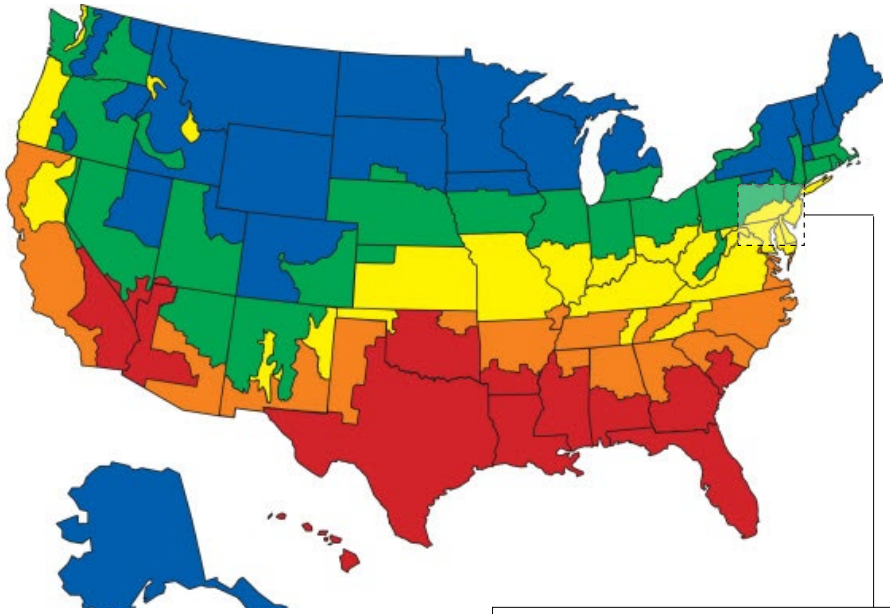
THERMAL AND VISUAL COMFORT MAXIMIZATION OF AN UNCONDITIONED SPACE

PHILADELPHIA, PA

DAWOON JUNG
FALL 2016 / ARCH 753 BUILDING PERFORMANCE SIMULATION
PENNDESIGN / UNIVERSITY OF PENNSYLVANIA



Climate Zones

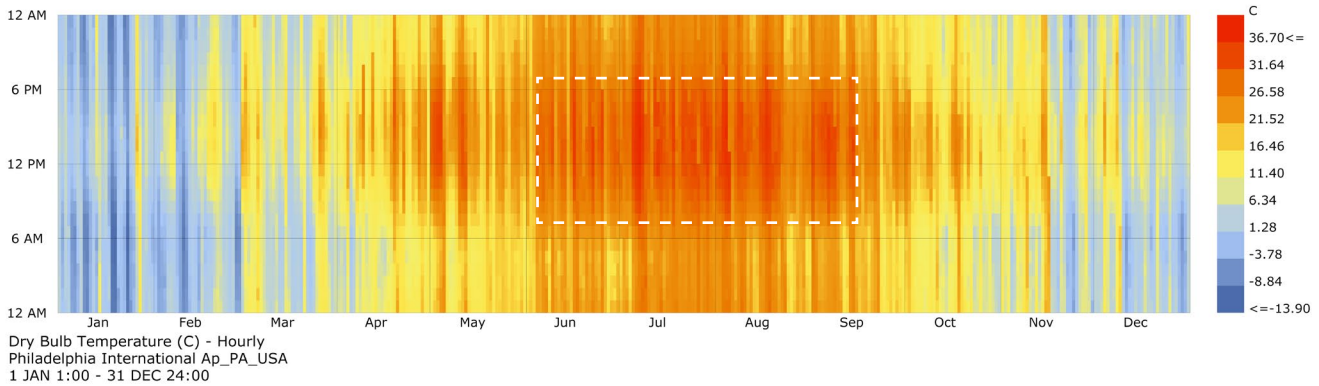
- Zone 1 is less than 2,000 CDD and greater than 7,000 HDD
- Zone 2 is less than 2,000 CDD and 5,500 ~ 7,000 HDD
- Zone 3 is less than 2,000 CDD and 4,000 ~ 5,499 HDD
- Zone 4 is less than 2,000 CDD and less than 4,000 HDD
- Zone 5 is 2,000 CDD or more and less than 4,000 HDD

WEATHER DATA: PHILADELPHIA.INTL.AP.7244080_TMY3
LATITUDE: 39.87
LONGITUDE: -75.23

Philadelphia is located on the eastside of the Us.
The characteristic of weather in Philadelphia has four obvious seasons such as spring, summer, Fall and winter. These four seasons tend to increase architectural needs regarding insulation, shading and enclosure.

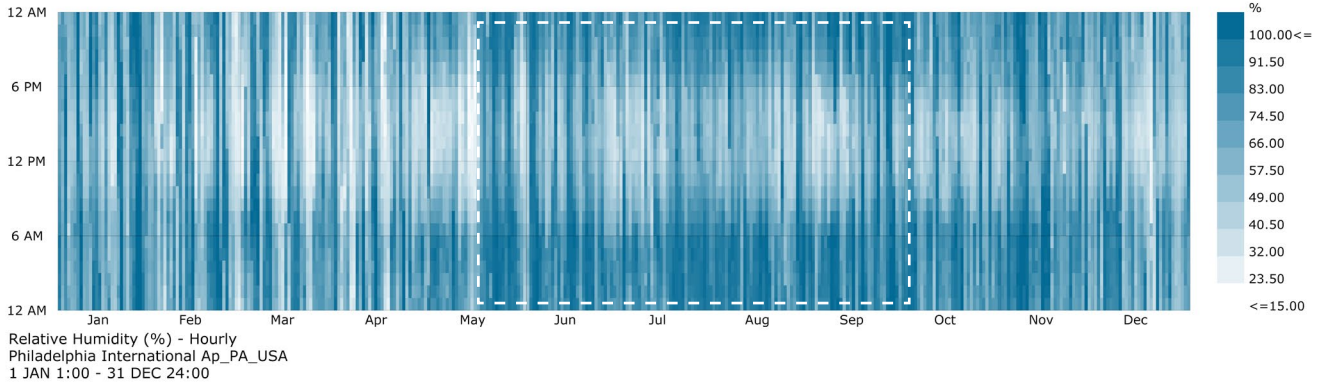
EXTERIOR FACTORS

DRY BULB TEMPERATURE



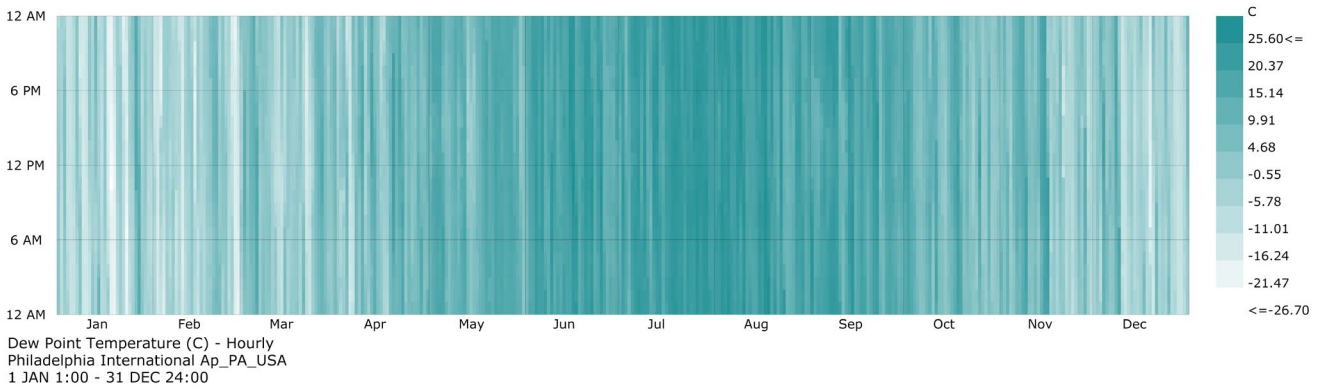
Since Philadelphia has four obvious seasons, sunlight is quite strong around summer, thus making people difficult to stay outside of building for a long period of time.

RELATIVE HUMIDITY



Philadelphia has quite different humidity depending on four seasons.
During summer season, Philadelphia is highly humid compared to other parts of the nation.
Opposed to summer seaon, winter is driest season especially from December to February.

