Building Performance Simulation
Final Project
Make Your Room the Dream Room

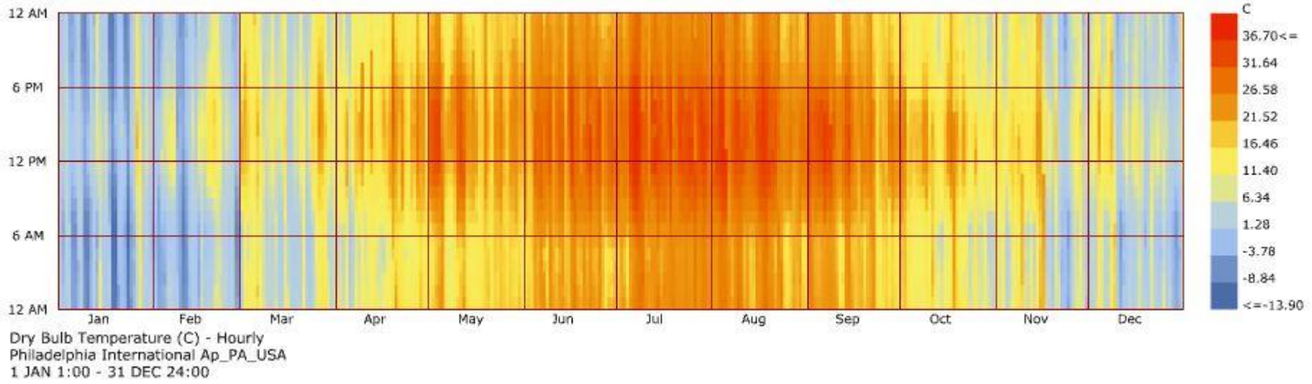
Climate Analysis of Philadelphia, Pennsylvania

Weather Data Analysis

Temperature

Philadelphia is the largest city in the Pennsylvania and the fifth-most populous in the United States. In general, Philadelphia has a temperate climate. Summers are typically hot and muggy, fall and spring are generally mild, and winter is cold.

As it can be perceived from the bar chart and 3Dchart of Dry Bulb Temperature, Philadelphia has varieties of temperatures depending to the specific seasons; from Nov. -Dec. to almost March and even April it is rather cold. It begins to get hotter afterwards and it is mostly in a mild temperature except for noon hours from June to Oct,. So, the most problematic time for Philadelphia is from 11 a.m. to 4 P.m. in these month so the cooling purchases should be taken in consideration. If we considered comfort zone from 18-22 C is it mostly bellow this zone. Consequently Heating Considerations in cold months can be put into action as well.

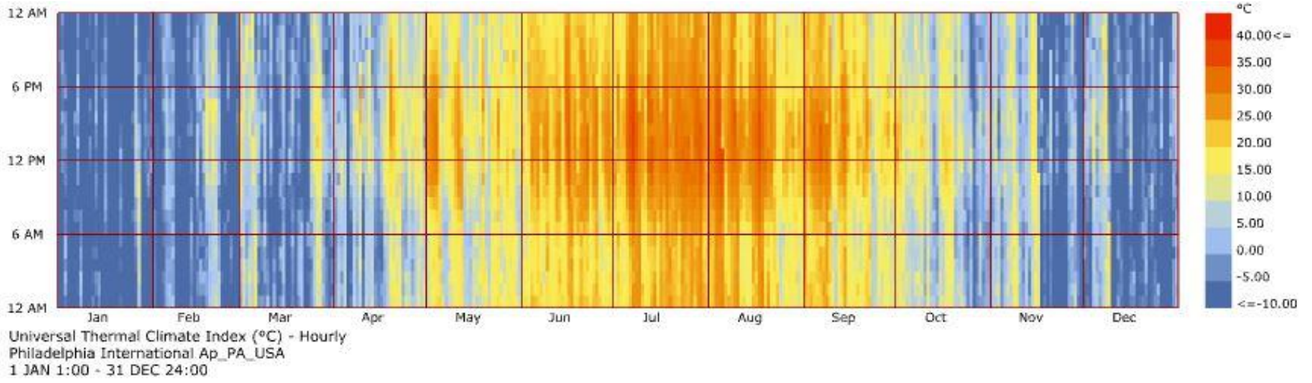


Dry Bulb Temperature

Here we can see a comparison between the actual Temperature and Universal Climate Index Temperature which is in fact, the feels like temperature. Universal Climate Index Temperature is a parameter to understand the temperature which people feel rather that what it is. In Philadelphia, it feels cooler than it seems. In cold seasons, it is a bit colder than the actual temperature and in hot seasons there are less times in which the weather gets really hot.

Design Strategy

So in the design strategies, these differences can be taken into consideration. As a result we should think of a way that we can get more sun in the houses in Winter and Fall and the solution may be to use larger windows with automatically controlled shadings so that when needed the shading would protect occupants from the sun and in cold seasons, the shadings would allow the sun light to warm the houses.



Universal Thermal Climate Index

Weather Data Analysis

Relative Humidty

With accordance to Relative Humidity Chart, it seems that Philadelphia is a city with nearly high amount of humidity with mostly over 50% . It just becomes less during noon hours which is not so helpful because the temperature in those hours are high so humidity can have a huge role in building designs in Philadelphia.

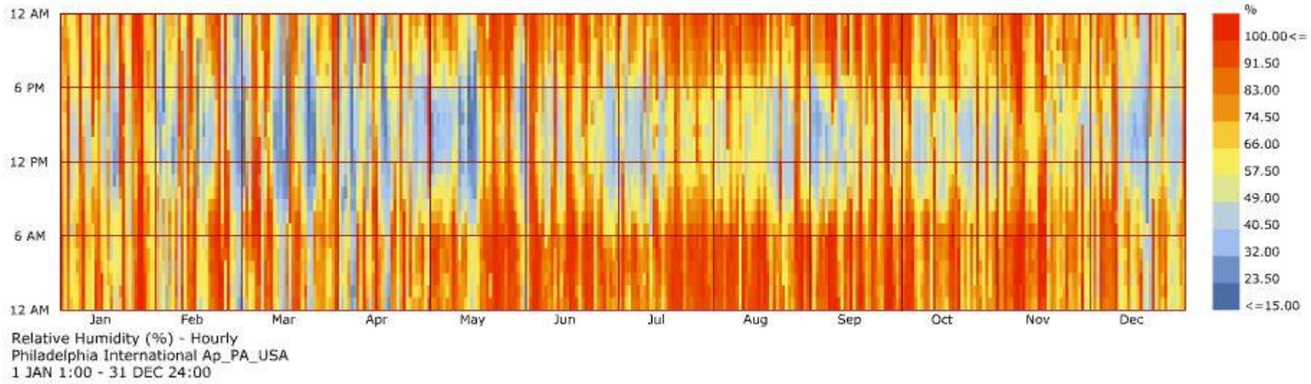
Designing Based on the Level of Humidity

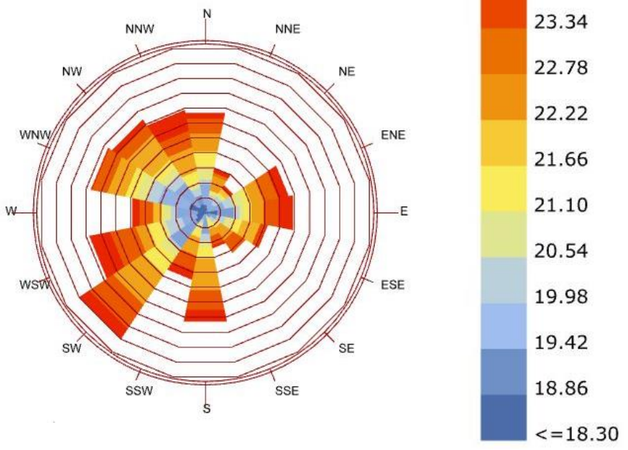
Humidity can be a parameter which is effective in the design process and designers should considered this factor. Ventilation and its design options is a way of reducing humidity in outdoor and indoor spaces which can be purchased through different kinds of designs methods and device. A design team can provide information based on comfort level in humidity and provide alternative examples to prevent the level of humidity to be out of comfort zone.

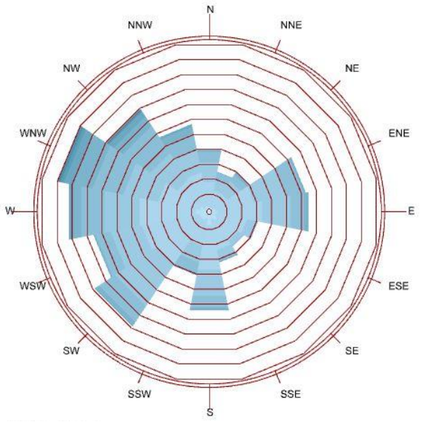
Wind Speed and Temperature Based on Direction

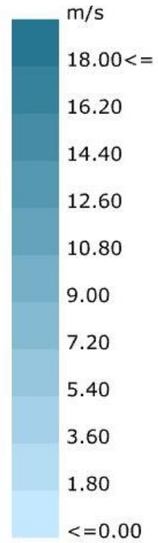
In weather data information, wind information can have a huge role in design in humid climates. Using wind data is the first way in ventilation purposes. As humidity can be problematic in Philadelphia buildings with regards to previous graphs, it is important to take wind data into account to provide the best ventilation for our spaces.

As it is shown in the wind speed chart, wind speed in Philadelphia is mostly in the comfort zone bellow 5 and there are rare moments that wind speed will be a problem and needs to be prevented. One approach that can be perceived in this subject is to design a powerful structural buildings which are resistant to high levels of wind speed.









Weather Data Analysis

Wind Based on Comfortable Zone

Apparently, wind is mostly flowed form South-West, West and North-West. Also, there is a mild wind flow from East and East-North-East. Based on these wind's speed and their degree, they can help a design team to design in a better way. Winds with temperatures in a comfort zone 18< a <24 can be used to make a natural ventilation for the buildings.

It is depicted that the best wind which is within the comfort zone is coming from South-West. Also North and North-West are other directions through which wind is flowed. So the ultimate result is that to have a better ventilation the best way is to direct the buildings towards west oriented to the south to exploit the mild wind in the comfort zone.

V = 5 m/s or 18 km/h onset of discomfort
V = 10 m/s or 36 km/h definitely unpleased
V = 20 m/s or 72 km/h dangerous

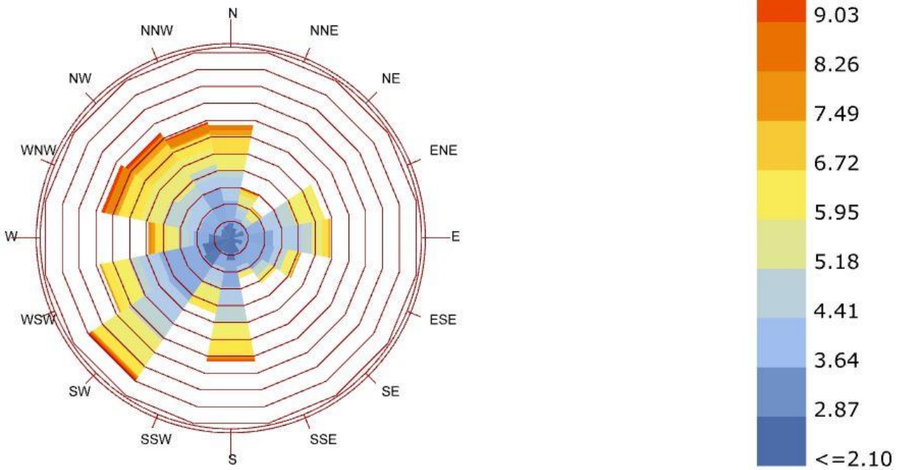
Total Cloud Cover

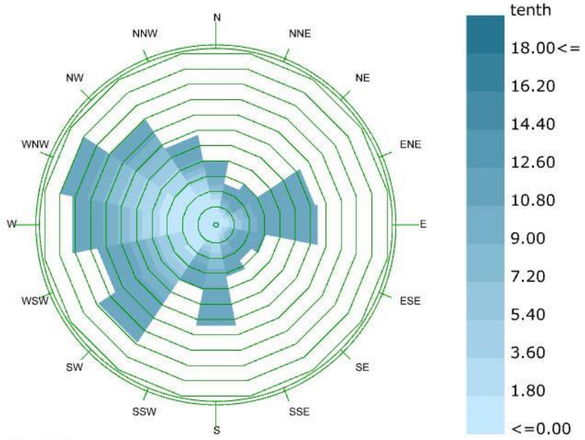
With regards to what can be perceived form the sun path and total cloudiness cover diagrams, those sun radiations which make problems for inner and outer spaces can be specified. It seems that during summer times and also in midday we have the most issues with sunlight, other than that sky would be mostly cloudy. So thermal comfort considerations should be out into action for these times.

Providing different kinds of shading in summers and middays would prevent the direct sunlight to inter inner spaces and omit them in other times would let the inner space to use the most of the sun and light. It is shown that Philadelphia is mostly cloudy half of the year. As a result, designers should consider this and try to find ways to get the most sunlight during the day.

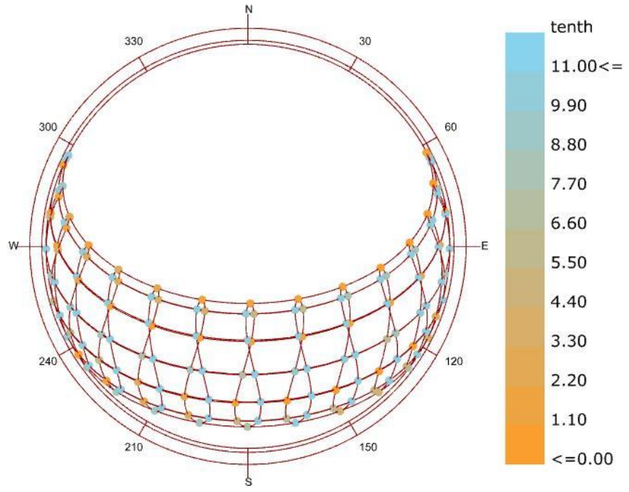
Conditional Wind Direction

18< Temperature <24
20< Relative Humidity <80
2< Wind Speed <10





Total Sky Cover



Sun Path Diagram

Weather Data Analysis Based on Thermal Comfort

Adaptive Comfort

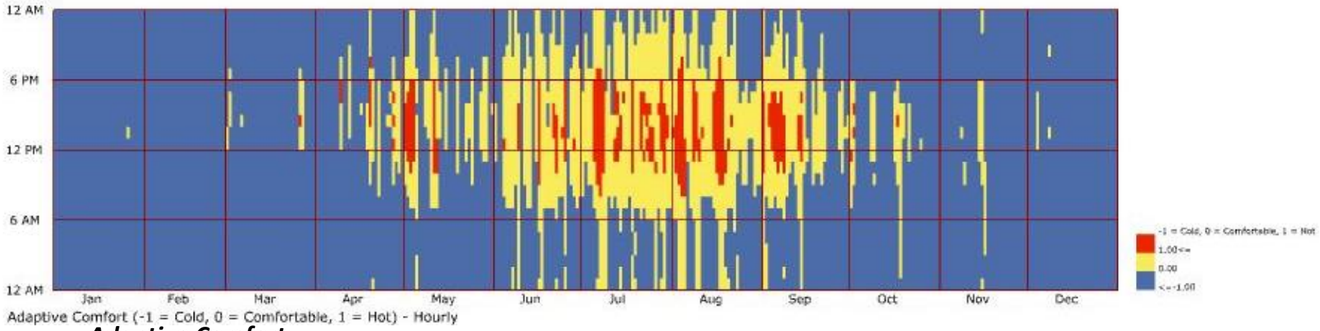
Based on thermal comfort calculations and comfort charts using ladybug, it seems that people in Philadelphia are not much comfortable in general. With regards to the climate, cold weather is more problematic than hot weather since the amount of times which is colder than the comfort zone is much more than hot days. So design strategies should be more allocated to prevent cold weather than to provide solutions for hot weather.

According to calculations, only about 20% of times people are comfortable. As it is shown in the adaptive comfort chart and comfortable or not figure, Fall and Winter are the seasons which has brought uncomfortable situation for residents. There is almost always uncomfortable situation in these seasons, so the effort should be put into provide better condition in these seasons.

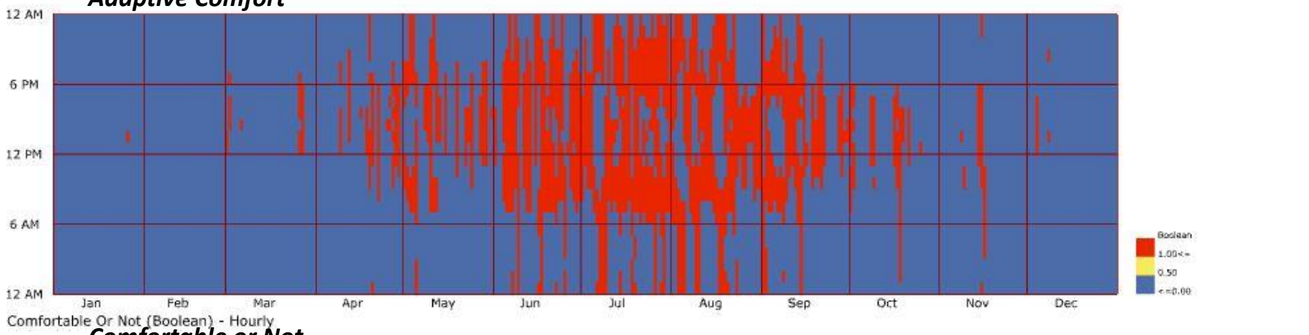
Percentage of Comfortable times : 19.26
Percentage of Hot hours : 3.47
Percentage of Cold hours : 77.26

Outdoor Comfort

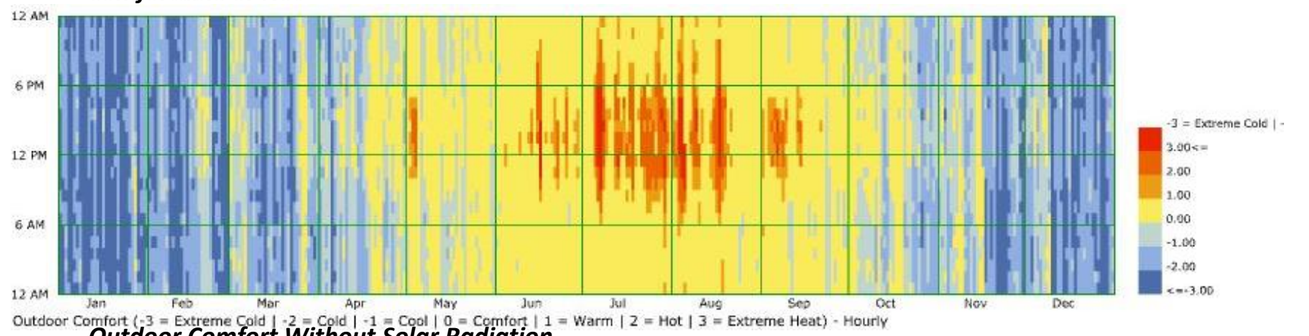
As in outdoor comfort and the comparison between outdoor comfort with and without solar radiation, it seems that when solar radiation is taken into account, it is much more better than the percentage of comfortable hours become higher. Apparently, during Summer and Spring it is pretty much comfortable outside but in Fall and Winter it is mostly colder than what is considered as comfortable zone.



