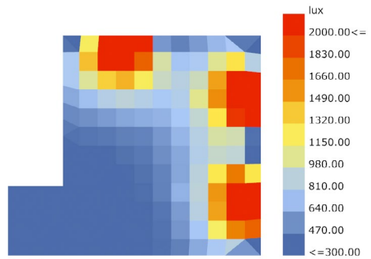
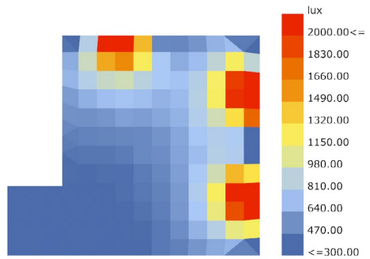
21 JUN 9:00



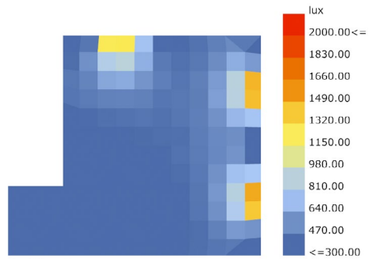
0: illuminance
21 DEC 9:00



0: illuminance
21 MAR 12:00

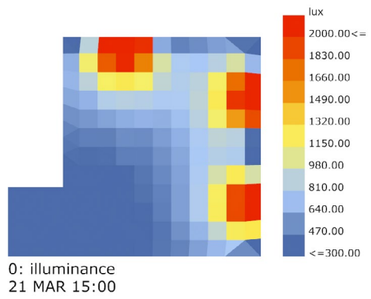


0: illuminance
21 JUN 12:00

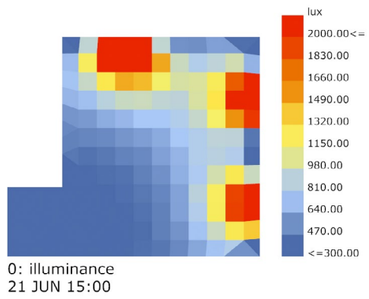


0: illuminance
21 DEC 12:00

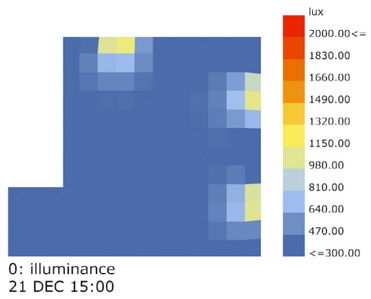
For my room, basically at 9 am would get more light than the other two time's. When it comes to the winter, as for December, the lights is hard to get into deep in my room. So may I should add an reflect board in front of the windows to make more light in.



0: illuminance
21 MAR 15:00



0: illuminance
21 JUN 15:00

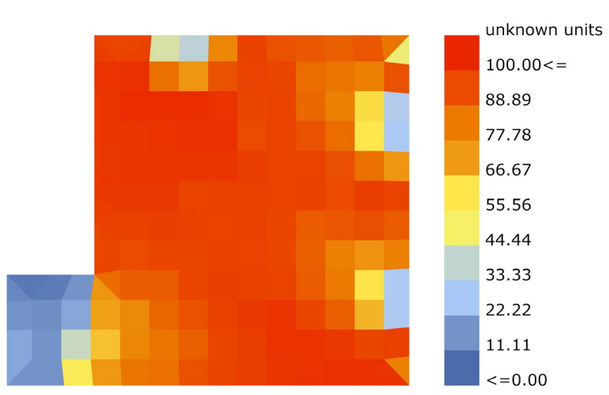


0: illuminance
21 DEC 15:00

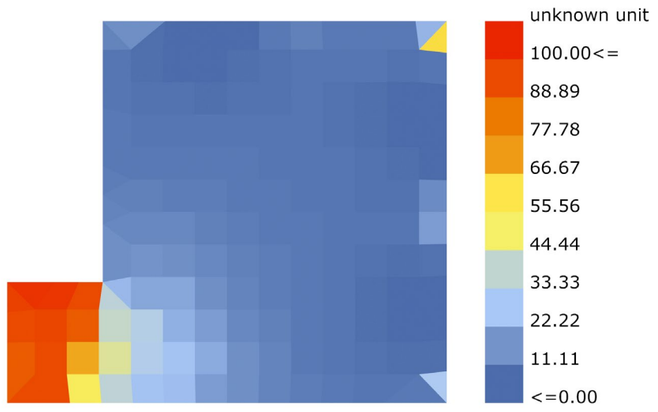
Daylight Analysis

UDI, <100, >2000

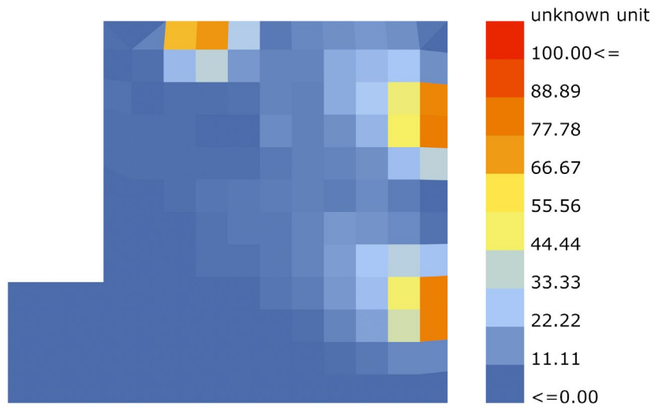
In general, my windows located in the proper space, which could make the UDI almost very high. And for most of the area is in good condition. So, how to block some light when the light is too strong would be my major task.