DEW POINT TEMPERATURE



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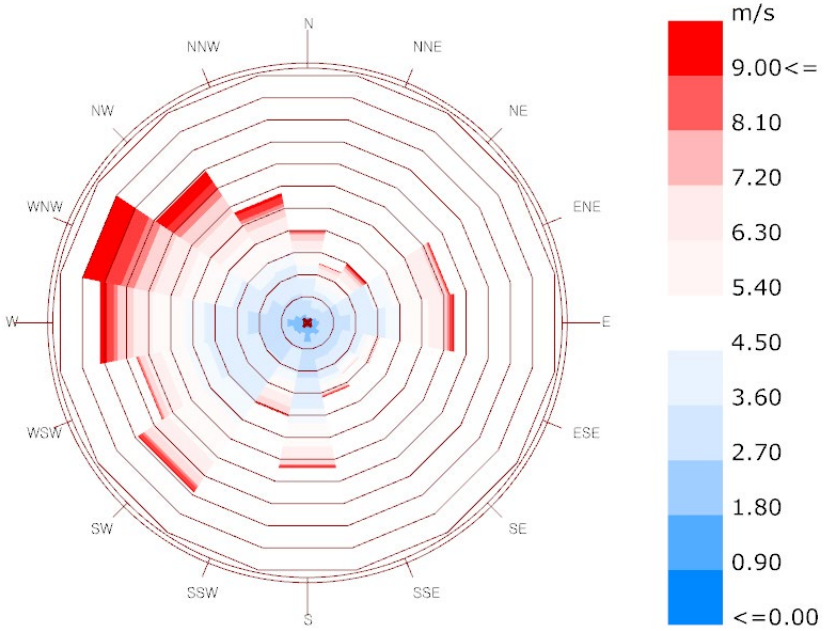
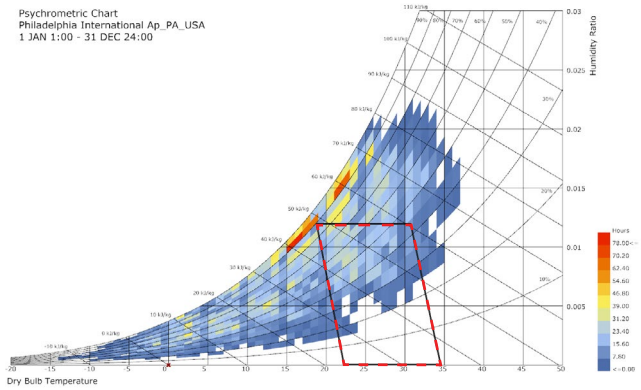
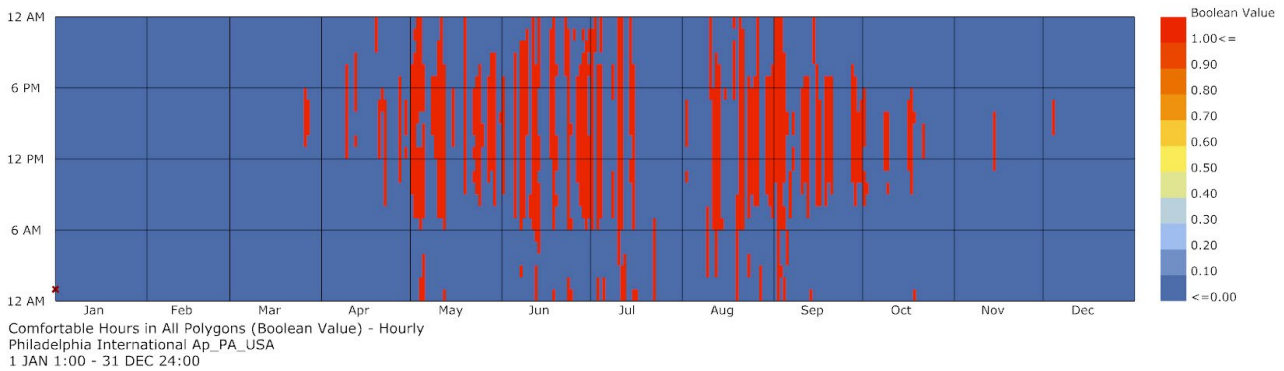


Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 2.81% of the time = 246 hours.
Each closed polyline shows frequency of 1.0%. = 90 hours.

Wind at Philadelphia mainly comes from WNW (West-Northwest) direction. Also there is no specific season when wind become strong. All year around, wind blows evenly.



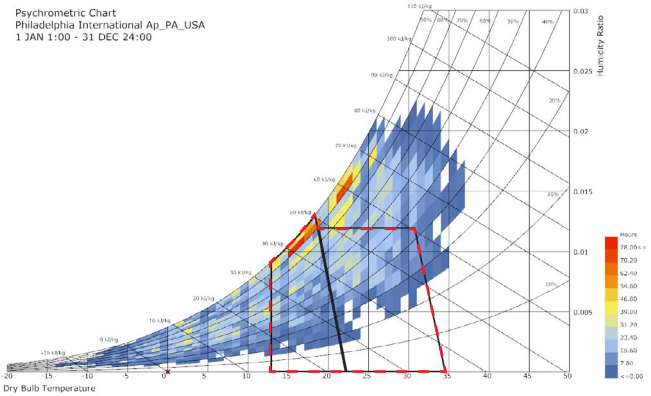
Normal condition



Psychrometric chart in Philadelphia
Cloth Level : 0.6 ~ 1.0
Total Comfort Percent : 12%

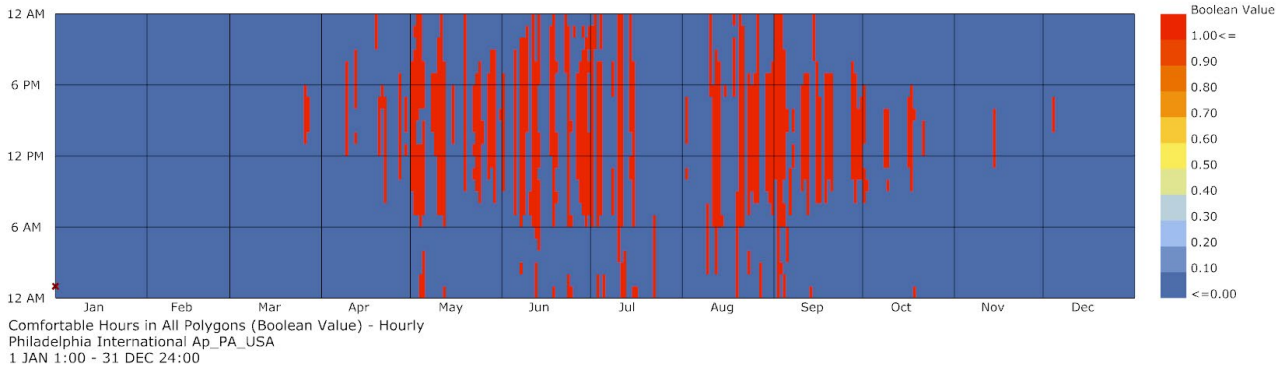
Comfort

Discomfort



Passive Strategy

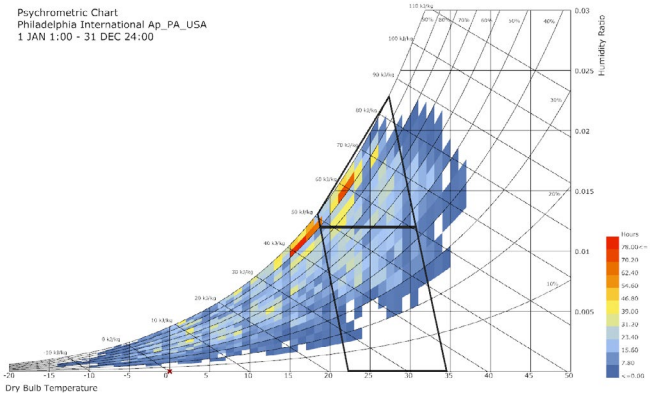
Internal Heat Gain



Psychrometric chart in Philadelphia
Cloth Level : 0.6 ~ 1.0
Total Comfort Percent : 32.55%