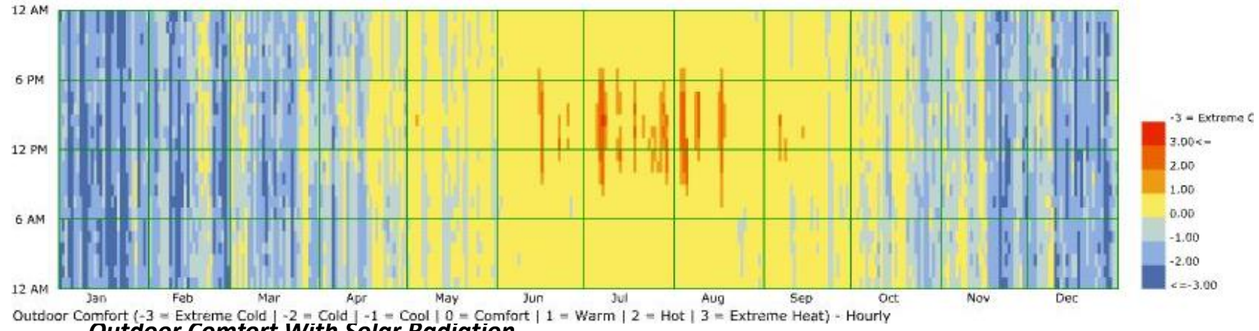
Adaptive Comfort



Comfortable or Not



Outdoor Comfort Without Solar Radiation



Outdoor Comfort With Solar Radiation

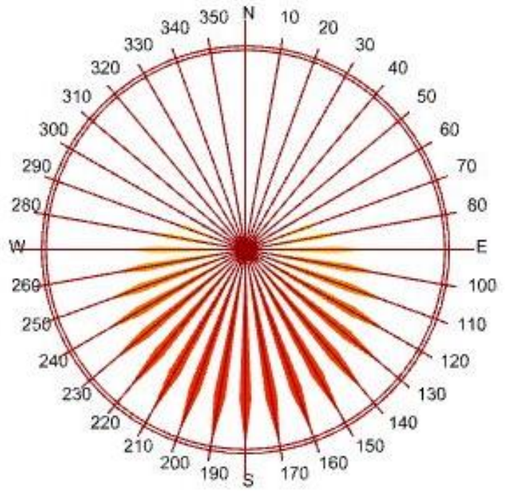
Weather Data Analysis Based on Radiation

Solar Radiation Analysis

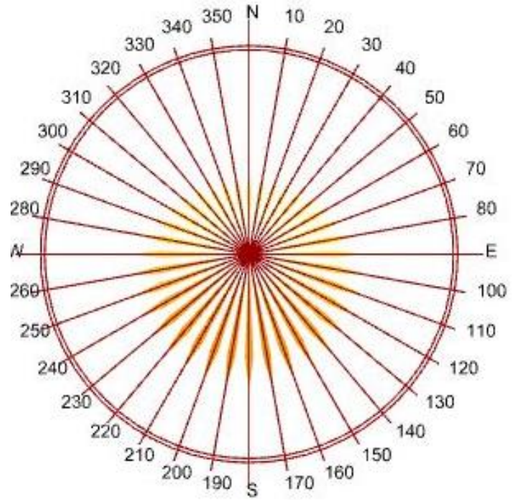
With regards to solar radiation, the highest radiation can be seen in the south. And it north nearly there is not any radiation. There is an overall diffused radiation towards all directions, but direct radiation mostly happens in south and east-south and west-south. So in the design strategies, it is important to locate windows and even solar panels towards south when we want to use solar radiation and sun light.

Sky Dome

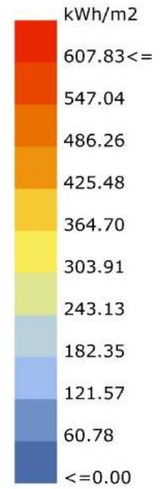
As it can be figured out from the Sky Dome, although the direct radiation is mostly from the south, but the angle of sun is higher than radiation from east and west. Consequently, we should be more concerned about west and east radiations. On the other hand, when it comes to using sunlight, south is the best direction to think of.

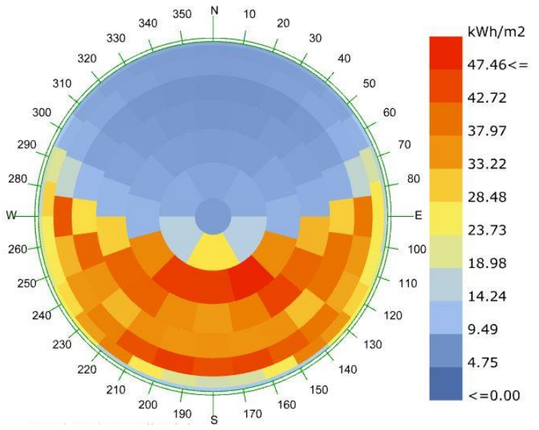


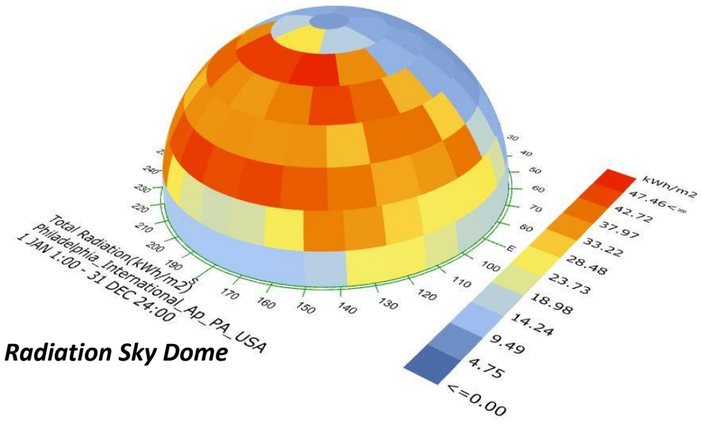
Direct Radiation



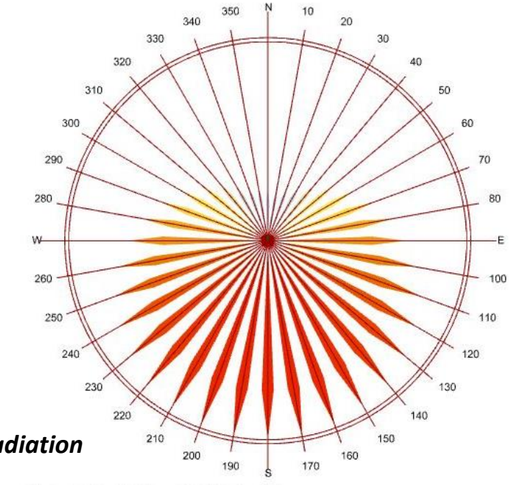
Diffuse Radiation



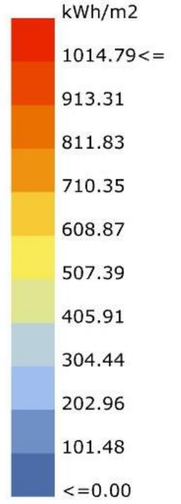




Total Radiation Sky Dome



Total Radiation

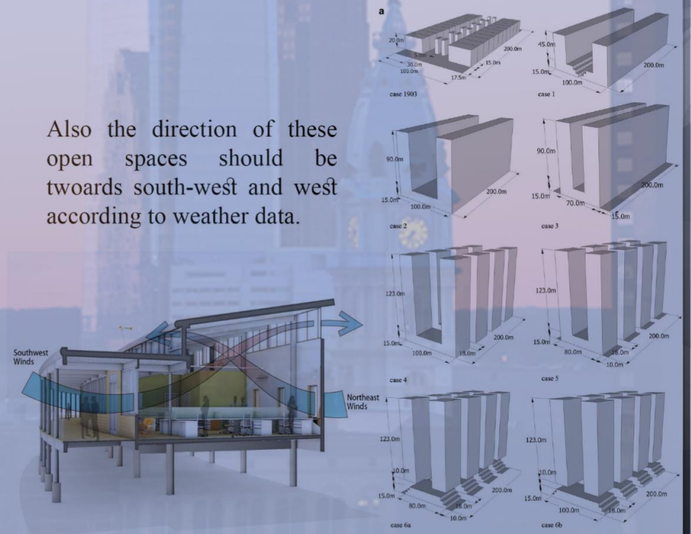


Three Passive Design Strategies

1. Natural Ventilation By Corridors and Vacant Spaces

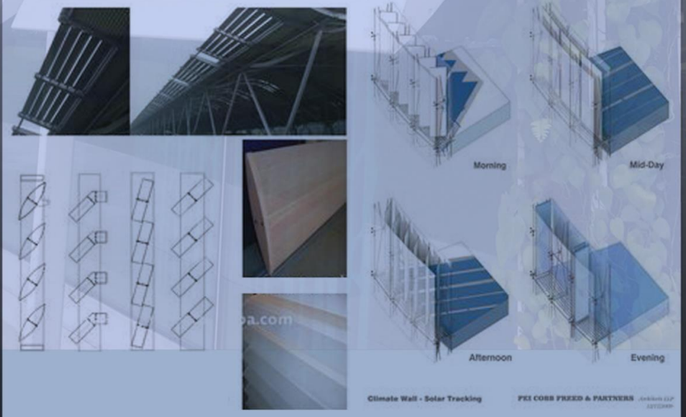
As we understood from the graphs, wind has a huge capacity in philadelphia for being used as natural ventilation. So we can substitude it with mechanical devices in our designs. A designer can mange openings and corridors in a way that natural ventilation can be provided.

Also the direction of these open spaces should be twoards south-west and west according to weather data.



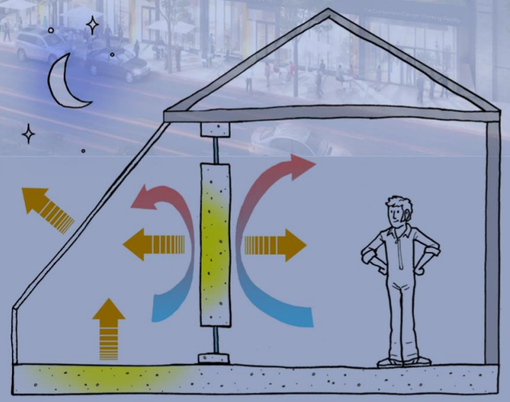
2. Providing automatic vertical and horizontal shadings to manipulate sunlight

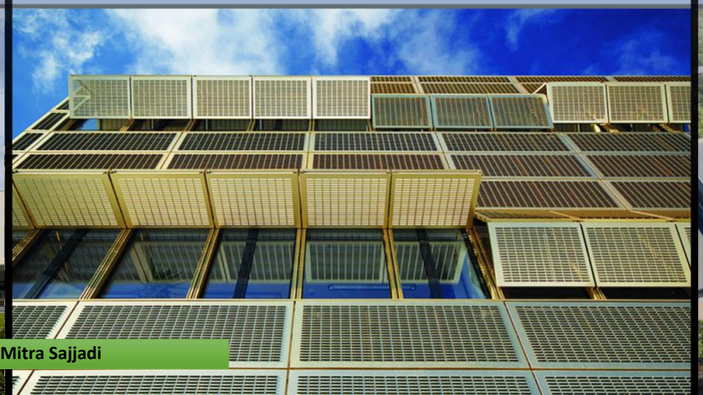
This strategy will allow building to get the sunlight whenever it needs it and prevent it whenever it is bothering. This way using sunlight as a natural resource for providing comfort will be a responsive method of design because it is more efficient. As it was shown in the sunpath graphs, during noon are the times that we need shading in summer and during winter or early morning we need more sunlight.



3. Night-Flushing in cloudy times to make the best use of sun.

Night-flushing is a way in which sunlight is obsorbed during the day and the heat which is saved wil return to the sapce. This can be acheived with absorbing sunlight devices. This method of passive design can be purchased through Fall and Winter times according to the weather data analysis that the amount of sunlightis low and it should be used as much as possible.





Weather Data Analysis Based on Climate Change

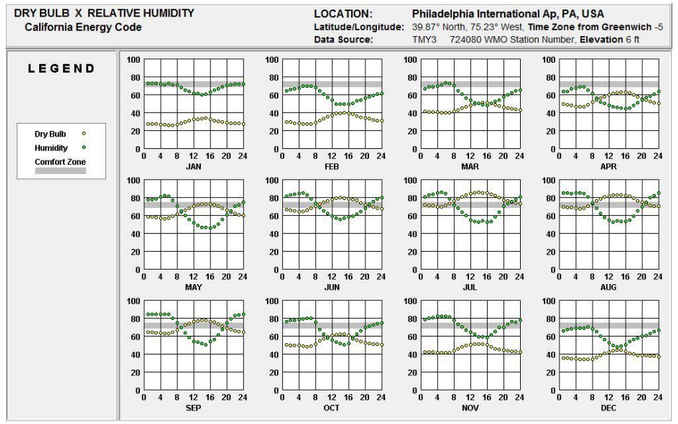
The graphs in this page are to make a comparison between present situation of weather data and the projection of weather data for 2050. The projection data is achieved by CCWorld Climate Generator Website and downloaded through some excel procedures.

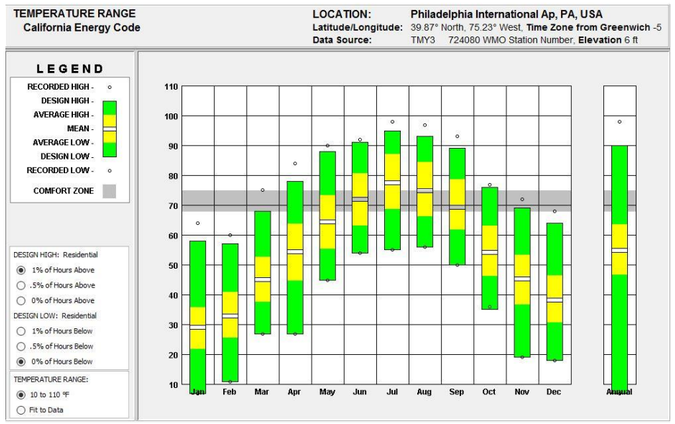
In terms of Relative Humidity, there are some fluctuations. It seems that humidity will be more problematic as time goes by. With regards to the graph it is predicted that level of humidity will be a bit further from comfort zone. So in the design strategy, ventilation strategies should be kept and even the emphasis should be more on this issue.

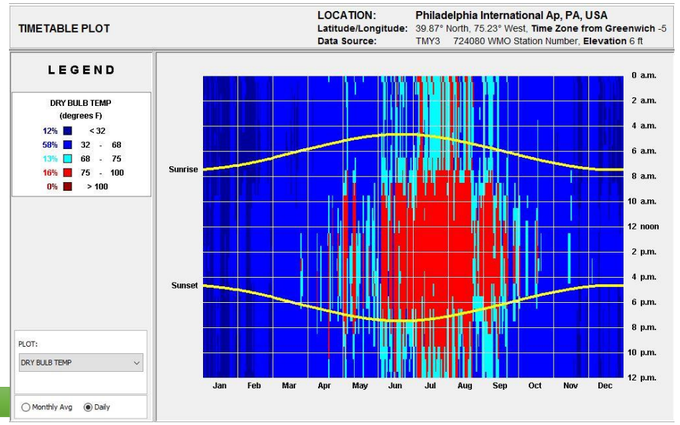
In terms of temperature, it seems that the weather will be much hotter and also the hours and the range of the times which weather is hot will also be larger. It is predicted that in general, 26% 75_100 degree F will be achieved, whereas this percent is 16% for recent condition. So in our design strategy shadings will be much more effective. Also, Cooling Systems should also be taken into account.

Eventually, designers should put a lot more concentration on human comfort as it will be less and less as time goes by.

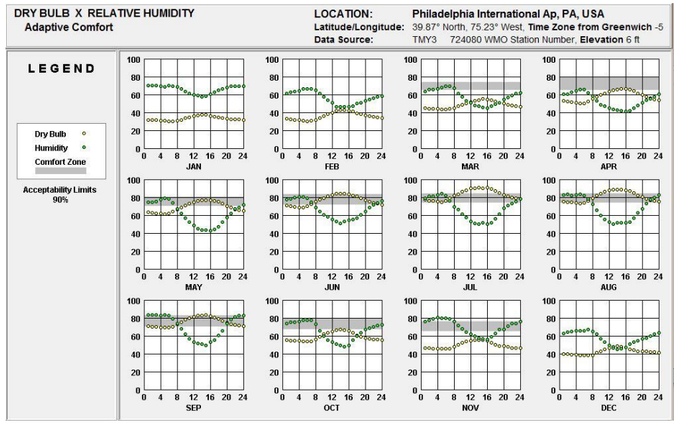
Present weather data analysis

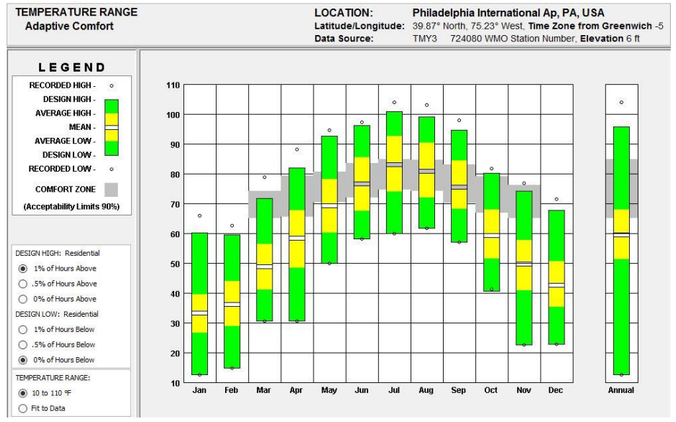


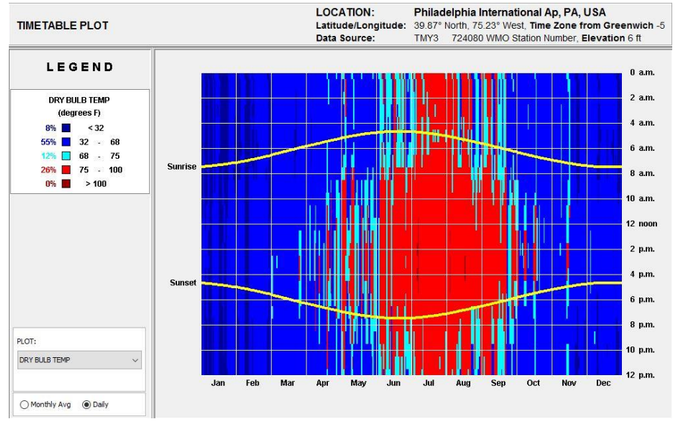




2050 Projection of weather data analysis







Analysis of My Base Case Model

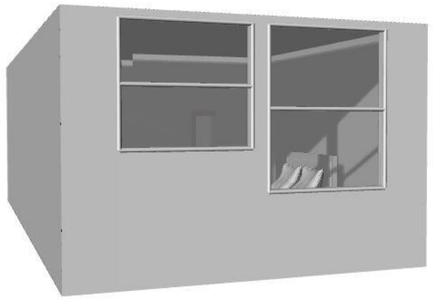
- ***Daylighting Analysis***
- ***Glare Analysis***
- ***Energy Balance***
- ***Thermal Comfort***

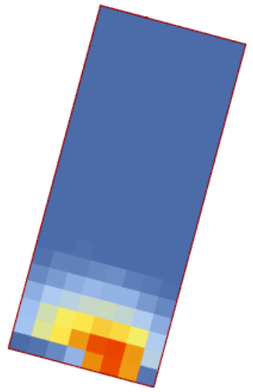
Daylighting Analysis of Base Model

The results are from Grid Base Simulation of Daylighting Analysis in Ladybug and Honeybee. Three months were picked; 3th, 6th an 12th . And three times of the day; morning noon and afternoon. The unit is illuminance and the range in between 300_2000 which is an accepted range for a typical office room. 2000 and over this range can be considered as too bright and having glare issues. And 300 and below that can be considered as dark.

According to the illuminance levels Much of the glare is for afternoon, and then noon. Also, the most problematic month is March. In the morning there is not much glare in all three month.