UDI



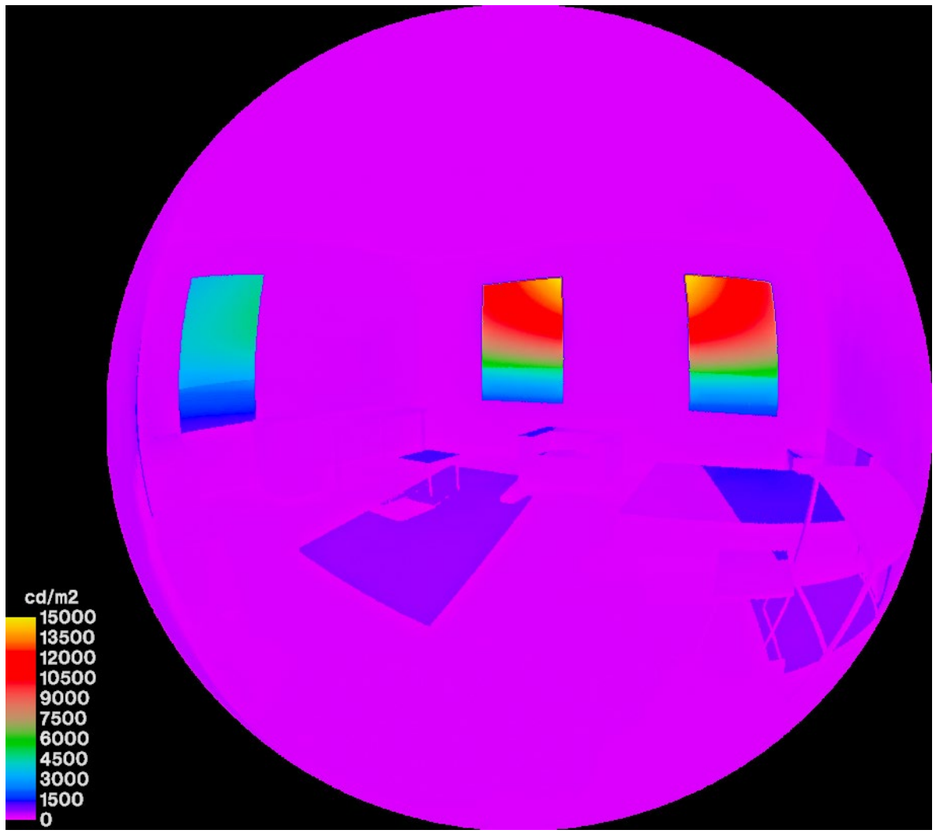
<100



>2000

Glare Analysis

Point Time Glare Analysis

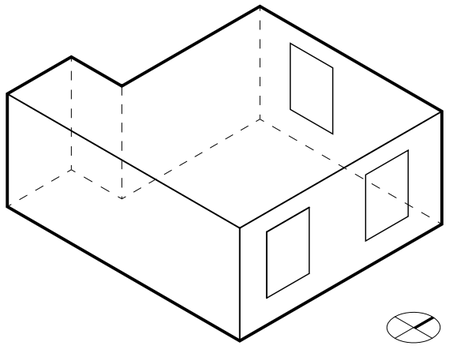


For the glare, majorly happens around the windows. This image is the 9 am March 21th. This also suggest me to add some sading system to the window. While can block some light and decrease the light to the comfort strength and also decrease the chance you feel glare.

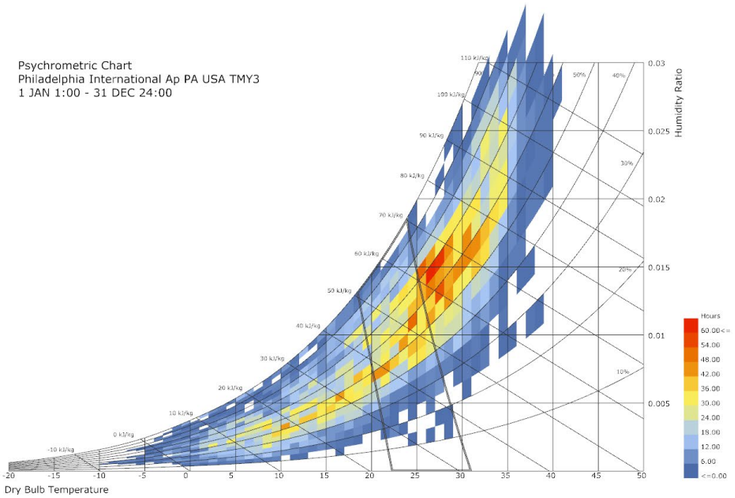
Thermal Comfort Analysis

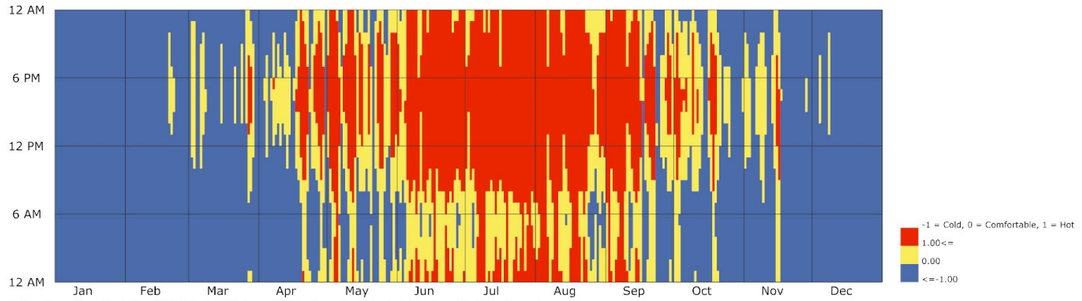
PMV Comfort and Adaptive Comfort

```
Comfortable (%): 21.07
hot (%):         25.97
cold (%):        52.96
```

