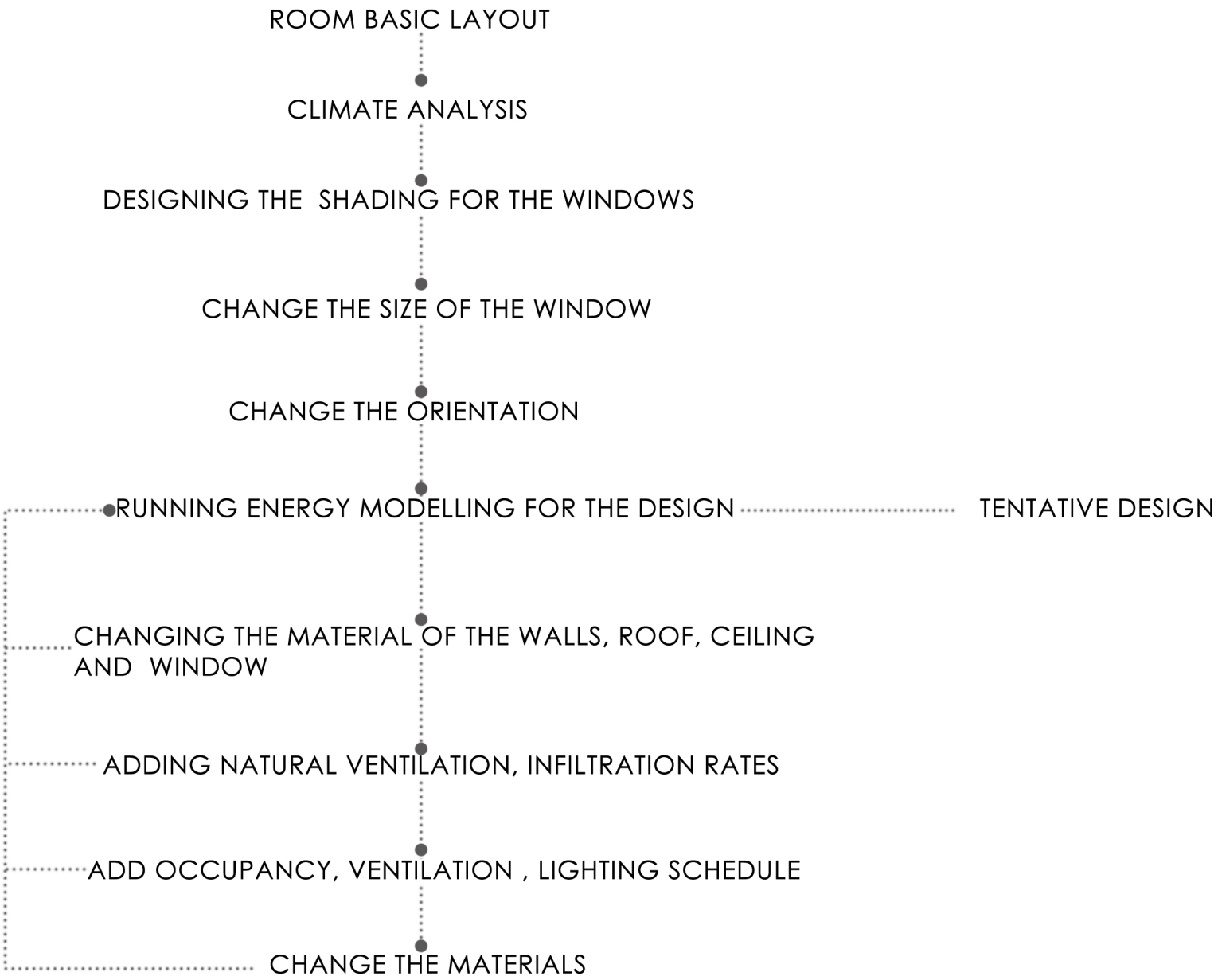
BUILDING PERFOMACE SIMULATION

ARCH 753

SUBMITTED BY : **NAMAN GUPTA**

APPROACH

PROBLEM : HOW TO IMPROVE COMFORT LEVELS IN AN EXISTING ROOM



LAYOUT OF THE ROOM

BASIC LAYOUT O F THE ROOM

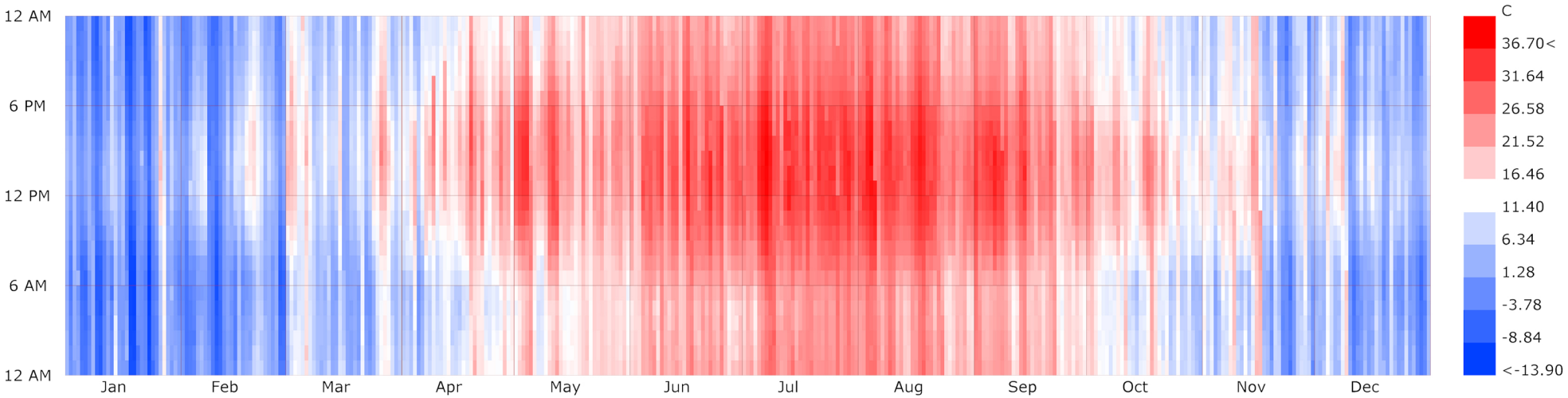
Plan

Section

Located in Philadelphia, United States. This room is a part of 5 bedroom apartment. Windows are located on the wall facing east side with a existing overhang. Two wall are attached to other rooms in the house

CLIMATE ANALYSIS OF PHILADELPHIA

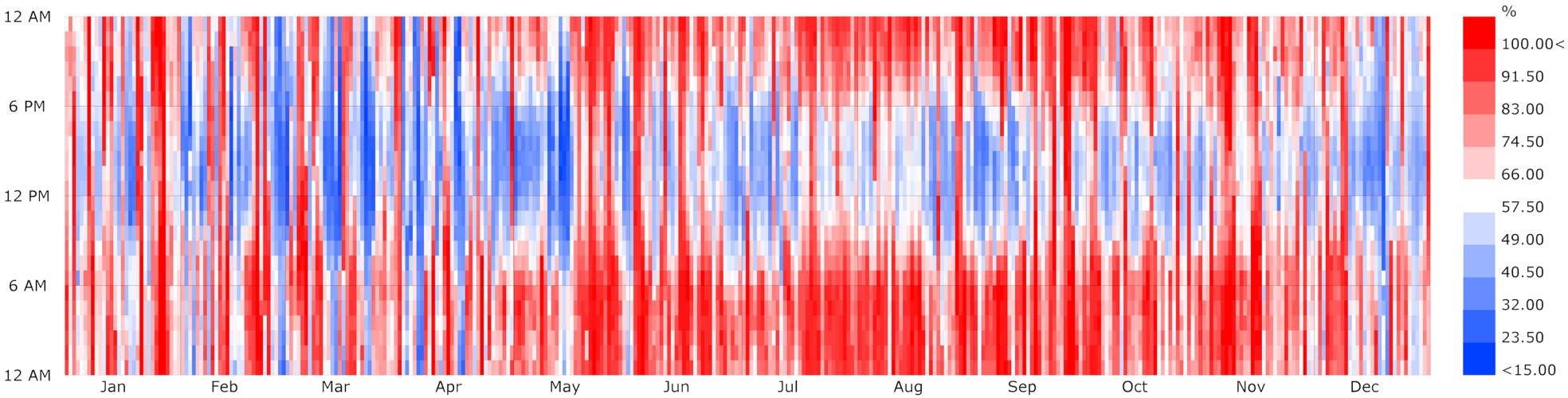
DRY BULB TEMPERATURE



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

The outdoor temperature in Philadelphia ranges from -14 degree Celsius to 37 degree Celsius. We generally have higher temperature from 10:00AM to 5:00PM.

RELATIVE HUMIDITY

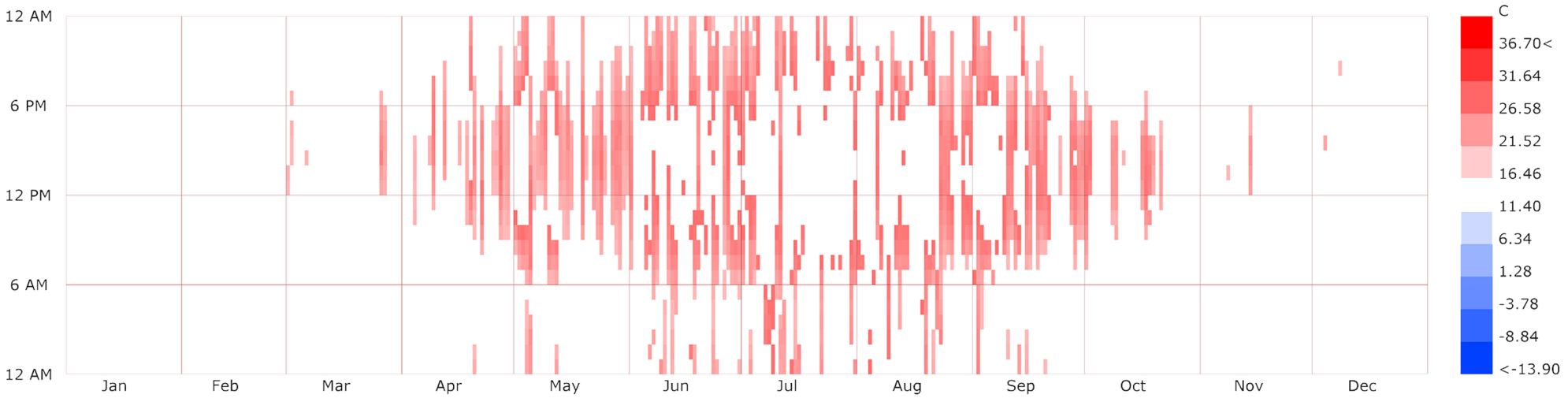


Relative Humidity (%) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

Philadelphia has higher relative humidity during the night and early morning. On an average it less than 50 % during the day

CLIMATE ANALYSIS OF PHILADELPHIA

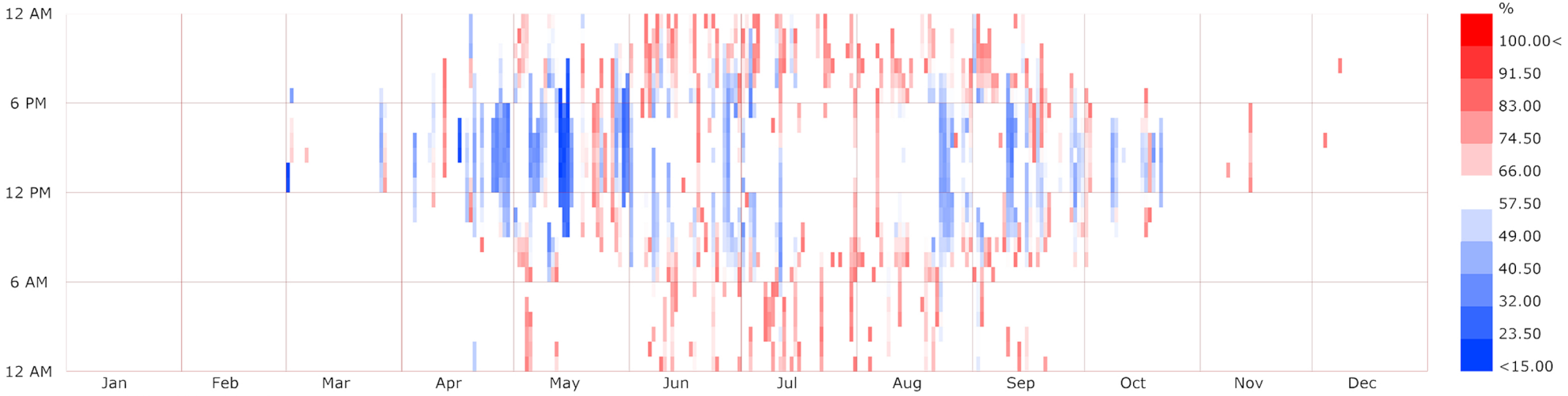
18<DRY BULB TEMPERATURE <26



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

According the conditional statement, we have comfortable time during the daytime from April to October

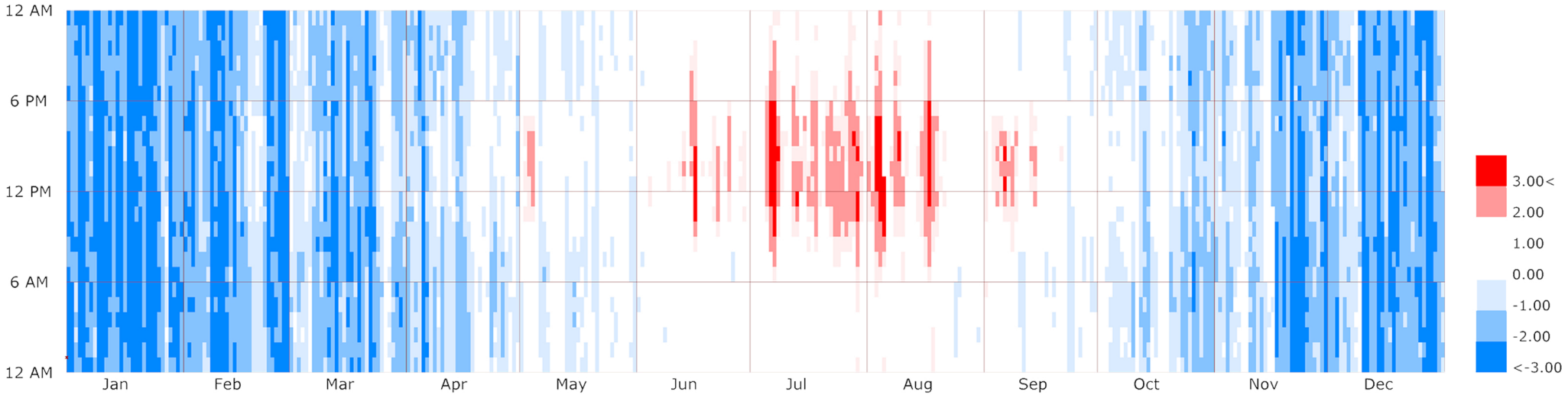
RELATIVE HUMIDITY<50%



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

CLIMATE ANALYSIS OF PHILADELPHIA

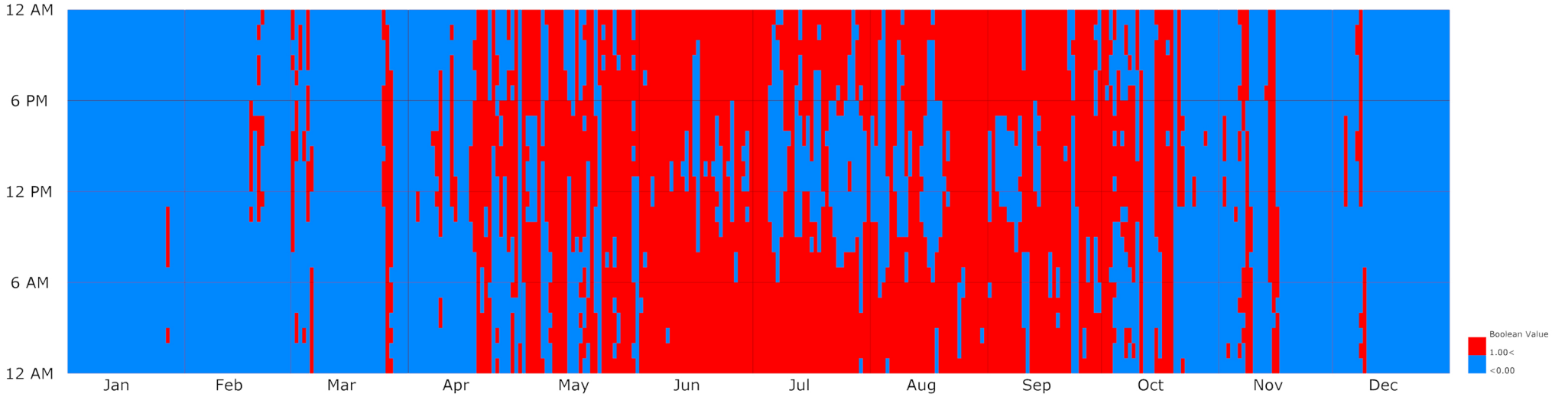
OUTDOOR COMFORT



Outdoor Comfort (-3 = Extreme Cold | -2 = Cold | -1 = Cool | 0 = Comfort | 1 = Warm | 2 = Hot | 3 = Extreme Heat) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

Outdoor is comfortable for 41 % of the hear. It has very less heat stress which mainly happening during the day in the hottest month. It has only 4 % of heat stress.

PHILADELPHIA IS COMFORTABLE FOR HOW MUCH TIME

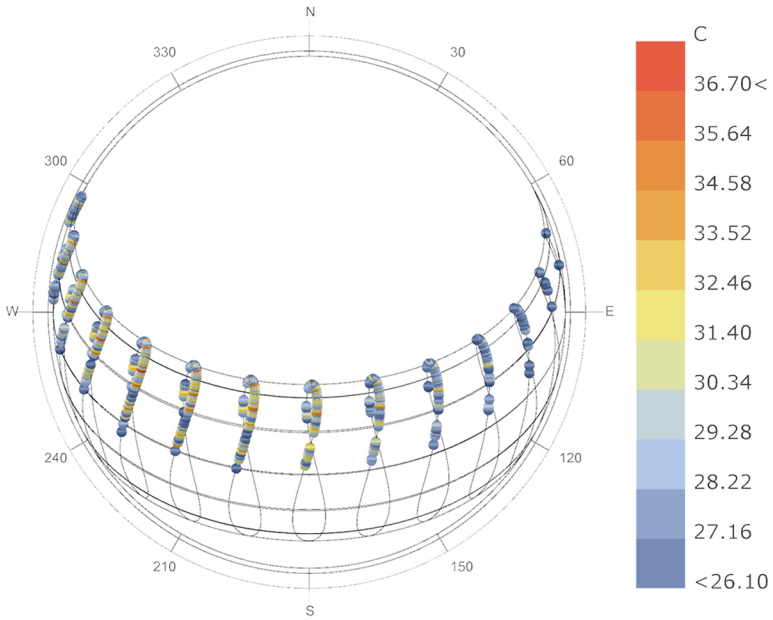


Comfort or Not (Boolean Value) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

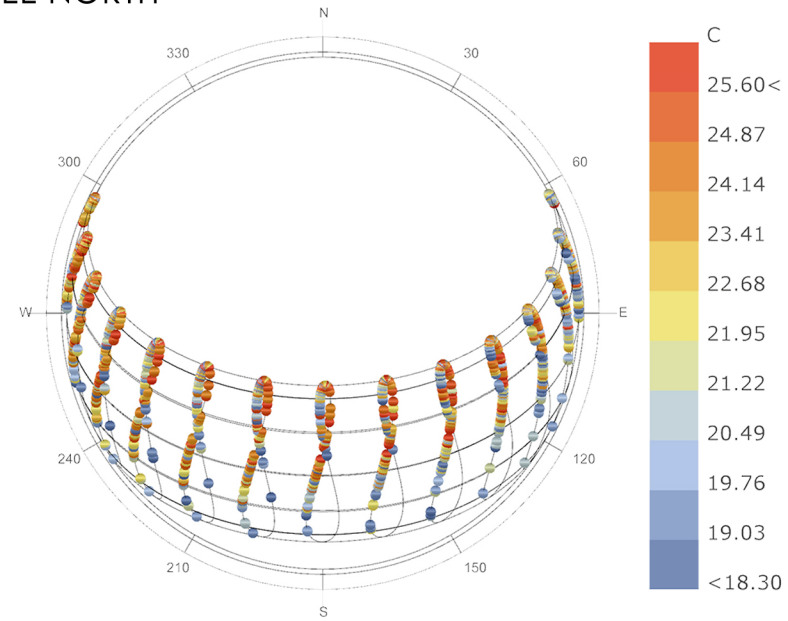
Red coloured area represents the times of year when Philadelphia is comfortable. Winter is not comfortable at all. Summer is mostly comfortable except the hottest months.