General Percentage of Room which is Too Bright : 30 %
General Percentage of Room which is Too Dark : 60 %
General Percentage of Room which is well daylit: 10 %





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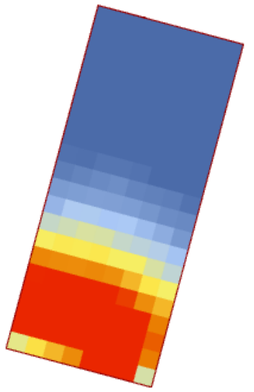
21 MAR 9:00



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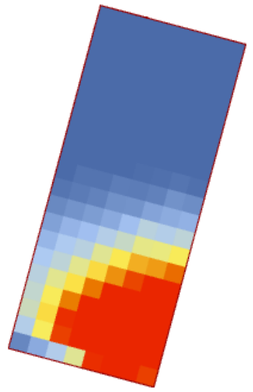

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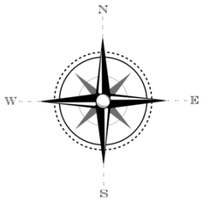

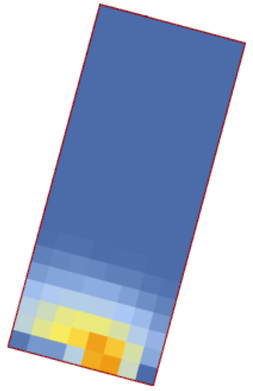

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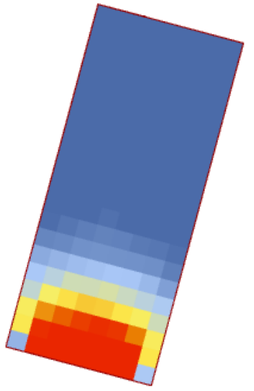

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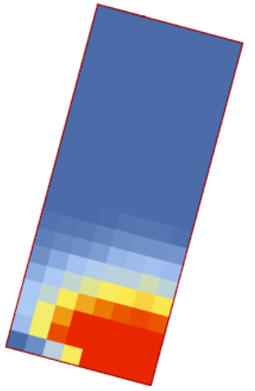

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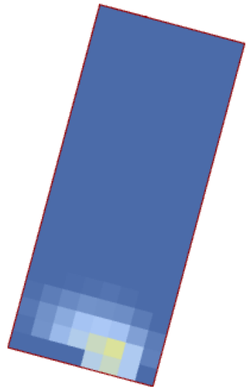

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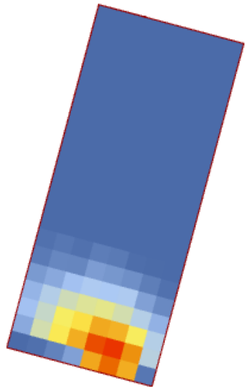

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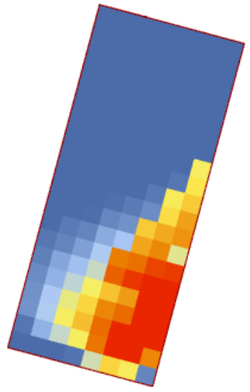

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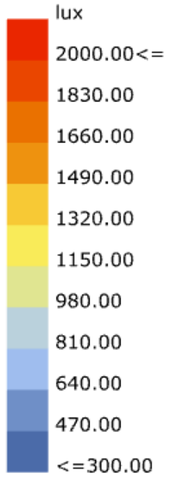
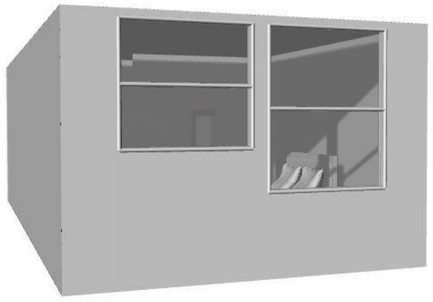


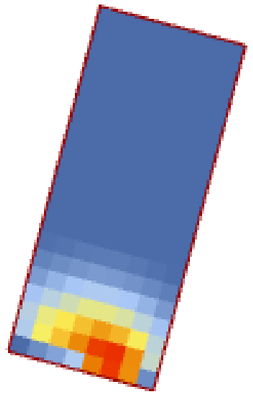
Daylighting Analysis of Base Model

Revised Daylighting Analysis With Material and Thickness Consideration

In the revised analysis model, material, thickness of the objects and surfaces, radiance parameters have been taken into consideration. The result shows that a difference is accrued by adding these parameters. It seems that illuminance levels is higher and the amount of glare is also less in comparison with the previous analysis. The problematic times remained the same, but the illuminance levels is more problematic which was not expected. Now more of the room has better daylighting overall.

General Percentage of Room which is Too Bright : 35 %
General Percentage of Room which is Too Dark : 50 %
General Percentage of Room which is well daylit: 15 %





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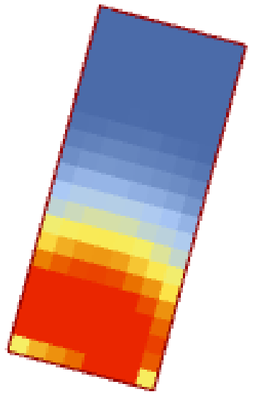

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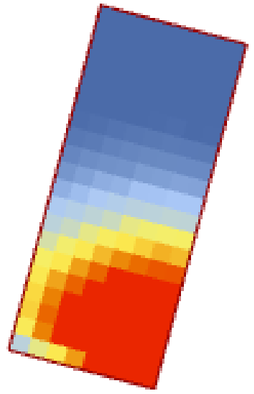

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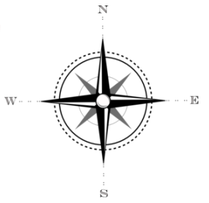

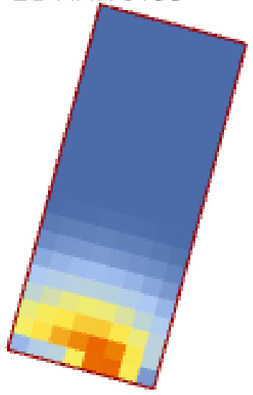

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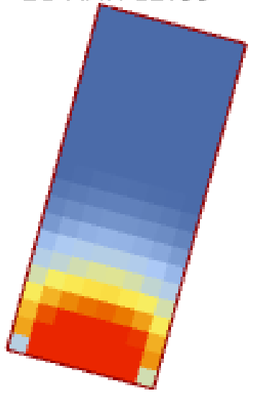

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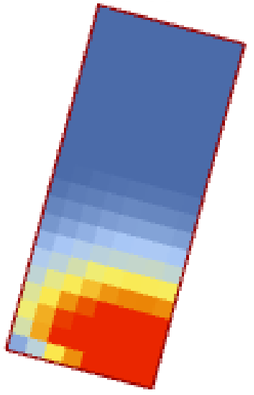

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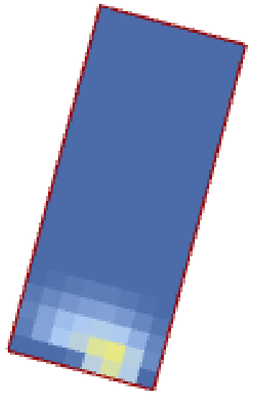

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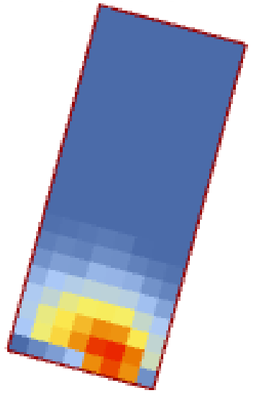

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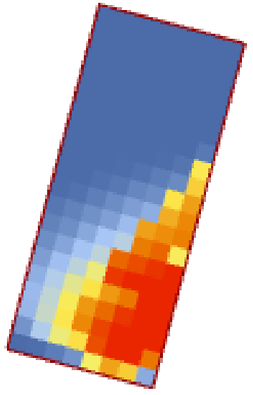
21 DEC 12:00



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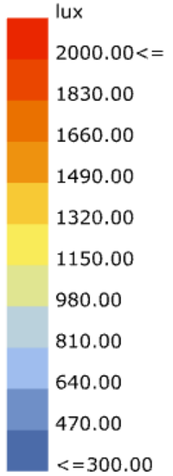
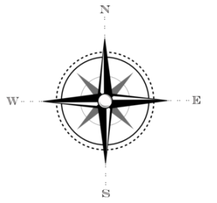
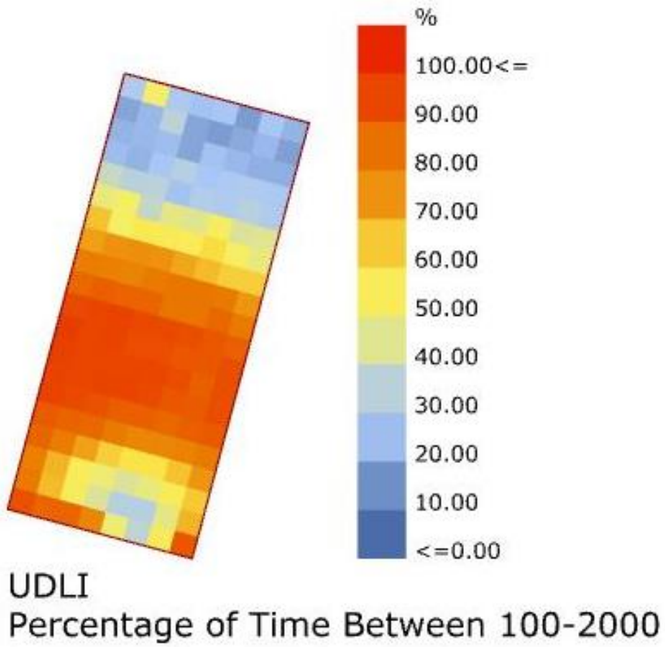


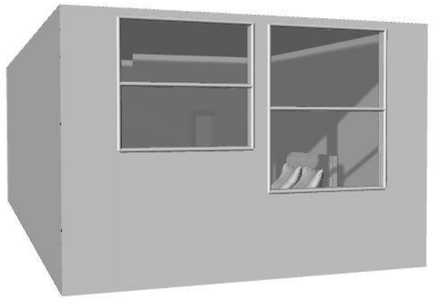
Annual Daylighting Analysis of Base Model



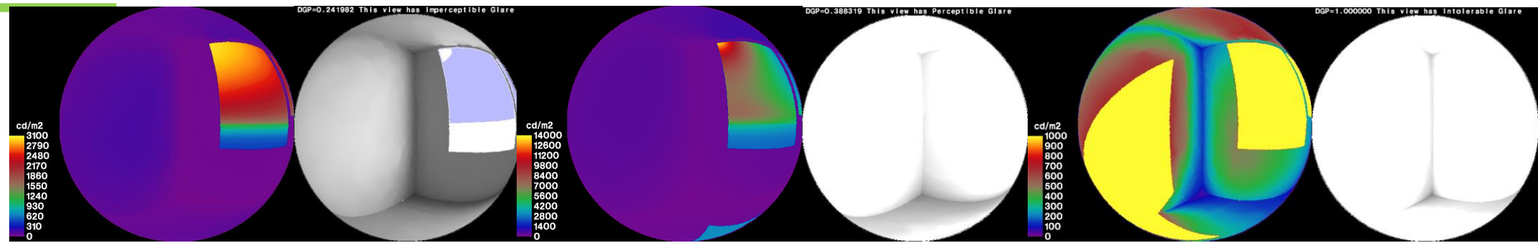
The analysis is for annual daylight analysis and the result is took from UDLI which is useful daylight illuminance based on percentage of hours which UDLI is between 100-2000. According to results, Much of the room has enough daylight within the considered boundary. The rest is unoccupied zone, so the room seem to be in good condition overall. Just below the right window is a bit dark and only around 30 % of the time that part is well daylit.



UDLI
Percentage of Time Between 100-2000

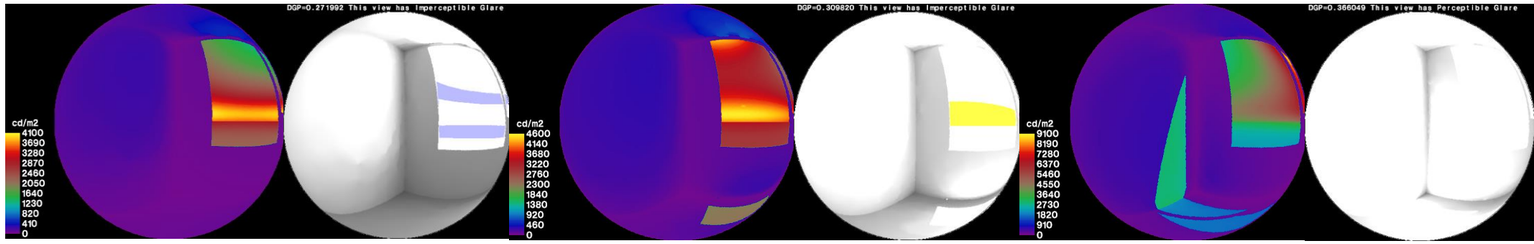


Glare Analysis of Base Model



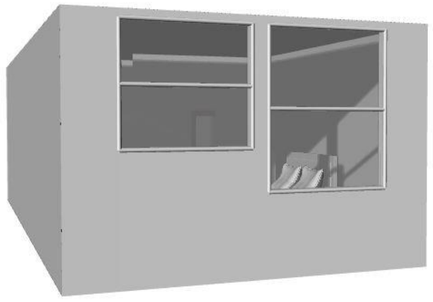
With glare analysis, the time format was same as daylighting analysis for better comprehension. The analysis receipt changed to image base analysis in grasshopper to get the glare result. The percentage of glare probability is shown on the top corner of each page. Imperceptible glare means that the mentioned view in that specific time has not glare issues, perceptible means that there are glare but it is tolerable and intolerable glare means the view has issues with glare.

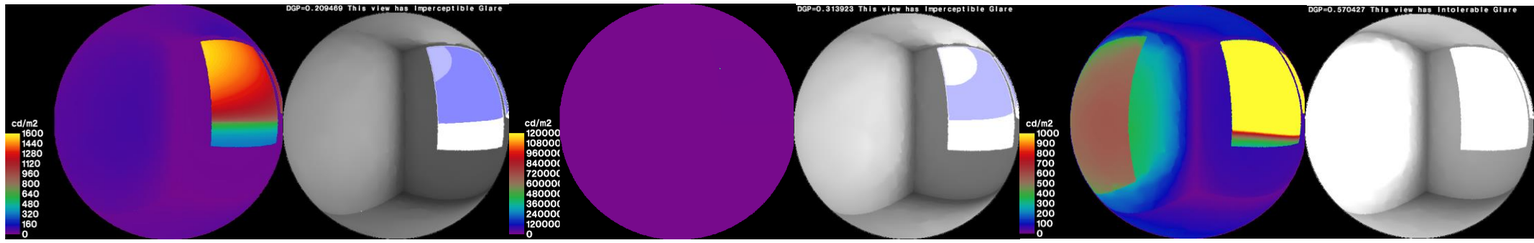
21 March 9:00 | 21 March 12:00 | 21 March 15:00



According to the results, most of the glare issue is for noon and afternoon and mainly in March and after that in June. The most Problematic time is March 15:00 which has intolerable glare. So in design a shading device we should be more careful about direct sunlight with high angle sun rather than low angle sun in the morning.

21 June 9:00 | 21 June 12:00 | 21 June 15:00





21 December 9:00 | 21 December 12:00 | 21 December 15:00

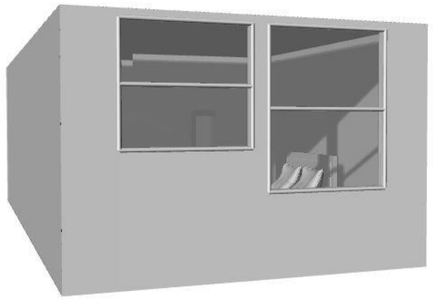
Energy Balance Analysis of Base Model

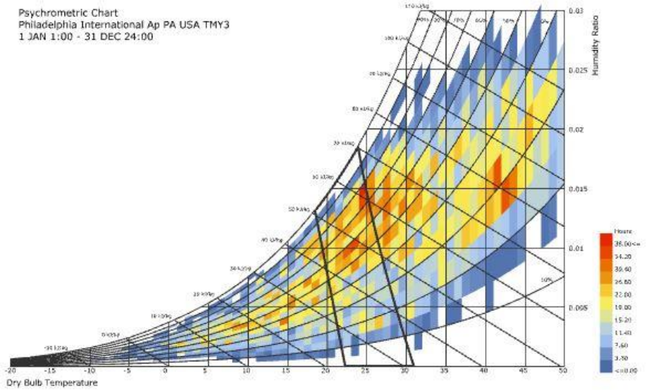
Thermal Comfort Based on Energy Simulation

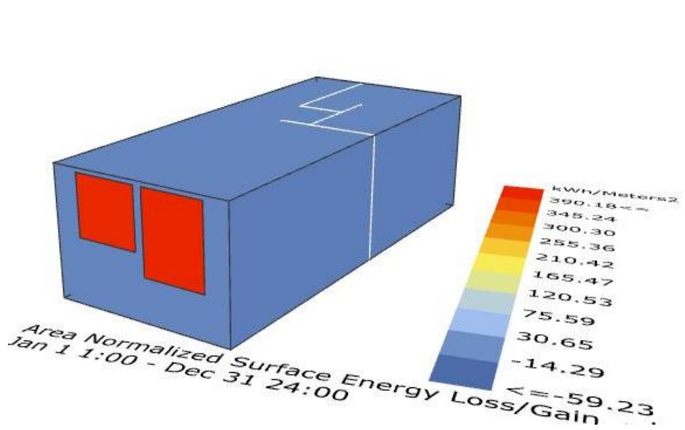
Existing Model

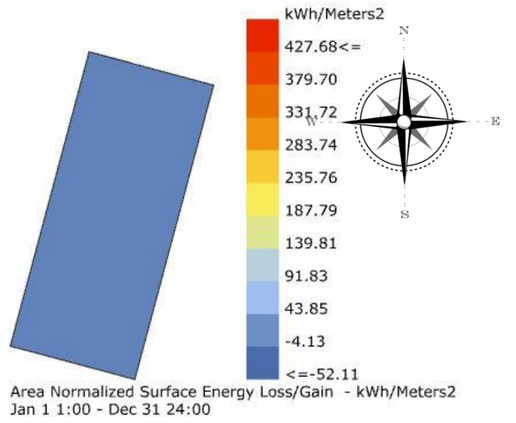
Much of the problem : Opaque Conduction & Solar Gain

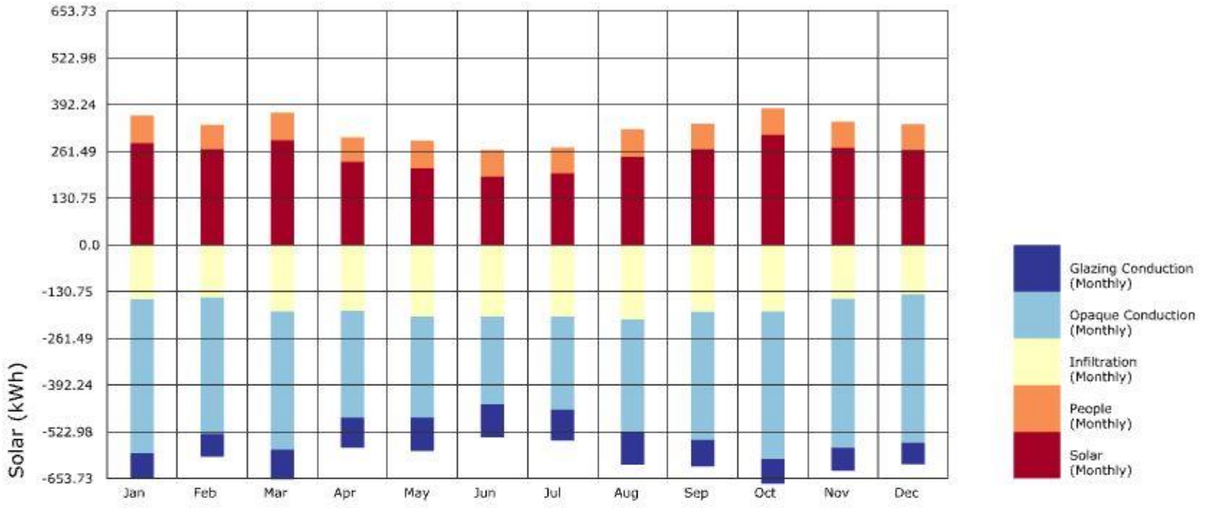
Percentage of Comfortable Hours : 18.63 %
Percentage of Hot hours : 39.35 %
Percentage of Cold hours : 42.02 %
Depth and Number of Blinds : 0
R value for Wall : 5.5
R value for Window : 1
R value for Roof : 9.2
Thermal Mass : Slab Construction
Air Change hour : 0