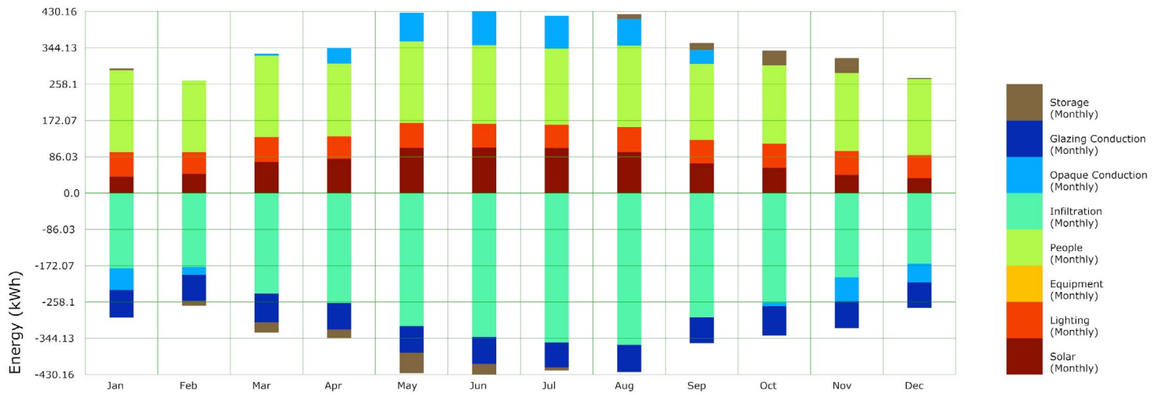


Comfortable (%): 21.07
hot (%): 25.97
cold (%): 52.96





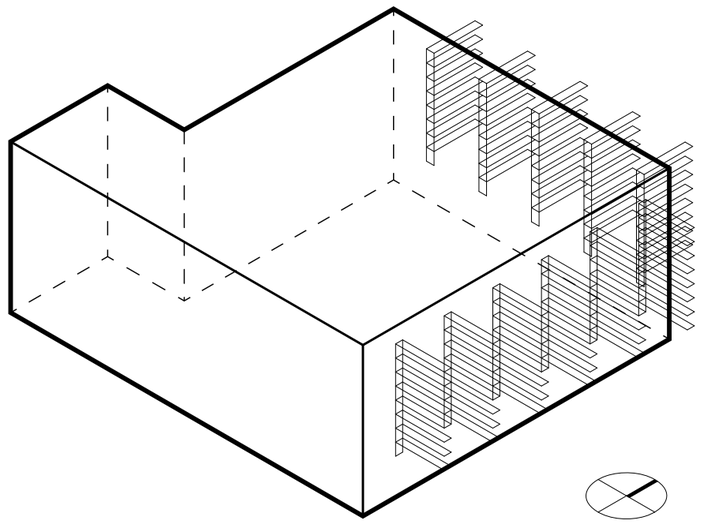
Adaptive Comfort for ZONE_4_T (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



Office Energy Balance

Design Proposals Comparison

The improvement of different aspects

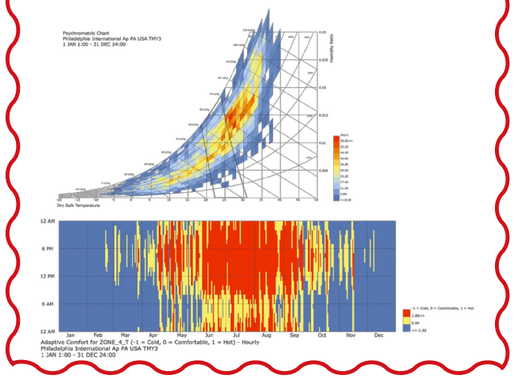


Step One - Change the Size of the Windows

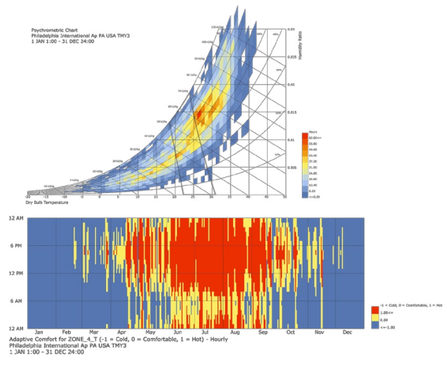
1. Test the North side Windows

Since the Shape of the windows does not matter the. So, I test the ratio of the glaze area from **0.1~0.9** and then choosing the best solution.

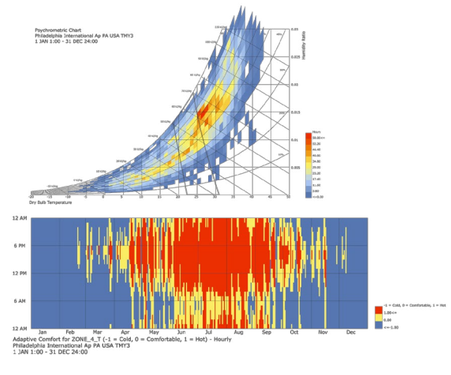
Comfortable (%): 21.18
hot (%): 25.74
cold (%): 53.08



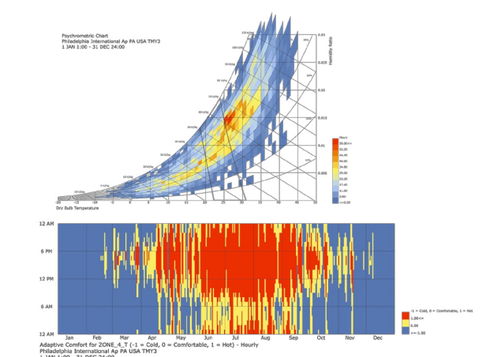
Comfortable (%): 20.95
hot (%): 26.31
cold (%): 52.74



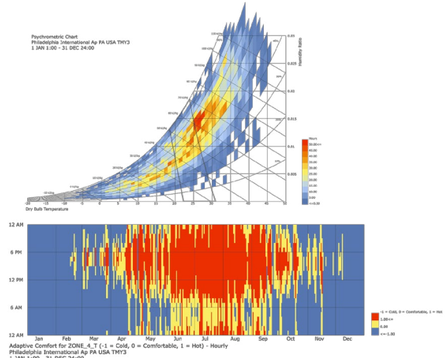
Comfortable (%): 20.53
hot (%): 26.84
cold (%): 52.64



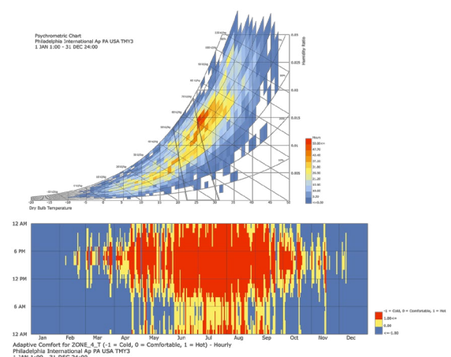
Comfortable (%): 20.4
hot (%): 27.18
cold (%): 52.42



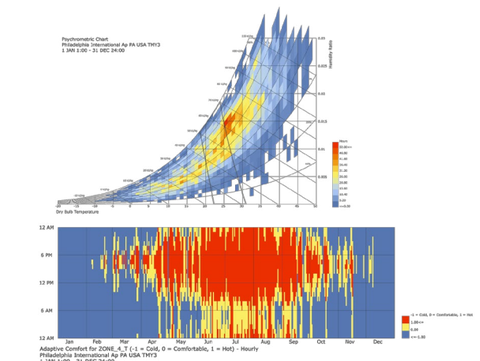
Comfortable (%): 20.4
hot (%): 27.36
cold (%): 52.24