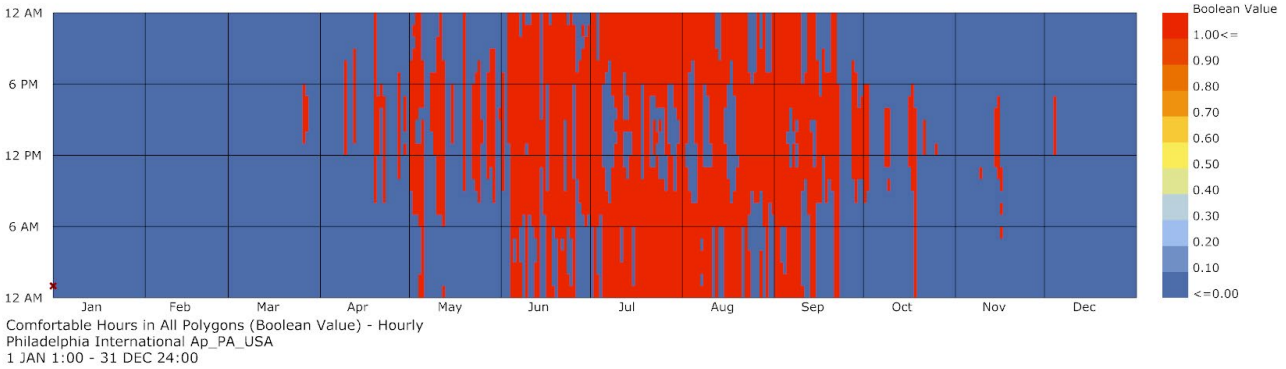
Comfort

Discomfort



Passive Strategy

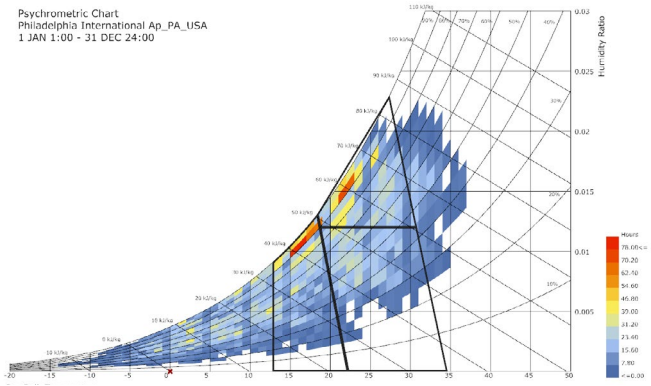
Dehumidification



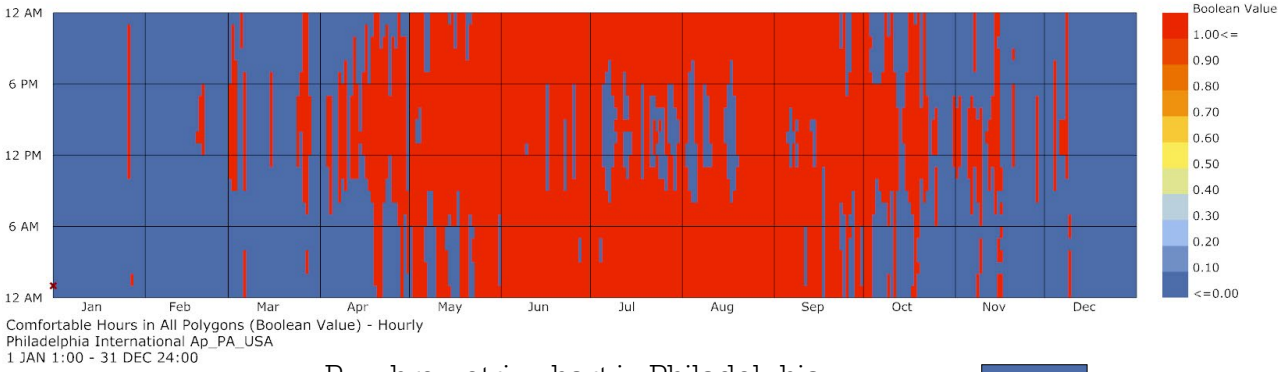
Psychrometric chart in Philadelphia
Cloth Level : 0.6 ~ 1.0
Total Comfort Percent : 28.20%

Comfort

Discomfort



Dehumidification
+ Internal heat Gain

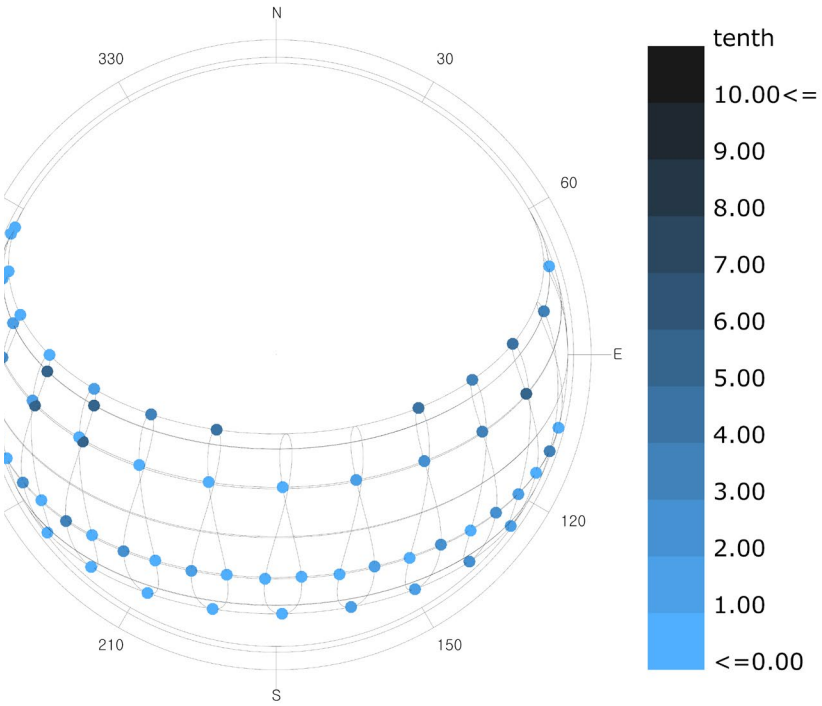


Psychrometric chart in Philadelphia
Cloth Level : 0.6 ~ 1.0
Total Comfort Percent : 48.07%

Comfort

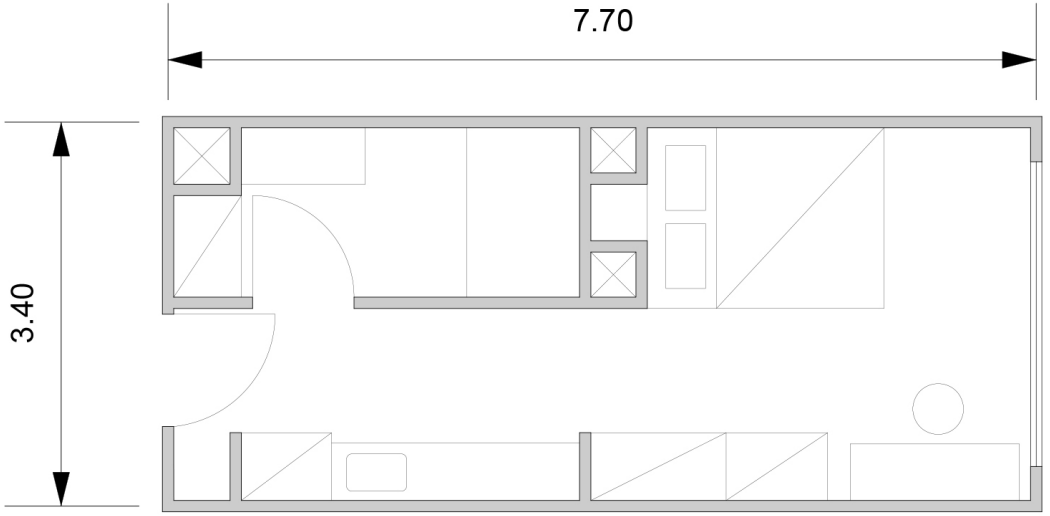
Discomfort

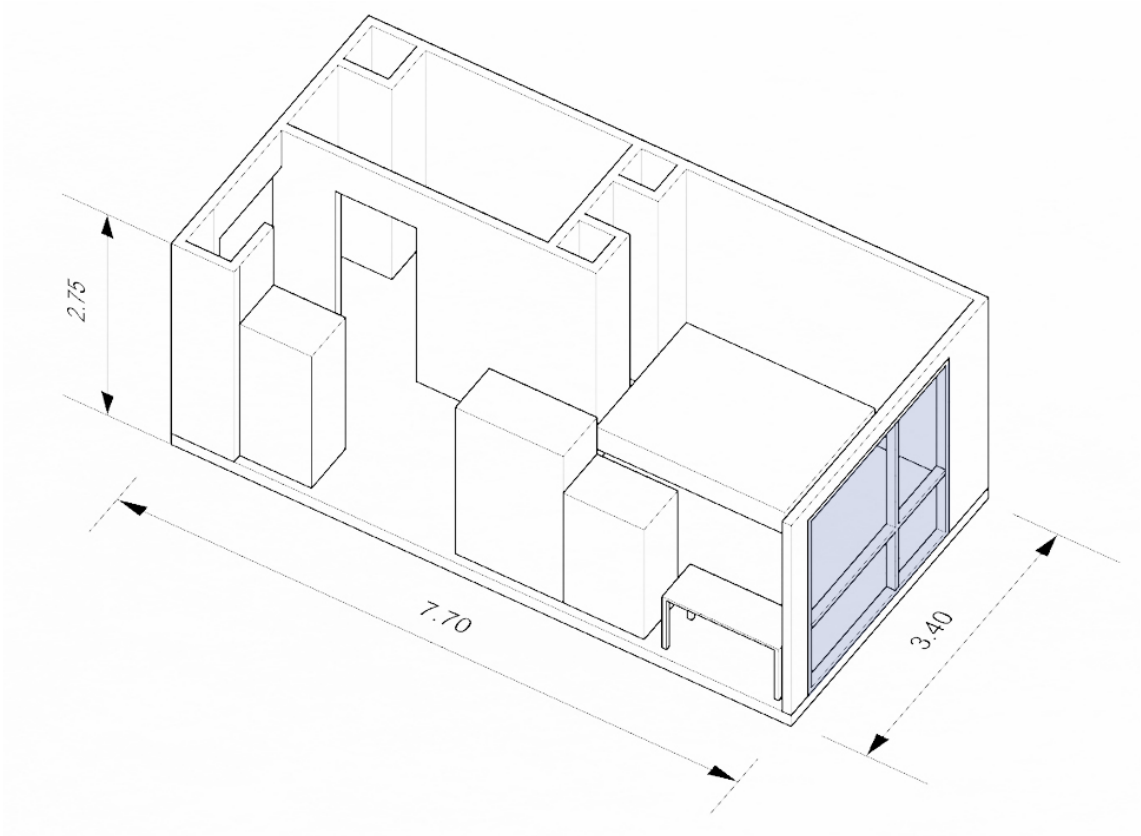
According to the analysis, using strategy for internal heat gain and dehumidification are effective way to improve the comfort of weather.