CLIMATE ANALYSIS OF PHILADELPHIA

SUN PATH - LATITUDE OF PHILADELPHIA IS 40 DEGREE NORTH



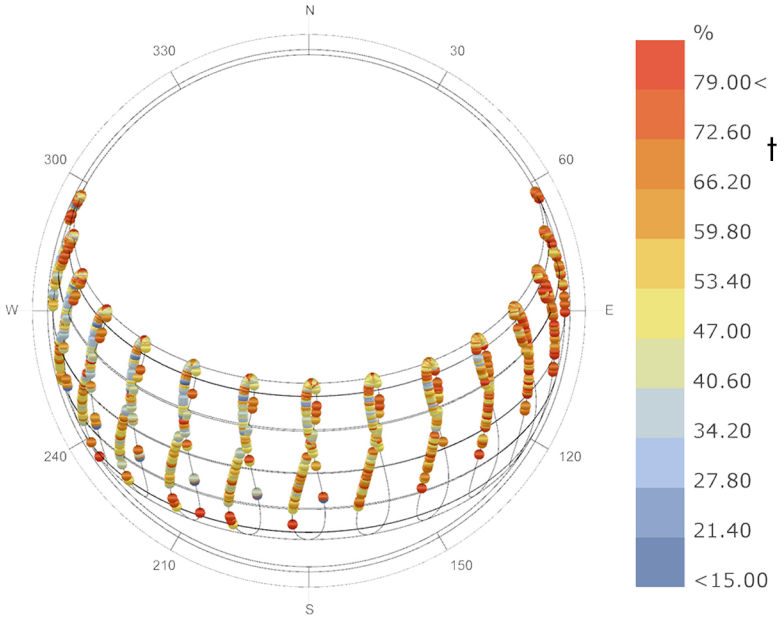
Outdoor temperature > 26 degree

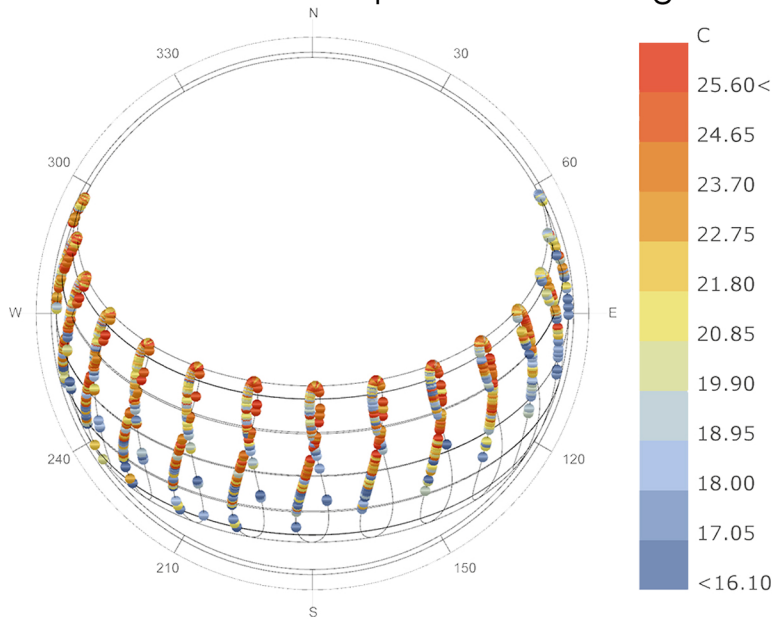


18<Outdoor temperature < 26 degree

11:00 AM TILL 6:00 PM we have high temperature from May to September. During this time we need to avoid sunlight from entering the building i.e. west and south west windows should be avoided.

Windows can be provided in east or south direction along with shading devices.





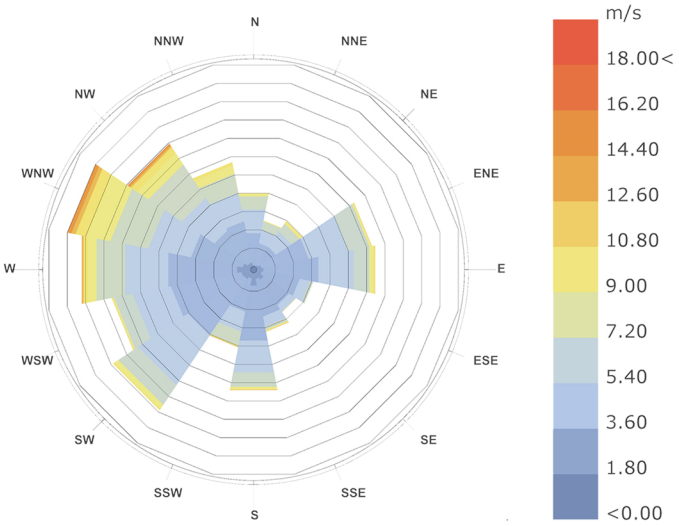
To maintain the comfortable range of Rh we should look into the wind wind speed as well.

Relative Humidity <50 % and 18<Outdoor temperature < 26 degree

CLIMATE ANALYSIS OF PHILADELPHIA

WIND ROSE DIAGRAM FOR PHILADELPHIA

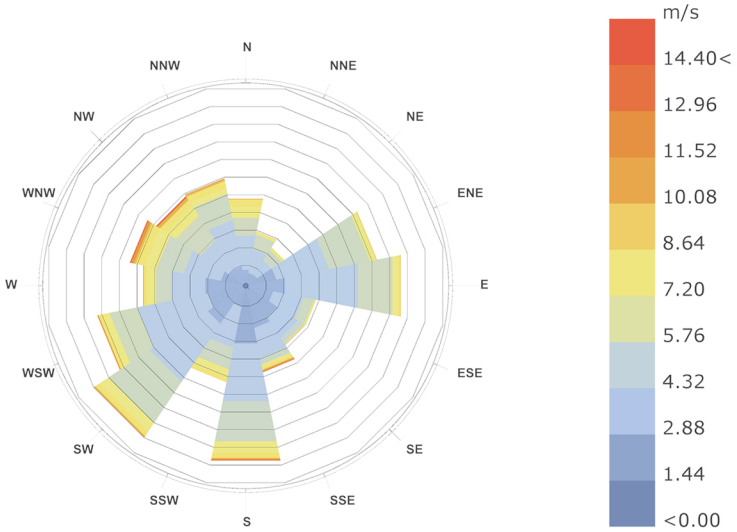
Wind direction of Philadelphia



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.

Average wind direction for Philadelphia is WNW and West

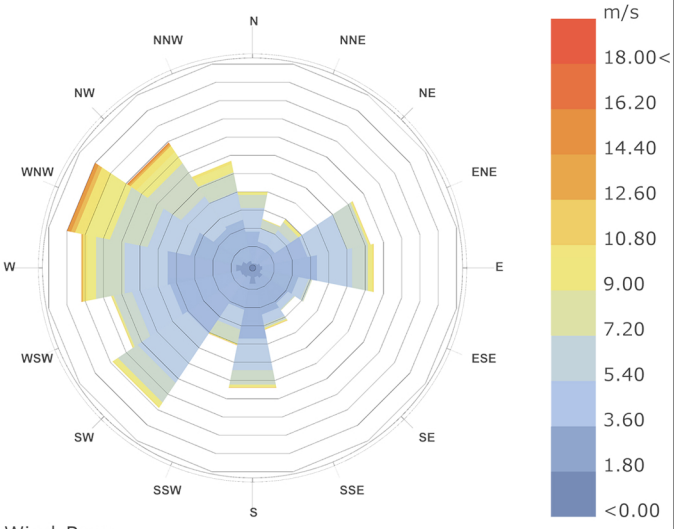
18<Outdoor temperature < 26 degree



Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.72% of the time = 63 hours.
Each closed polyline shows frequency of 0.3%. = 27 hours.
... ...
Conditional Selection Applied:
Wind Speed<80
and 16<Dry Bulb Temperature<26
2702.0 hours of total 8760.0 hours (30.84%).

Wind direction when the outdoor temperature is between 18 to 26 degree is SW or south. South is a better direction for placing windows as it fulfils the criteria of sun position also.

Outdoor temperature > 26 degree

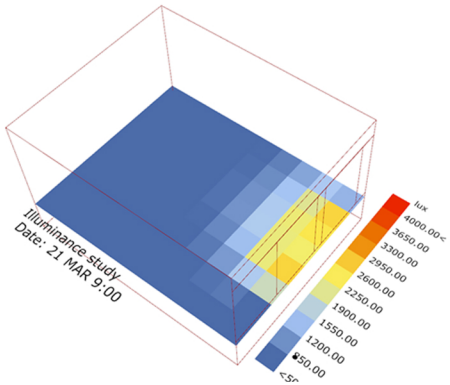
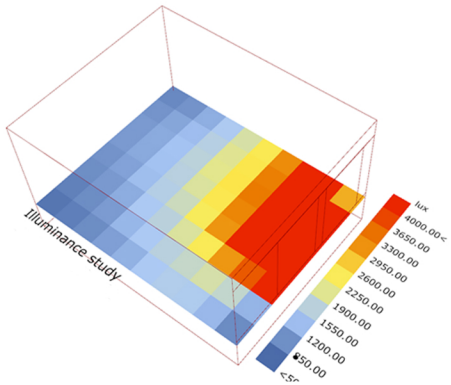
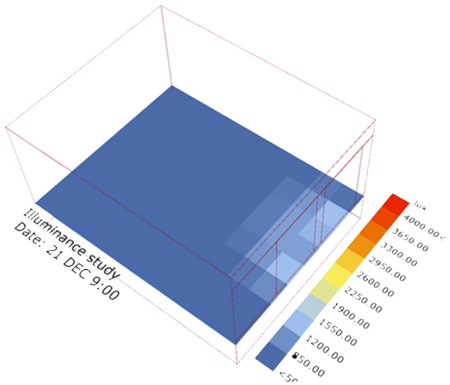
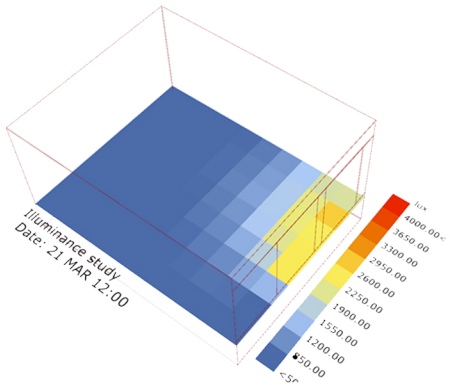
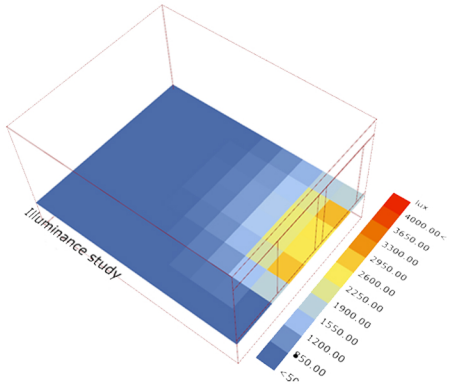
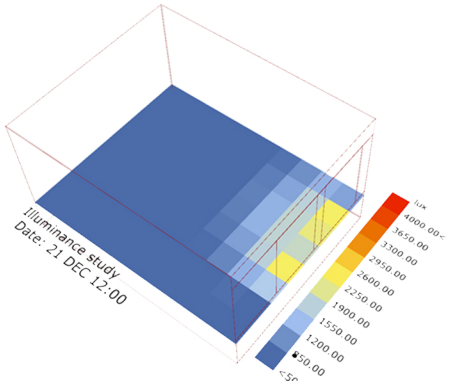
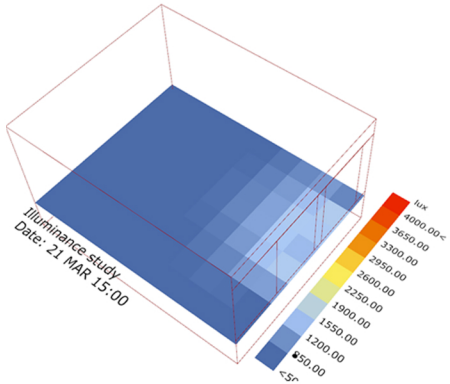
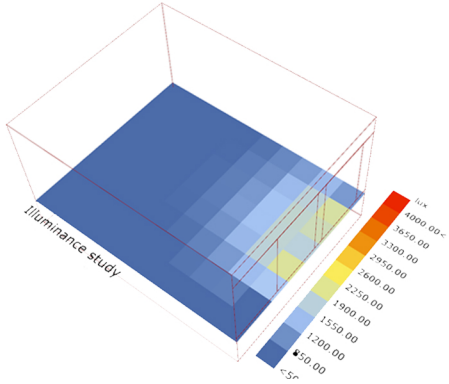
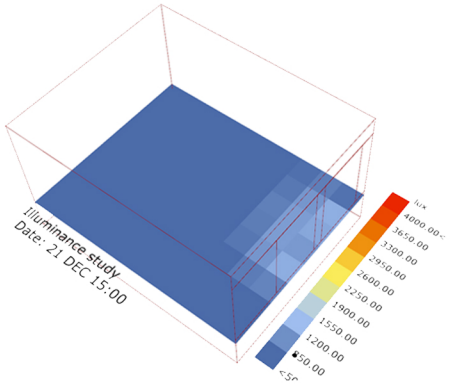


Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 2.81% of the time = 246 hours.
Each closed polyline shows frequency of 1.0%. = 90 hours.
... ...
Conditional Selection Applied:
Wind Speed<26
8503.0 hours of total 8760.0 hours (97.07%).

Wind direction when the outdoor temperature is greater than 26 degree is SW, WNW, and West. We should avoid placing windows in this direction because it will make warm air pass through the room.

DAYLIGHT SIMULATION OF THE ROOM

POINT IN TIME ANALYSIS FOR 9 TIMES FOR THE YEAR

	MARCH 21ST	SEPTEMBER 21ST	DECEMBER 21ST
9:00 AM			
12:00 PM			
15:00 PM			

Both the windows of the room are facing east side. we generally have a problem around 9:00 AM when direct sun is entering the room.

We need to design a shading device, which can reduce the excess light during morning time.

Although morning light is good for our health, during summer months its going to cause problem.

DAYLIGHT SIMULATION OF THE ROOM

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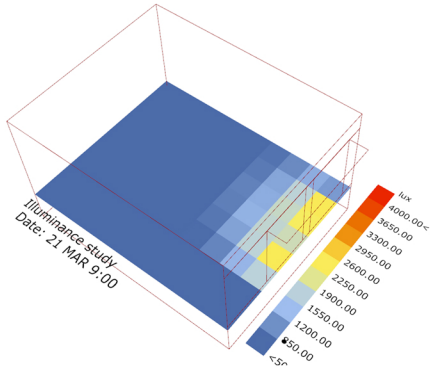
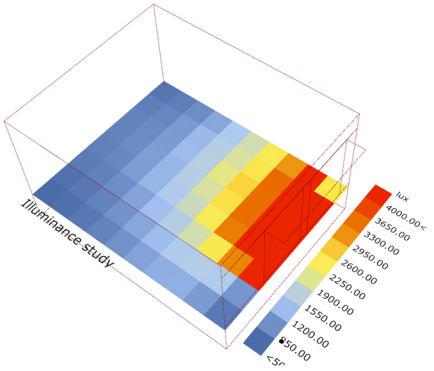
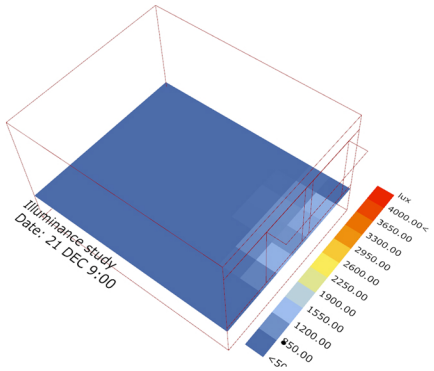
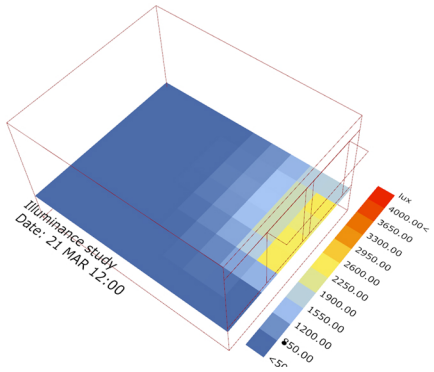
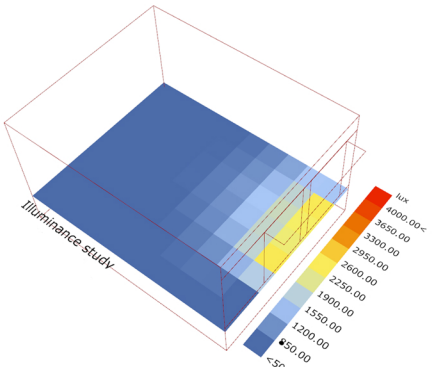
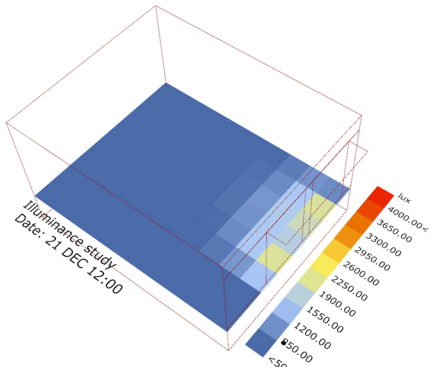
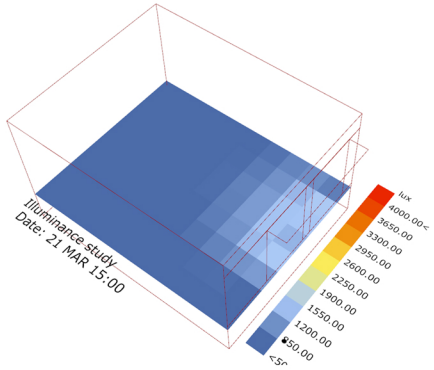
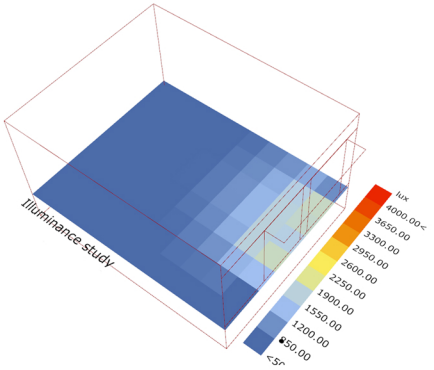
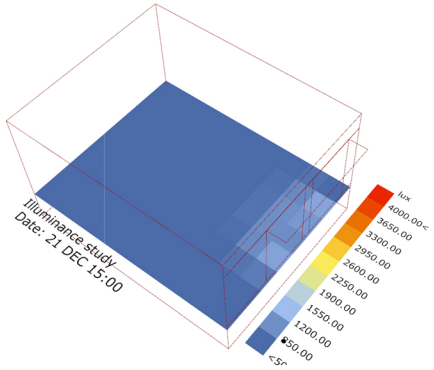
9:00 AM			
12:00 PM			
15:00 PM			

SHADING DESIGN II

We are able to reduce the amount of daylighting in the morning.