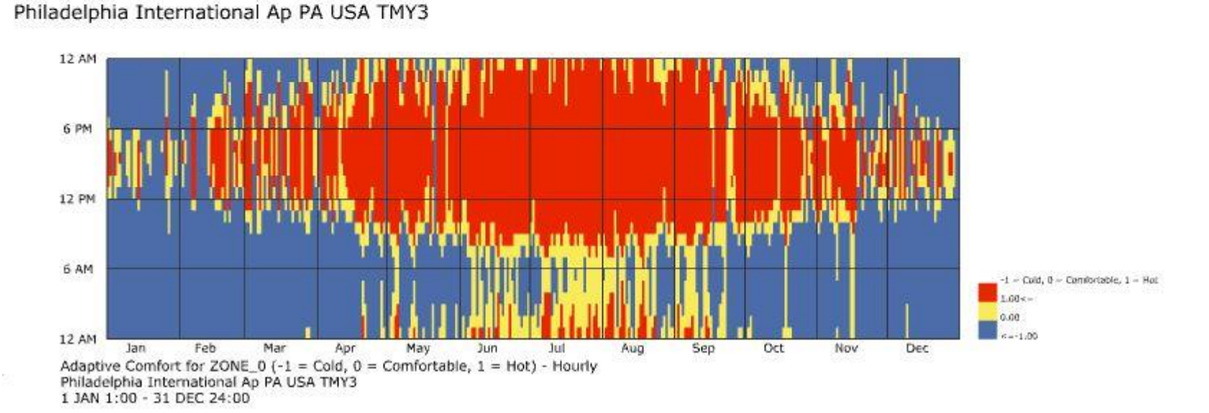












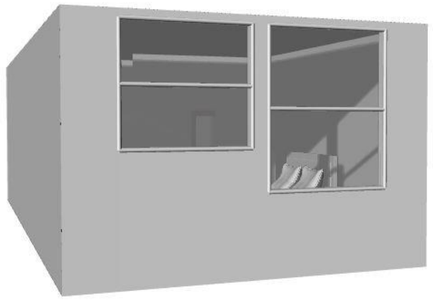
Energy Balance Analysis of Base Model

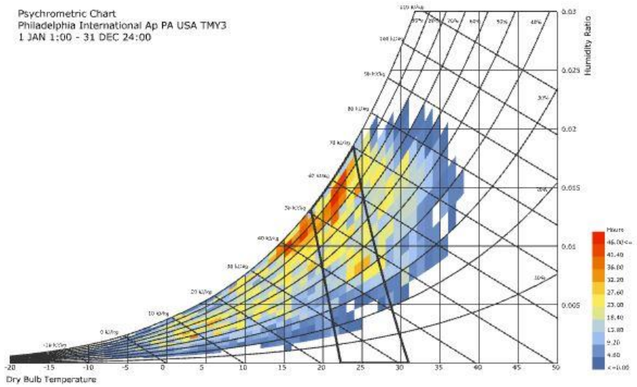
Natural Ventilation and Lighting Schedule Calculated

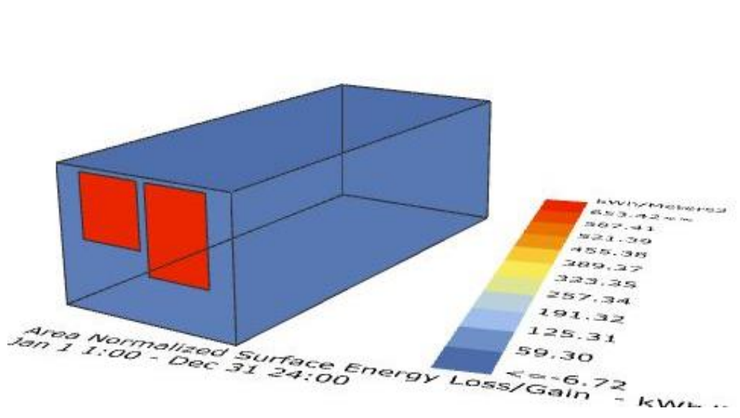
Existing Model

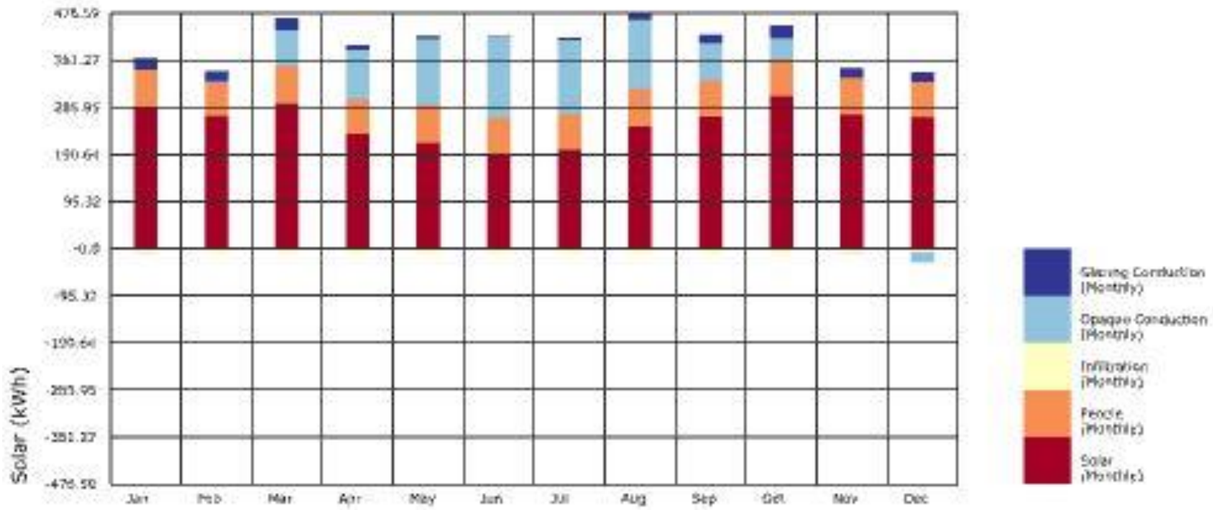
Much of the problem : Opaque Conduction & Solar Gain

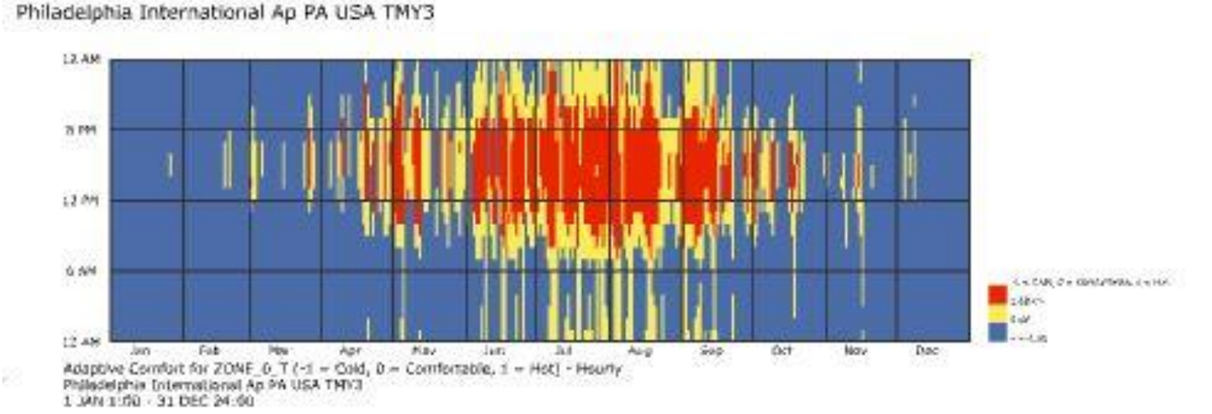
Percentage of Comfortable Hours : 17.05 %
Percentage of Hot hours : 11.93 %
Percentage of Cold hours : 71.02 %
Depth and Number of Blinds : 0
R value for Wall : 5.5
R value for Window : 1
R value for Roof : 9.2
Thermal Mass : Slab Construction
Air Change hour : 1











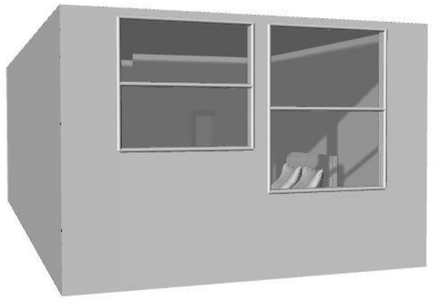
Major Design Issues and Strategies

Base Case Design Problems

- ***Glare Problems During Noon and Afternoon***
- ***Darkness of the Room Mostly During Morning***
- ***Room is Mostly Hot During Spring and Summer***
- ***Room is Mostly Cold During Winter and Fall***
- ***Solar Gain is Mostly from Window and Other Parts Don't Have Solar Gain***

Design Strategies

- ***Control the Glare with a Suitable Shading Device***
- ***Replace a Wider Window to Get Light More Deep into the Room***
- ***Control the Thermal Comfort with Materials and Thickness of the wall***
- ***Control the Coldness and Hotness of the Room with Natural Ventilation and Air Flow***



Trial and Error for Design Solution

- ***High R Values***
- ***Medium R Values*** ←
- ***Low R Values***

- ***Window Condition*** →
- ***Construction***
- ***Orientation***
- ***Air Flow Rate***
- ***Thermal Mass***

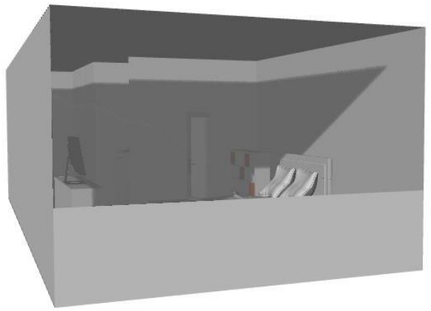
- ***Fully Window***
- ***Vertical Shading***
- ***Horizontal Shading***
- ***Number of Shading Devices***
- ***R Value of Windows***

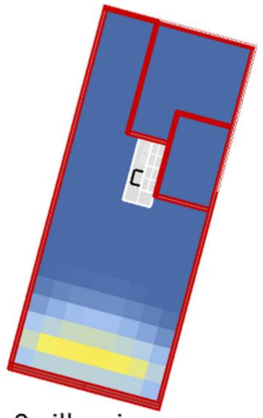
Trial and Error for a Better Daylighting

Widening the Window Horizontally

The first try was to make the window fully extended to see if we can make the light to penetrate more deep into the room and then think about shading the glare. The approach is that the light is coming deeper into the room but definitely the glare has became more.

The proposed idea is to improve the amount of light comes into the space and try to control the glare and unwanted lights with shading designs. Definitely, the amount of glare is more compared to the existing model. But the solution is to cover it with a shading design and the reason was to take the control of light coming into the area and also improve aesthetic part of the design simultaneously.





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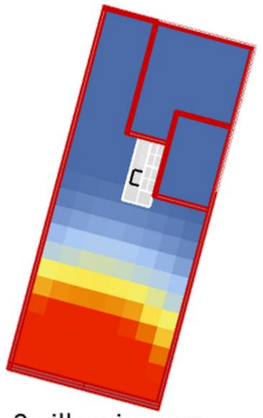

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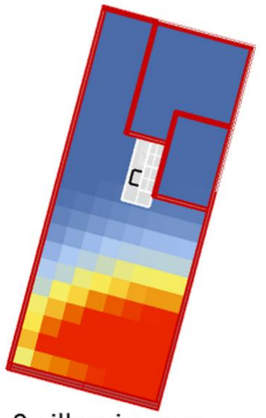

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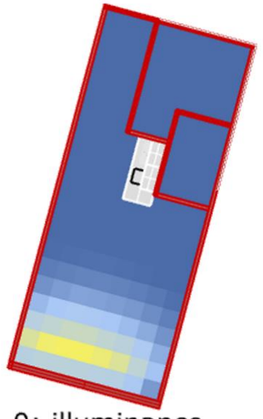

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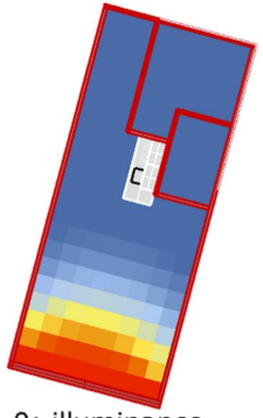

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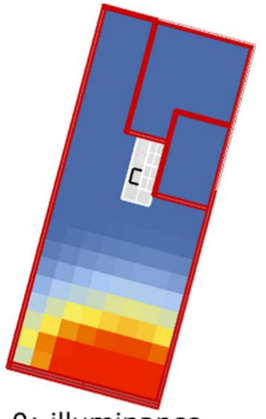

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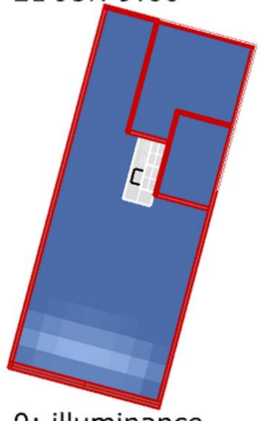

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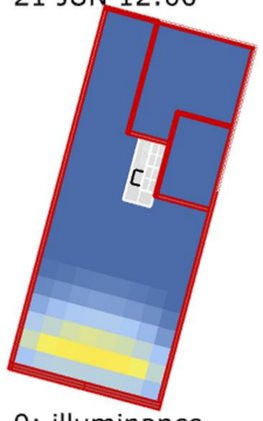

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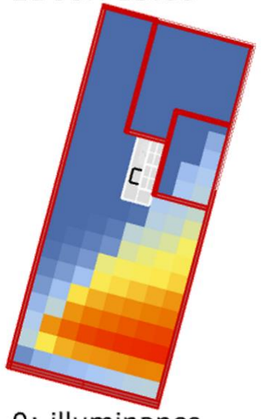

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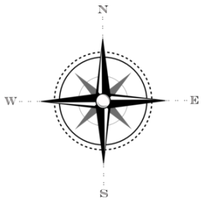
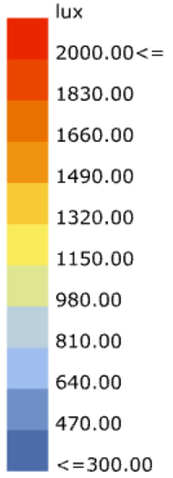
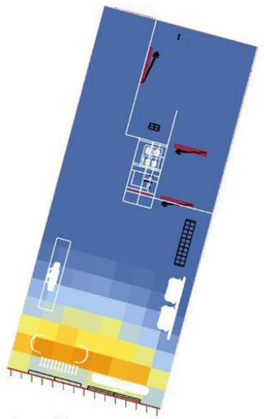




Trial and Error for a Better Daylighting

Adding Vertical Shading Device

Then the second try was to add some shading to see the effect of that on the glare. Some progress is happened but there are still so much glare in noon and afternoon overall. So an alternative shading should be considered.



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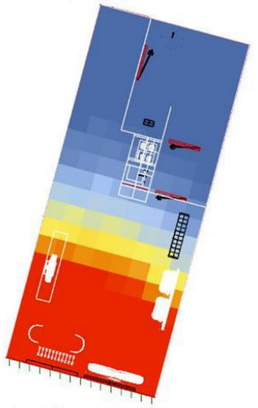

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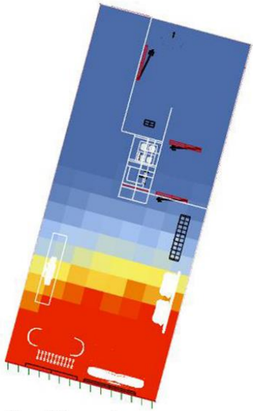

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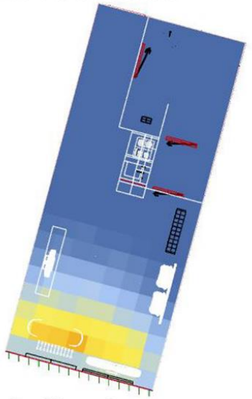

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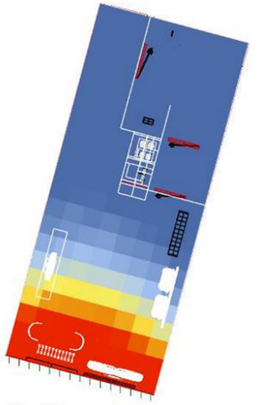

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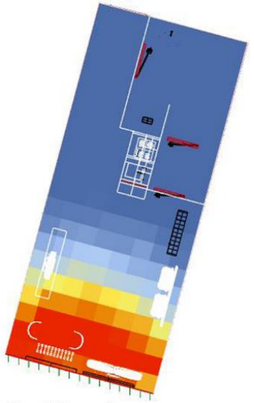

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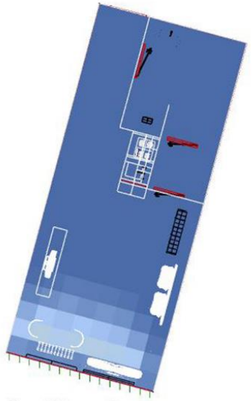

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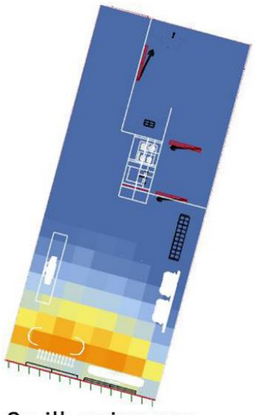

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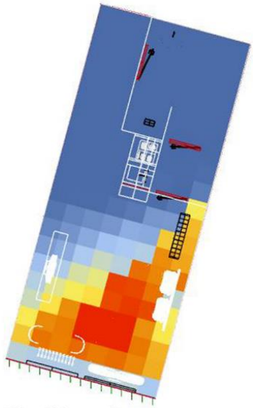
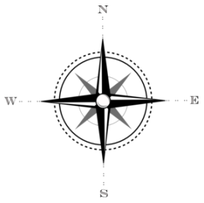
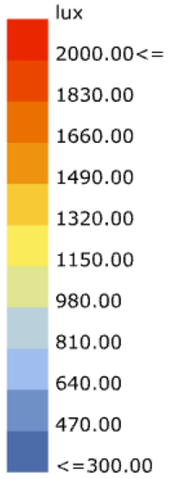


0: illuminance
21 DEC 15:00

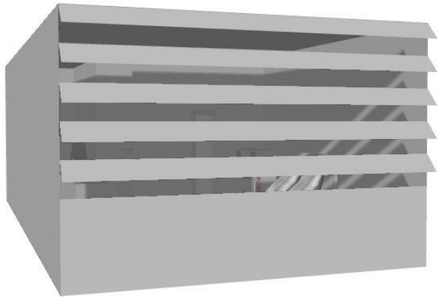


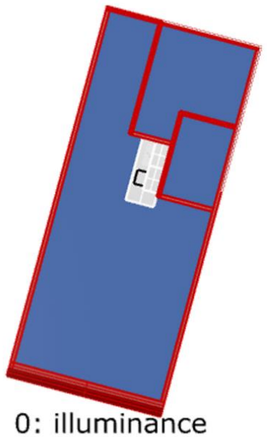


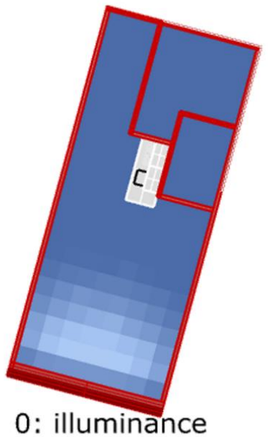
Trial and Error for a Better Daylighting

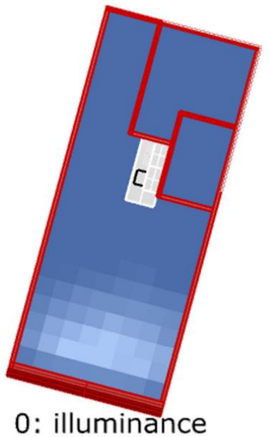
Changing Vertical Shading to Horizontal Shading

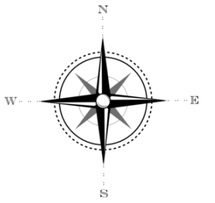
In this level, I tried to design a horizontal shading to cover much of the glare and compared to the analysis withought considering Rad Parameters, the amount of daylight coming to the space has became pretty low. Most of the times the illuminance values are 300 Lux or less than that. Thus, maybe there would be more need of daylight penetration into the area. The resaon to add horizontal shading was to control a huge amount of glare and see how this kind of shading can effect the internal spaces. In comparison to vertical shading the effect is much higher, but the problem is it has became too dark.