ı-Path Diagram - Latitude: 39.17
ırly Data: Total Cloud Cover (tenth)
timore Blt Washngtn IntL_MD_USA
... ...
ıditional Selection Applied:
tal Cloud Cover < 6
0 hours of total 145.0 sun up hours(42.07%).

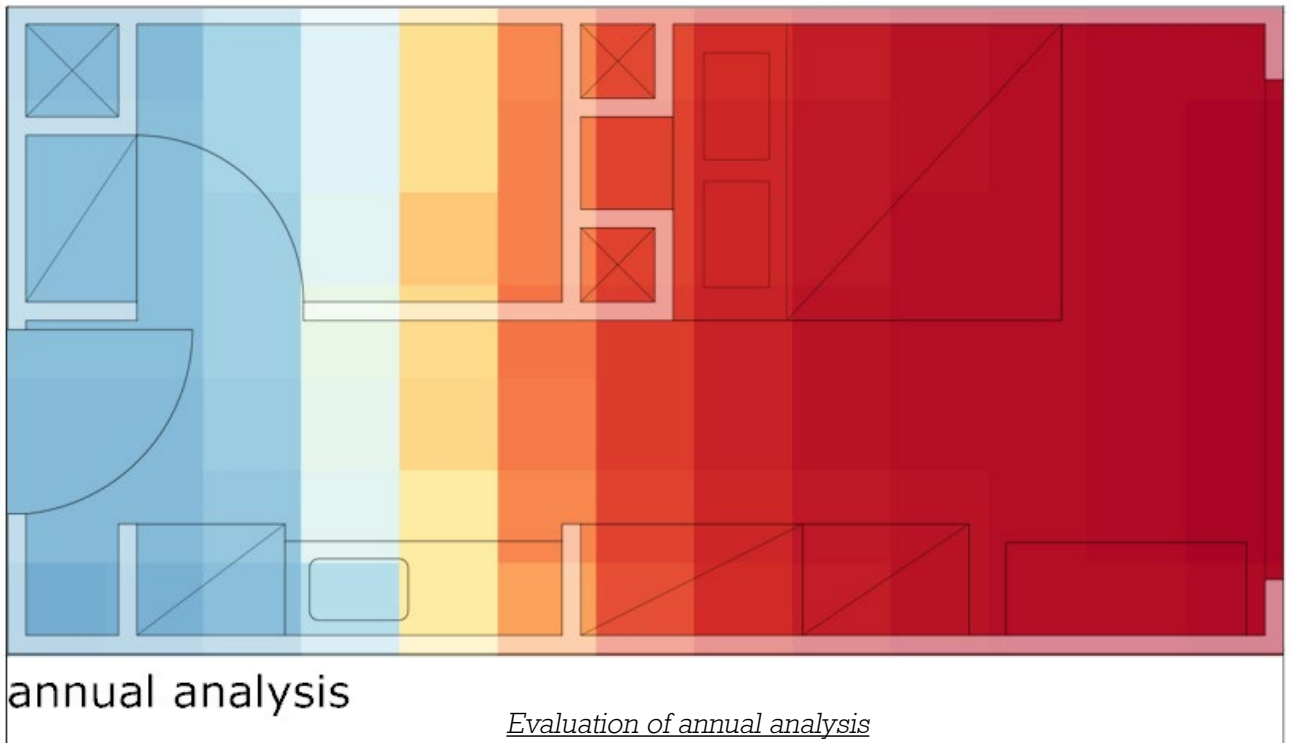
Psychrometric chart in Philadelphia
Cloth Level : 0.6 ~ 1.0
Total Comfort Percent : 28.20%





Test Room

Area: 26.18 m2
Glazing area: 6 m2
Orientation: East- Southeast
Program: Midrise Apartment
Occupied Hour: 7AM -12PM



Evaluation of annual analysis

Since the light deeply get into this room, it hard to have asleep until late morning.
Furthermore, the heat usually makes this room too hot until noon.

Glare Amalysis

Glare analysis is tested at 9 points of time on the position, where user uses computer and glare might be an issue on screen.
The results show only at 9 am, December 21st has a problem with glare, the other 8 points of time have imperceptible glare. Shading device can be used to improve this situation.

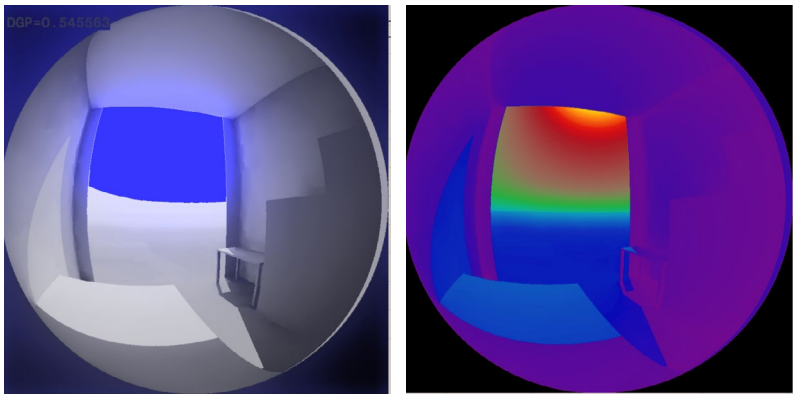
Problem

Usually, I use this room from 9 to 12PM. However, around this time, sunlight is too strong especially from May to September at 9AM which is intolerable.