But still, it is more than required. We need more horizontal shading to control the daylight

DAYLIGHT SIMULATION OF THE ROOM

POINT IN TIME ANALYSIS FOR 9 TIMES FOR THE YEAR

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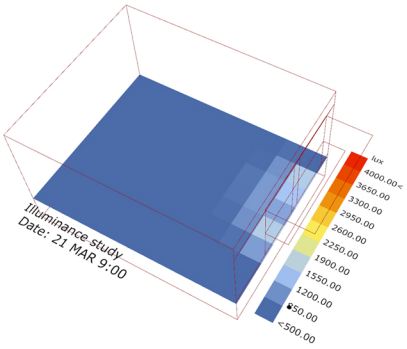
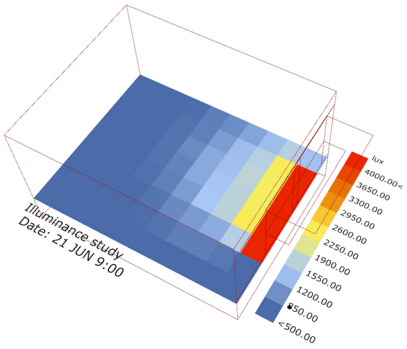
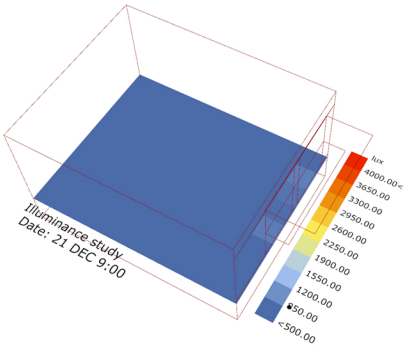
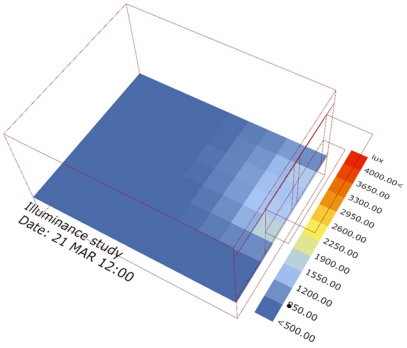
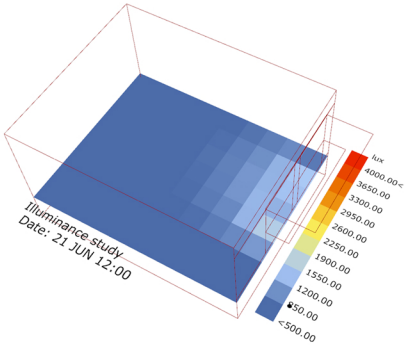
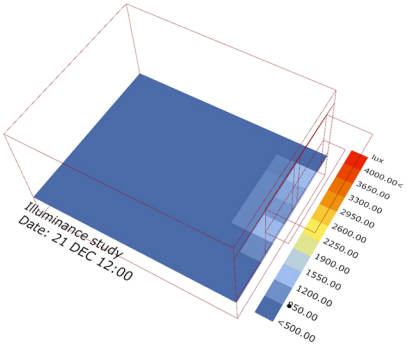
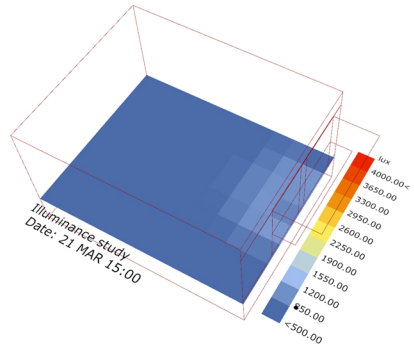
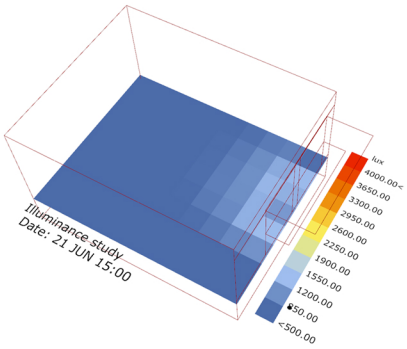
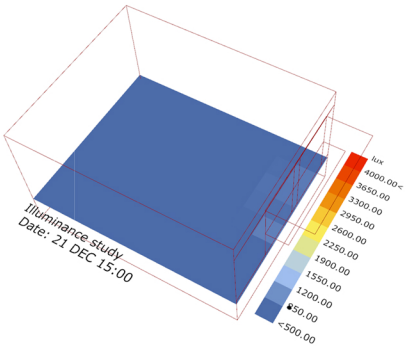
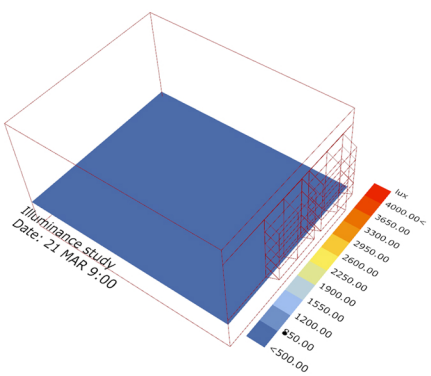
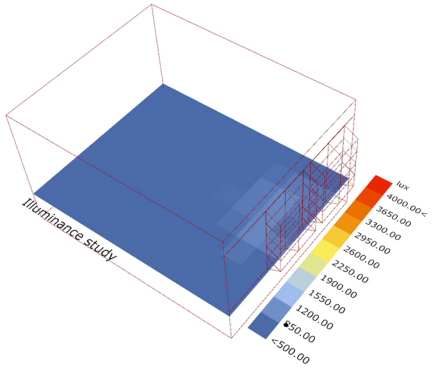
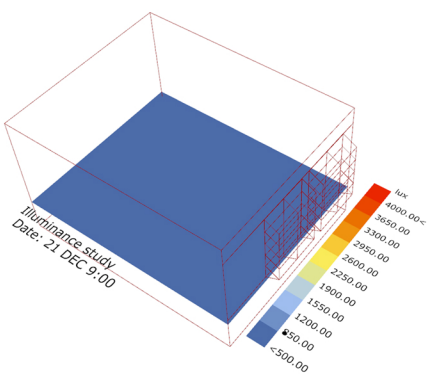
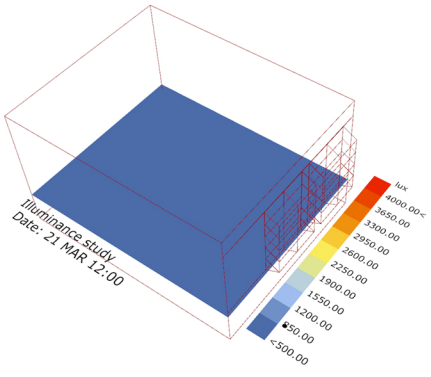
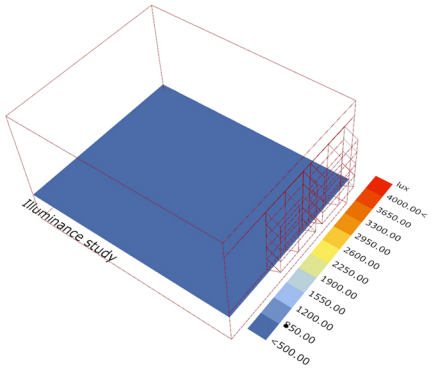
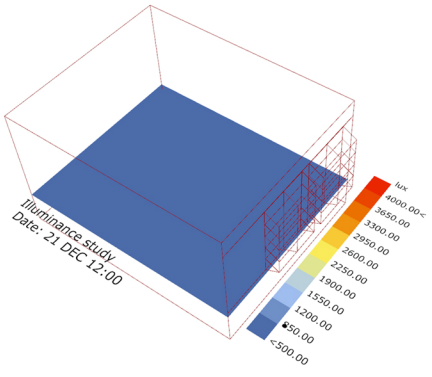
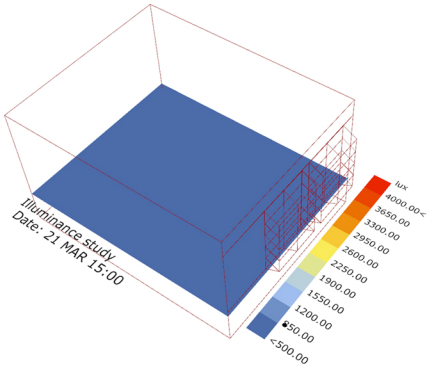
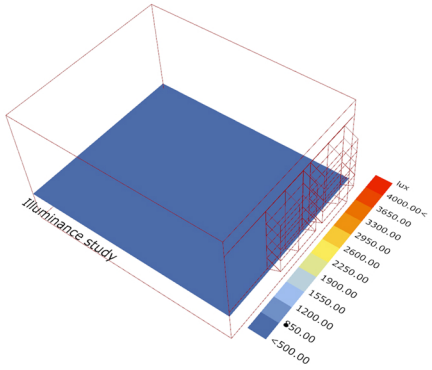
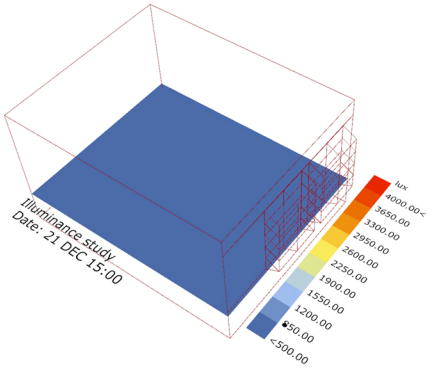
9:00 AM			
12:00 PM			
15:00 PM			

SHADING DESIGN III

We are able to reduce the amount of daylighting in the morning. But we have a particular strip in the morning near the window which requires to be shaded.

DAYLIGHT SIMULATION OF THE ROOM

POINT IN TIME ANALYSIS FOR 9 TIMES FOR THE YEAR

	MARCH 21ST	SEPTEMBER 21ST	DECEMBER 21ST
9:00 AM			
12:00 PM			
15:00 PM			

SHADING DESIGN IV

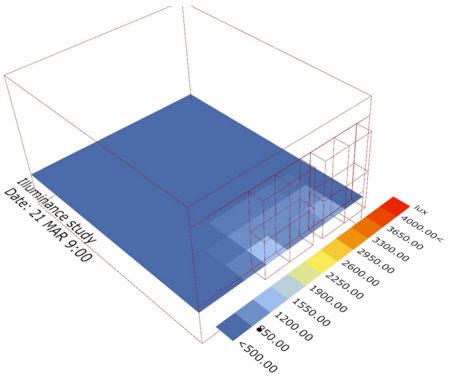
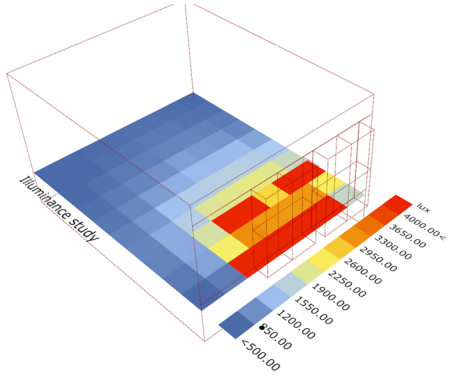
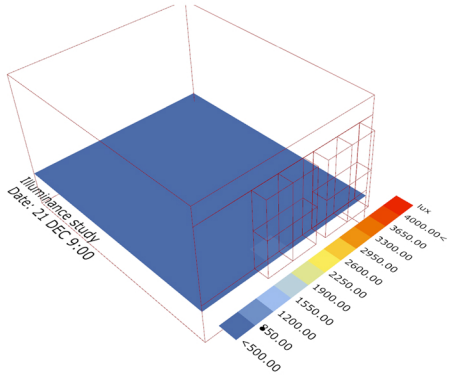
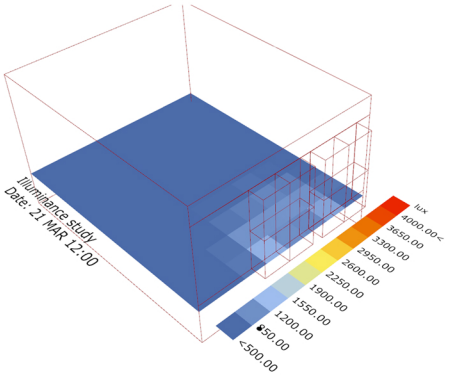
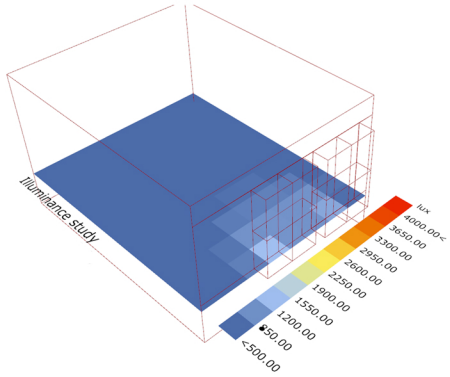
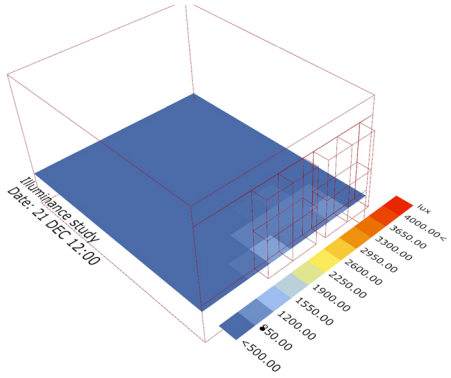
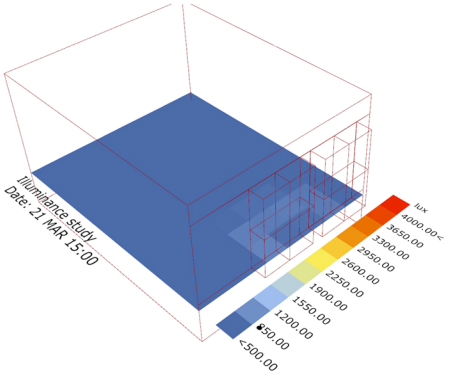
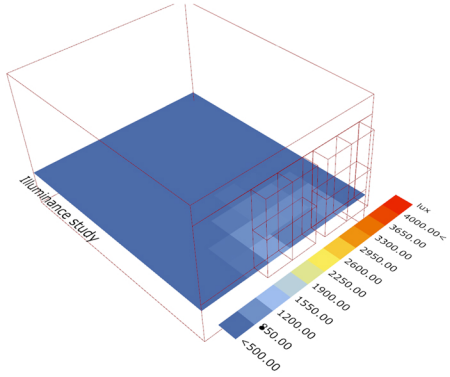
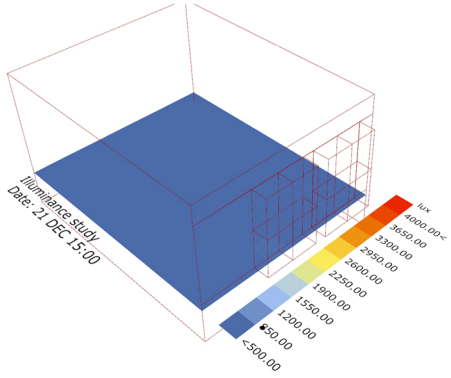
Introduction of angle in the shading has helped in reduction of the light.

With this we are able to reduce the daylight during summers, but it might be too dark for the other portion of the room.

We to open the shading device a little bit.

DAYLIGHT SIMULATION OF THE ROOM

POINT IN TIME ANALYSIS FOR 9 TIMES FOR THE YEAR

	MARCH 21ST	SEPTEMBER 21ST	DECEMBER 21ST
9:00 AM			
12:00 PM			
15:00 PM			

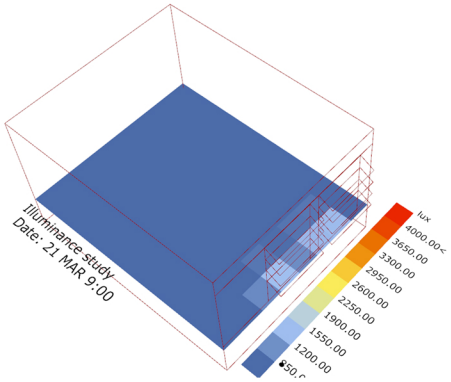
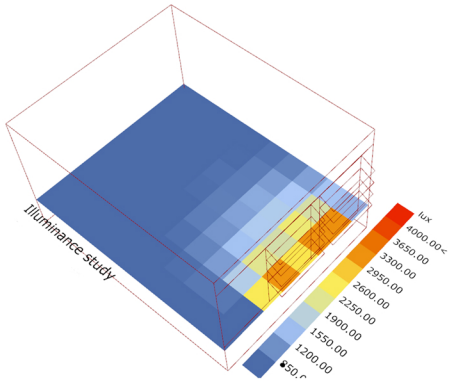
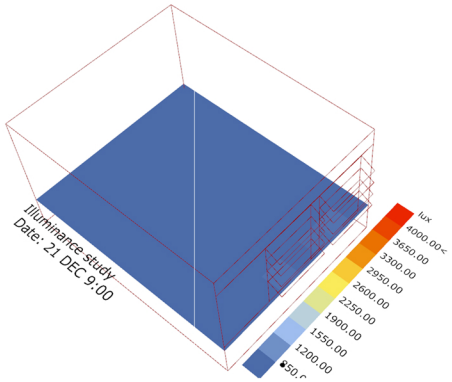
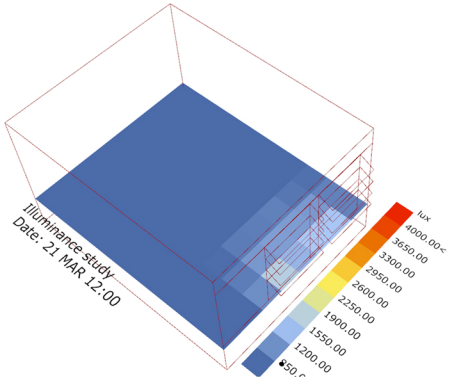
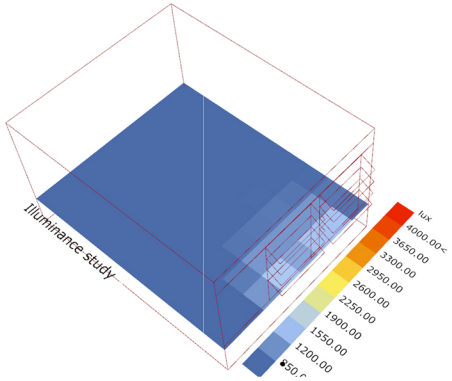
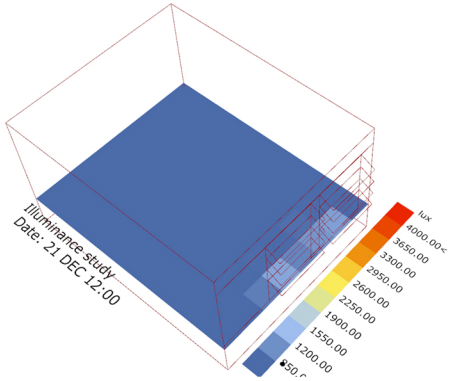
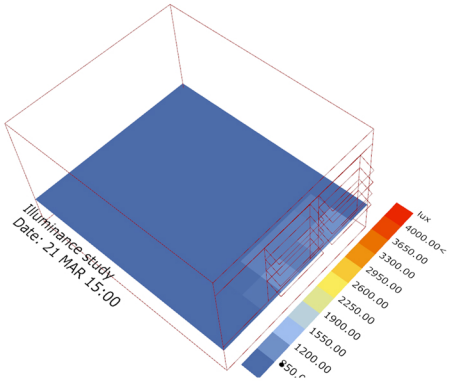
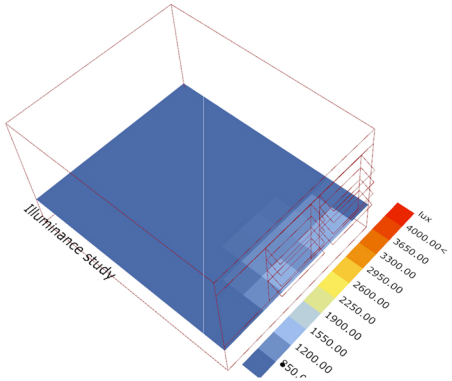
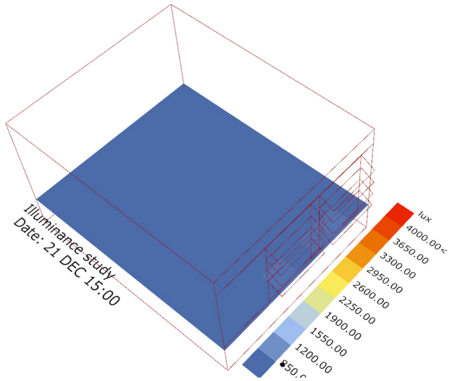
SHADING DESIGN V

With spreading out the Louvers, we have more than enough daylight in the room.