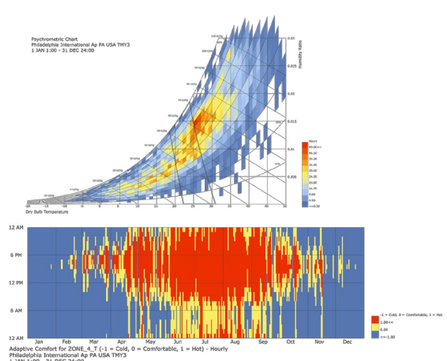
Comfortable (%): 20.13
hot (%): 27.71
cold (%): 52.17



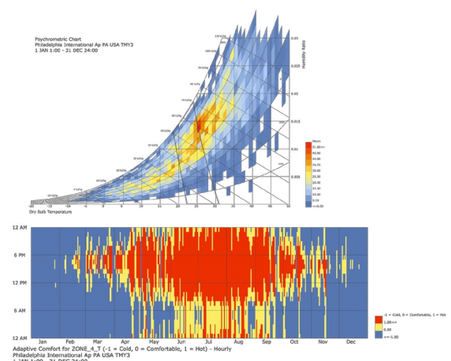
Comfortable (%): 19.74
hot (%): 28.06
cold (%): 52.2



Comfortable (%): 19.51
hot (%): 28.24
cold (%): 52.25



Comfortable (%): 19.39
hot (%): 28.45
cold (%): 52.16

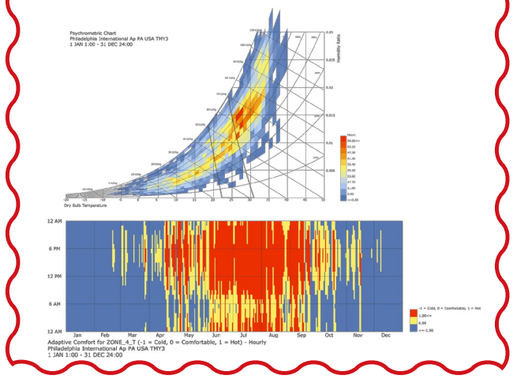


Step One - Change the Size of the Windows

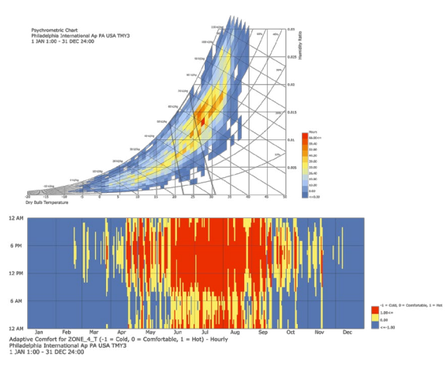
2. Test the East side Windows

Since the 0.1 for the north would be the best,then I test the ratio of the glaze area from **0.1~0.9** for the east side and then choosing the best solution.

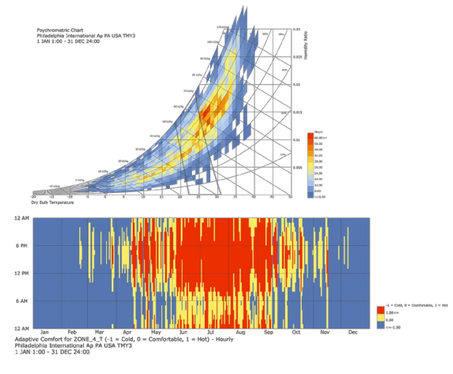
Comfortable (%): 21.42
hot (%): 25.86
cold (%): 52.73



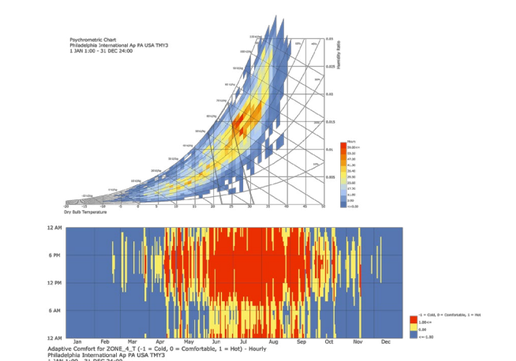
Comfortable (%): 21.37
hot (%): 25.68
cold (%): 52.95



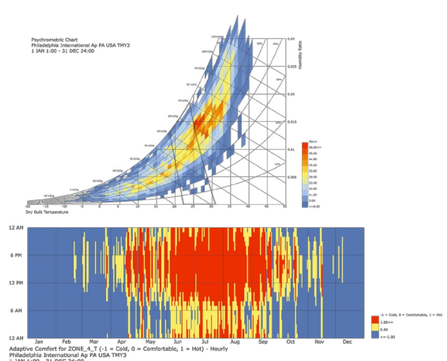
Comfortable (%): 21.1
hot (%): 25.7
cold (%): 53.21



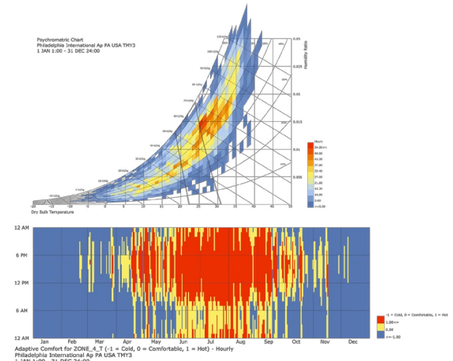
Comfortable (%): 20.96
hot (%): 25.66
cold (%): 53.38



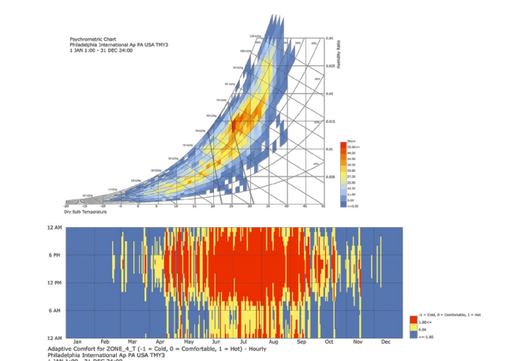
Comfortable (%): 20.83
hot (%): 25.58
cold (%): 53.58