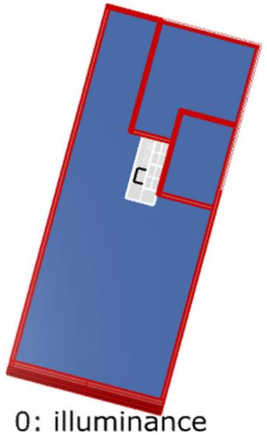


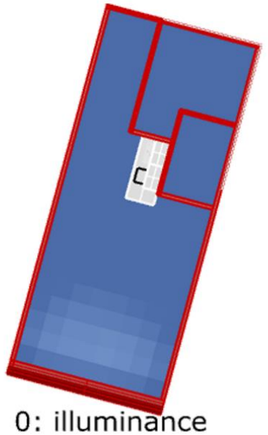


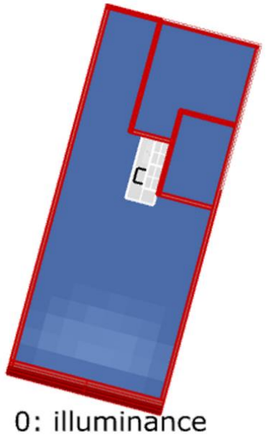


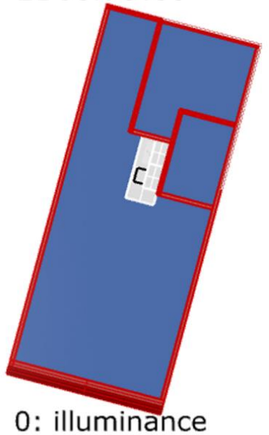


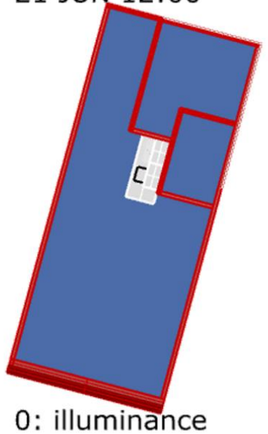


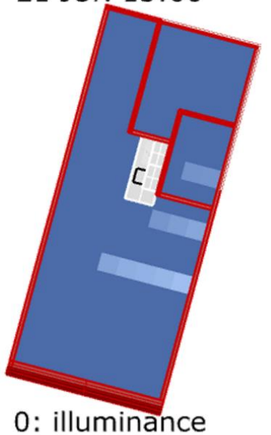


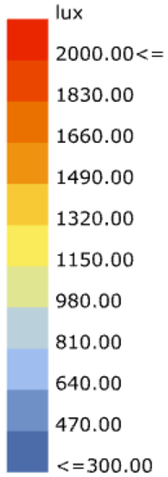




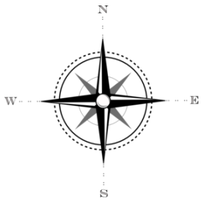






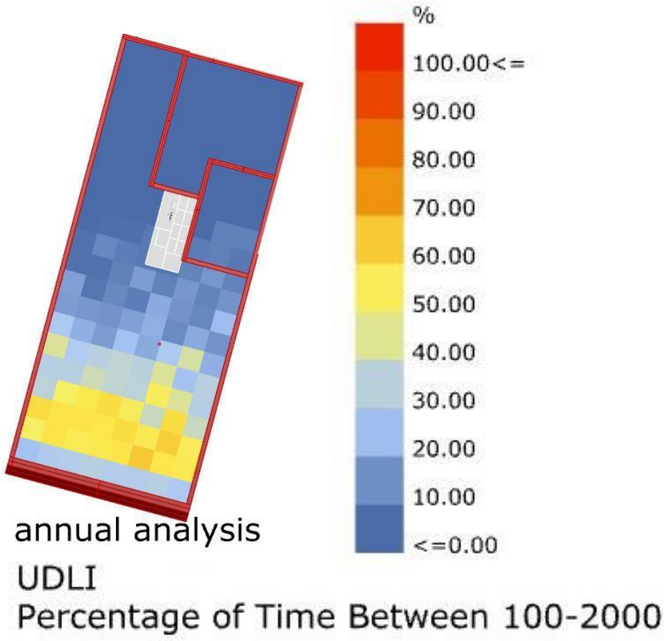


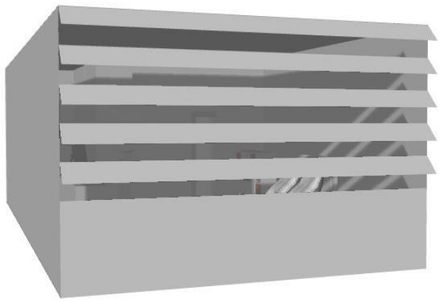
Trial and Error for a Better Daylighting



Annual Analysis for Horrizontal Shading

I ran the annual analysis for the horizontal shading design from point in time grid based analysis. The problem with my final design was that although almost all of the glare was omitted, but the amount of daylight illuminance had become low and much of the room was not bright at all. As it can be seen from the annual daylight analysis, not a huge portion of room can have useful daylight during a year. And the highest percentage can go up to roughly 60 % in the parts that the room have daylight. So this shading can not be really useful for a desired room.

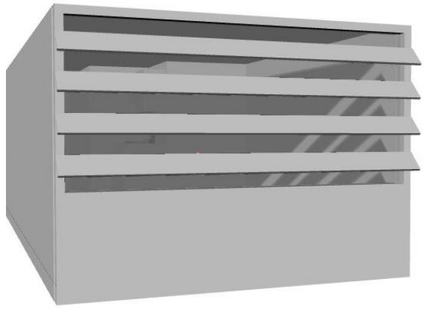


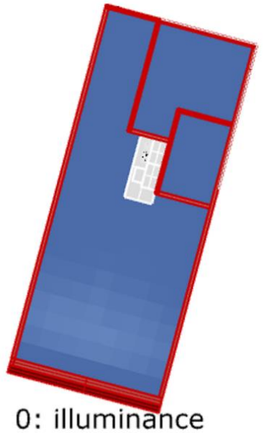


Trial and Error for a Better Daylighting

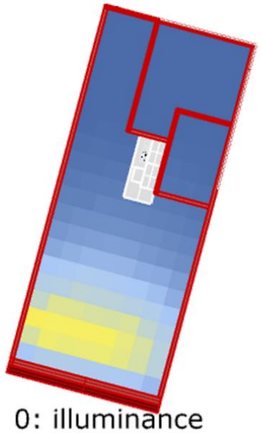
Change Numbers of Horizontal Shading

Decreasing the number of horizontal shading cause in a better result which the amount of daylighting is better than the previous one. In this case, it seems that we would not have any glare issues and the illuminace levels of daylight is pretty much acceptable. So that can be a good shading design solution for glare issues. Yet it may still be too dark in some parts specially in the morning. We should make some changes to get a better daylight in the room.

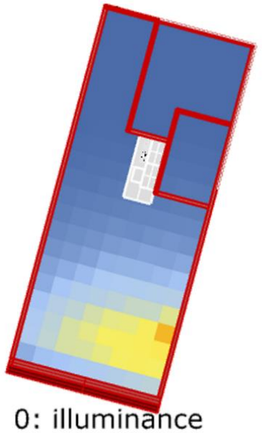




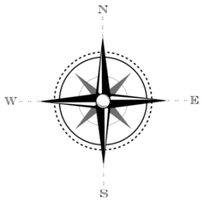
0: illuminance
21 MAR 9:00

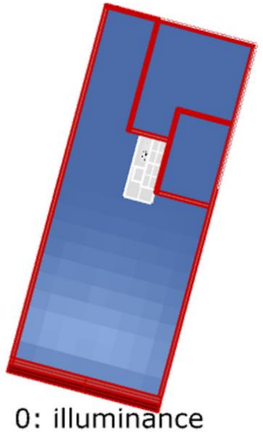


0: illuminance
21 MAR 12:00

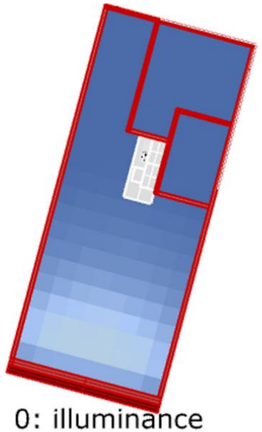


0: illuminance
21 MAR 15:00





0: illuminance
21 JUN 9:00



0: illuminance
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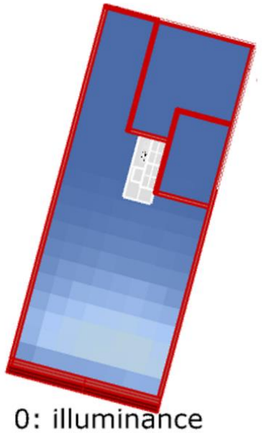

0: illuminance
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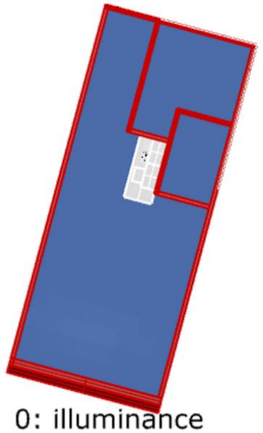
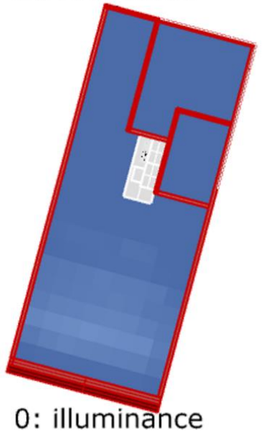


0: illuminance
21 DEC 9:00



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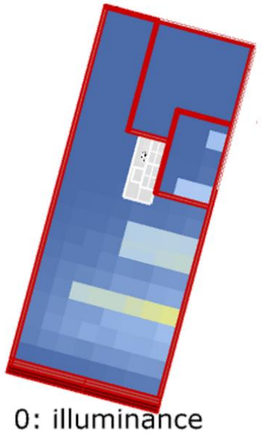

0: illuminance
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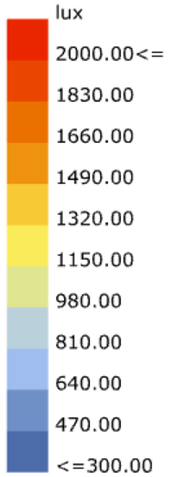
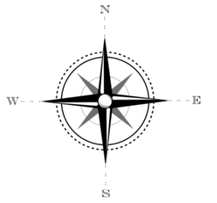
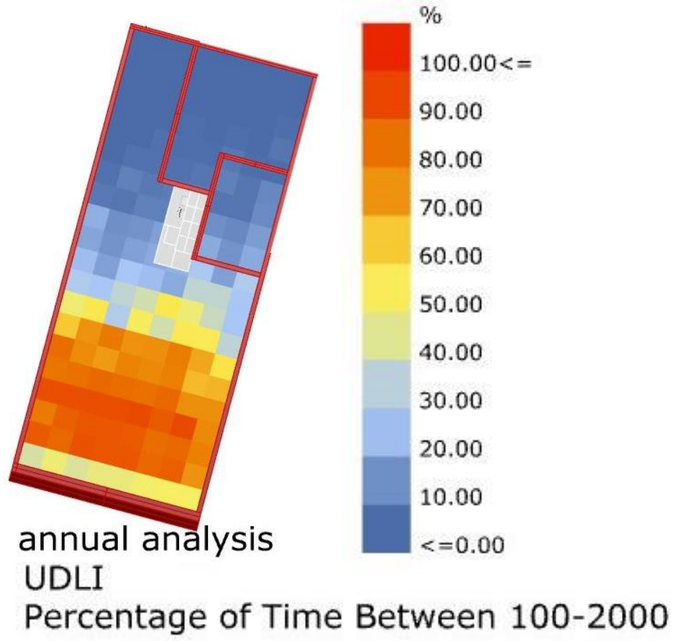


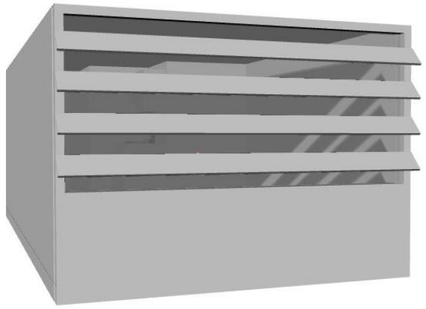
Trial and Error for a Better Daylighting



Annual Analysis for Revised Horrizontal Shading

In the second step, I changed the number of horizontal shadings into 4 instead of 5 and I increased the spaces between each shading to improve the amount of daylight which is penetrated into the room. I ran the annual analysis for my revised shading design and with regards to the results which I am getting, it is apparently enhanced to a great deal in terms of UDI and now much of the room has useful light up to even 90-100 % over a year. So the change was useful in my design, Now the question is what would be the point in time daylight in this situation? I checked that analysis for this shading design to see if that would cause a problem in terms of glare probability. The other thing was whether I can improve UDI for this room and still keep the problematic parts in terms of glare covered.

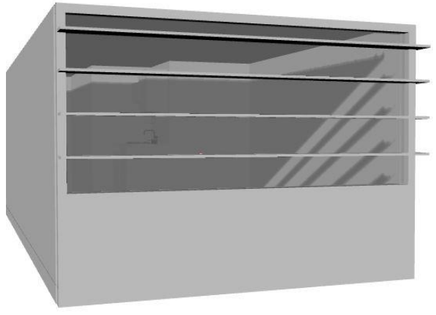


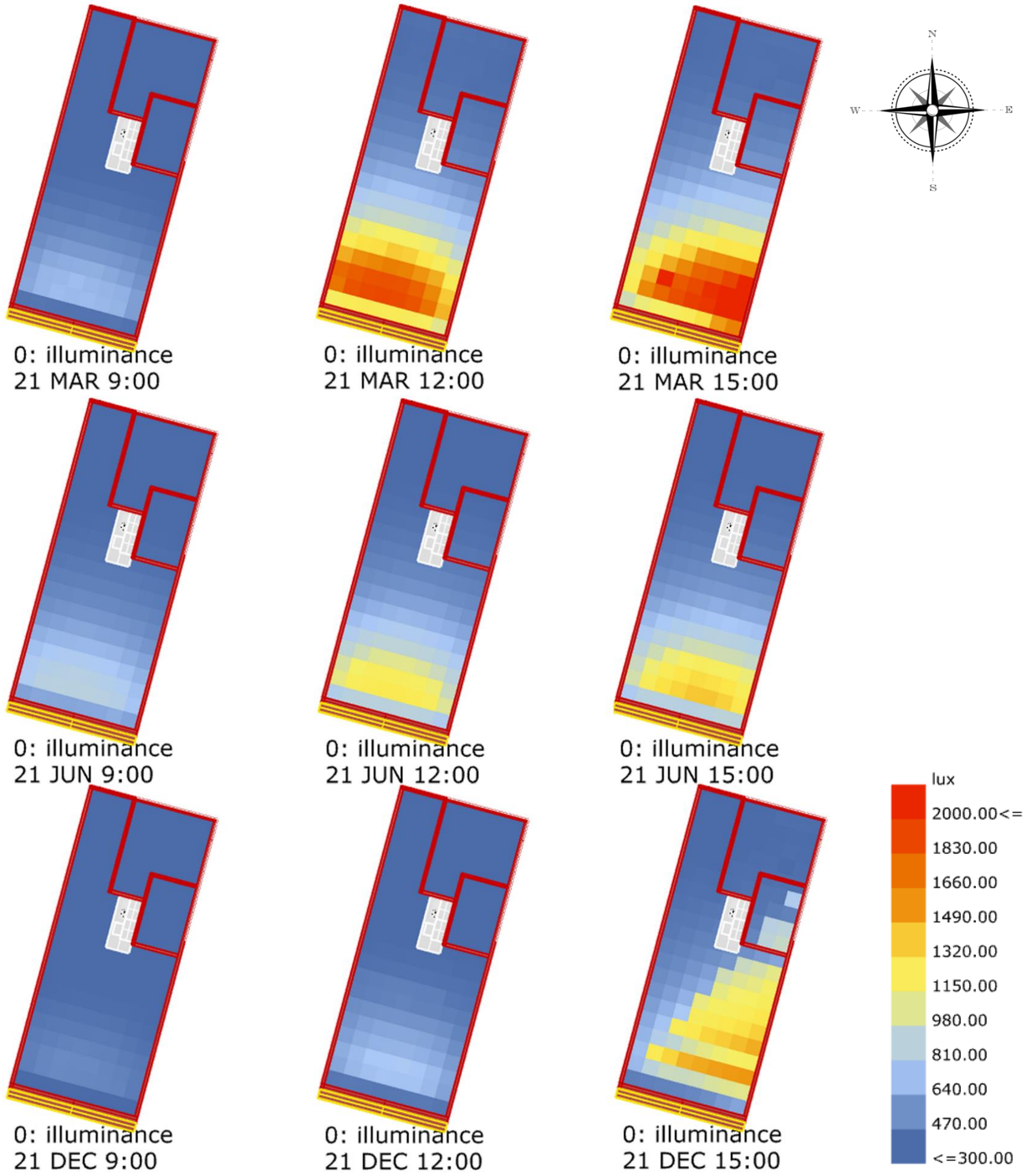


Trial and Error for a Better Daylighting

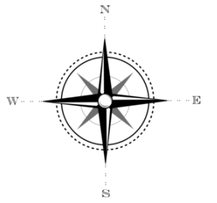
Change Angle of Horizontal Shading

In this improved case which gave me the best result for UDI, we are having problem with glare in noon and afternoon of March and probably some other times which is not analyzed. But apparently the times that we have no glare is much more than the times that we have glare. So it is either having glare in some rare times or being not well daylit. With this comparison this design mag be better and more efficient.