We need to go back to the previews design and make little changes into that to get more useful daylight.

DAYLIGHT SIMULATION OF THE ROOM

POINT IN TIME ANALYSIS FOR 9 TIMES FOR THE YEAR

	MARCH 21ST	SEPTEMBER 21ST	DECEMBER 21ST
9:00 AM			
12:00 PM			
15:00 PM			

SHADING DESIGN VI

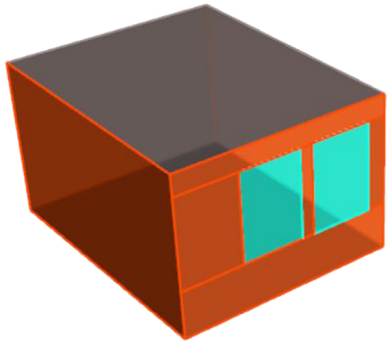
By removing the vertical shading we able to get better daylight inside the room.

The shading is working best for this scenario , we can use deflector to redirect diffused light till the end of the room .

DAYLIGHT AUTONOMY

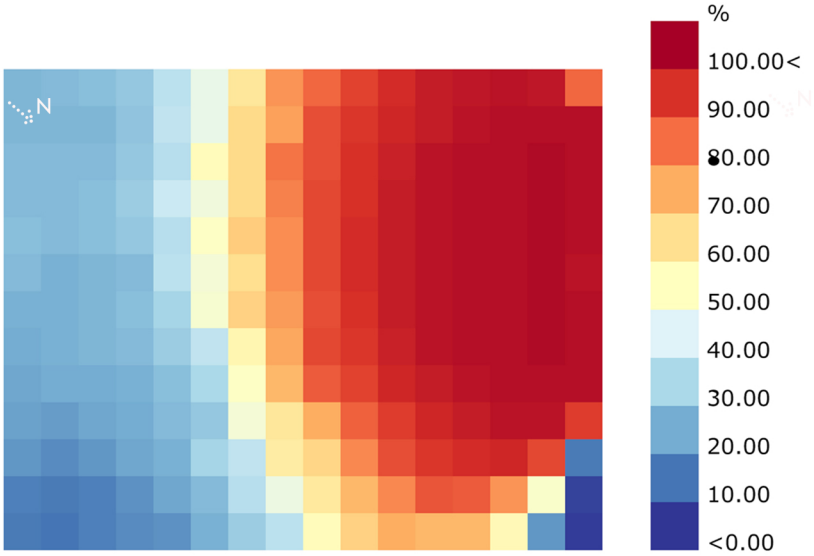
POINT BASED ANNUAL DAYLIGHT ANALYSIS THE RE-EVALUATION

BASELINE SCENARIO



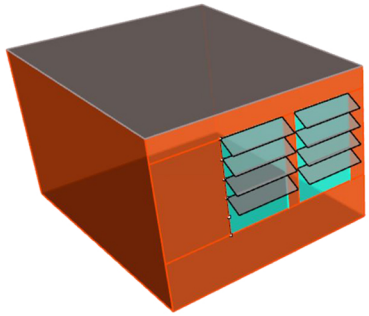
The half of the room is getting useful daylight through out the year.

The area near the windows is getting more daylight, and it is causing visual discomfort.



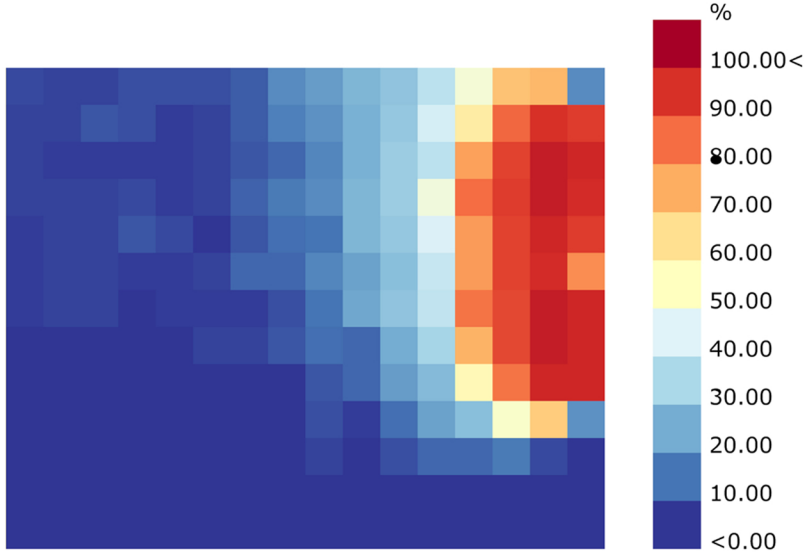
Daylight Autonomy

PROPOSED DESIGN



When we add horizontal shading devices, the percentage of the room getting UDI decreases.

We need to redesign the room so that we can increase the UDI without causing visual discomfort.

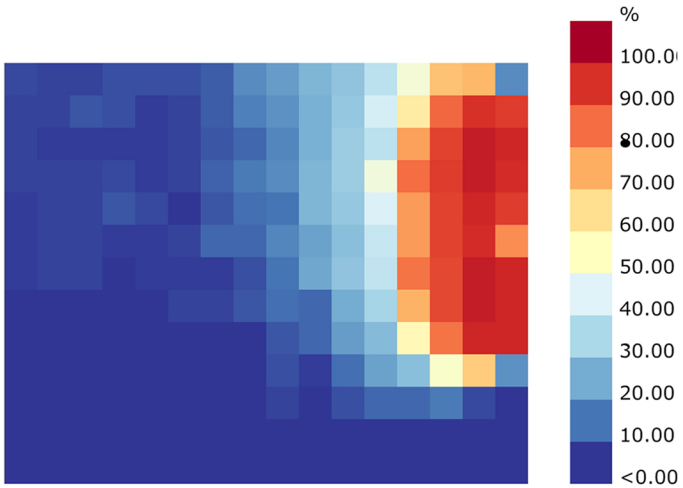


Daylight Autonomy

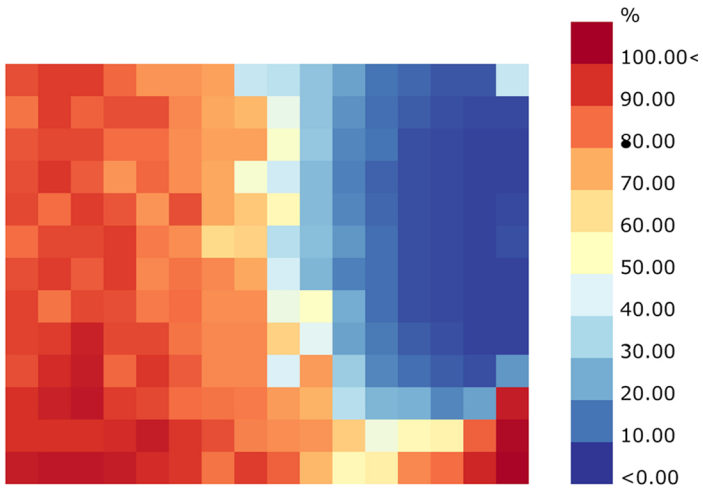
DAYLIGHT AUTONOMY

POINT BASED ANNUAL DAYLIGHT ANALYSIS THE RE-EVALUATION

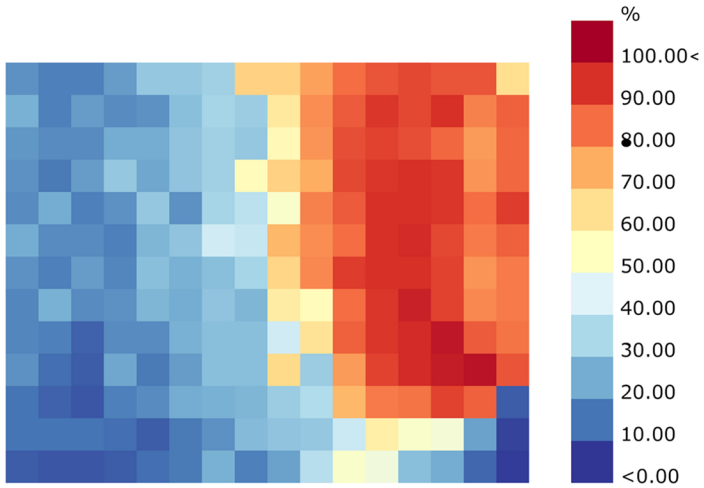
DAYLIGHT AUTONOMY



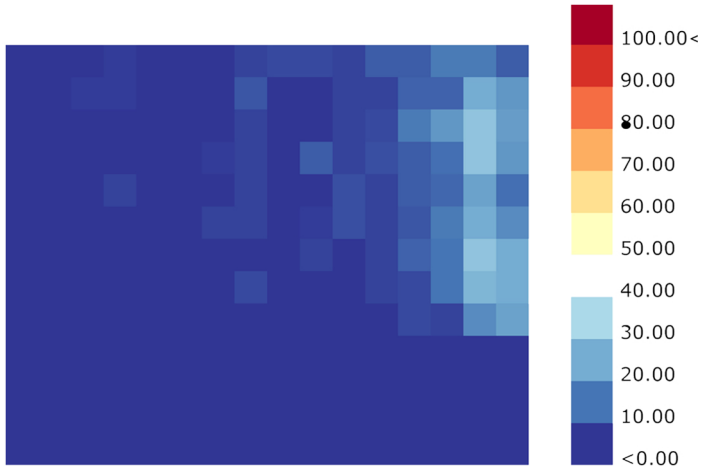
USEFUL DAYLIGHT ILLUMINANCE >100 LUX



USEFUL DAYLIGHT ILLUMINANCE 100 - 2000 LUX



USEFUL DAYLIGHT ILLUMINANCE>2000 LUX



PROPOSED DESIGN

The design proposed, provides useful daylight only in half of the room .

The area which is away from the windows (the other half of the room) have daylighting less than 100 lux for approximately 80% of the times.

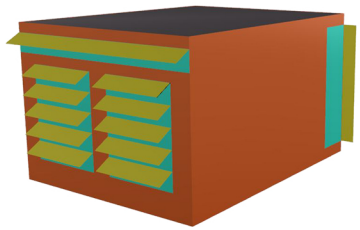
The design proposed did not perform well . So we need to increase the useful daylight in the back of the room.

In order to do so, the geometry of the windows has to be changed and also add new windows.

DAYLIGHT AUTONOMY

POINT BASED ANNUAL DAYLIGHT ANALYSIS THE RE-EVALUATION

NEW PROPOSED DESIGN

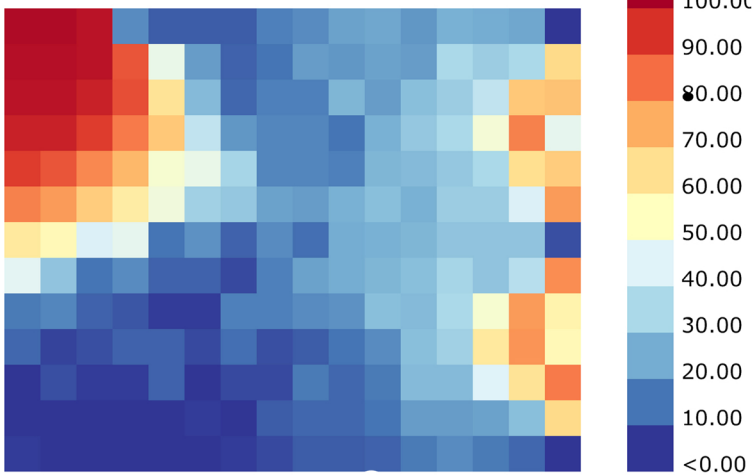


A window in the top has been made so that the light can penetrate till the end of the room, and for the same reason, a window in the north has been provided which will not cause glare and will increase the lighting in the room.

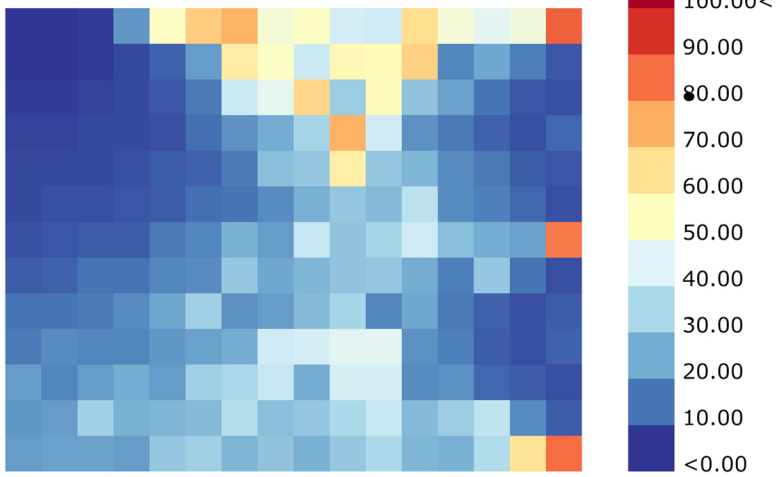
This scenario is performing better than the previous one, as more than 50 % of the room is getting useful daylight for more than 50 % of the times.

30% of the room is still getting daylight less than 100 Lux, so we still have scope to increase the UDI. Only the corner of the north window has daylight more than 2000 lux.

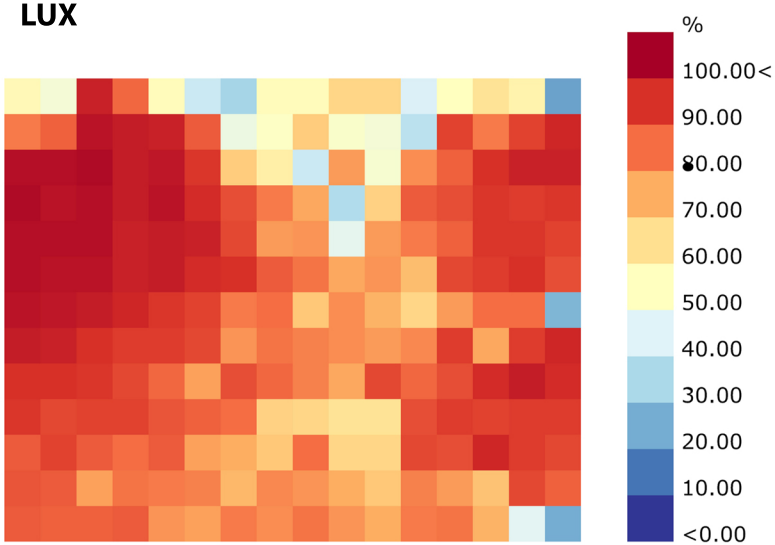
DAYLIGHT AUTONOMY



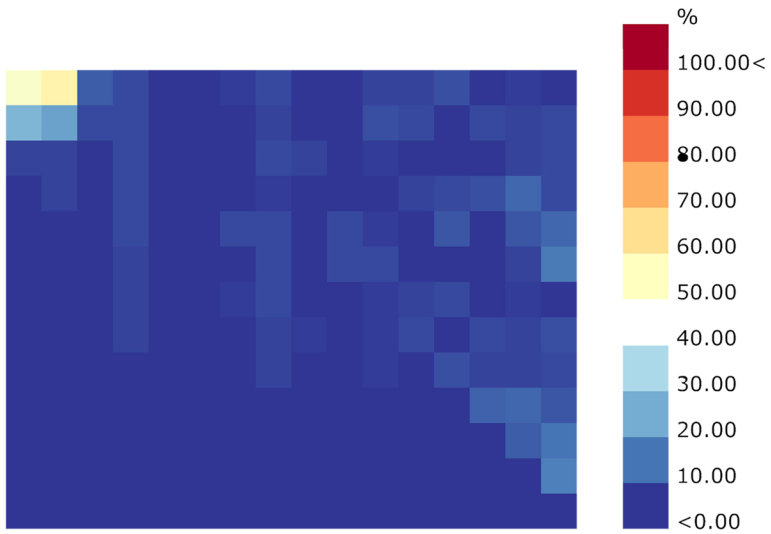
USEFUL DAYLIGHT ILLUMINANCE >100 LUX



USEFUL DAYLIGHT ILLUMINANCE 100 - 2000 LUX



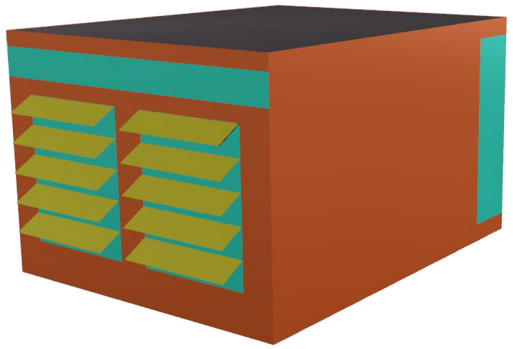
USEFUL DAYLIGHT ILLUMINANCE>2000 LUX



DAYLIGHT AUTONOMY

POINT BASED ANNUAL DAYLIGHT ANALYSIS THE RE-EVALUATION

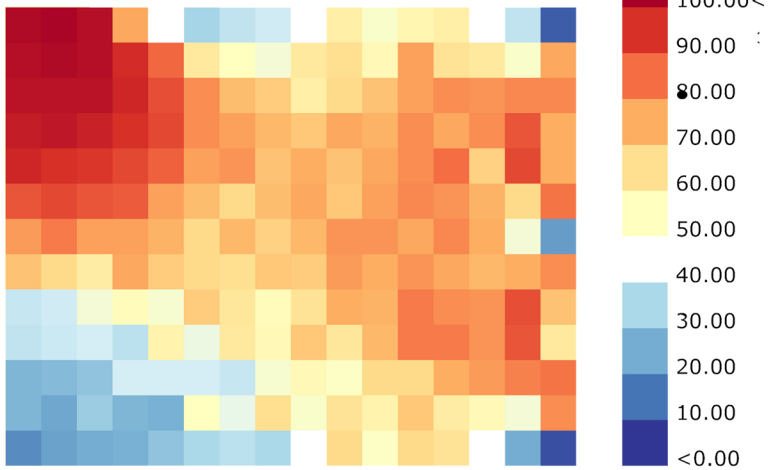
NEW PROPOSED DESIGN - II



To increase the UDI of the room, a shade of upper slit and north window has been removed. More light enters the room. This scenario is performing the best, as more than 85 % of the room is getting useful daylighting for more than 80% of the times. The area which has light less than 100 lux is negligible. The area near north side of the window has more than 2000 lux of daylight.

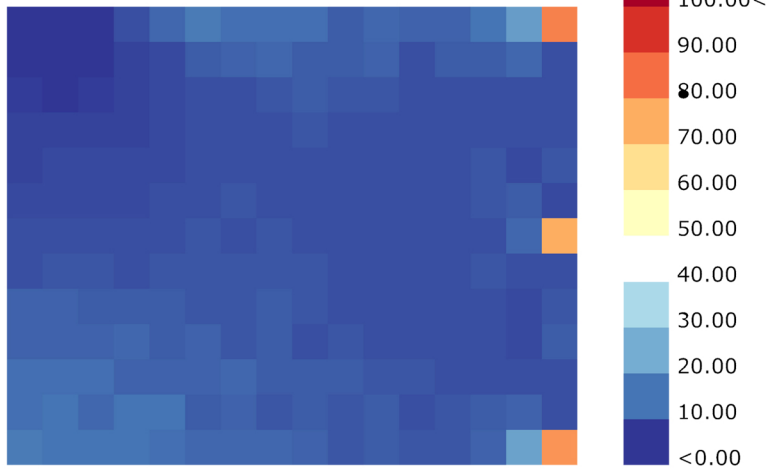
Further, materials and ambient bounce have been changed, to increase the UDI in the room.