Imperceptible: <35%
Perceptible: 35-40%
Disturbing: 40-45%
Intolerable: >45%

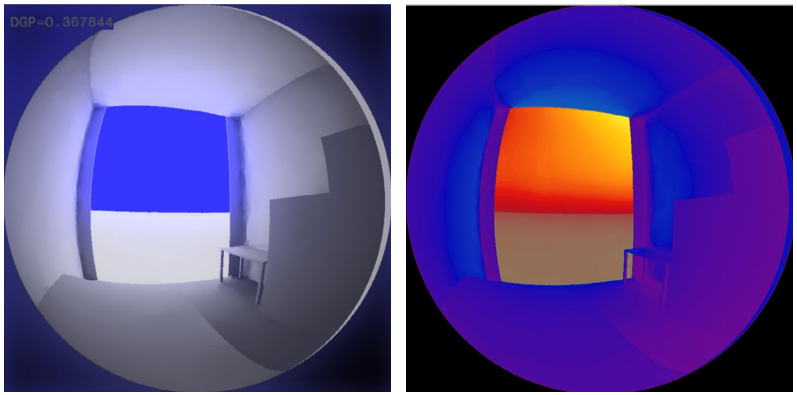
June

9AM



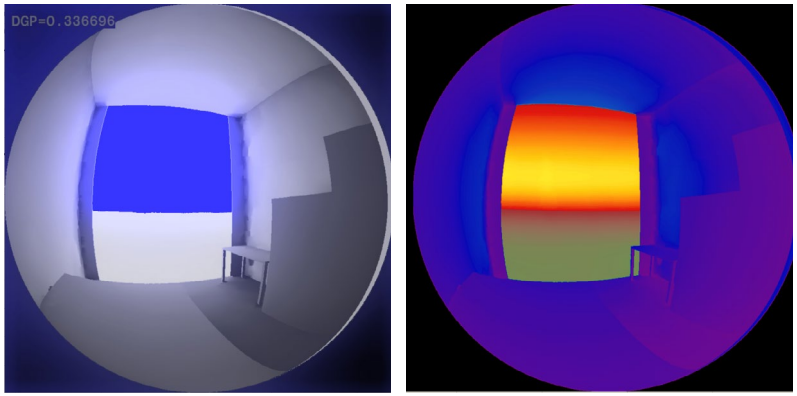
DGP: 54%

12PM



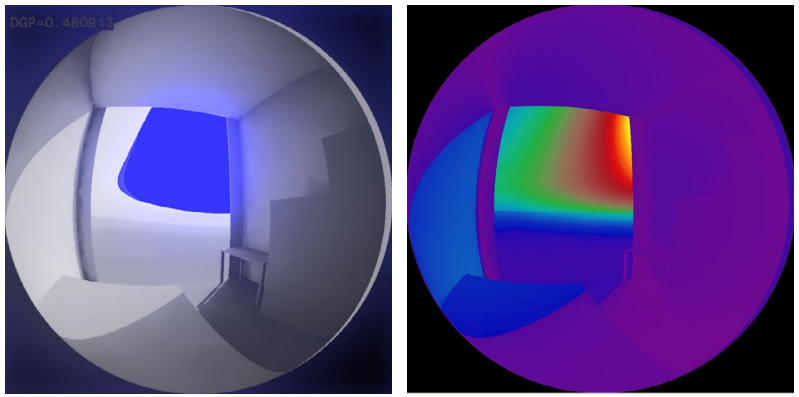
DGP: 36%

15PM

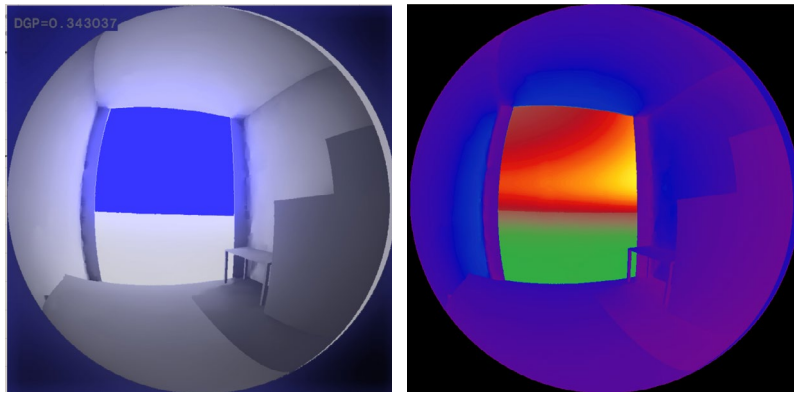


DGP: 33%

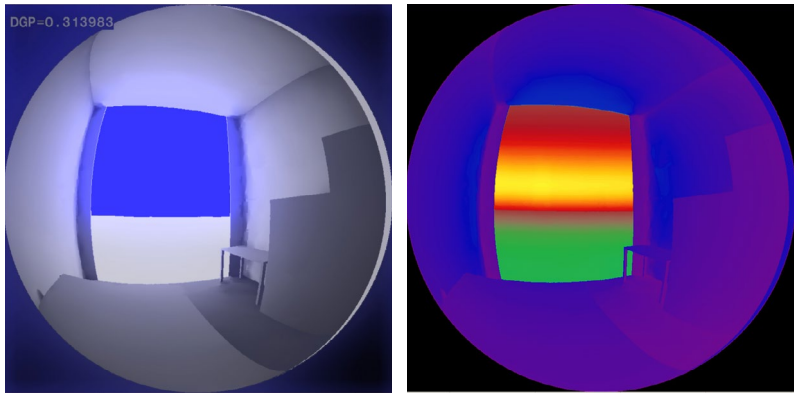
September



DGP: 48%

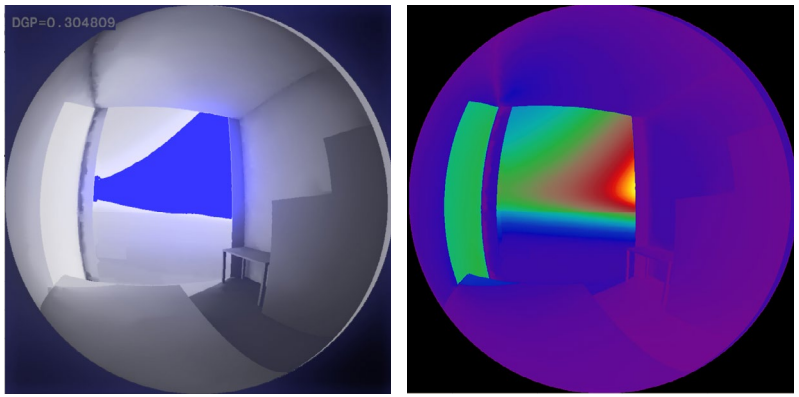


DGP: 34%

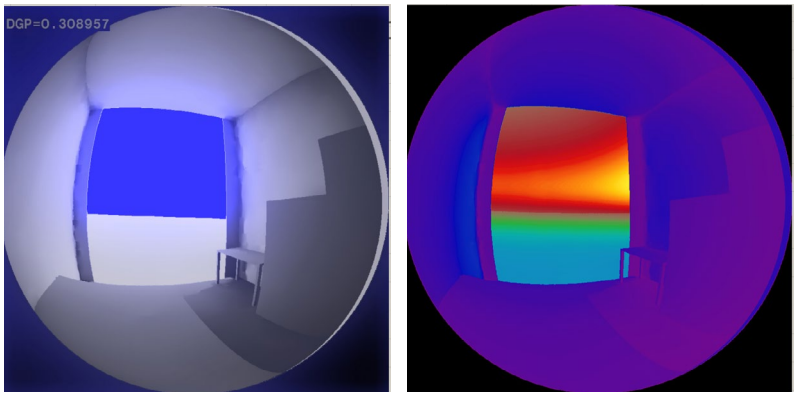


DGP: 31%

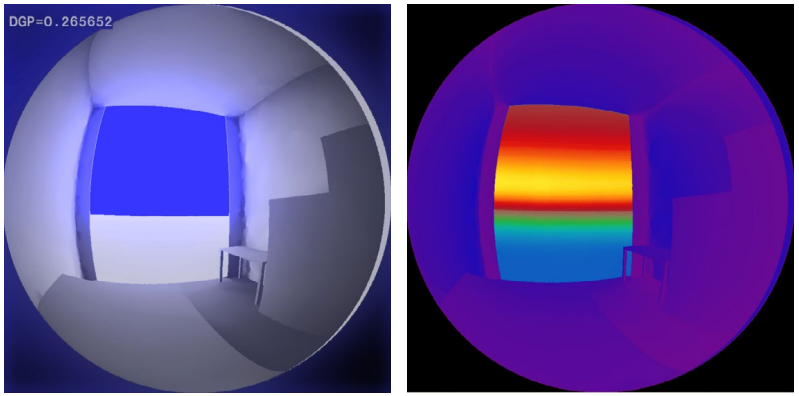
December



DGP: 30%



DGP: 30%



DGP: 26%

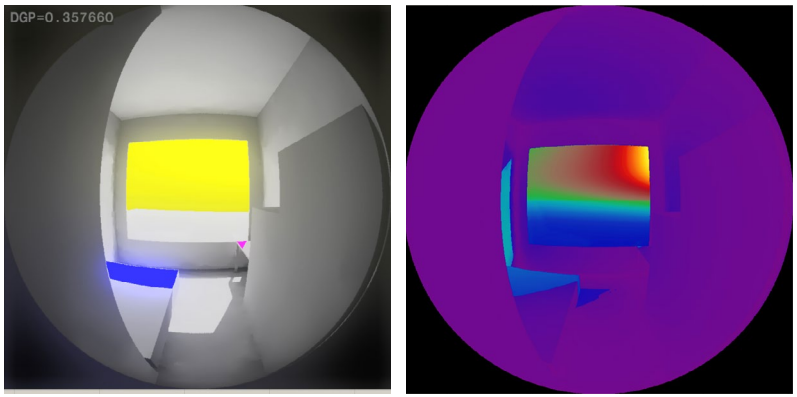
Solution

Intolerable time zones are eliminated by reducing the size of the window, making the room more comfortable to reside.

Imperceptible: <35%
Perceptible: 35-40%
Disturbing: 40-45%
Intolerable: >45%

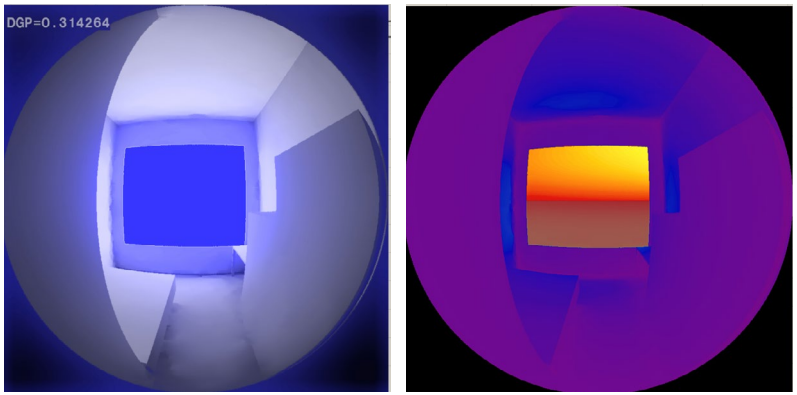
June

9AM



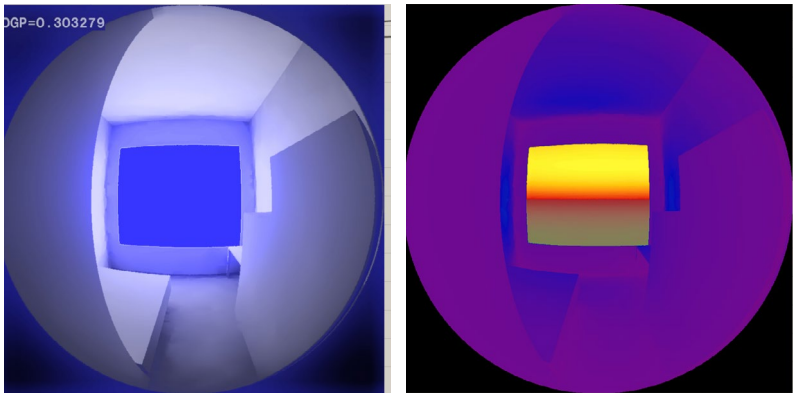
DGP: 35% (Before_54%)