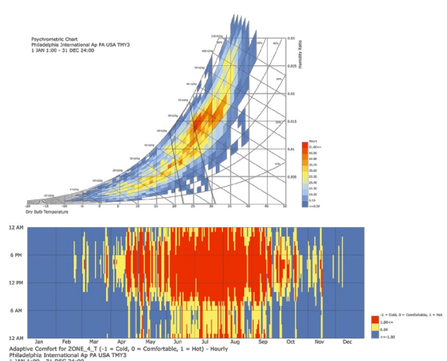
Comfortable (%): 20.66
hot (%): 25.46
cold (%): 53.88



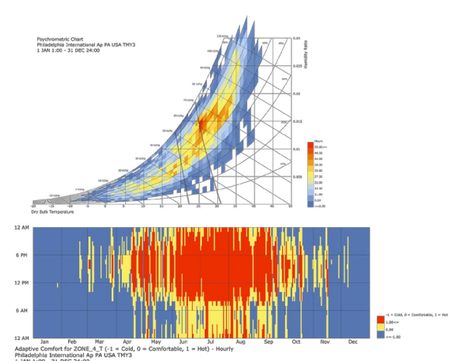
Comfortable (%): 20.67
hot (%): 25.34
cold (%): 53.98



Comfortable (%): 20.67
hot (%): 25.09
cold (%): 54.24

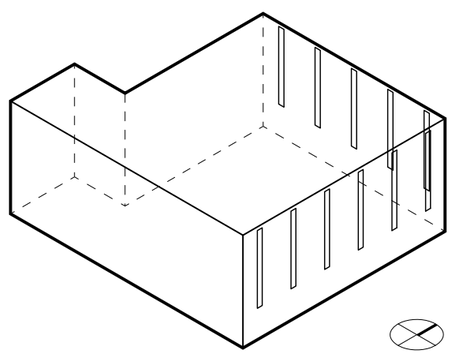


Comfortable (%): 20.64
hot (%): 24.97
cold (%): 54.39

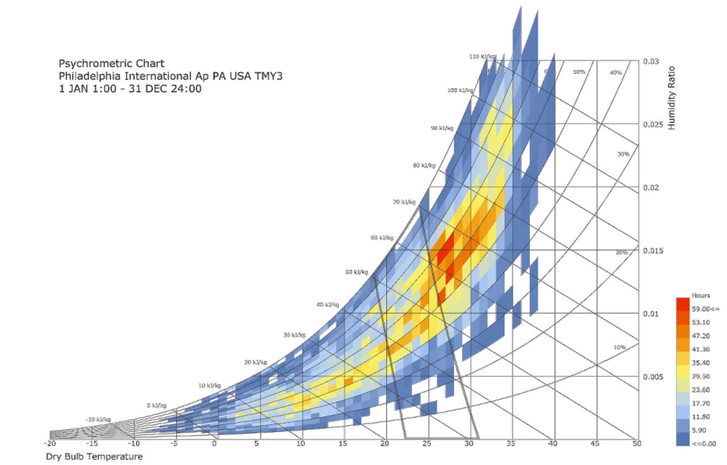


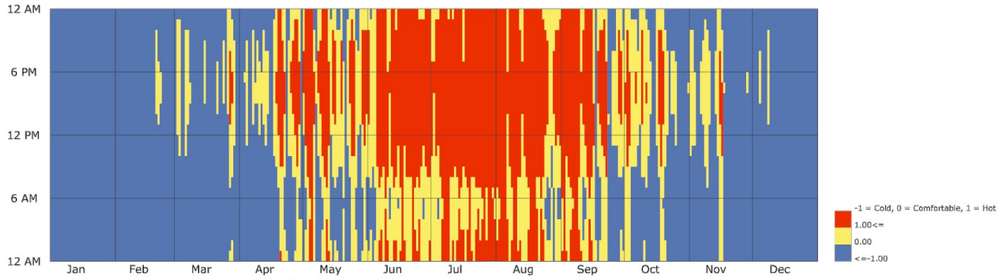
Step One - Change the Size of the Windows

```
Comfortable (%): 21.42
hot (%):         25.86
cold (%):        52.73
```

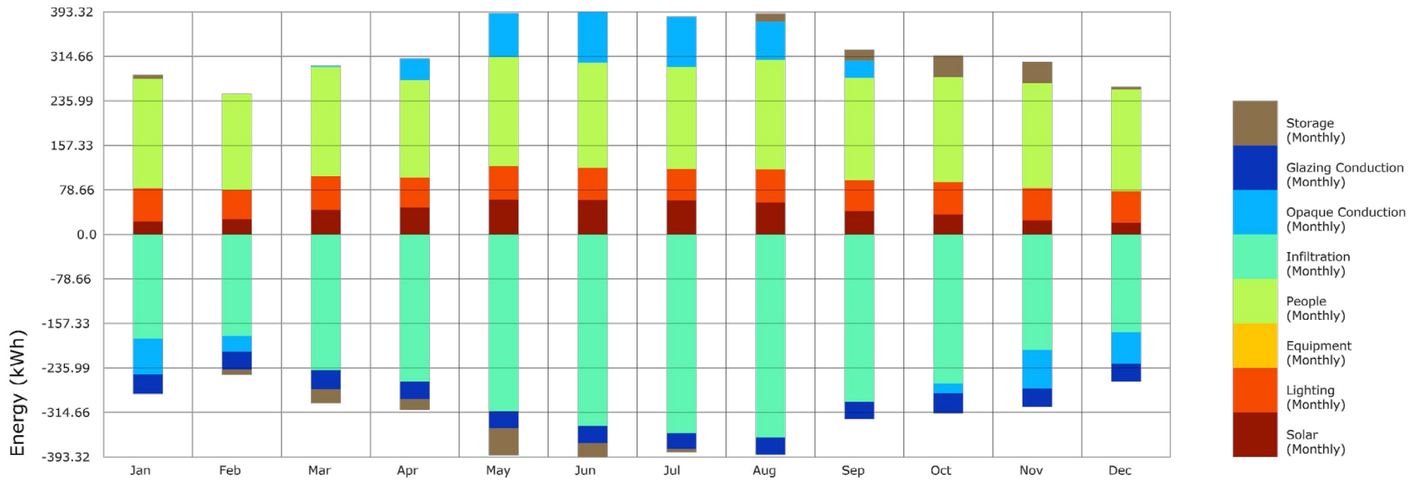


Comfortable (%): 21.42
hot (%): 25.86
cold (%): 52.73





Adaptive Comfort for ZONE_4_T (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