DAYLIGHT AUTONOMY



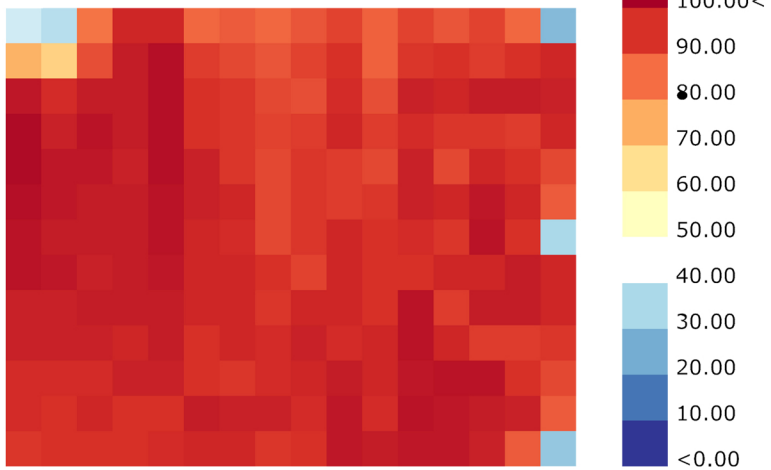
Daylight Autonomy

USEFUL DAYLIGHT ILLUMINANCE >100 LUX



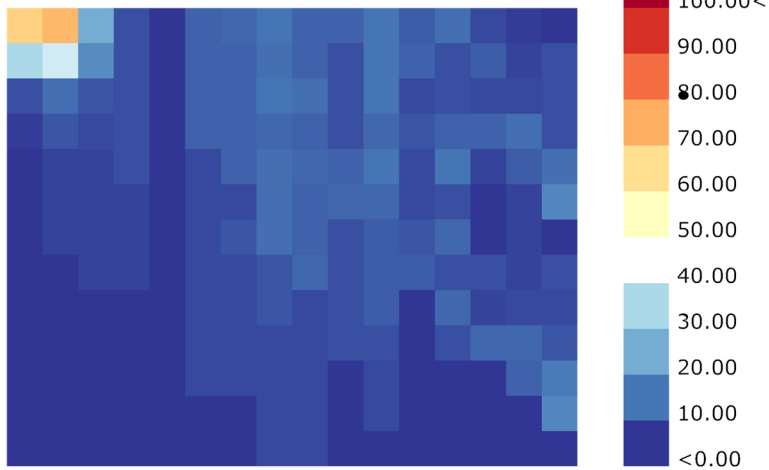
Daylight Autonomy

USEFUL DAYLIGHT ILLUMINANCE 100 - 2000 LUX



Daylight Autonomy

USEFUL DAYLIGHT ILLUMINANCE>2000 LUX

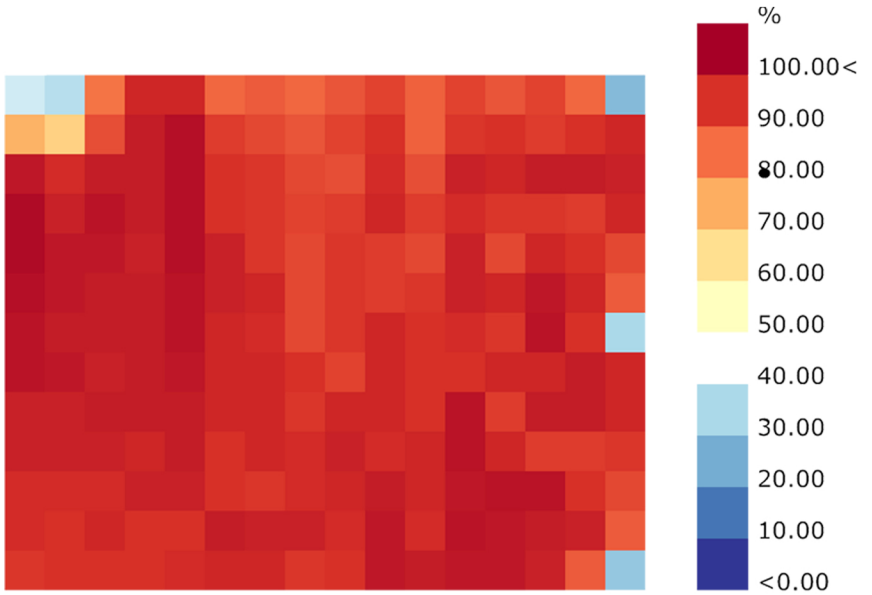


Daylight Autonomy

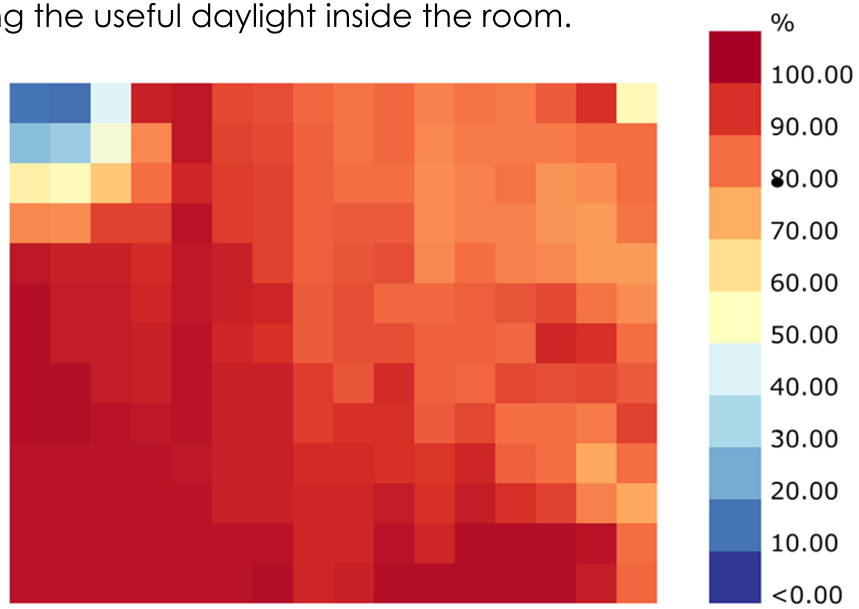
DAYLIGHT AUTONOMY

POINT BASED ANNUAL DAYLIGHT ANALYSIS THE RE-EVALUATION

The analysis is done for proposed design - II.
More reflective materials have been used, to spread the light.
Comparison of the three scenarios:
Change in geometry has a better impact on UDI, as compared to materials and radiance parameters.
The reflective materials are increasing the daylight, which is reducing the amount of useful daylight in the room.
So we would not prefer high reflectance material with the large opening of the windows.
Also, if we increase the ambient bounces with highly reflective materials the UDI tend to reduce further, increasing the glare and more than necessary daylight in the room (>2000 lux).Maximum UDI can be achieved in the base scenario only.
As glare is creating problem in the north side of the room. we should remove the window. The horizontal strip above the other window is suffiecient in providing the useful daylight inside the room.

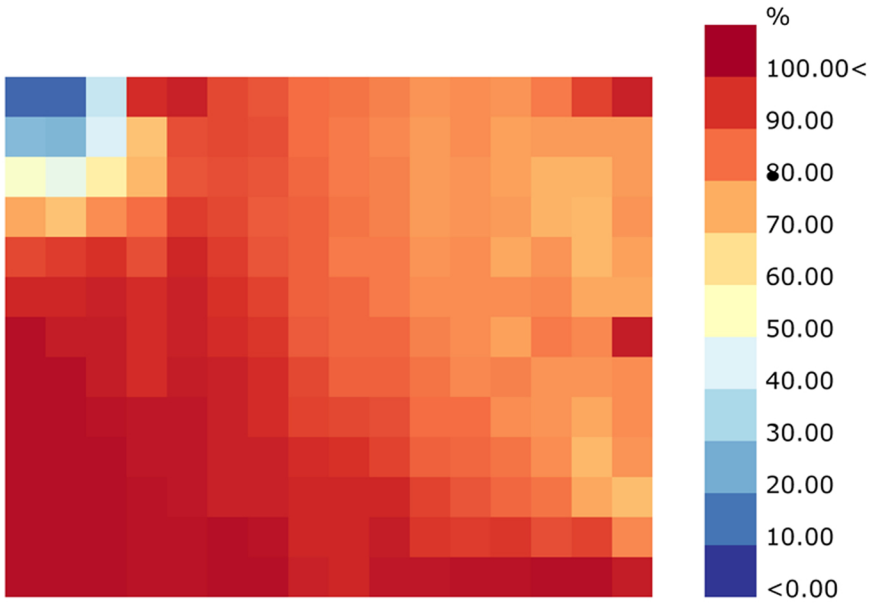


USEFULL DAYLIGHT ILLUMINANCE 100 - 2000 LUX - WITH BASE MATERIALS AND DEFAULT PARAMTERS



USEFULL DAYLIGHT ILLUMINANCE 100 - 2000 LUX - WITH VARIATION IN TYPE OF MATERIAL

SINGLE PANE GLASS - .96 , HIGH REFLECTANCE CEILING- .90
WHITE INTERIOR WALLS - .70



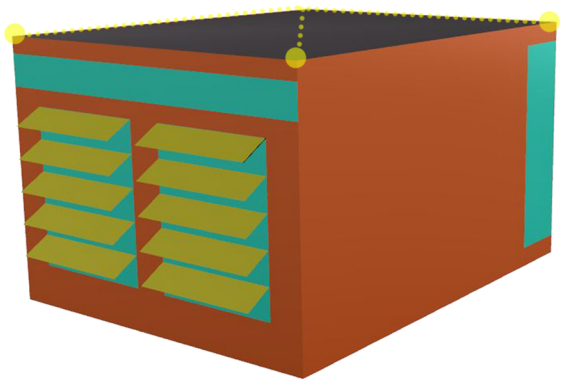
USEFULL DAYLIGHT ILLUMINANCE 100 - 2000 LUX - WITH VARIATION IN ABIENT BOUNCES

AMBIENT BOUNCES - 3

NAMAN GUPTA | MEBD

GLARE ANALYSIS

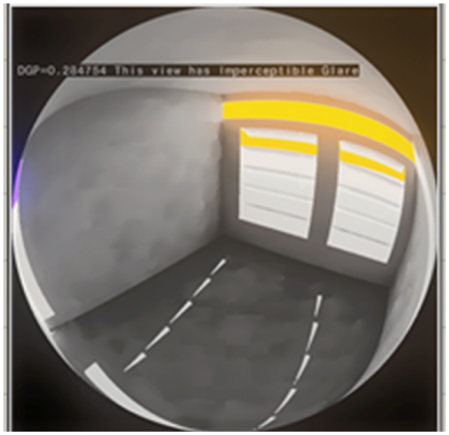
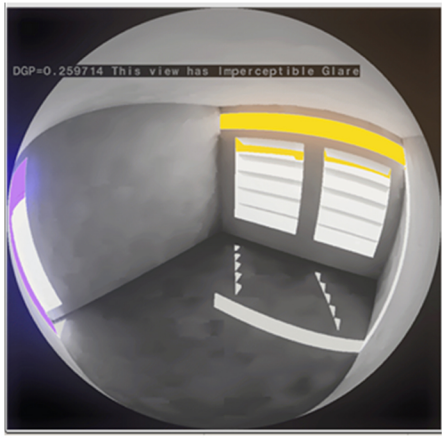
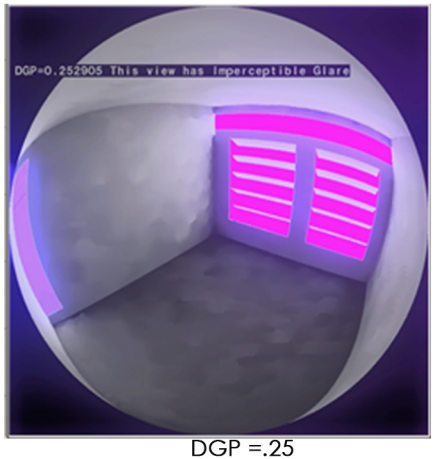
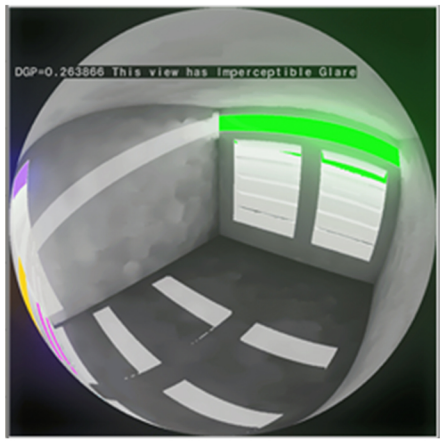
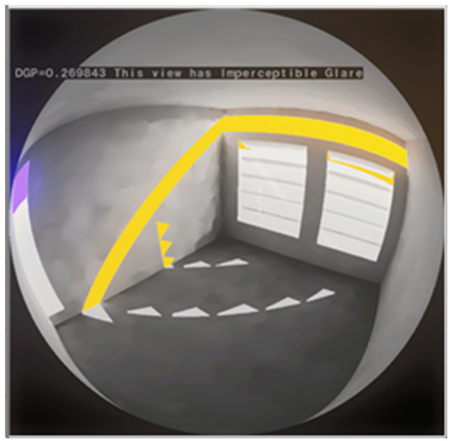
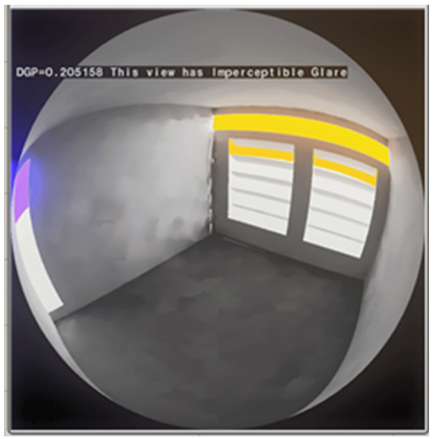
Direction of the analysis



For 9-point image-based glare analysis, Daylight Glare Probability is less than .35 (imperceptible glare). There would be no visual discomfort to the occupant with the proposed shading.

Areas where, we are able to get direct sunlight, for few hours, the occupant can move his location or with the help of blinds, direct sunlight can be reduced depending on the occupant's will.

Maximum amount of direct sunlight is coming inside the during winter and morning 9:00 am, when the sun is not harsh and can be desired by some.

	9:00 AM	12:00 PM	15:00 PM
MARCH 21ST	 DGP =.28	 DGP =.25	 DGP =.24
JUNE 21ST	 DGP =.25	 DGP =.26	 DGP =.25
DECEMBER 21ST	 DGP =.26	 DGP =.26	 DGP =.20

ENERGY MODELLING

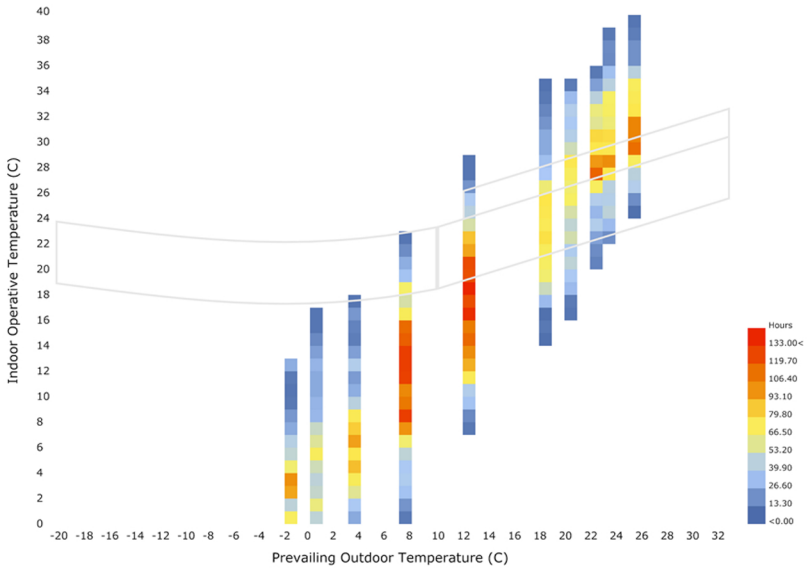
EXISTING LAYOUT

Existing Design with shading, with updated materials (ASHRAE 90.1-2010 EXT-WALL MASS CLIMATE ZONE 4)

Percentage of time when it is comfortable : 17 %
Percentage of time when it is hot : 34 %
Percentage of time when it is cold : 49 %

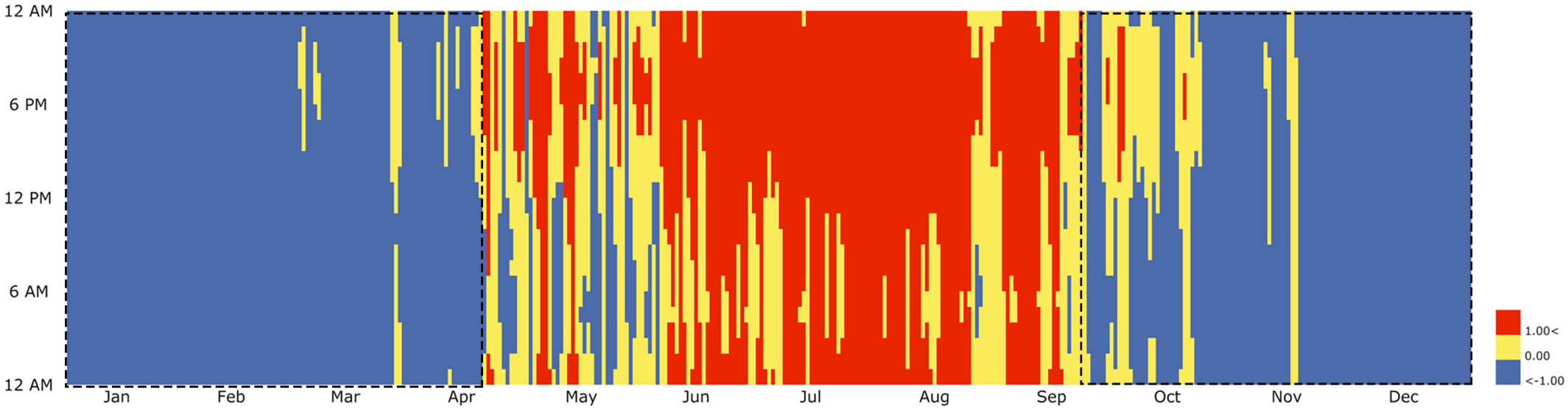
It has higher percentage of cold stress. So we can increase the window size and remove the shading so more solar gain can happen during winter
We can also increase the R value of the walls and ceiling , which will provide a better insulation to the room, making it comfortable.