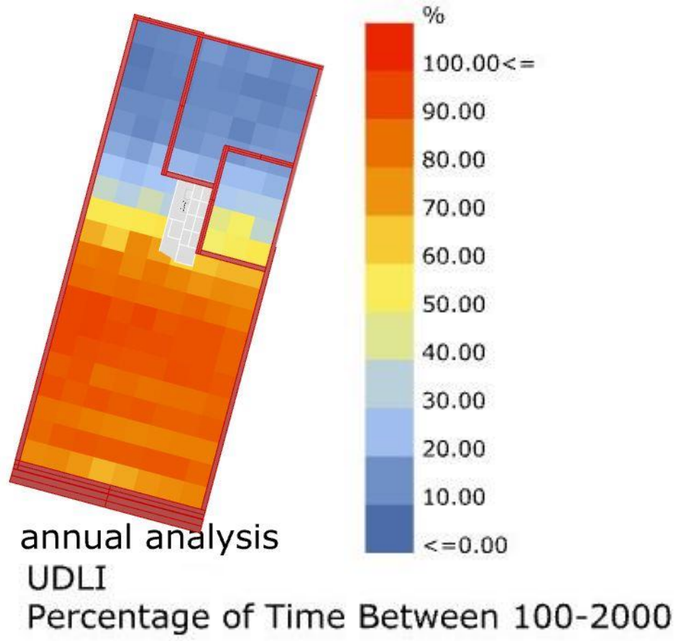


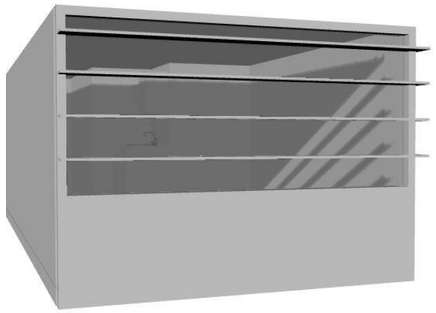
Trial and Error for a Better Daylighting



Annual Analysis for Final Revised Horrizontal Shading

In the final step, I changed the angle of horizontal shadings to let more of the light come into the room. I changed the angle into completely horizontal and perpendicular to window. As it can be seen from annual daylight analysis, now almost all useful part of the room can have daylight to a completely acceptable percentage. The other parts are just corridor and closed spaces and I don't really want them to be bright. So the problem with UDI is apparently solved. The only thing is that with this design I will probably have glare in parts of the room. So I ran the point in time analysis for both of my new designs to see the result of glare in my room.



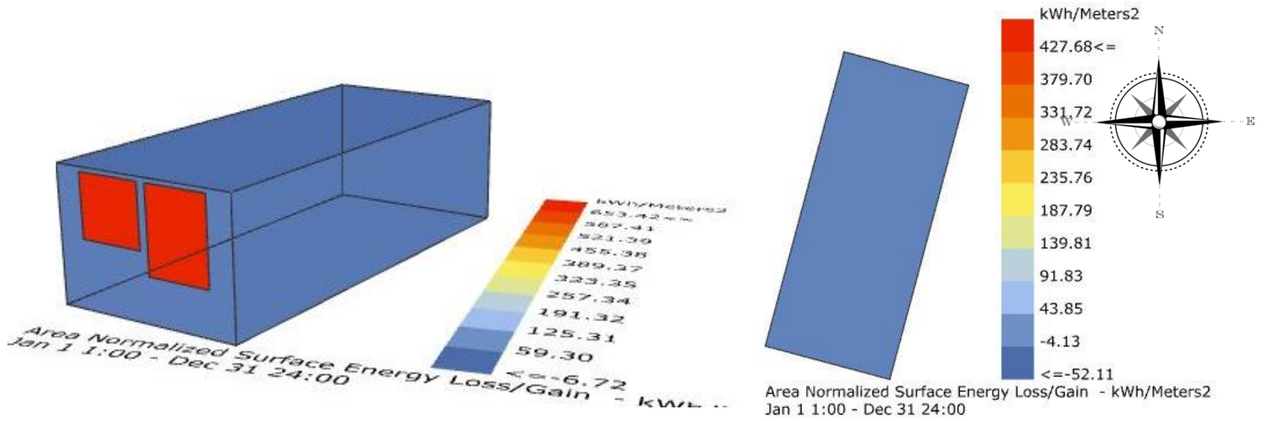


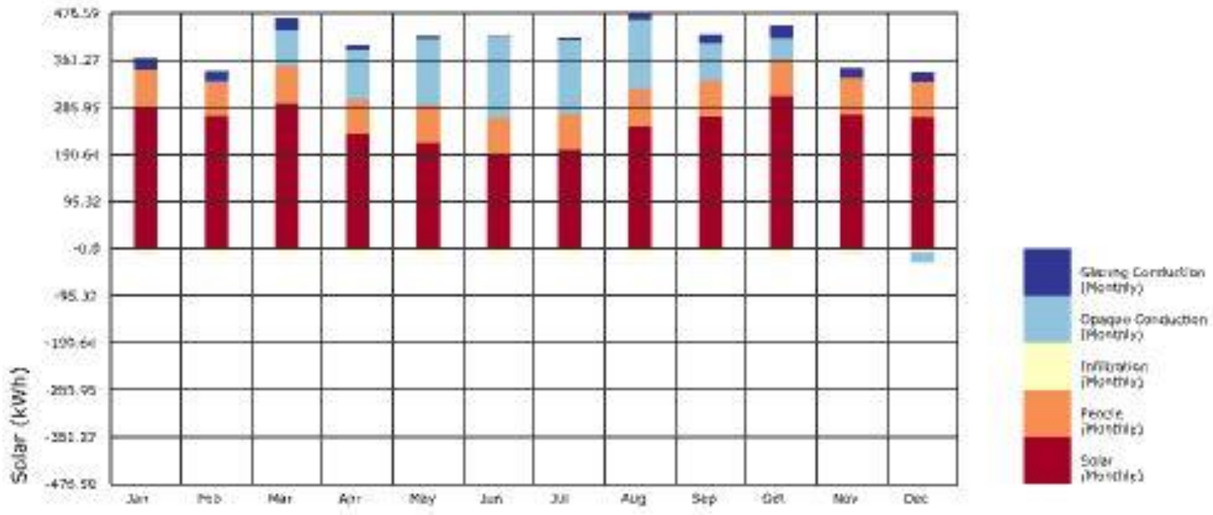
Energy Balance Analysis of Base Model

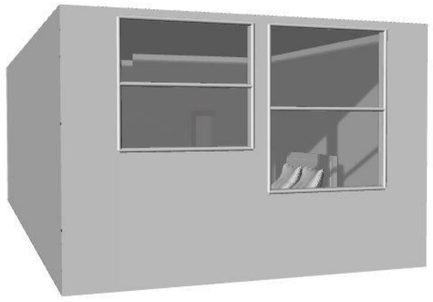
This is the base case analysis of Energy Simulation

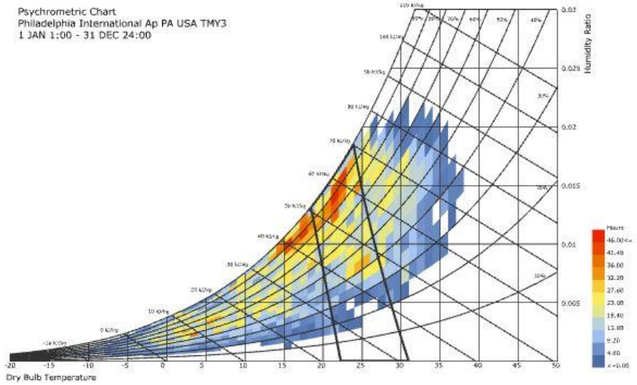
The try is to improve the percentage of comfortable hours by changing the parameters stated below. Changing the blinds condition, window size, thermal mass and construction materials.

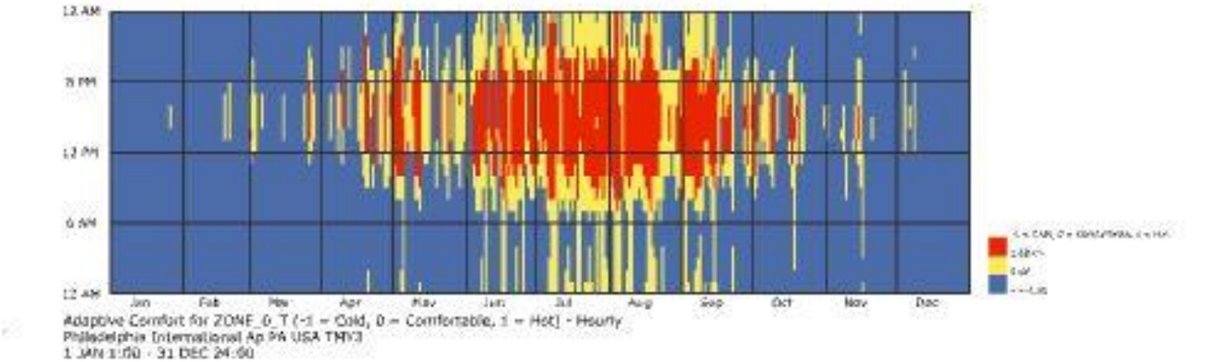
Percentage of Comfortable Hours : 17.05 %
Percentage of Hot hours : 11.93 %
Percentage of Cold hours : 71.02 %
Depth and Number of Blinds : 0
R value for Wall : 5.5
R value for Window : 1
R value for Roof : 9.2
Thermal Mass : Slab Construction
Air Change hour : 1







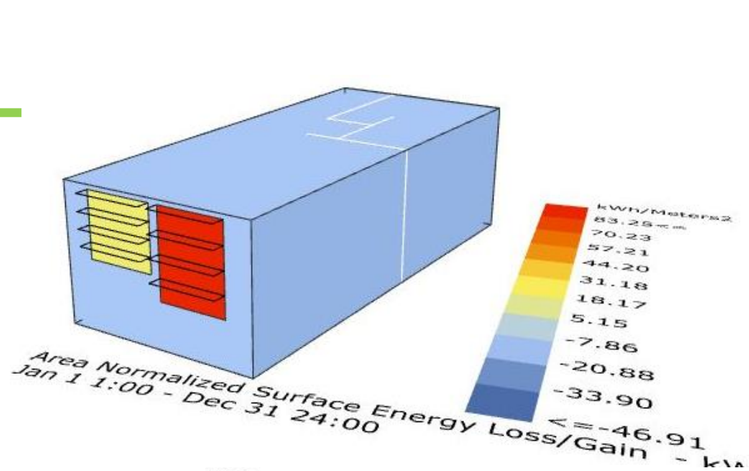


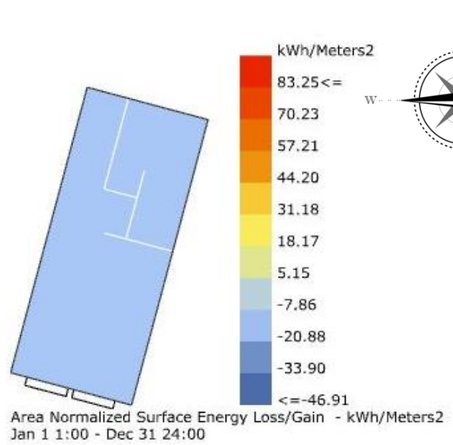


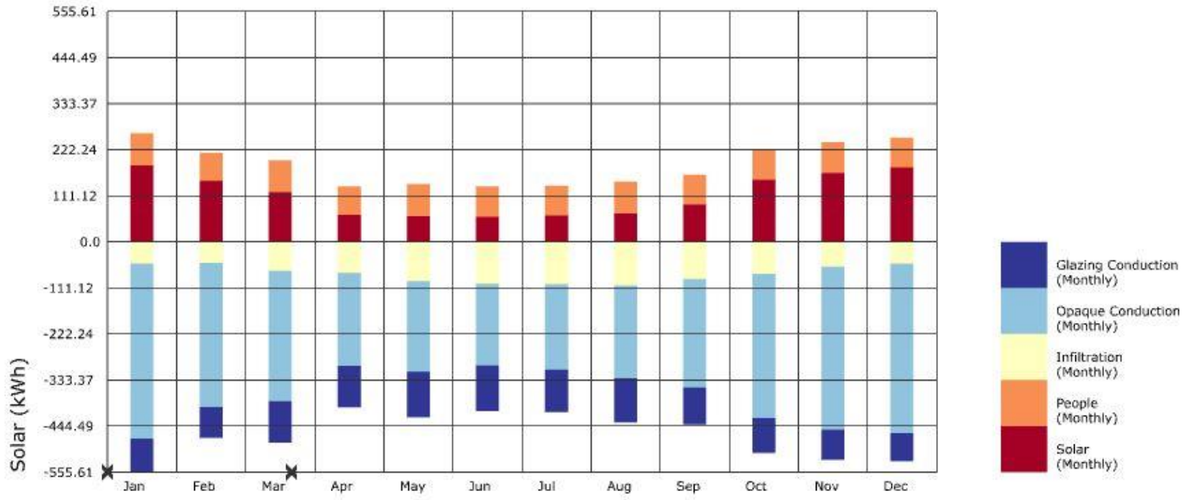
Trial and Error for a Better Thermal Comfort

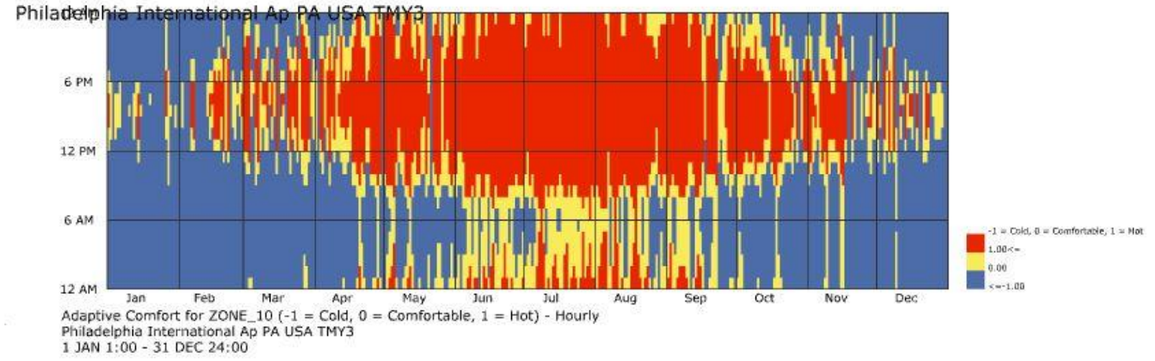
First Try
Blinds were added
Solar Gain Became less
Much of the problem : Opaque Conduction

Percentage of Comfortable Hours : 19.78 %
Percentage of Hot hours : 33.96 %
Percentage of Cold hours : 46.26 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 5.5
R value for Window : 1
R value for Roof : 9.2
Thermal Mass : Slab Construction
Air Change hour : 0





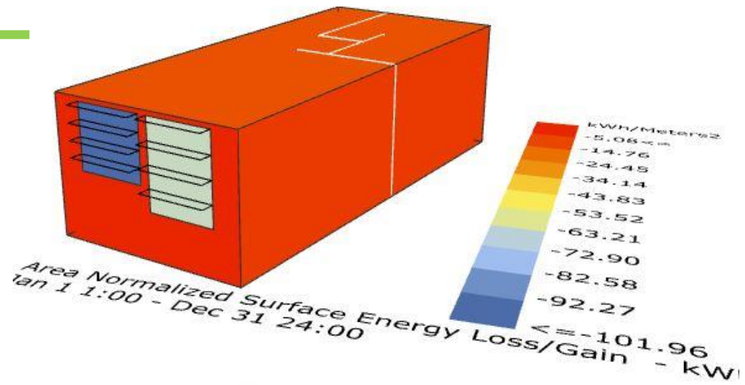


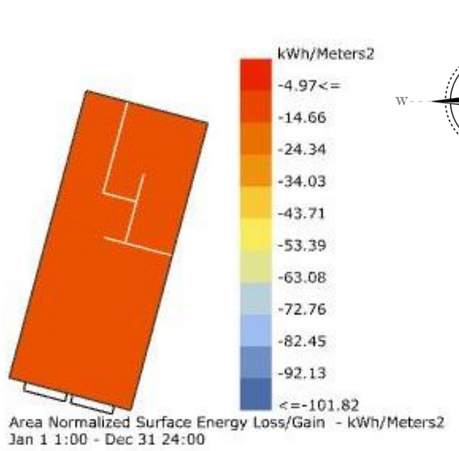


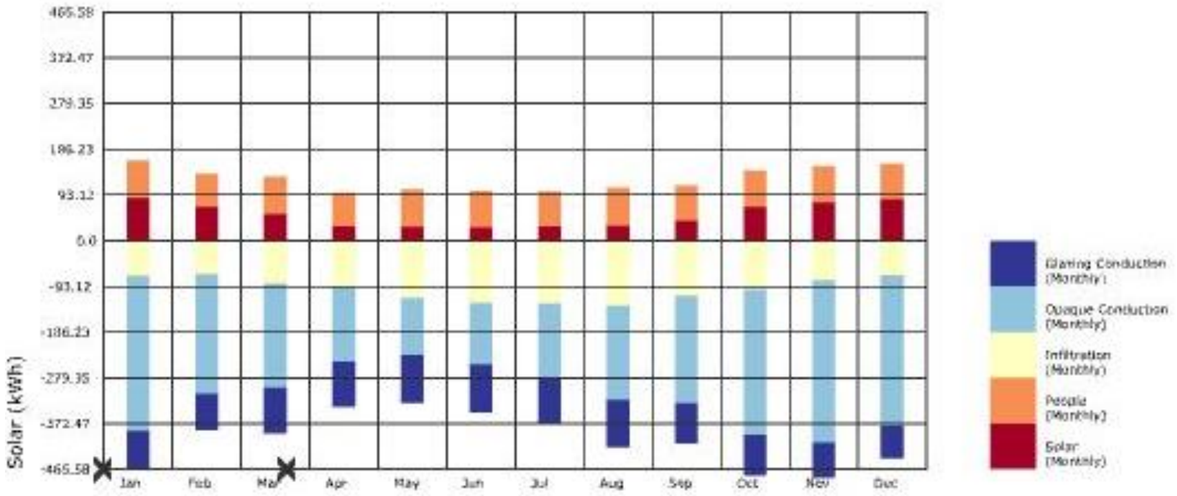
Trial and Error for a Better Thermal Comfort

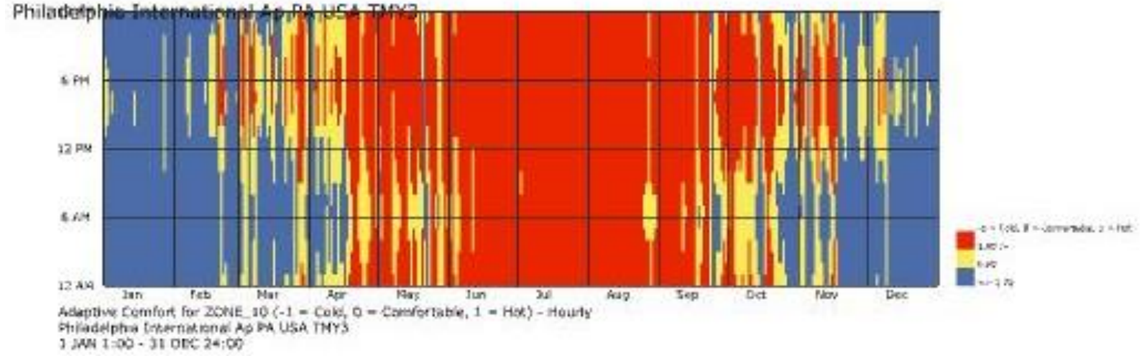
Higher R values were considered
Solar Gain Became less
Much of the problem : Still Opaque Conduction which was not expected due to higher R values

Percentage of Comfortable Hours : 19.67 %
Percentage of Hot hours : 45.7 %
Percentage of Cold hours : 34.63 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 8.7
R value for Window : 1.7
R value for Roof : 14.8
Thermal Mass : Slab Construction
Air Change hour : 0