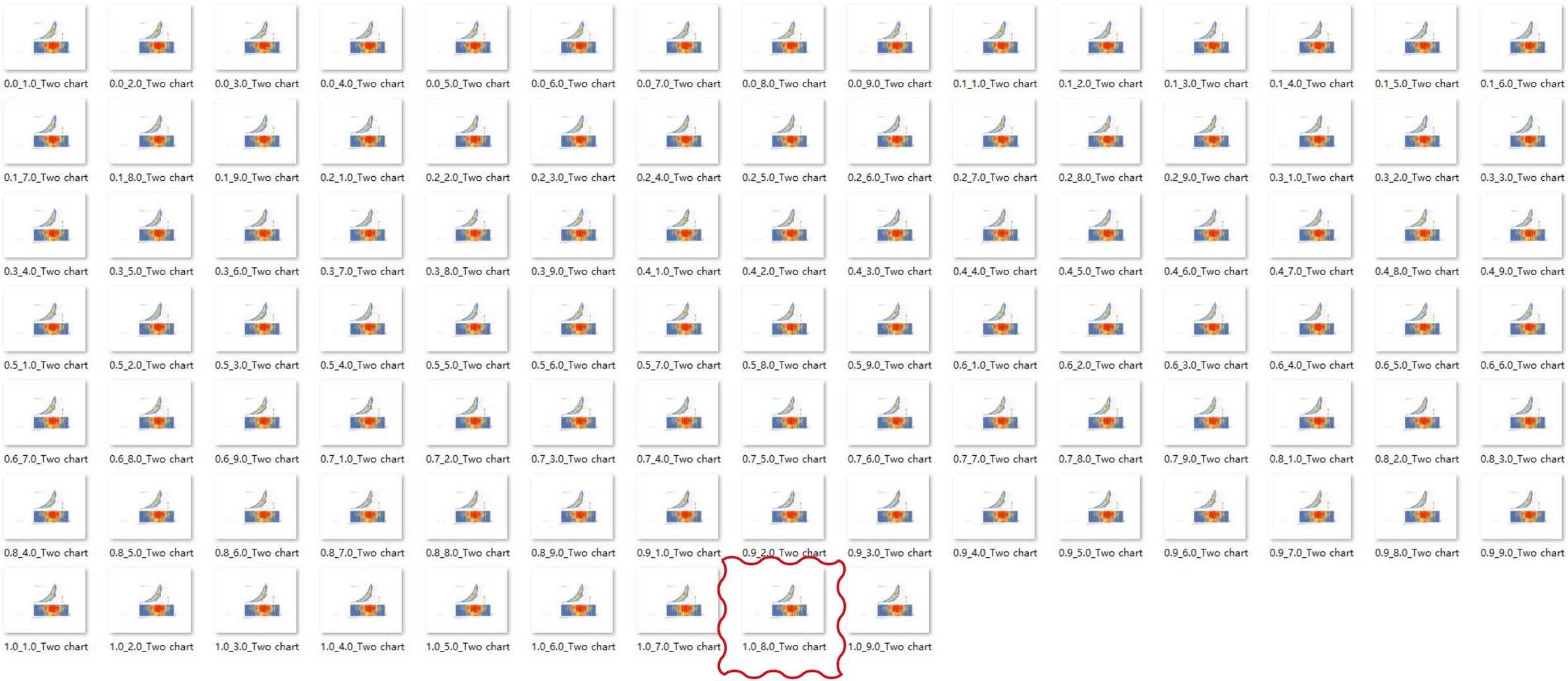


Office Energy Balance

Step Two - Adding the Shading System

Since the blinder can be changed as number and depth. So, I set the number from **1～9** and the depth from **0.1～1.0**m.

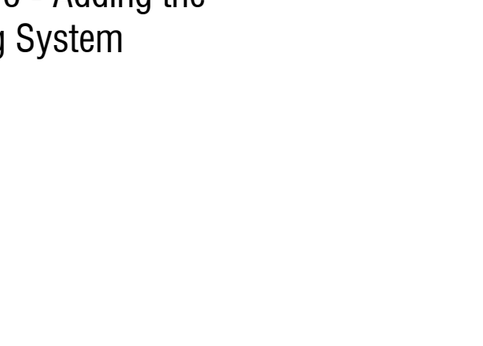
There are 99 types of results. I just choose the best one.