12PM



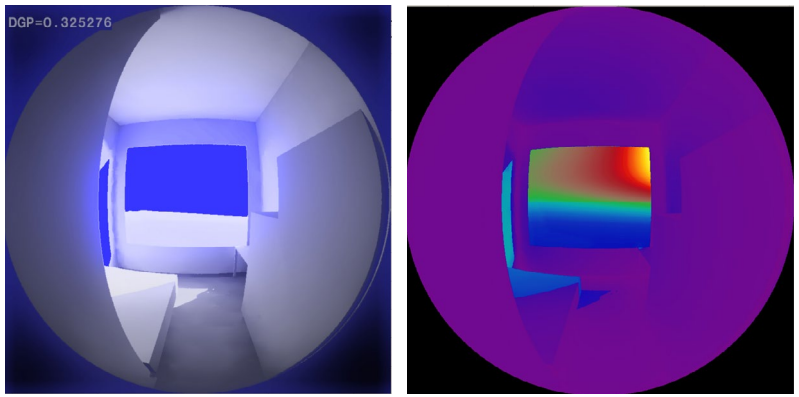
DGP: 31%

15PM

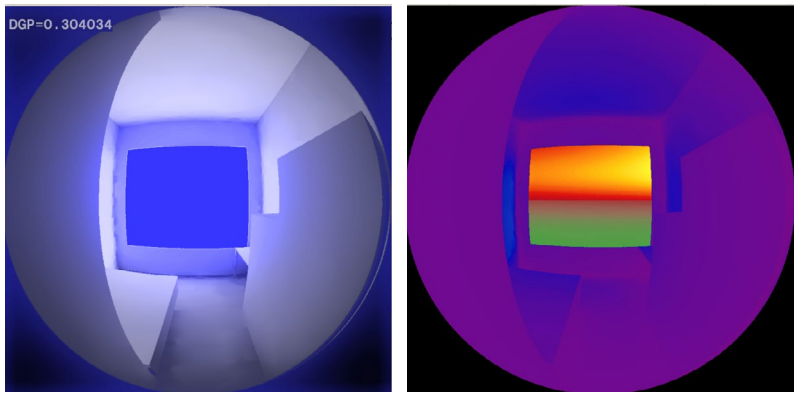


DGP: 30%

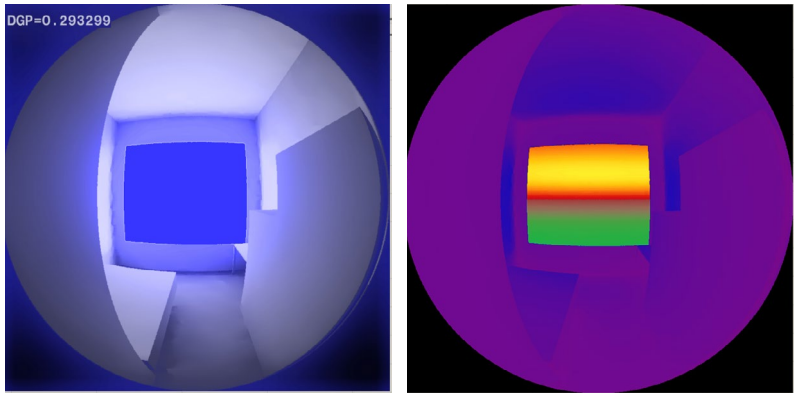
September



DGP: 32% (Before_48%)