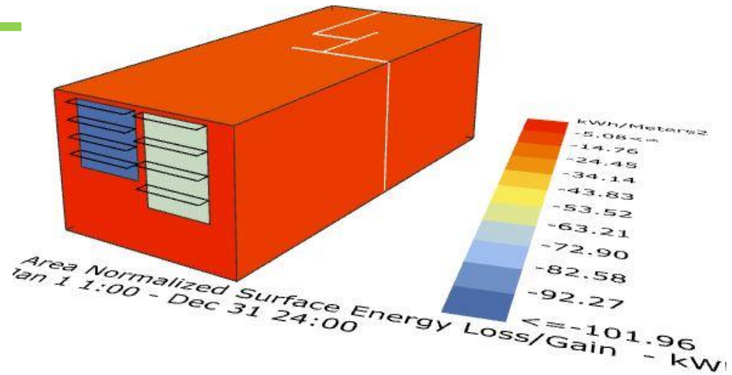


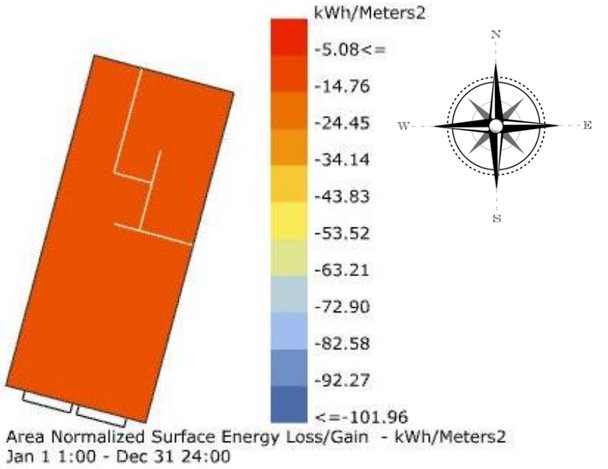


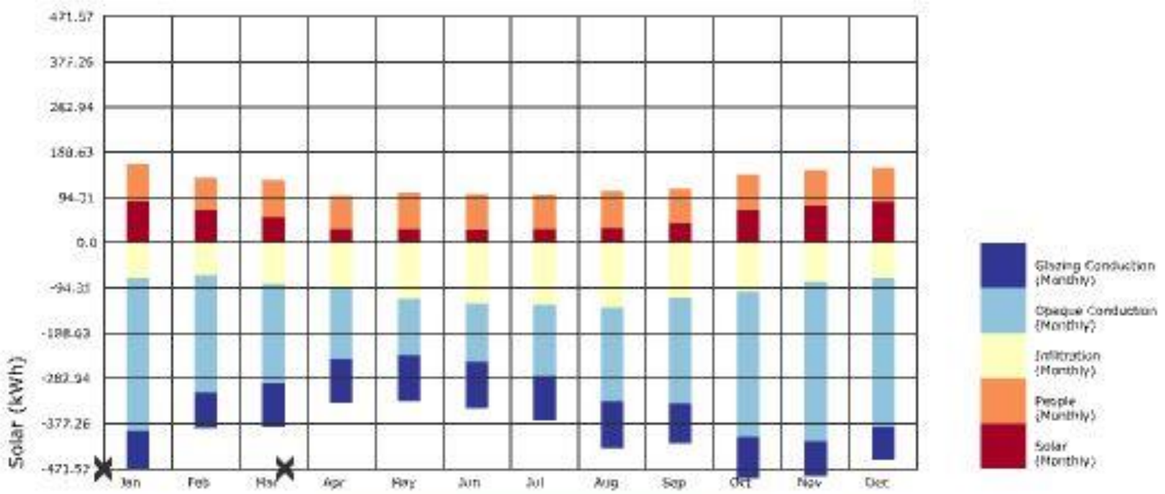
Trial and Error for a Better Thermal Comfort

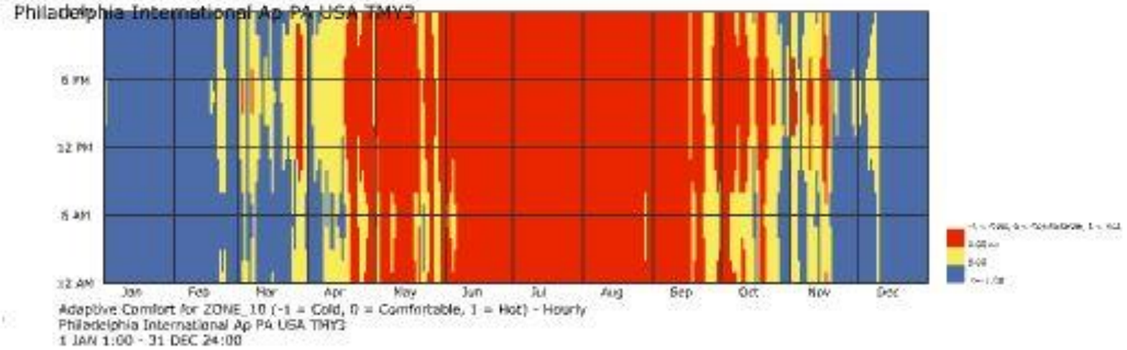
Thermal Mass changed
Solar Gain Became less
Much of the problem : Still Opaque Conduction which was not expected due to higher R values
Not so much changed occurred

Percentage of Comfortable Hours : 19.99 %
Percentage of Hot hours : 45.97 %
Percentage of Cold hours : 34.04 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 8.7
R value for Window : 1.7
R value for Roof : 14.8
Thermal Mass : 4 inch concrete
Air Change hour : 0



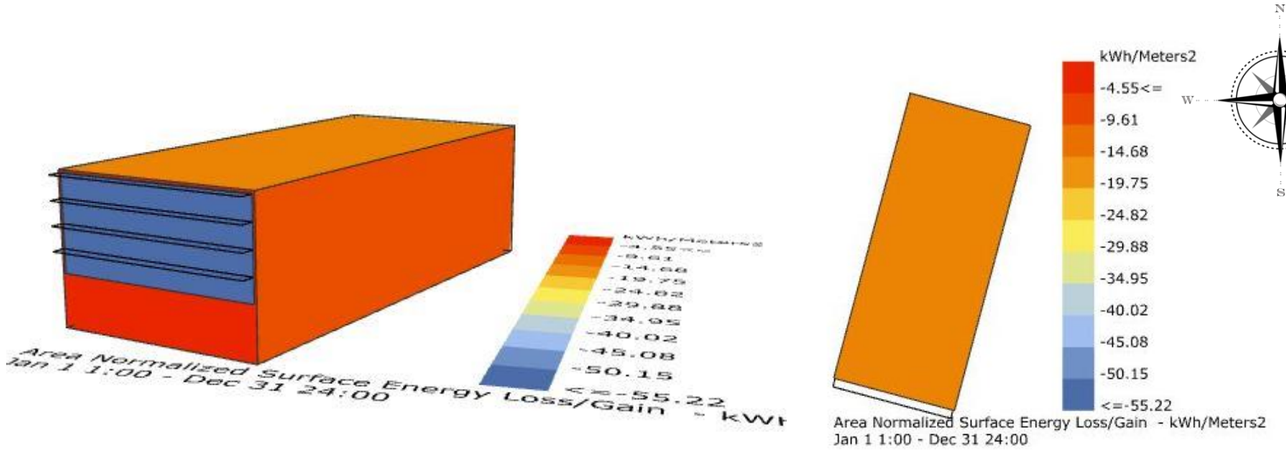






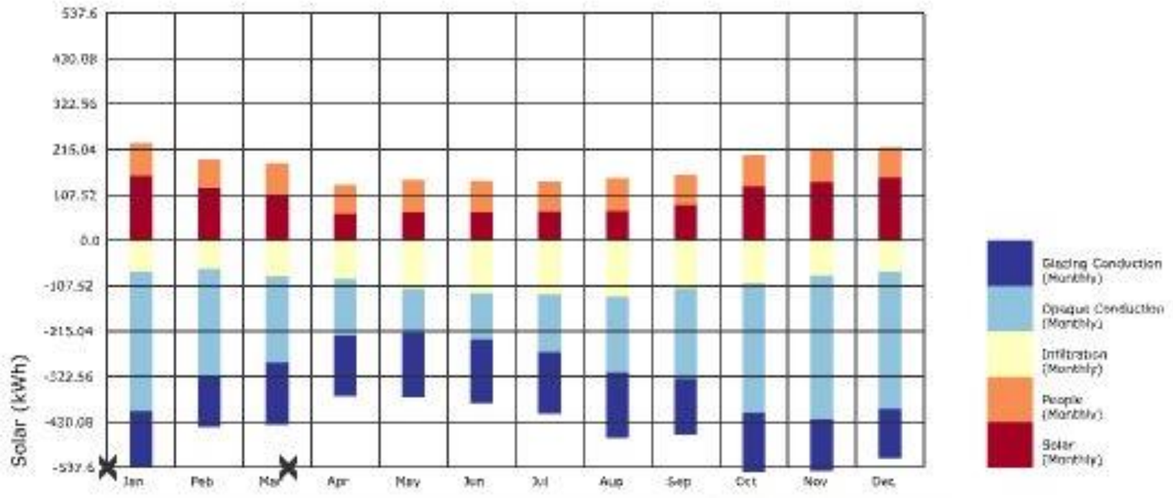
Trial and Error for a Better Thermal Comfort

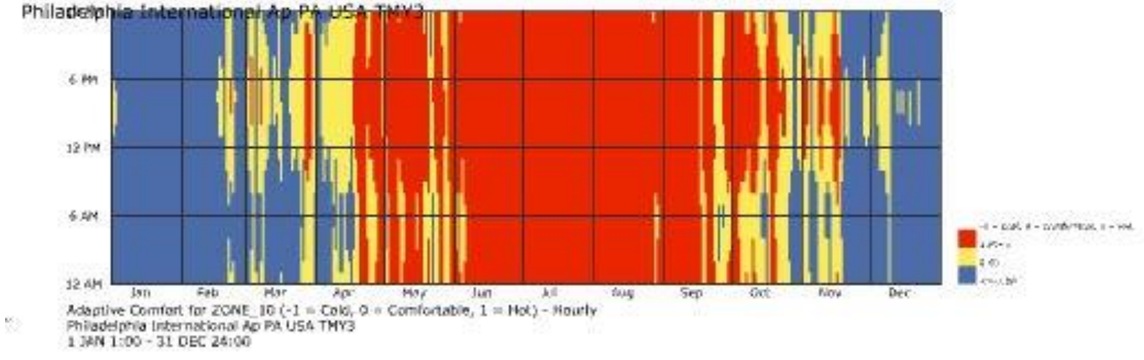
Much of the problem : Opaque Conduction and Glazing construction



Extended Horizontal Window Substituted

Percentage of Comfortable Hours : 20.53 %
Percentage of Hot hours : 45.29 %
Percentage of Cold hours : 34.19 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 8.7
R value for Window : 1.7
R value for Roof : 14.8
Thermal Mass : 4 inch concrete
Air Change hour : 0

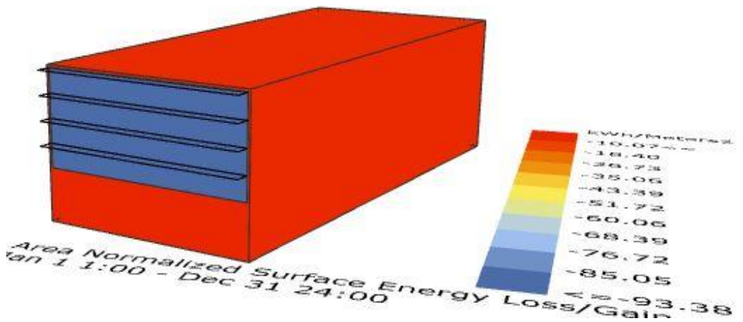


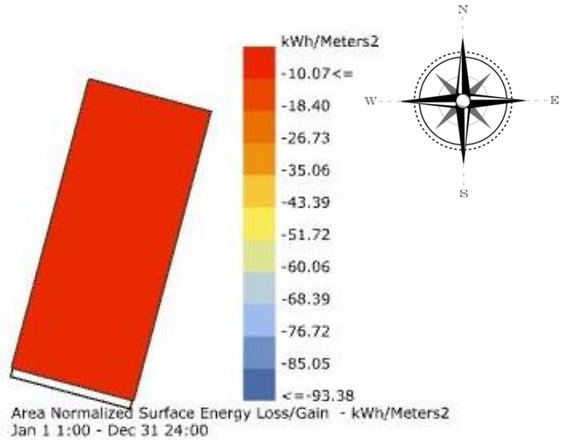


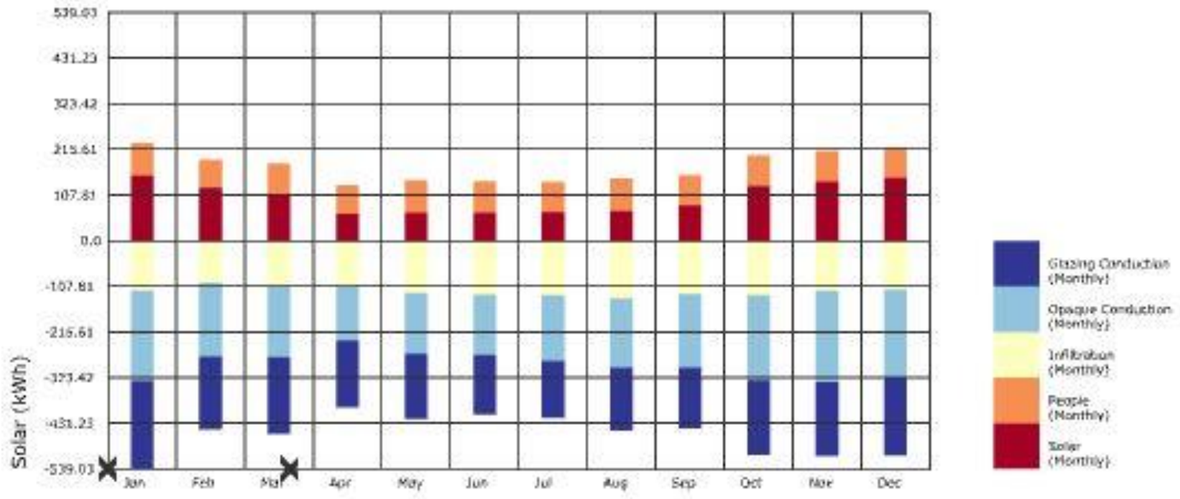
Trial and Error for a Better Thermal Comfort

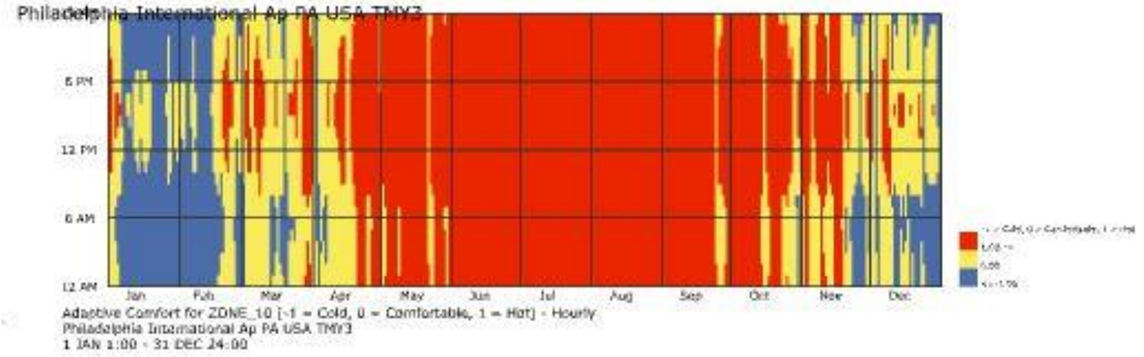
R values changed to highest value
Much of the problem : Opaque Conduction and Glazing construction
Percentage of comfortable hours became higher, but percentage of hot hours became extremely high due to trapping the air inside the room

Percentage of Comfortable Hours : 26.63 %
Percentage of Hot hours : 57.48 %
Percentage of Cold hours : 15.89 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 1.9
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2







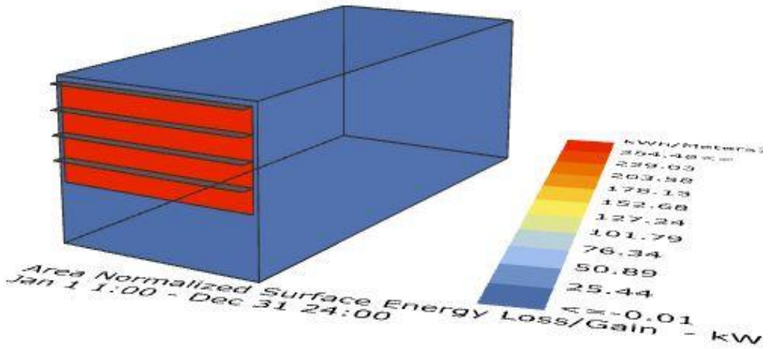


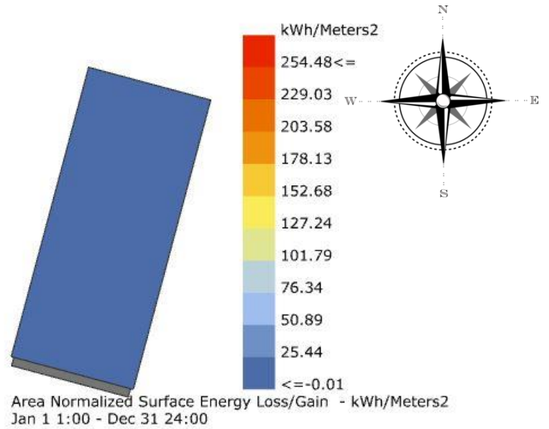
Trial and Error for a Better Thermal Comfort

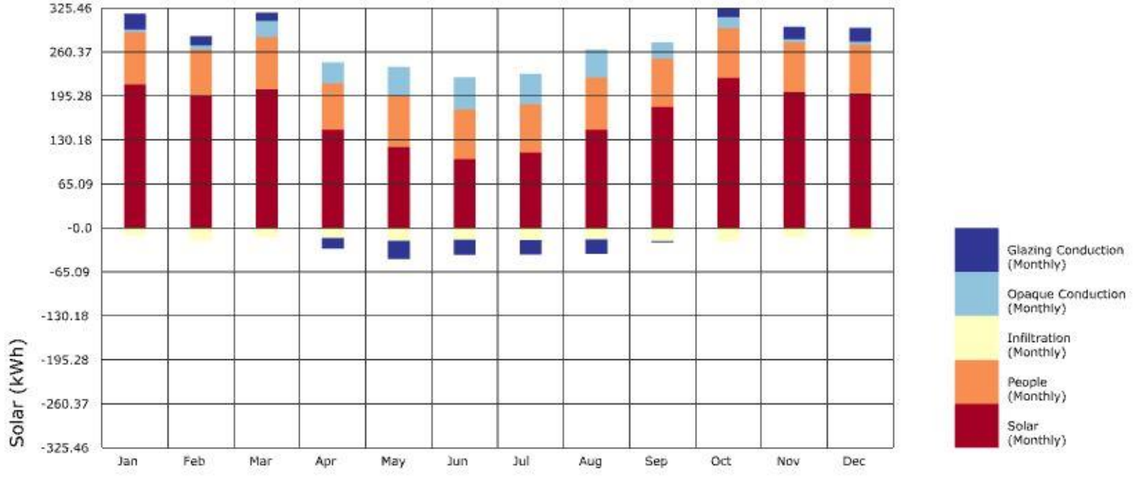
Natural Ventilation and Lighting Schedule added to the Design
Much of the problem : Solar Gain

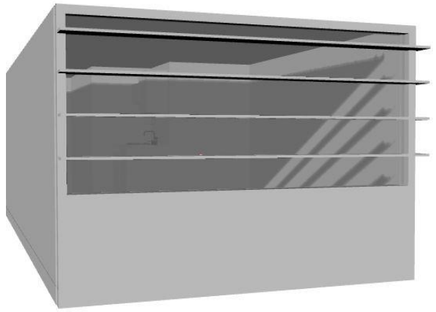
In this Level I added natural ventilation and lighting schedule to the design solution and tried to get a better percentage with these considerations. According to the results, most of the time the problem is with coldness and that should be considered in following changes in parameters.