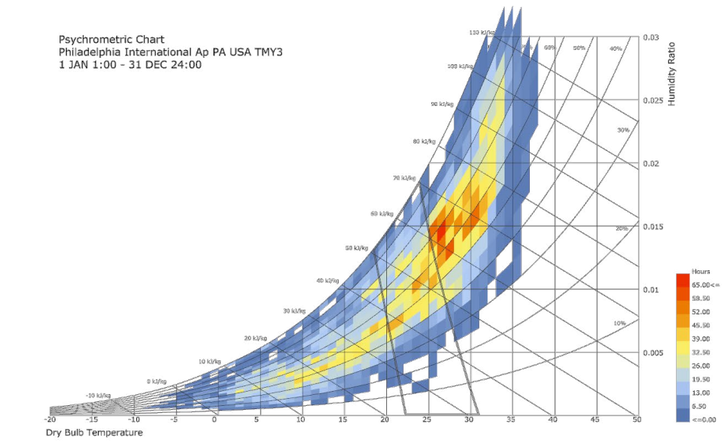


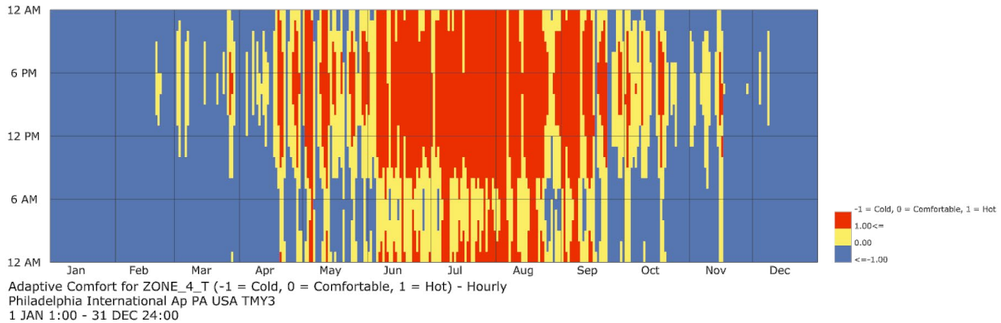
Step Two - Adding the Shading System

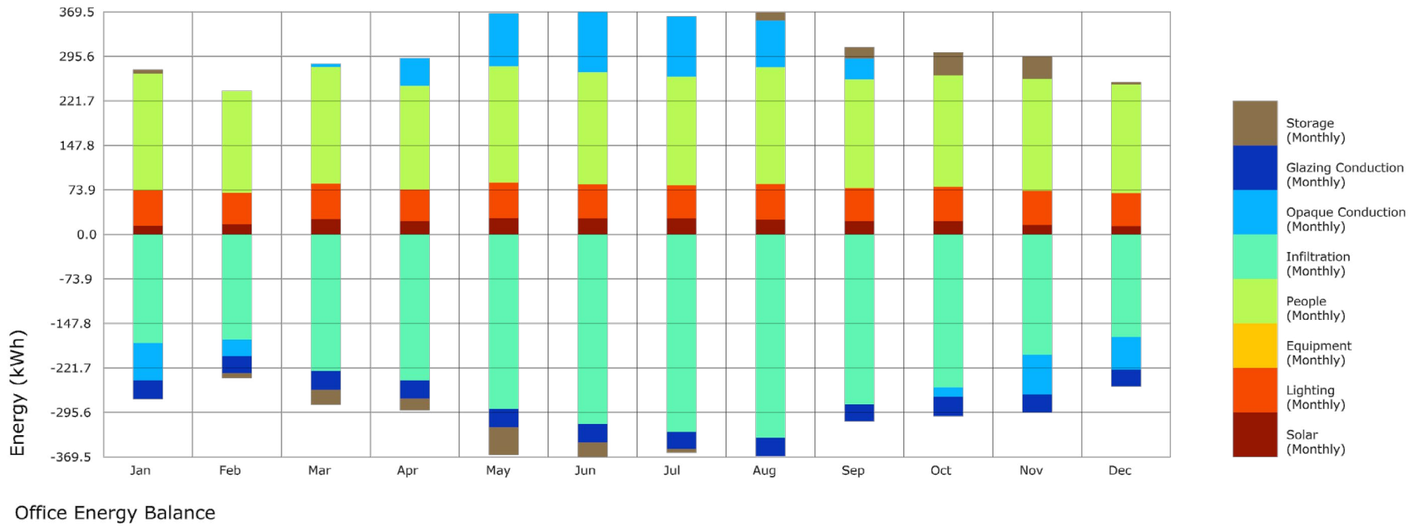
```
Comfortable (%): 22.4
hot (%):         23.5
cold (%):        54.1
```

Comfortable (%): 22.4
hot (%): 23.5
cold (%): 54.1









Office Energy Balance

Step Three - Changing the Construction

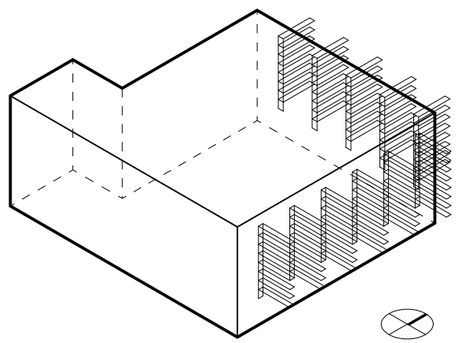
Exterior Wall:R5.8
Exterior Windows:R1.7
Exterior Roof: 34.4