ADAPTIVE COMFORT CHART



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA



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

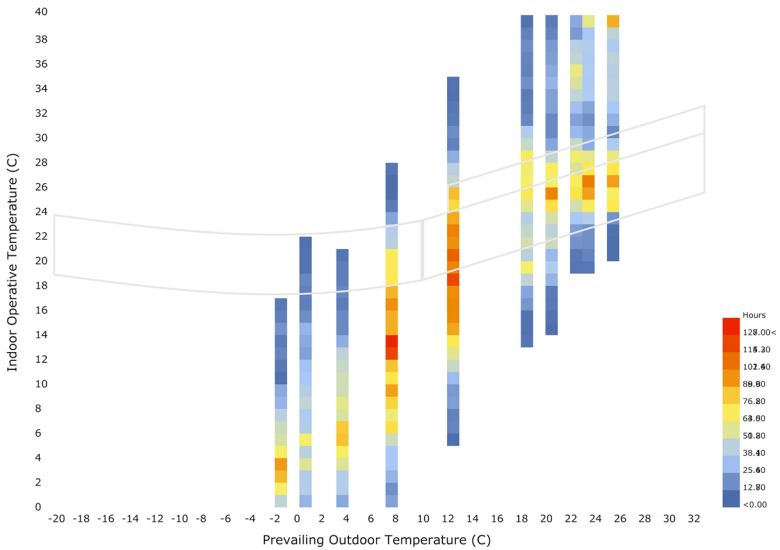
ENERGY MODELLING

NEW PROPOSED DESIGN

Percentage of time when it is comfortable : 14 %
Percentage of time when it is hot : 40 %
Percentage of time when it is cold : 46 %

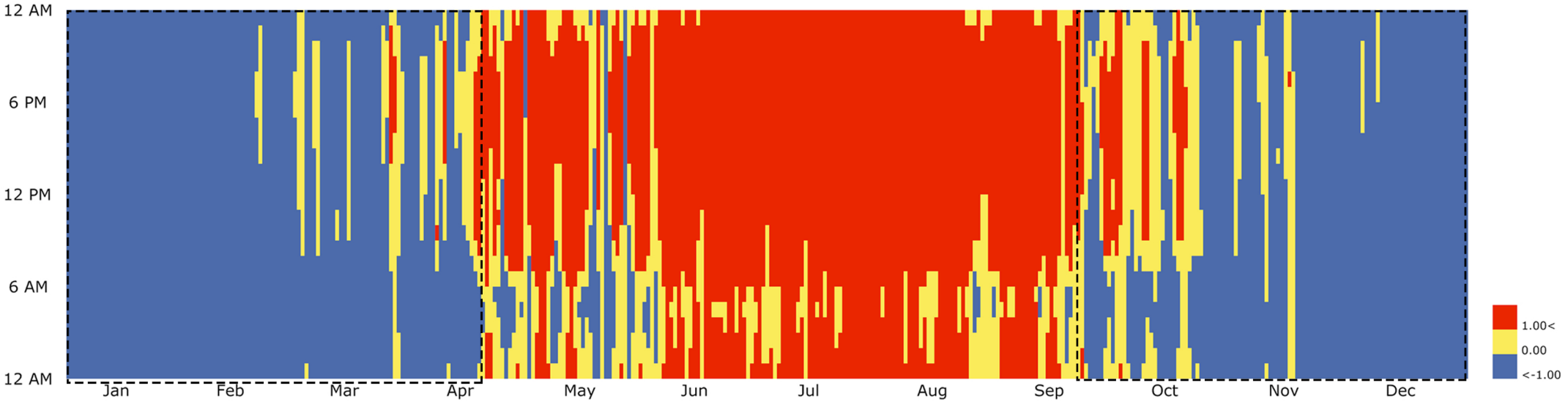
The design proposed earlier doesn't perform equally well in terms of energy which was performing really well in terms of daylighting.
We still have a higher percent of cold stress.
Orientation of the windows should be changed and tested. The best suited direction would be south, as it will provide natural ventilation as well.
The next step should be to increase the R value of the material .
The data presented in the adaptive comfort chart tells us how much temperature we need to increase or decrease in order to achieve the comfort range.

ADAPTIVE COMFORT CHART



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

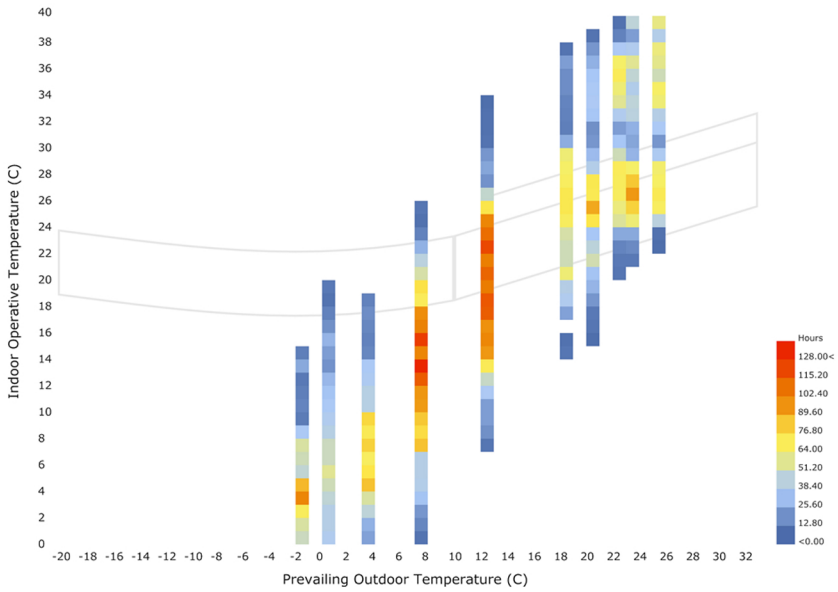
COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA



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

ENERGY MODELING

ADAPTIVE COMFORT CHART



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

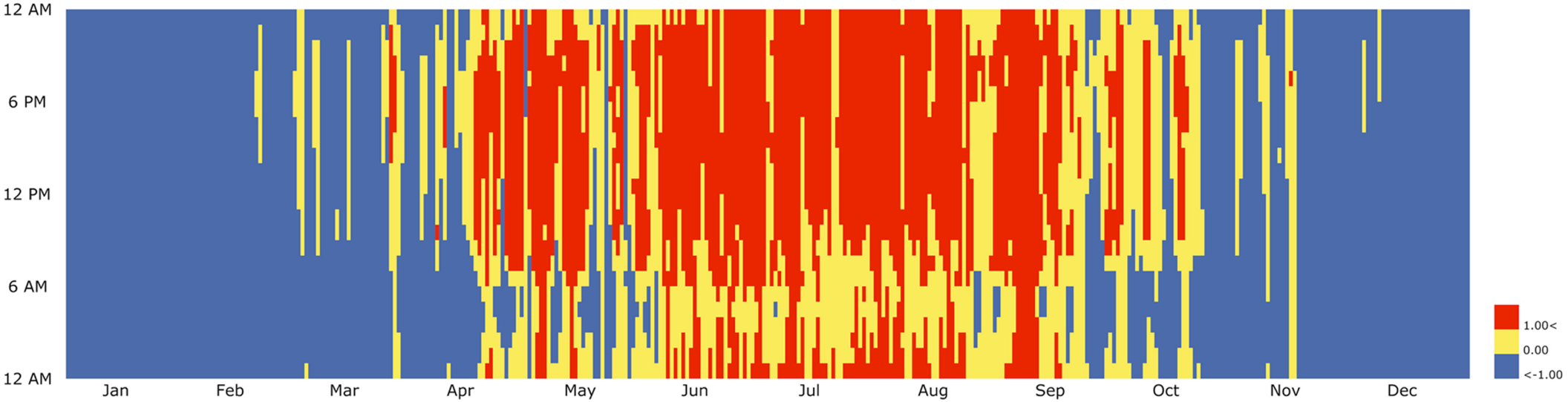
NEW PROPOSED DESIGN

Proposed Design with shading, with updated materials (ASHRAE 90.1-2010 EXT-WALL MASS CLIMATE ZONE 4)

Percentage of time when it is comfortable : 23.7 %
Percentage of time when it is hot : 27.1%
Percentage of time when it is cold : 50 %

By changing the orientation(windows are facing south) , there is an increase in the percentage of comfort and reduce the number of warm hours, but we are not able to reduce the cold stress. We need to increase the massing of the walls to reduce the cold stress add natural ventilation to reduce hot stress

COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA



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

ENERGY MODELING

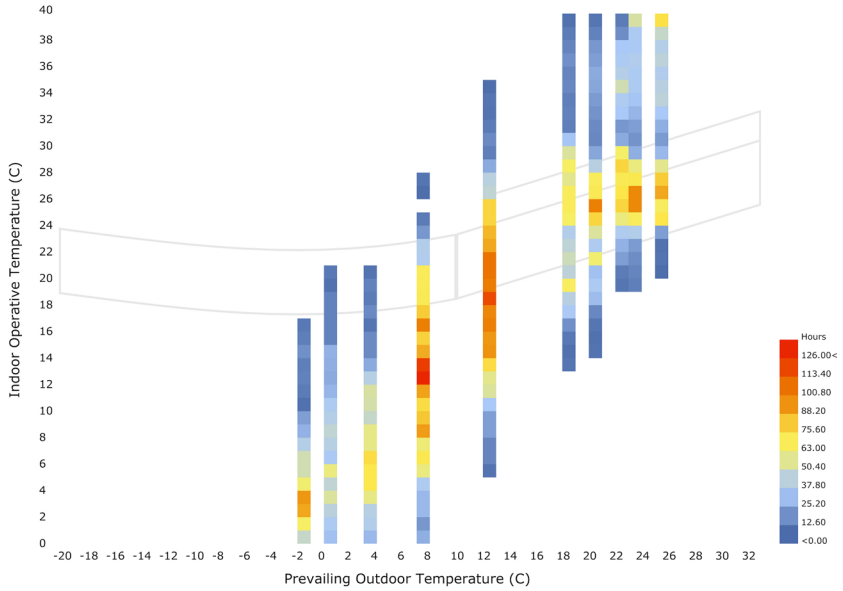
ADAPTIVE COMFORT CHART

NEW PROPOSED DESIGN

Proposed Design with shading facing south, with updated materials (ASHRAE 90.1-2010 EXT-WALL MASS CLIMATE ZONE 4)

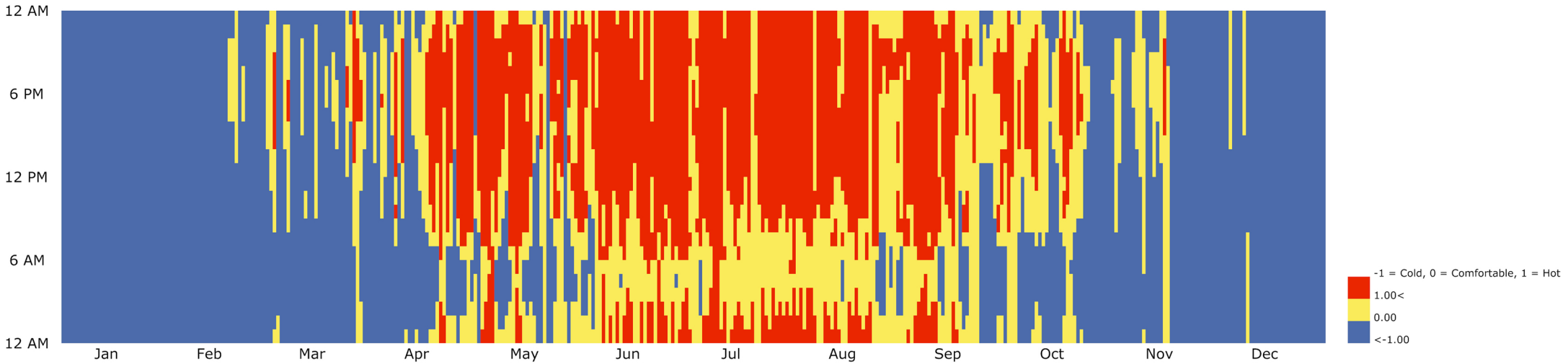
Percentage of time when it is comfortable : 25 %
Percentage of time when it is hot : 24%
Percentage of time when it is cold : 51 %

By adding infiltration in the building, there is a little increase in the percentage of comfort and reduction in the number of warm hours, but we are not able to reduce the cold stress.



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

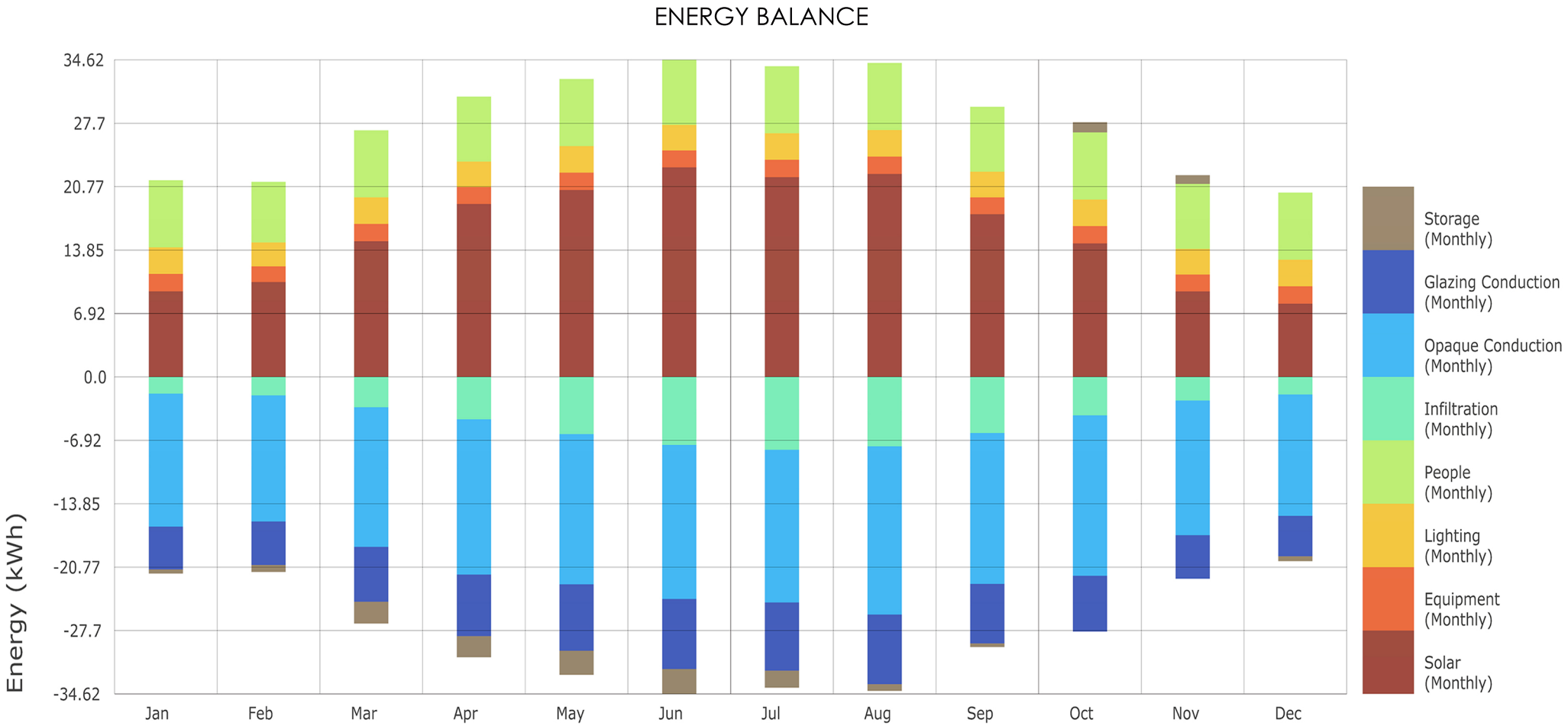
COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA



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

ENERGY MODELING

The data represented in energy balance graph shows that the maximum amount of heat which is being added up in the room is because of the sun and the heat which we are losing is because of glazing material and Major because of opaque conduction which is the walls.
By changing materials of opaque conduction and by changing the properties of glass we would able to achieve higher comfort levels and less variation from the comfort range.



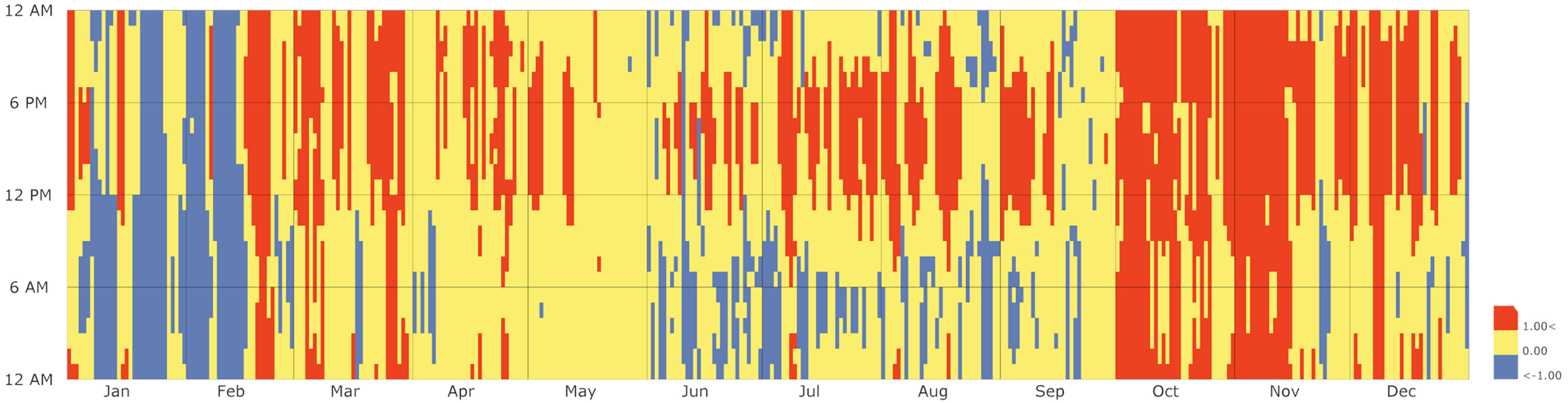
ENERGY MODELING
INCREASING THE COMFORT IN THE ROOM

By changing the material of the walls , ceiling and roof with higher R-value there is huge impact on the cold stress. It reduces drastically.
Materials used are
(Wall-ASHRAE 90.1-2010 EXTWALL STEELFRAME CLIMATEZONE ALT-RES 2-6
Roof: ASHRAE 90.1-2010 EXTROOF IEAD CLIMATEZONE 2-8
Floor:ASHRAE 90.1-2010 ATTICFLOOR CLIMATEZONE 2-7)

The level comfort achieved is: 56.2%
Percentage of time when it is hot: 29.4%
Percentage of time when it is cold: 14.3%

To reduce th heat stress we can increase the infiltration rates and make schedules for infiltration, occupancy and lighting schedules, so that there is less energy consumption.

COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA



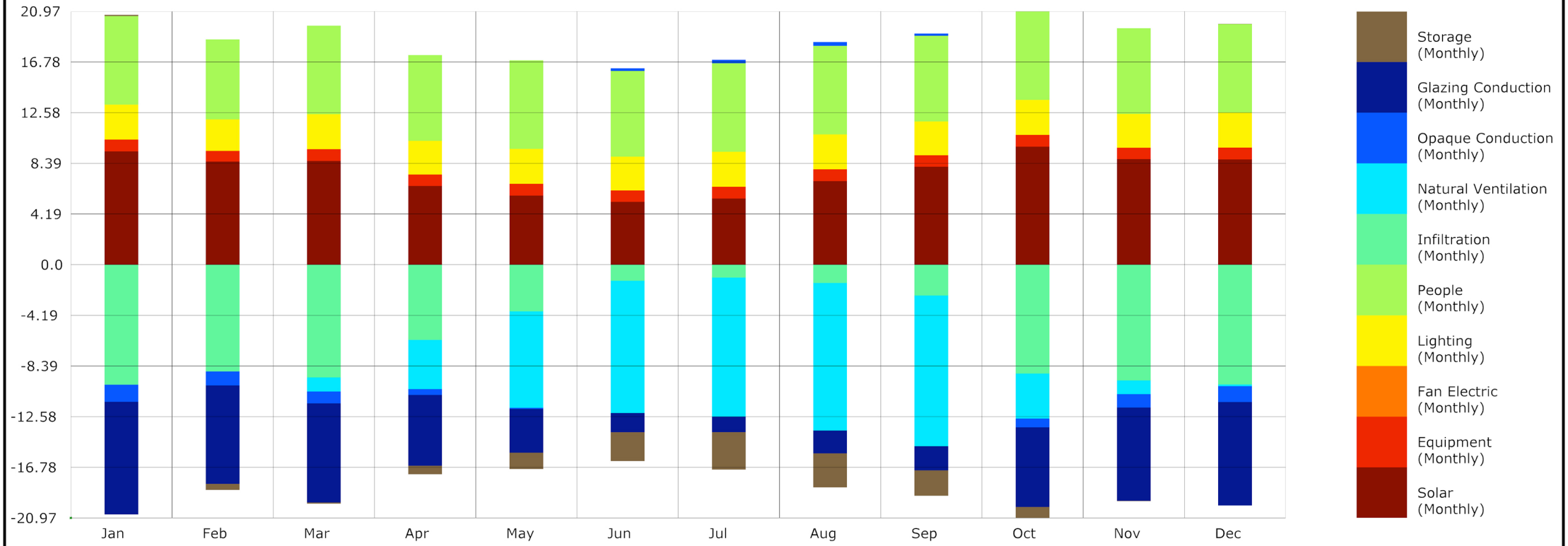
Adaptive Comfort for NAMAN_ROOM (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

ENERGY MODELING

ENERGY BALANCE

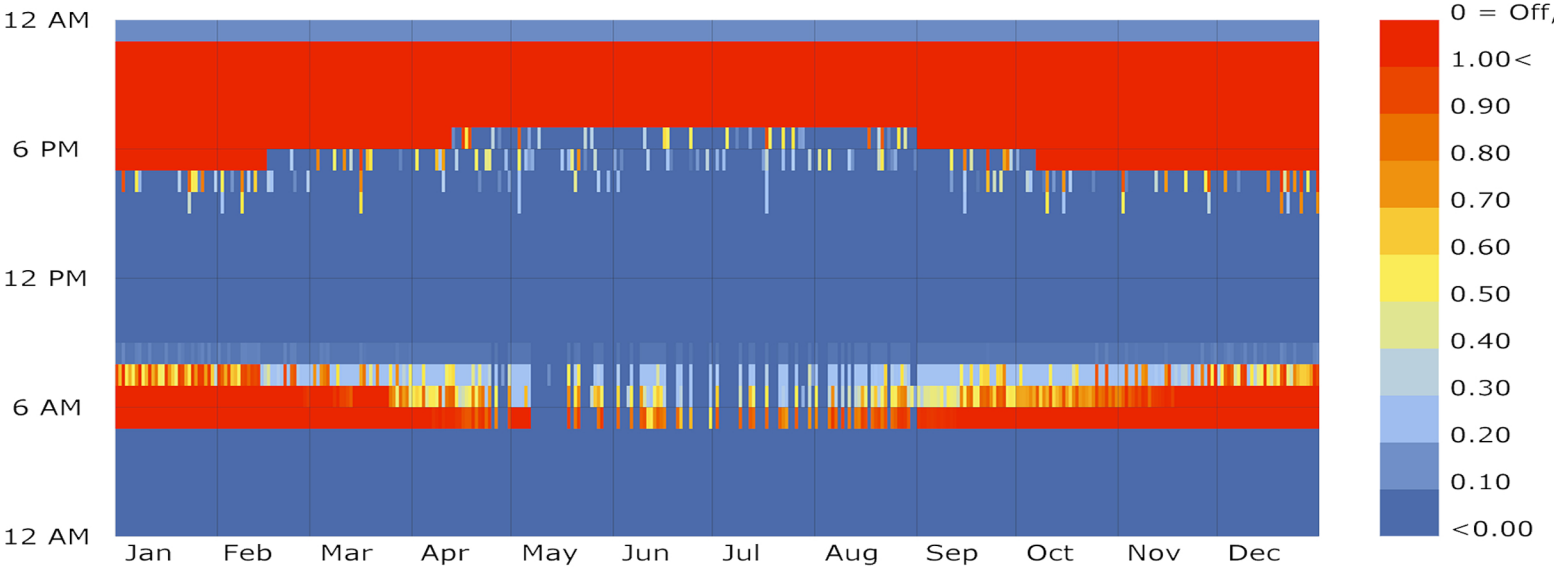
The maximum gain which is happening in the room is because of people and solar gain. we can add an occupancy schedule to reduce the load gained. During Summers the energy is lost because of ventilation, by adding a schedule made from weather file of Philadelphia, can reduce it. during winters energy is lost because of the glazing. we need to make need to change the properties of glazing and also infiltration rate is high for winters.

We do not need to change the material of opaque surfaces as very less heat is lost because of it.



ENERGY MODELING

SCHEDULES

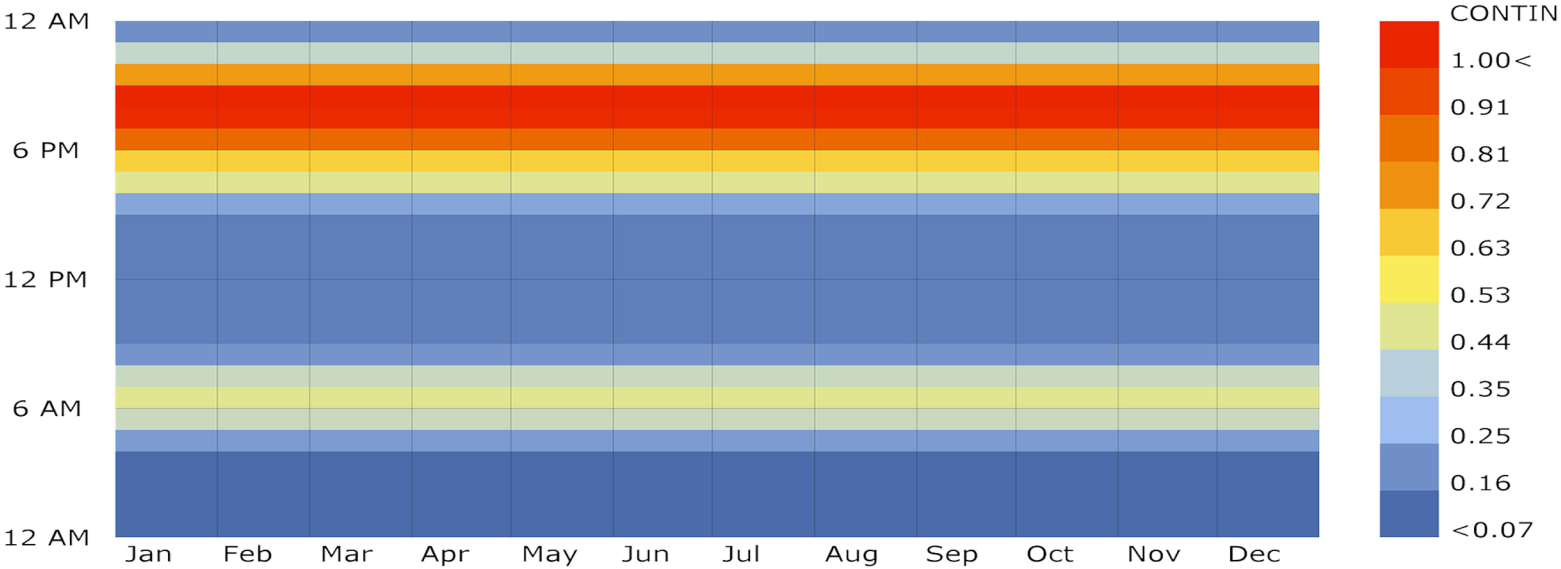


Lighting Switch Profile (0 = Off, 1 = On) - Hourly

1 JAN 1:00 - 31 DEC 24:00

LIGHTING SCHEDULE CUSTOMIZED FOR ROOM

Lighting schedules based on available daylight inside the room.
From 10:00 pm to morning 5:00 am we do not require light as the occupant would be sleeping. and during the day there is sufficient day light in the room so we don't require light.
In evening and early morning we require lights in the room to be working.



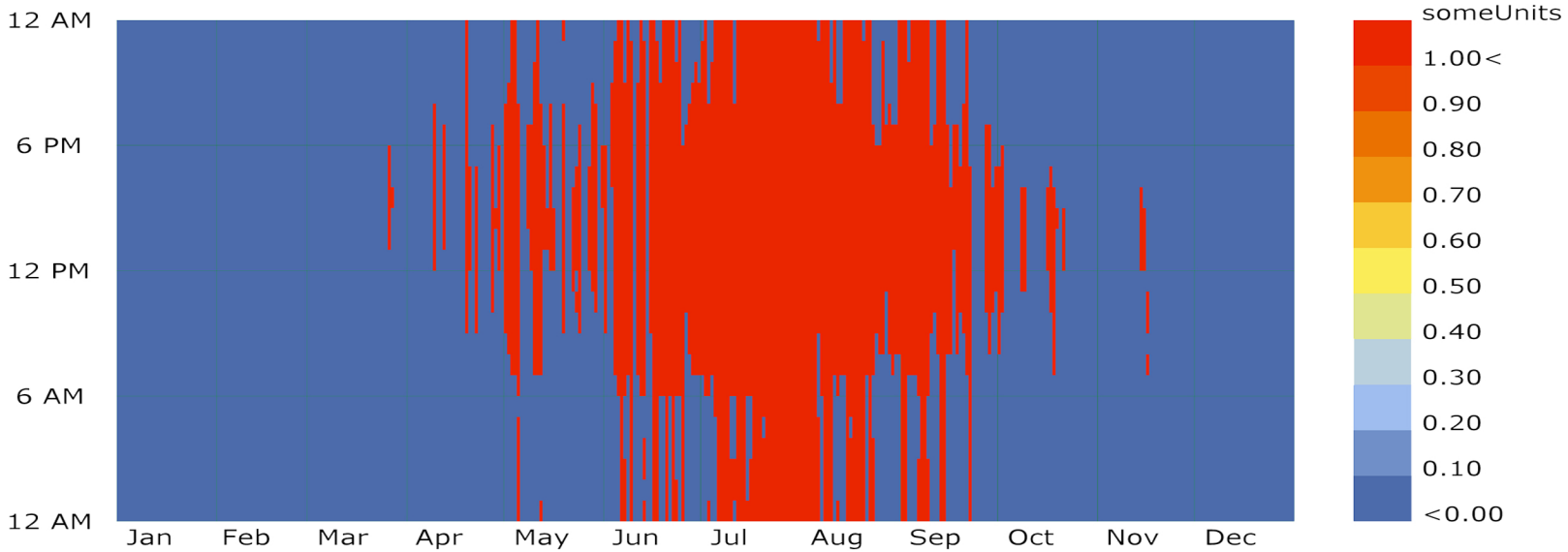
MidriseApartment Apartment Light (CONTINUOUS) - Hourly
schedule:year
1 JAN 1:00 - 31 DEC 24:00

GENERAL LIGHTING SCHEDULE

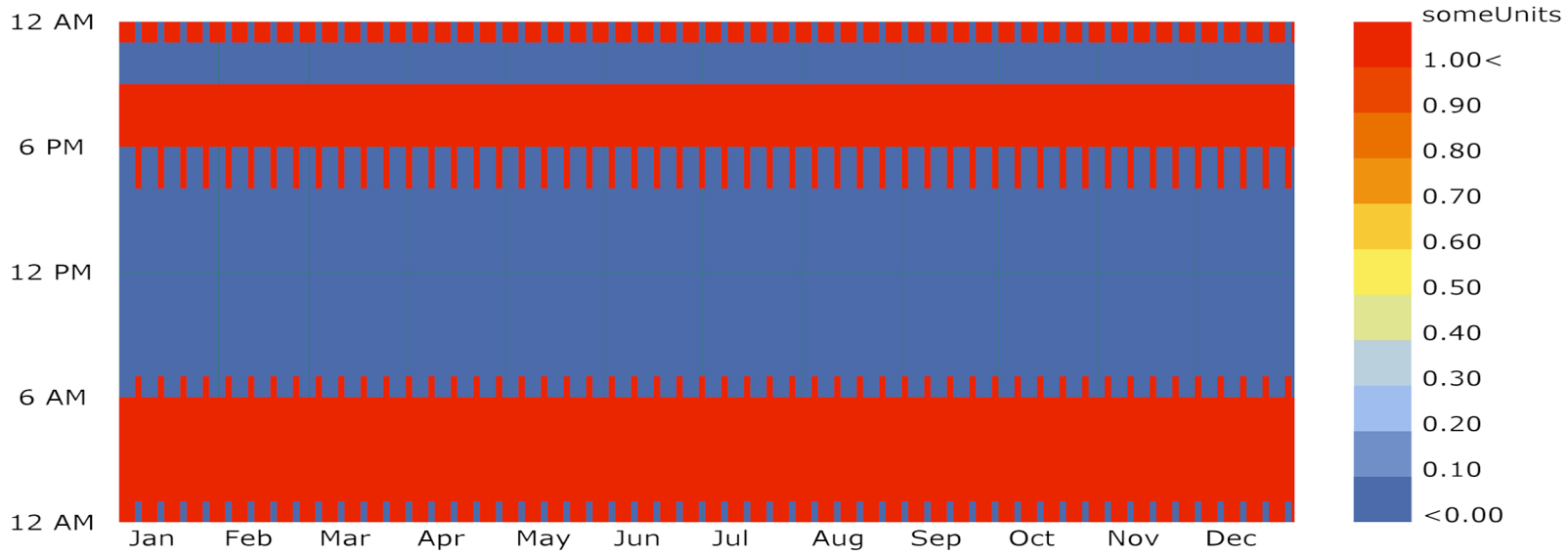
This is an ideal lighting schedule. We can see the difference during winter when days are shorter.
Both the schedules have similar trend for the year.

ENERGY MODELING

SCHEDULES



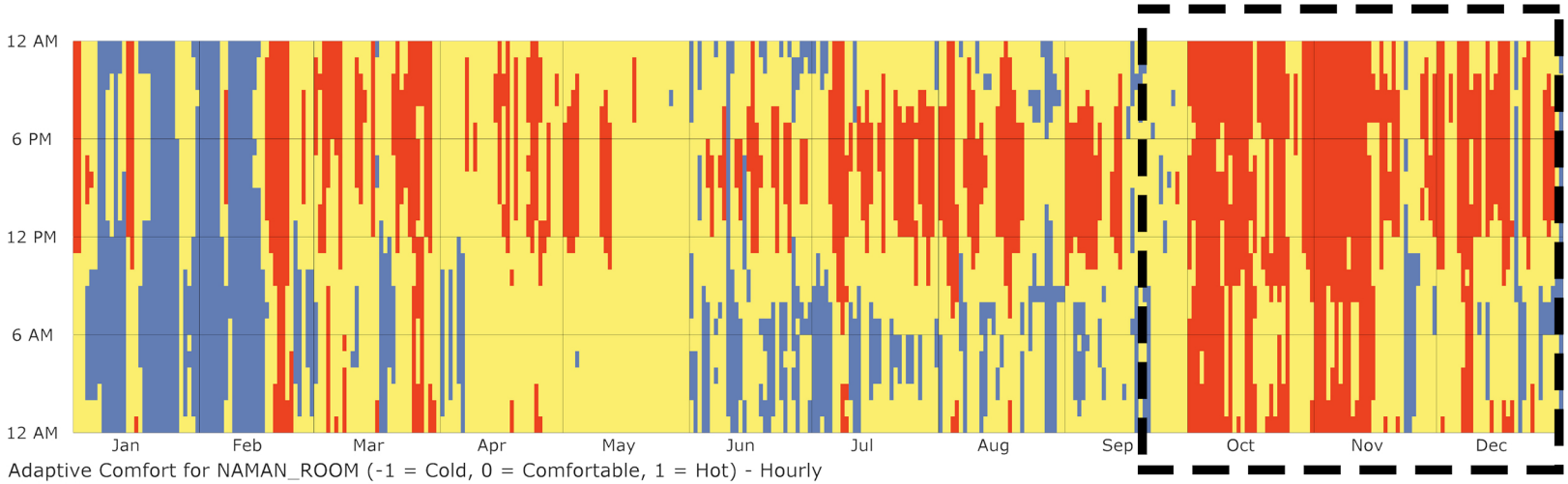
INFILTRATION SCHEDULES DEPENDING ON THE OUTDOOR TEMPERATURE



CUSTOMIZED OCCUPANCY SCHEDULES

ENERGY MODELING

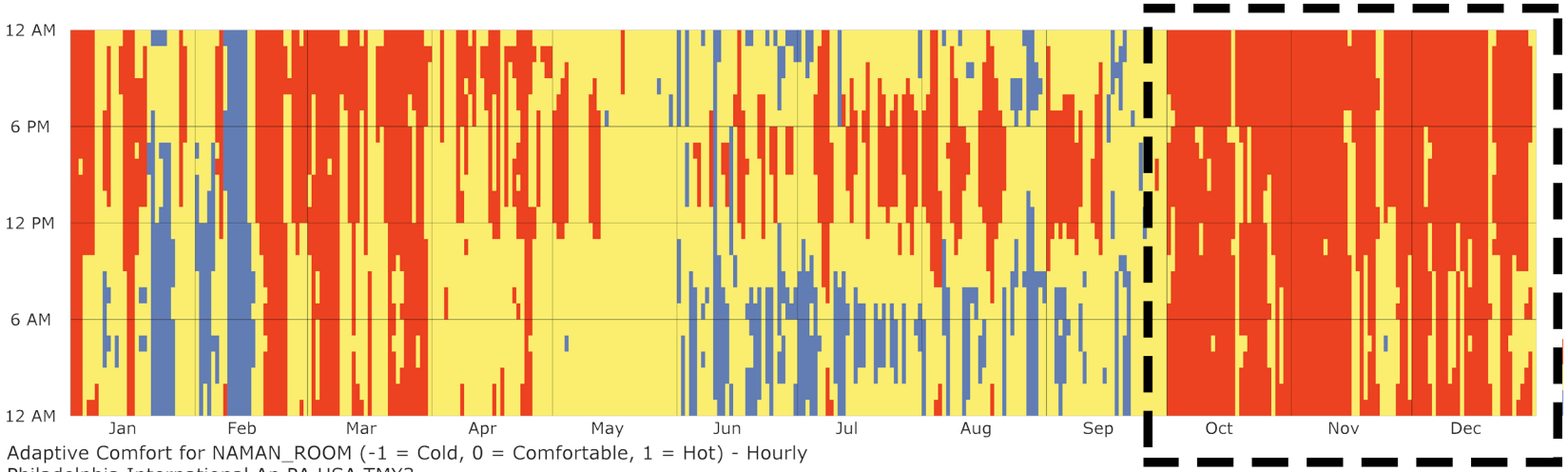
COMFORT CHARTS



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

the level comfort achieved models is : 57%
Percentage of time when it is hot : 26%
Percentage of time when it is cold : 16%

Occupancy schedule: it is occupied at by person and a customized schedule has been made for students life.



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

The level comfort achieved models is : 56%
Percentage of time when it is hot : 30%
Percentage of time when it is cold : 12.9%

Infiltration schedule: windows will be open when the indoor temperature will be more than 20 degree

heat stress increases when we put schedules for opening and closing of windows in a very tight building (infiltration rate (.001).
When we need to increase the infiltration rate so that the heat stress reduces. It goes down from 40 % to 30 %
We need to add Natural ventilation to the model and change the properties of window to reduce heat gain during winter.

ENERGY MODELING

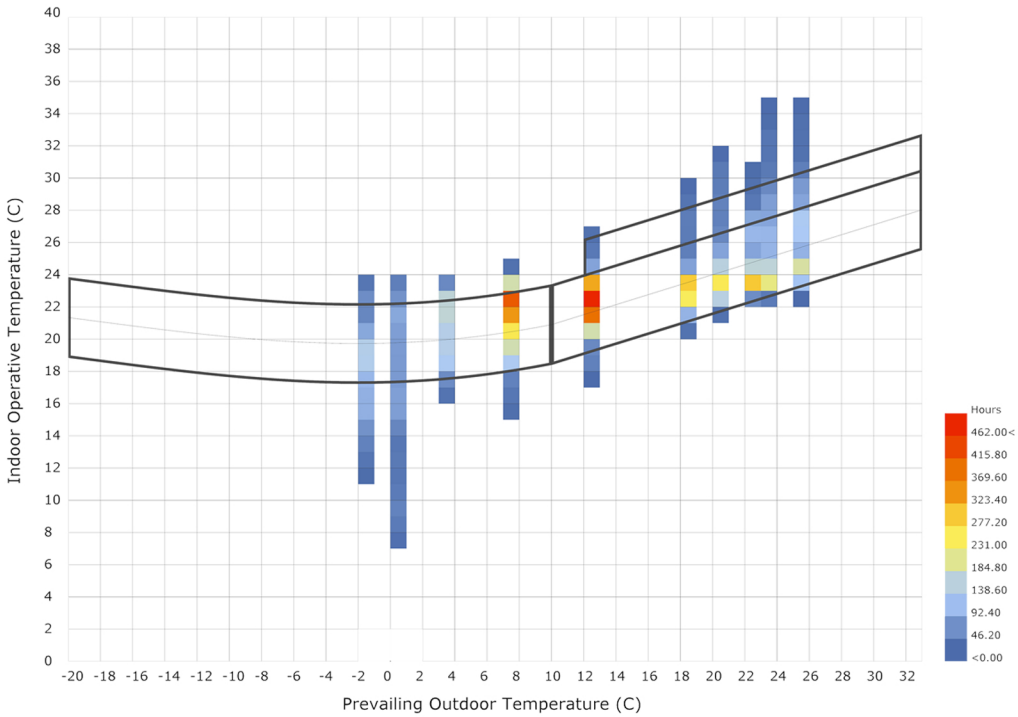
COMFORT CHARTS

By just adding natural ventilation we are able to increase the comfort levels from 56 to 76 %. heat stres has reduce significantly throught out the year.