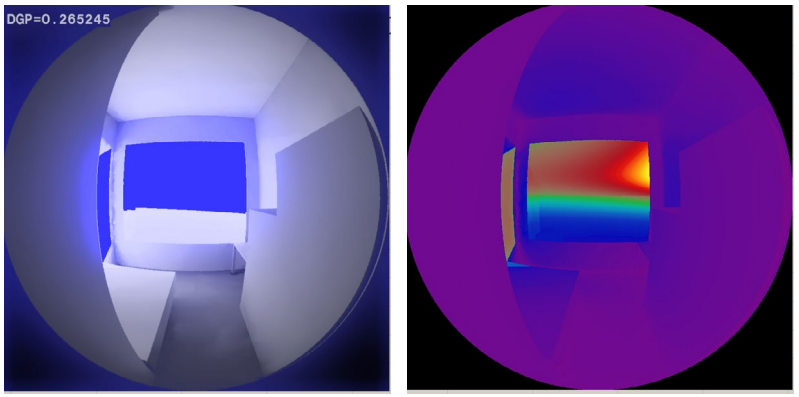


DGP: 30%

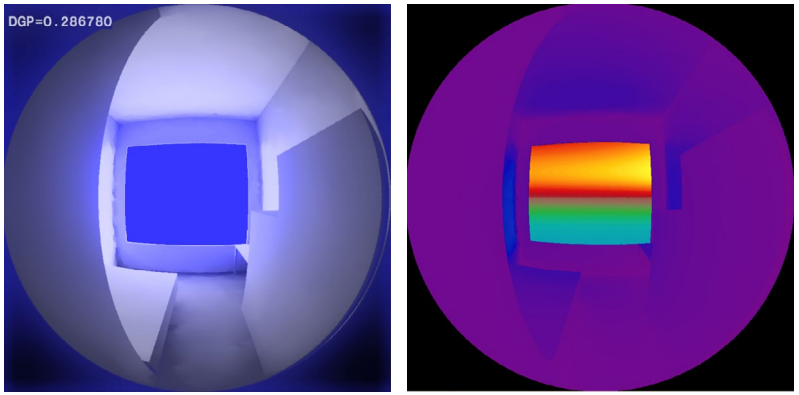


DGP: 29%

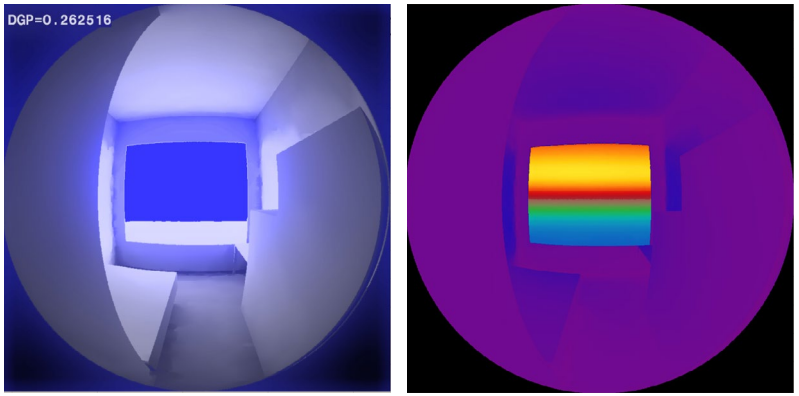
December



DGP: 26%

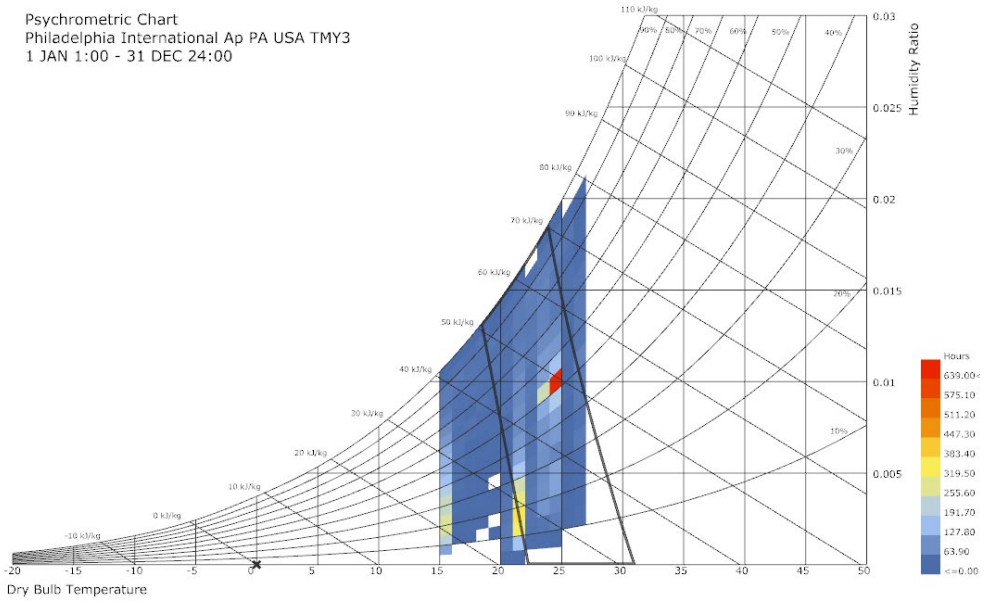


DGP: 28%



DGP: 26%

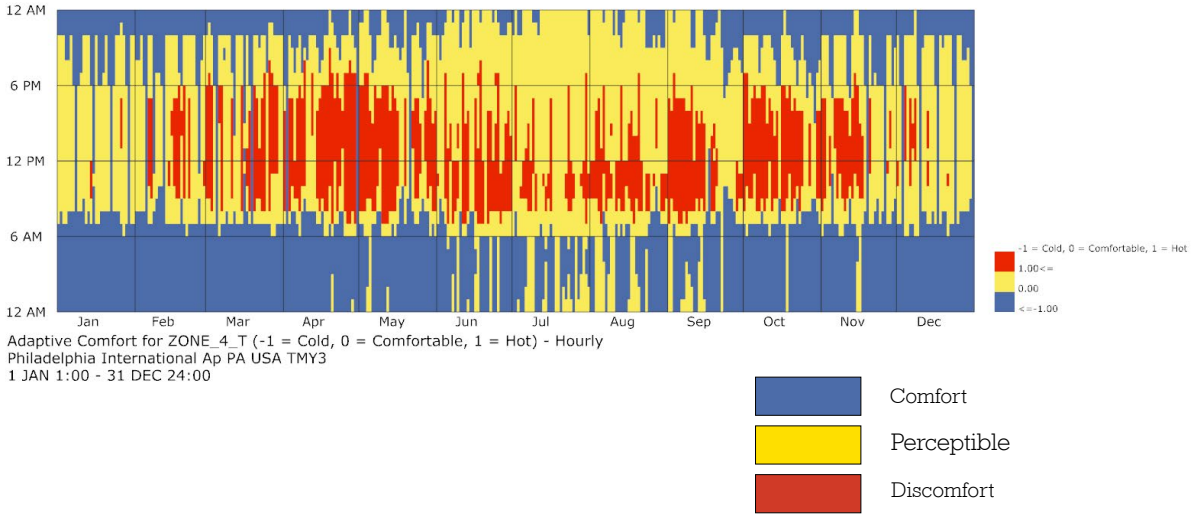
Present Condition



Psychrometric Chart of the room

Comfortable: 42.80%
Hot: 17.24%
Cold: 39.97%

Orientation : **East**

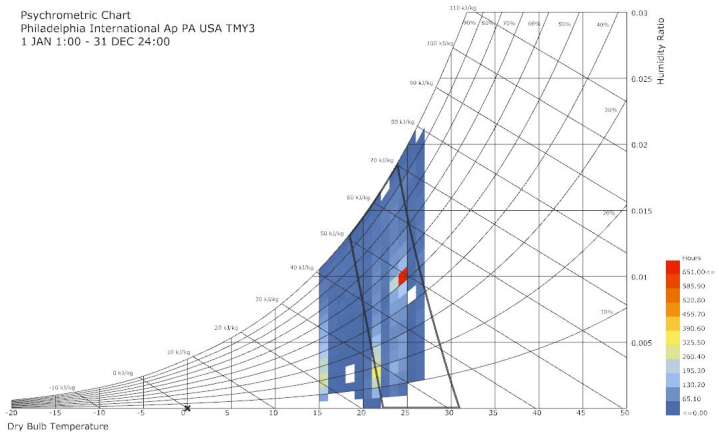


Adaptive comfort of the room by changing the orientation

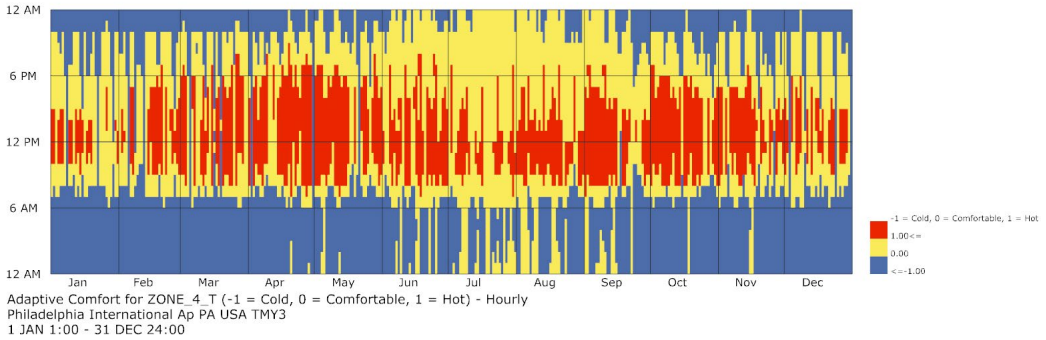
Result

By changing the orientation of the room, it is hard to improve comfortness in an abvious way.

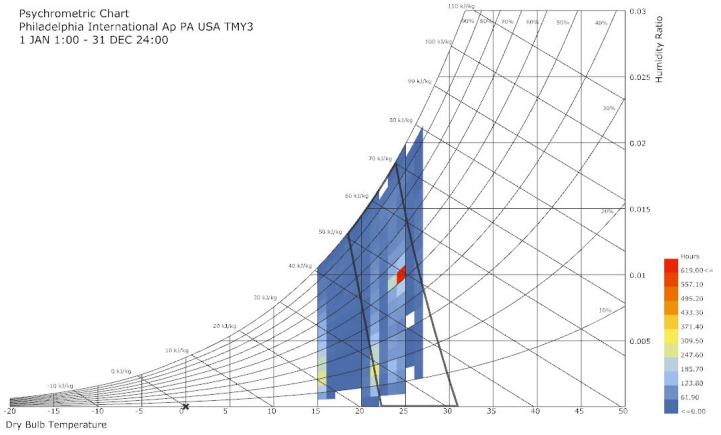
Changing Orientation



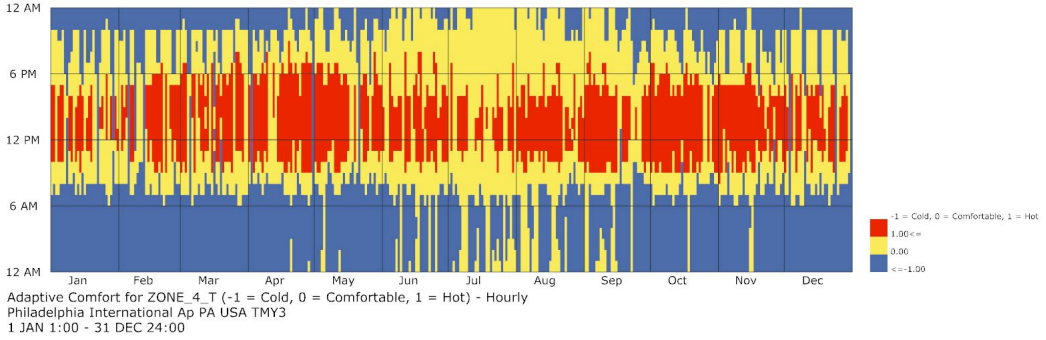
Orientation: **South East**



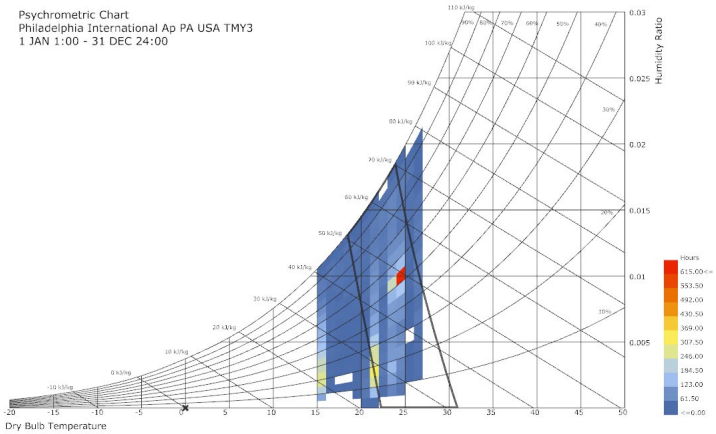
Comfortable: 38.97%
Hot: 21.35%
Cold: 39.68%



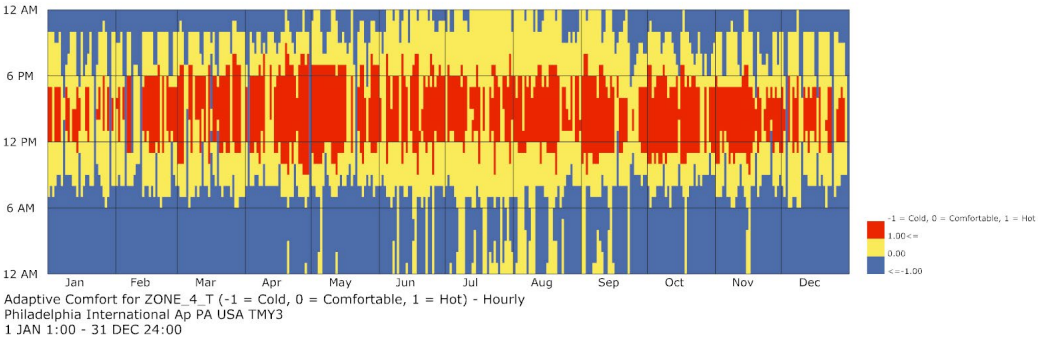
Orientation: **South**



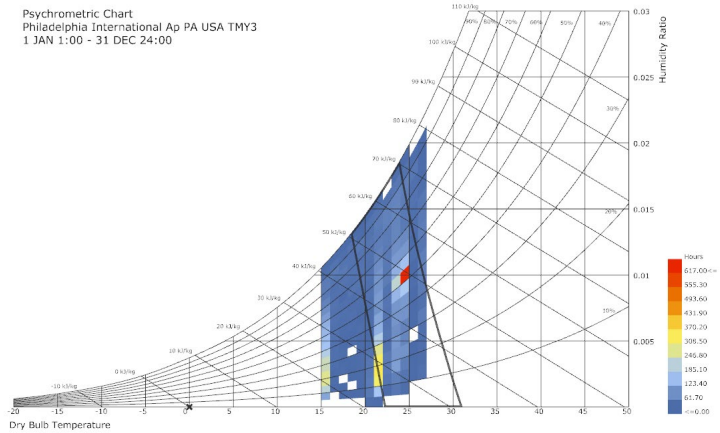
Comfortable: 37.57%
Hot: 22.04%
Cold: 40.39%