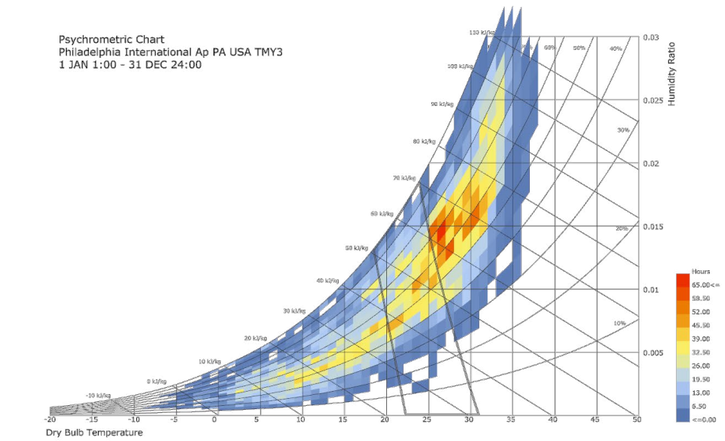
Air Exchange hours: 3 hours

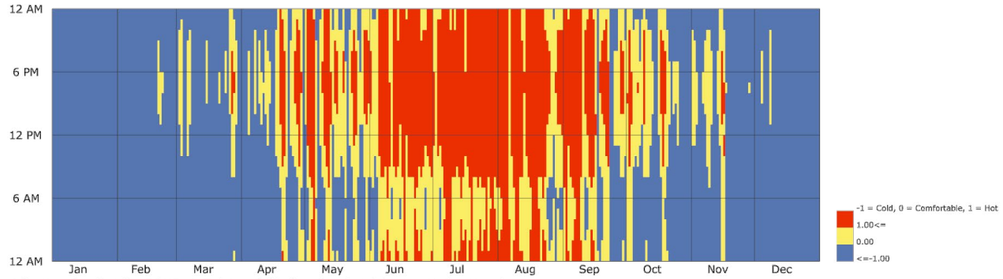
Shading: 1m
Numbers: 8

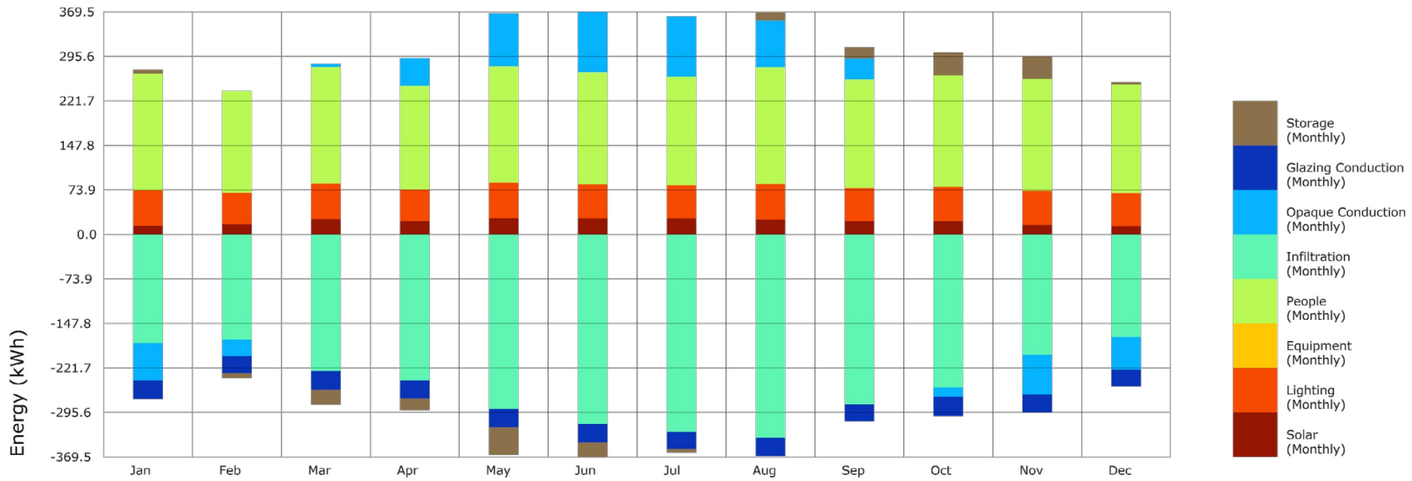
```
Comfortable (%): 22.4
hot (%):         23.5
cold (%):        54.1
```

Comfortable (%): 22.4
hot (%): 23.5
cold (%): 54.1





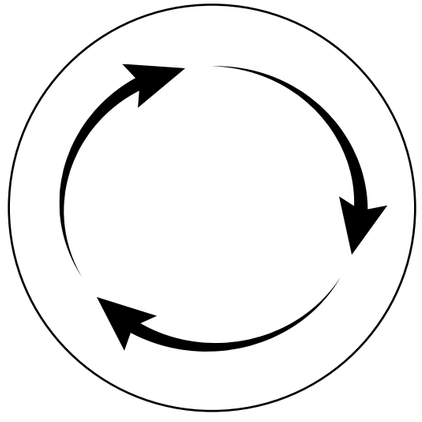




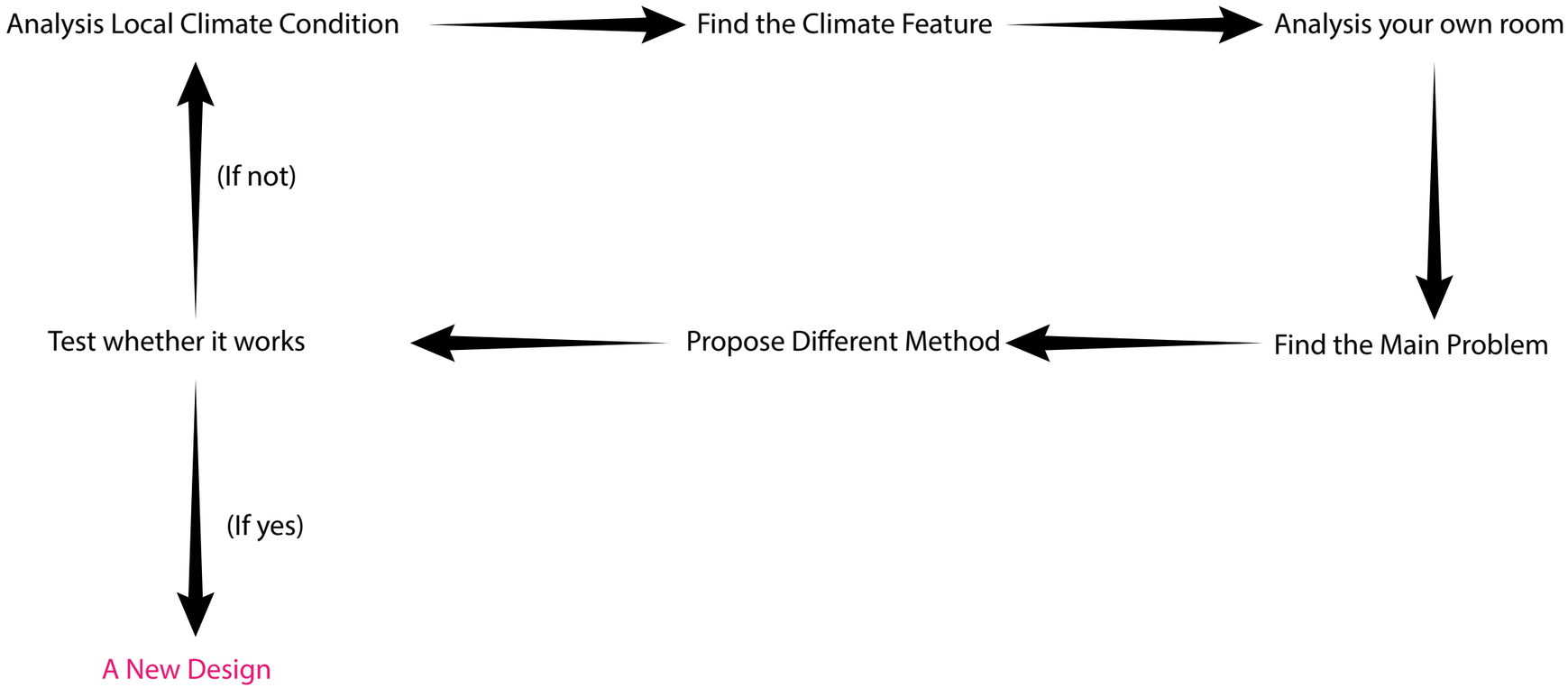
Office Energy Balance

Part 3:

Conclusion and Analysis



Work Flow



After do two case, I found the local climate is the most influence factor which sometime you can not avoid. Since, we just did a room which is not conditioned. So, so locations might impossible to make the PMV comfort to 50%. Since, there will be not enought thermal to make you feel comfort. And for the analysis tool, like the software we use, for a designer, at the beginning, they might help you refine the limitation. But, during the final process, it will be a test tool, to help you compare which one is the best.

For this project, since the time limitation, still have a lot to develop. What I did is trying to find out a best solution to make the PMV comfort larger.