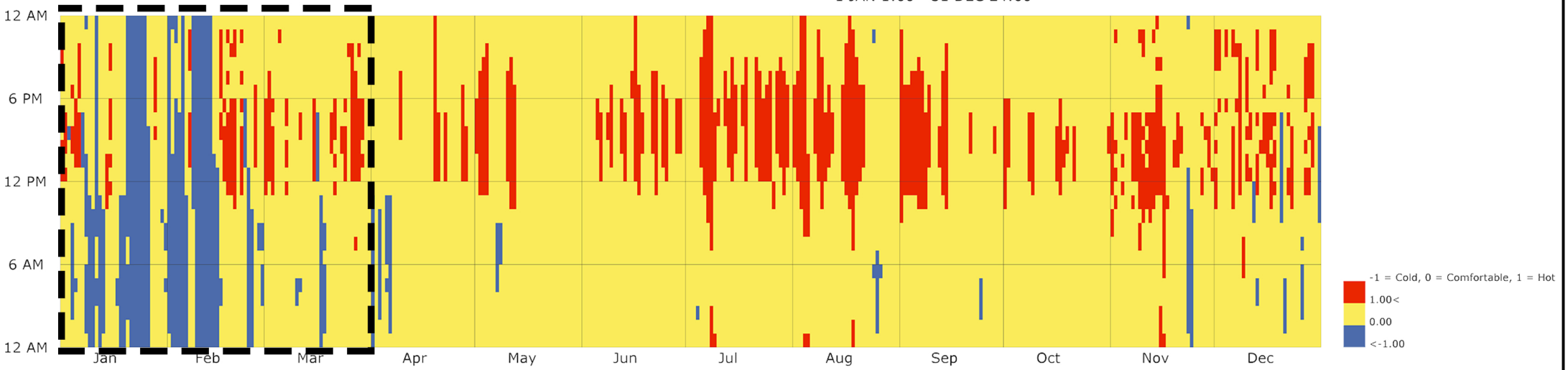
The level comfort achieved is: 79%
Percentage of time when it is hot: 13%
Percentage of time when it is cold: 8%

We are getting closer to make the room comfortable. As very few hours are not folling in the comfortable range.We need to focus on cold stress as it has more difference from the comfortable range (Adaptive comfort chart)

ADAPTIVE COMFORT CHART



COMFORTABLE TIME ZONES FOR A YEAR IN PHILADELPHIA

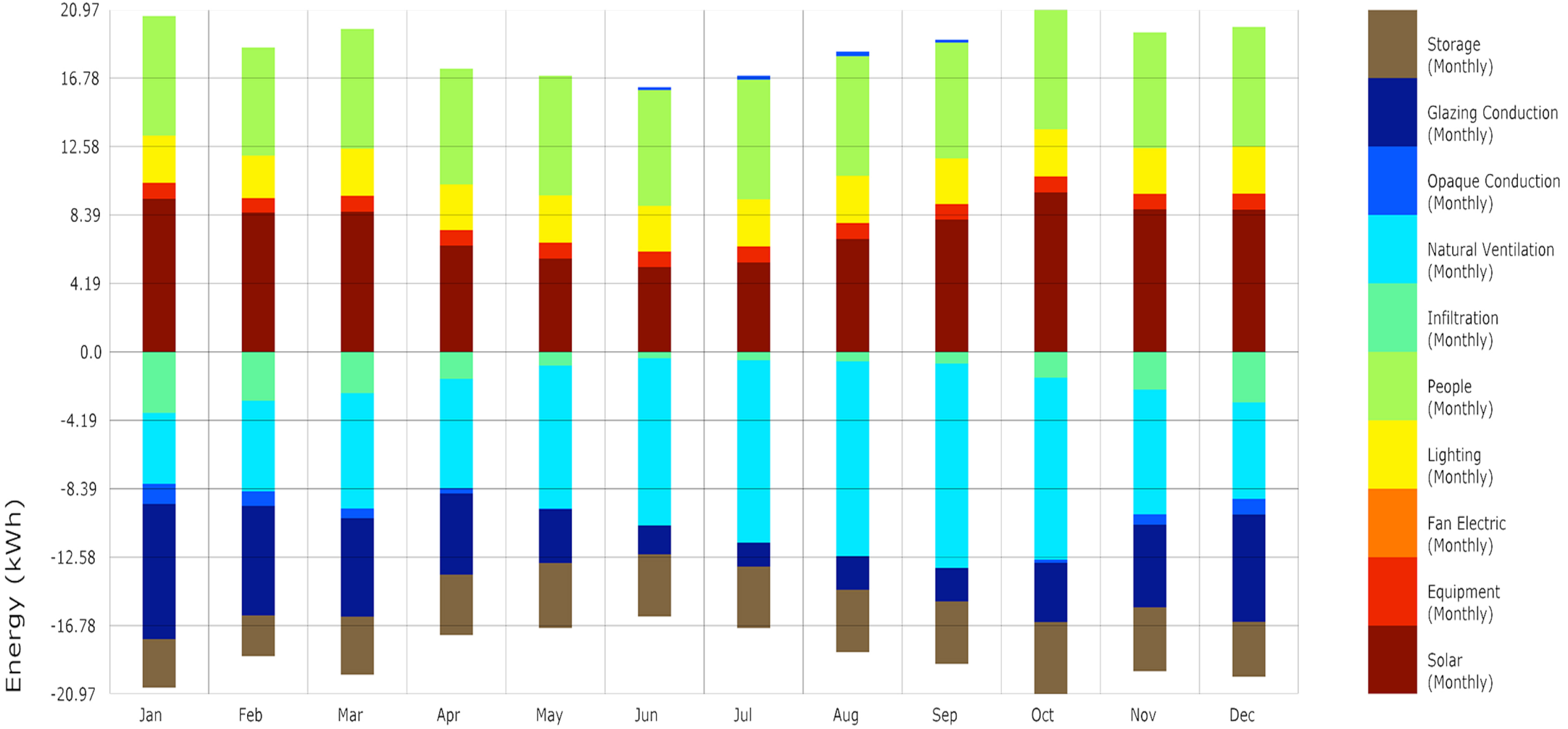


Adaptive Comfort for NAMAN_ROOM (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

ENERGY MODELING

ENERGY BALANCE

We need to edit the occupancy schedule, and customize the material for the window so that there is less solar gain and we are losing less amount of energy through glazing



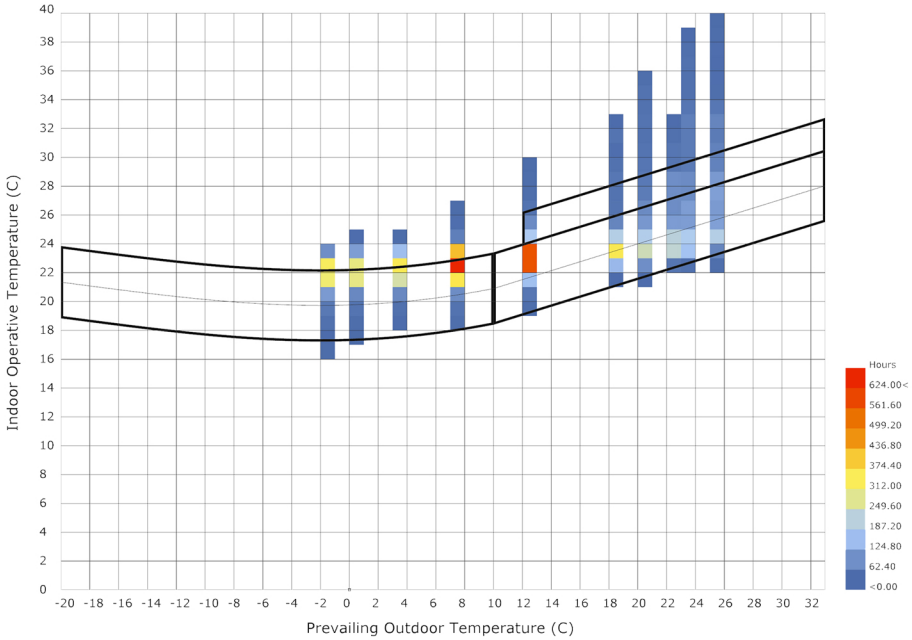
ENERGY MODELING

COMFORT MODEL

As energy is being lost because opaque glazing a new custom window was made. which reduce the finished the cold stress completely. These values vary from the code.(Chosen only for this study)

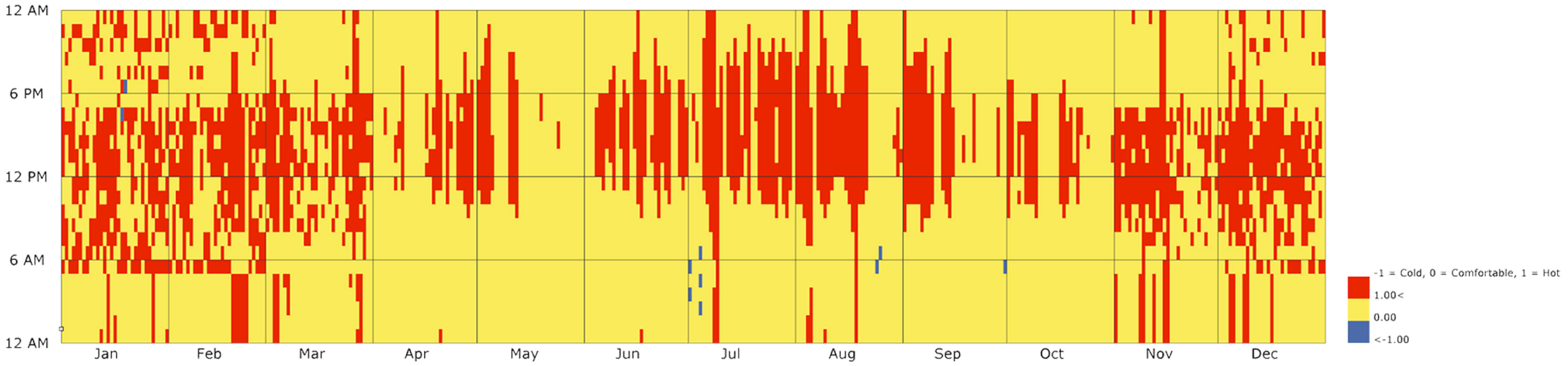
Percentage of time comfortable :72%
percentage of hot stress: 28%
Percentage of cold stress: 0%

Conductivity of the window needs to be increased, as hot stress has increase and comfort levels have decreased.
Infiltration rates needs to be increased so cool down the building.



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

COMFORT CHART WITH NEW WINDOW MATERIAL



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

ENERGY MODELING

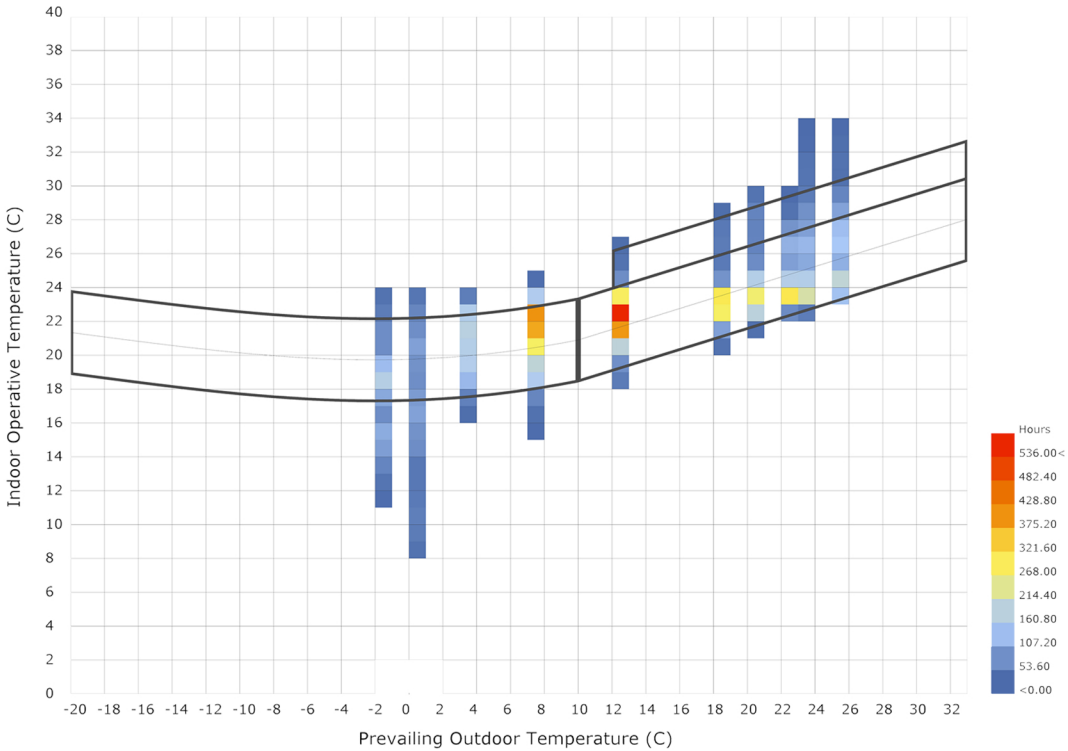
COMFORT MODEL

By increasing the infiltration rate, infiltration schedule and changing the properties of the window little bit we are able to reduce the hot stress and increase comfort levels.

Percentage of time comfortable :82%
percentage of hot stress: 10%
Percentage of cold stress: 8%

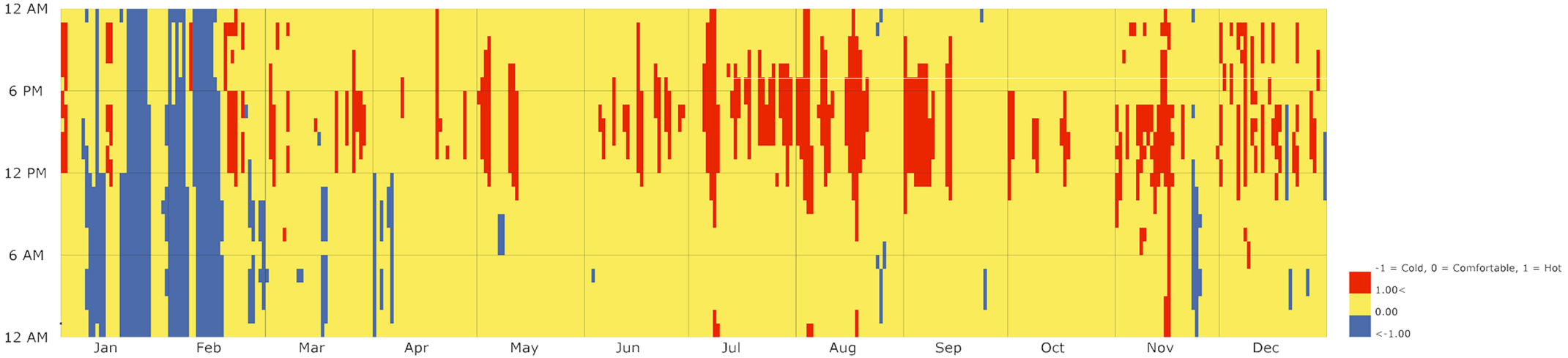
For the cold stress during the winters, one can increase the clothing and feel comfortable. In order to decrease one type of stress other one will always increase.

ADAPTIVE COMFORT CHART



Adaptive Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

COMFORT CHART WITH NEW WINDOW MATERIAL

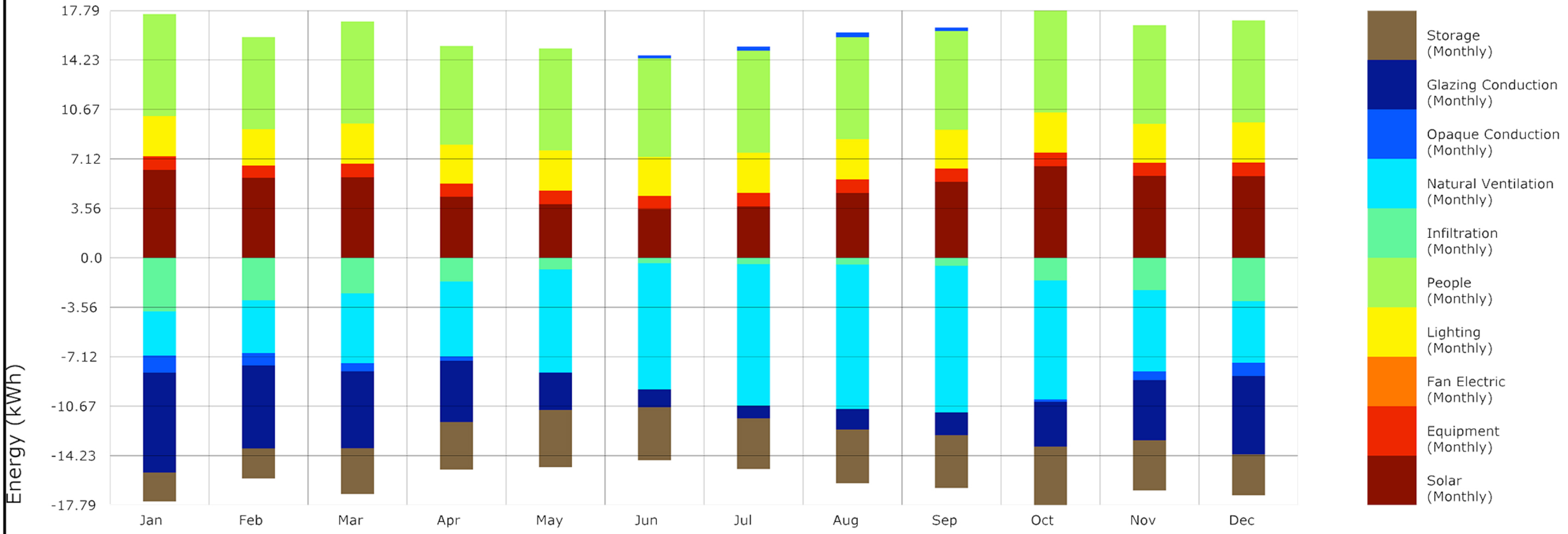


Adaptive Comfort for NAMAN_ROOM (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

ENERGY MODELING

ENERGY BALANCE

By changing the properties we are able to reduce the amount of solar gain. But we are not able to reduce the glazing conduction.
With the help of natural ventilation and infiltration we are able to reduce amount of heat gained inside the room.



CONCLUSION

There has been a significant increase in the level of comfort of the room It has gone up from 17 % to 18 %.

The entire problem was approached step by and re-running the simulations and analysis. Catering one problem at a time helped in understanding the nuances of the problem. and how it can be tackled in the real scenario.

A room can be made comfortable without the mechanical ventilation and heating if it is designed properly, my room is very cold in Winters especially during the night time, with some changes I have managed to make it comfortable for most of the times.

Natural ventilation is one of the things which has made a huge difference in the comfort levels. Using materials specified in the code. Various shading designs were tested before conducting the energy simulations.

The design that performed the best in the daylighting analysis, did not perform well in energy simulation due to which window area had to remove from the north side. During the daytime, the occupant is not at home, because of which energy modeling is given more importance.

I had assumed that east facing windows perform better, for the daylight and energy modeling but it was south facing windows which work better in the case of my room.

Materials specification of the construction made a difference as well. The idea was to warm up the room using different materials and shading device and then cool it down using infiltration and natural ventilation.

the time for which it has cold stress that is 8 %, a person can make it comfortable by adding more clothing layers