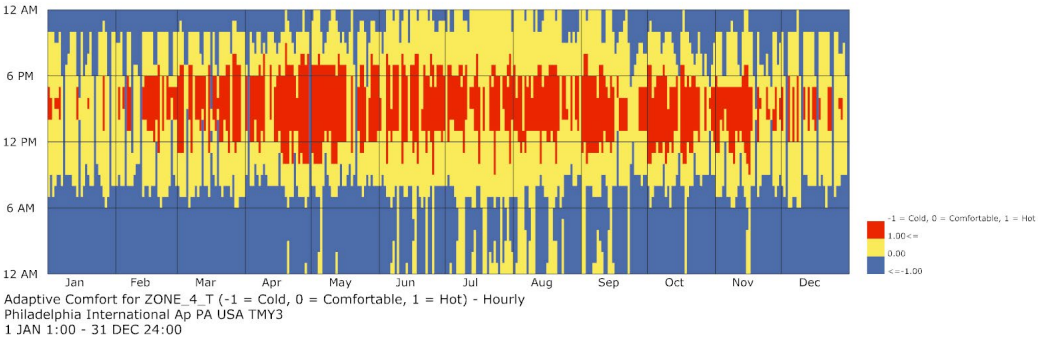
Orientation: **South West**



Comfortable: 38.38%
Hot: 20.34%
Cold: 41.28%



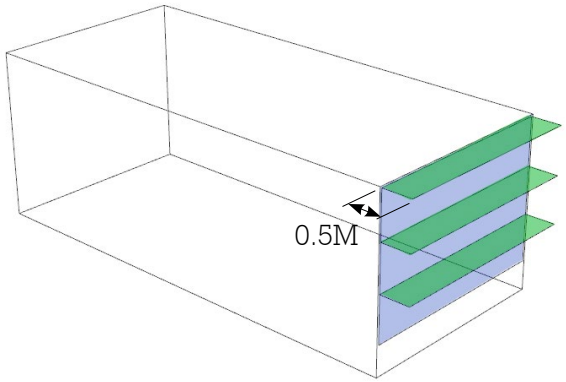
Orientation: **West**



Comfortable: 41.20%
Hot: 16.80%
Cold: 42.00%

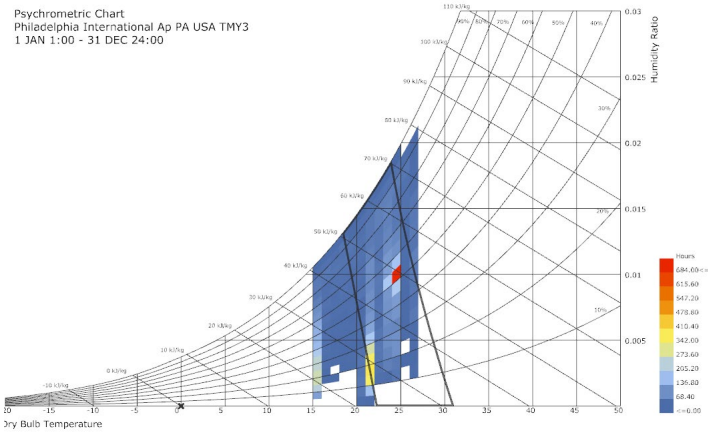
Adding Louvers

Three Louvers

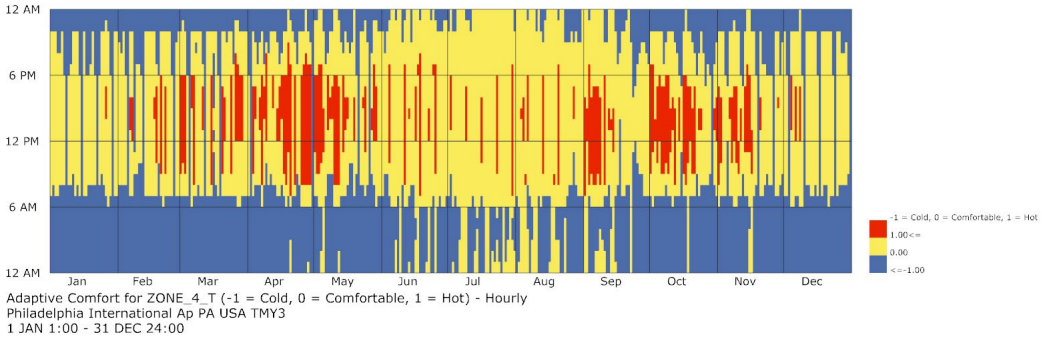


Installing three louvers on the eastside window makes to improve comfortness obviously.

42.80% ⟶ **49.81%**



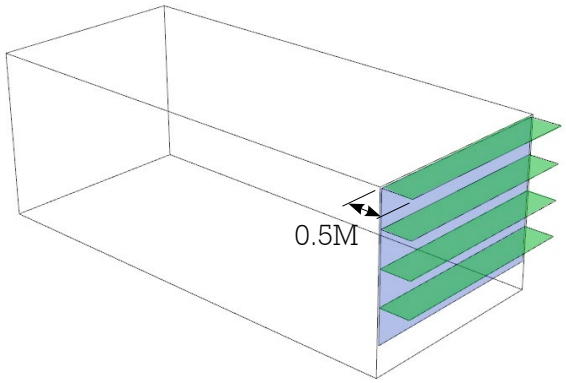
Orientation: **East**



Comfortable: 49.81%
Hot: 9.59%
Cold: 40.61%

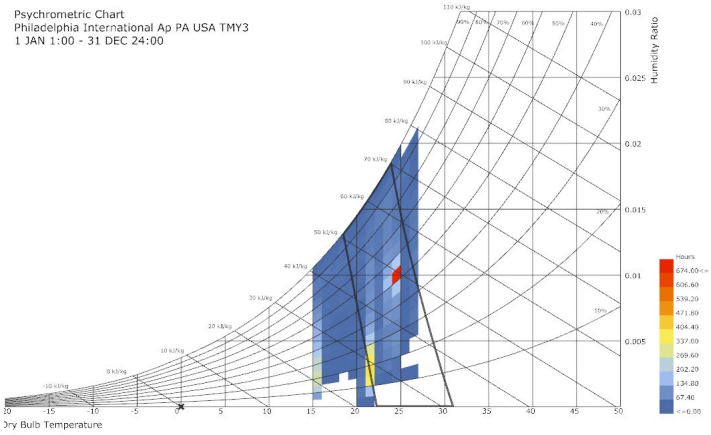
Adding Louvers

Four Louvers

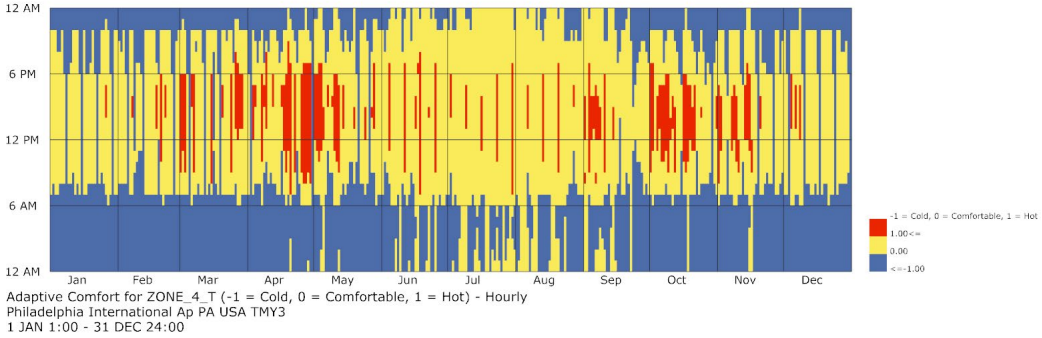


Installing three louvers on the eastside window makes to improve comfortness obviously.

42.80% ⟶ **51.69%**



Orientation: **East**



Comfortable: 51.69%
Hot: 7.28%
Cold: 41.03%

Design Proposal

Based on the analysis, the best way to improve the condition especially for the time from 9AM to 12PM is reducing the size of the entire window on East side. Since the window is too big, it helps to gain excessive heat into the room. Therefore, reducing the size of a window as 80% is appropriate to keep the nice view and reducing excessive energy through the window.

Second, adding louvers in front of the window is quite effective to improve comfortness on the room. When the louvers added, the comfortness is obviously improved.

These two design factors can improve this room in an efficient and effective way rather than changing orientation.