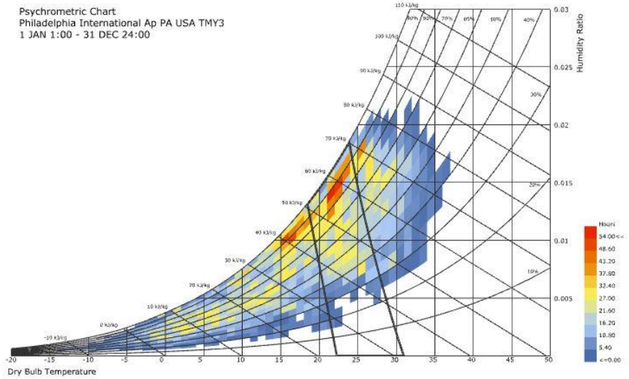
Percentage of Comfortable Hours : 20.05 %
Percentage of Hot hours : 5.67 %
Percentage of Cold hours : 74.28 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 1.9
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2

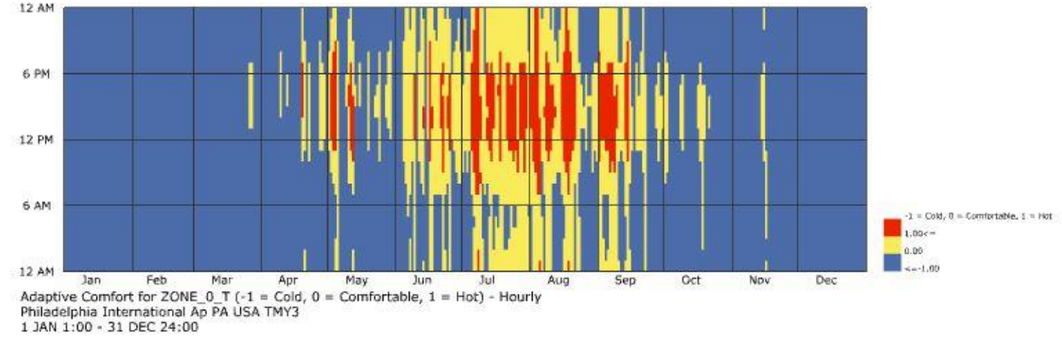










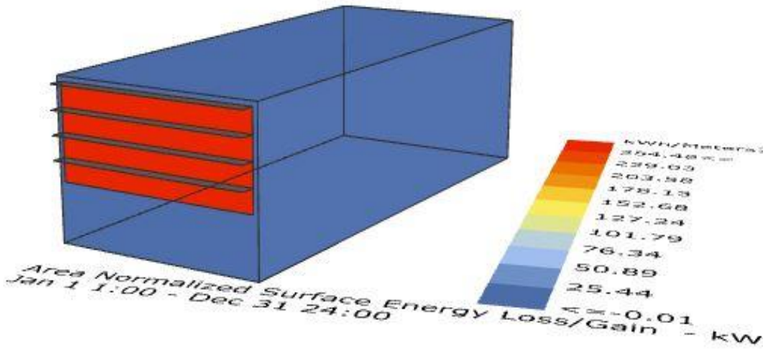


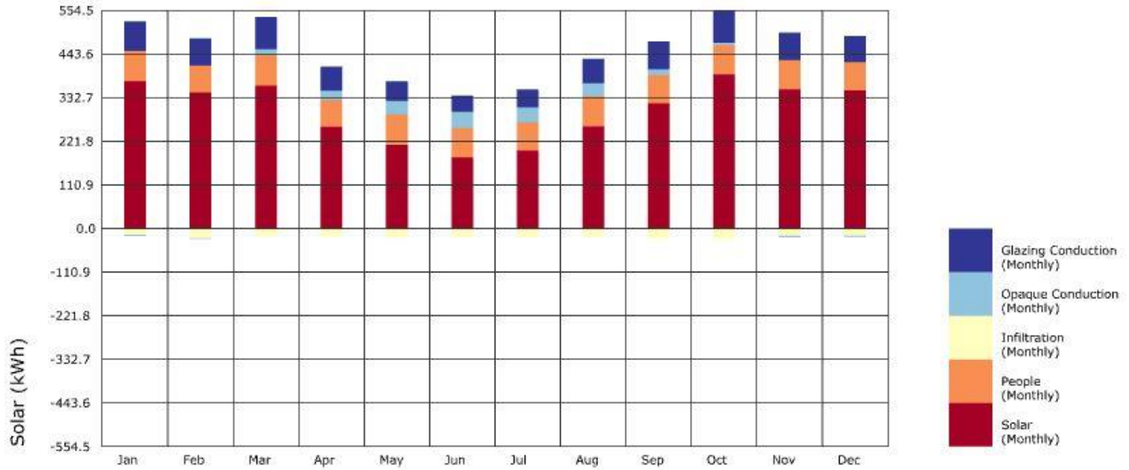
Trial and Error for a Better Thermal Comfort

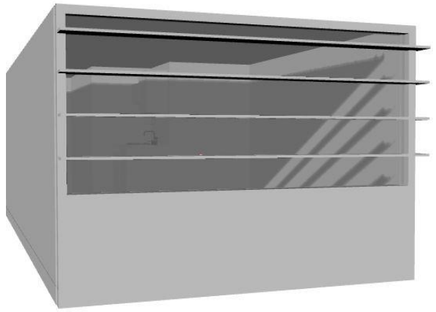
R Value for Window Reduced to 0.7

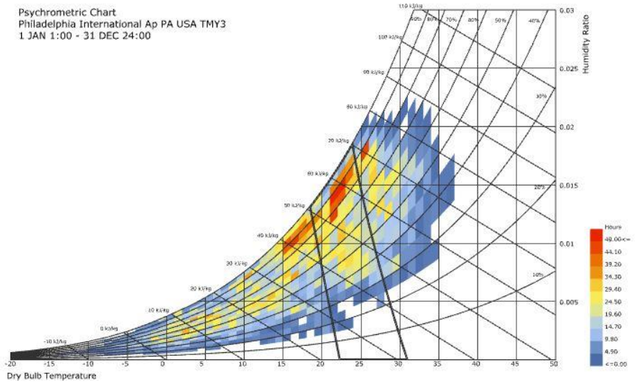
Playing with thermal mass, changing it to 8 inch, reducing air change per hour did not help the design that much. We need to reduce the percentage of cold hours, so we either had to gain the heat through windows and walls or store the heat which is gained. So I reduced the R value for window to increase solar gain.

Percentage of Comfortable Hours : 20.84 %
Percentage of Hot hours : 7.17 %
Percentage of Cold hours : 71.97 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 0.7
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2









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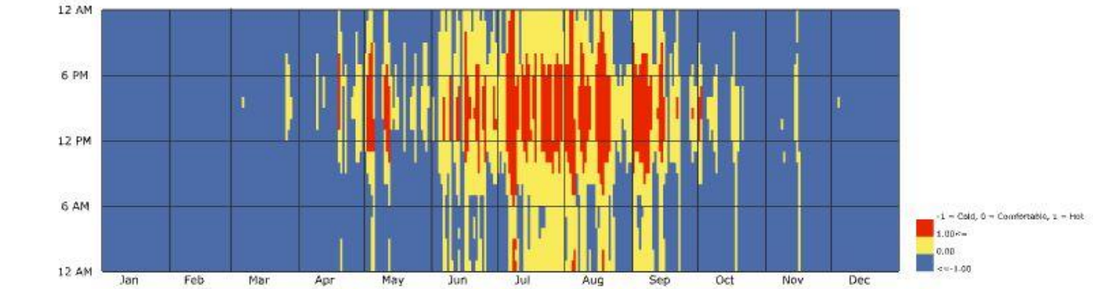
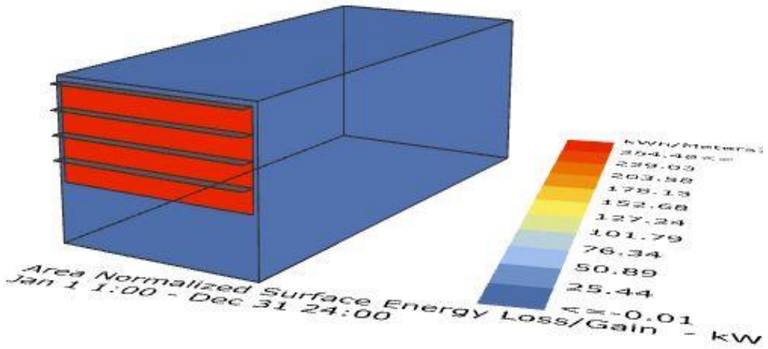


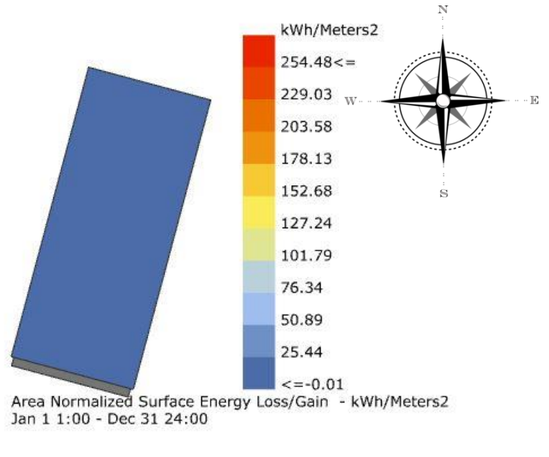
Trial and Error for a Better Thermal Comfort

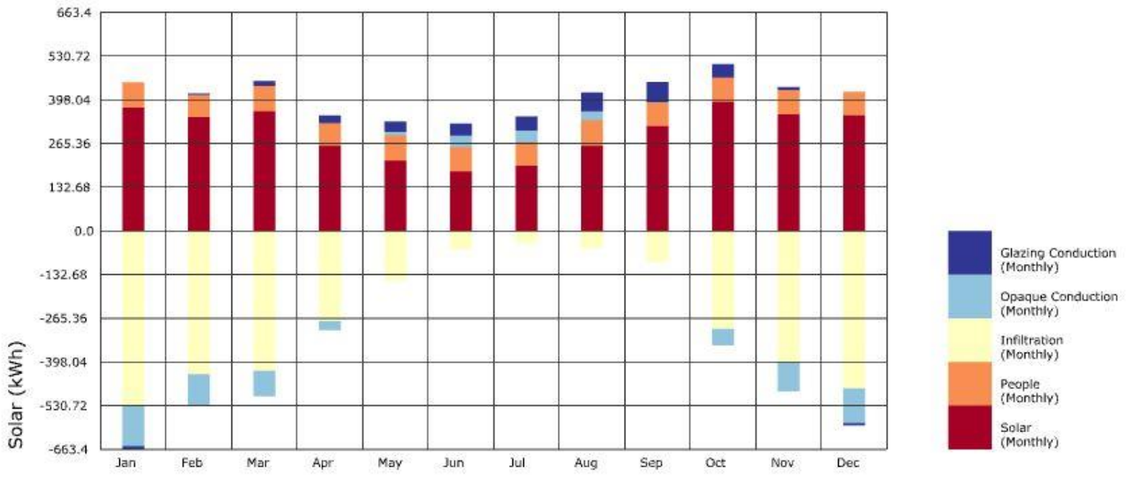
New Parameters Added for Setting the Right Natural Ventilation

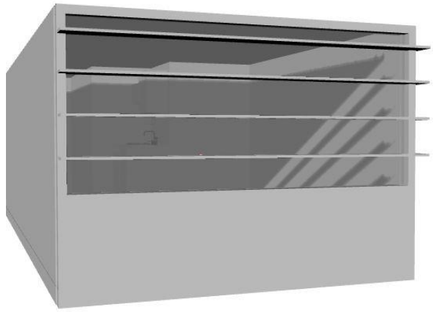
As the only problem was percentage of cold hours and that was apparently for setting natural ventilation and losing the heat in desired times, I tried to set the right parameters for natural ventilation to work and operate. The change was really outstanding compared to previous tries.

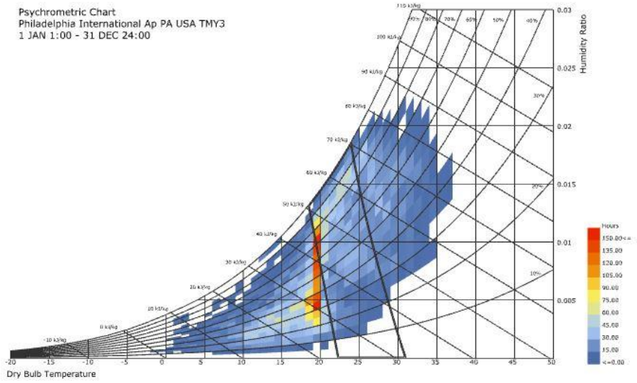
Percentage of Comfortable Hours : 41.84 %
Percentage of Hot hours : 9.25 %
Percentage of Cold hours : 48.92 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 0.7
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2
Min Indoor Temperature for Natural Ventilation : 20
Min Outdoor Temperature for Natural Ventilation : 10
Fraction of Glazing Area Operable : 0.3

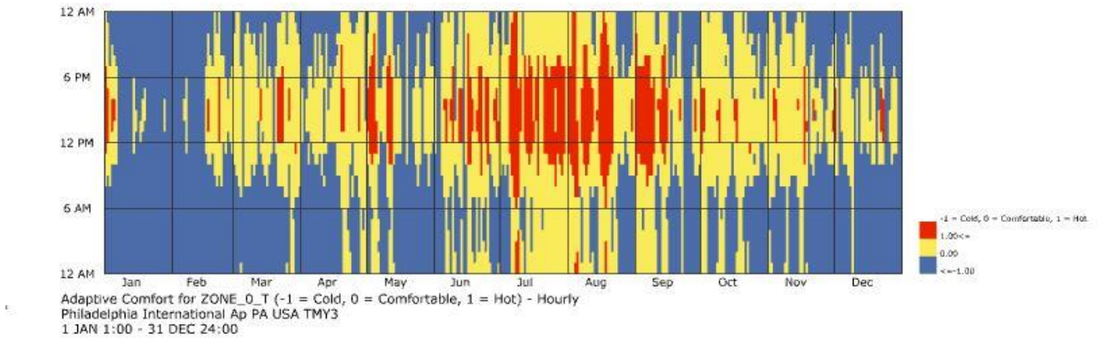










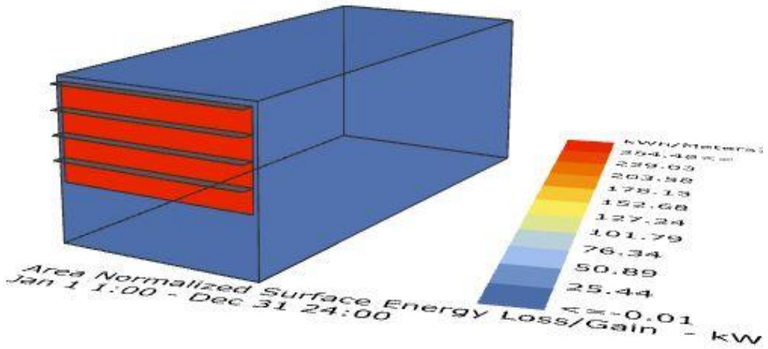


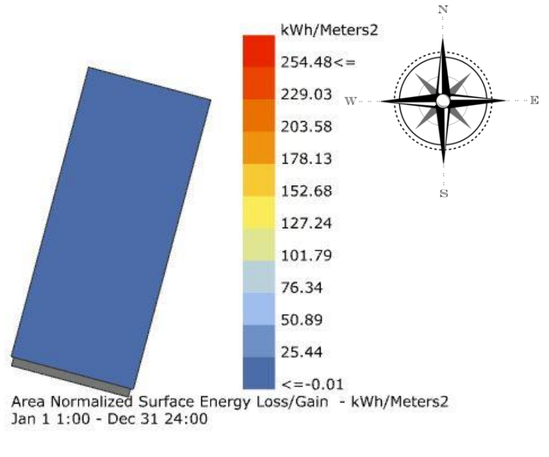
Trial and Error for a Better Thermal Comfort

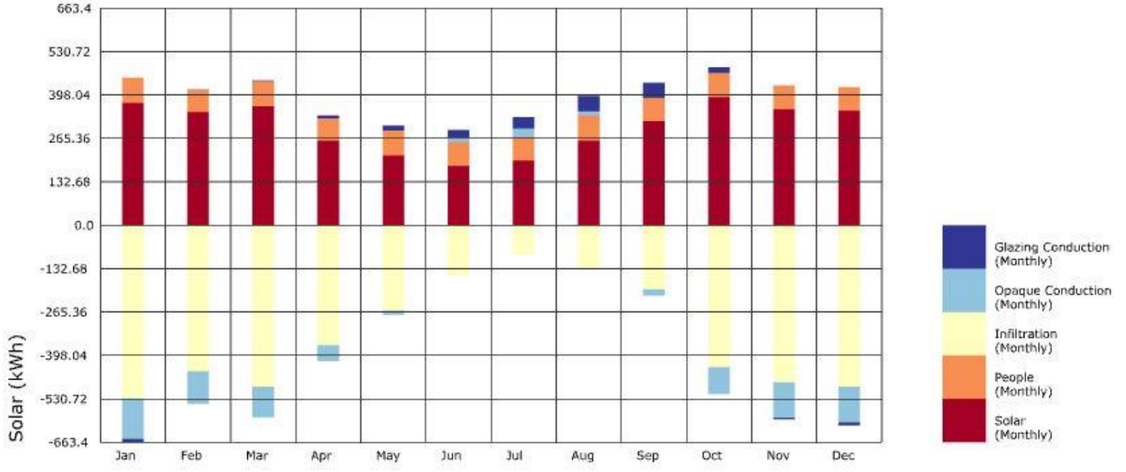
Setting a Higher Min Indoor and Outdoor Temp. for Natural Venetilation

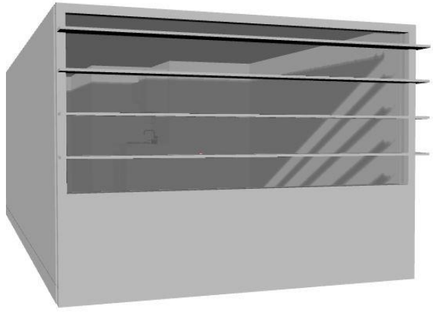
Because this room is being naturally controlled, I set the Min temp for natural ventilation higher to reduce percentage of cold hours. This change was completely helpful as I expected. The result is the percentage of cold hours has became closer to the percentage of hot hours.

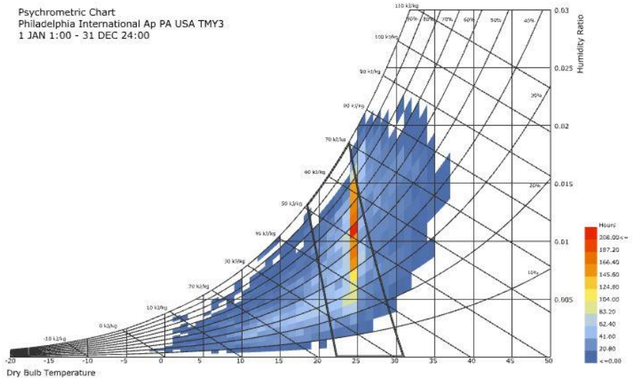
Percentage of Comfortable Hours : 51.02 %
Percentage of Hot hours : 18.66 %
Percentage of Cold hours : 30.32 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 0.7
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2
Min Indoor Temperature for Natural Ventilation : 25
Min Outdoor Temperature for Natural Ventilation : 15
Fraction of Glazing Area Operable : 0.3

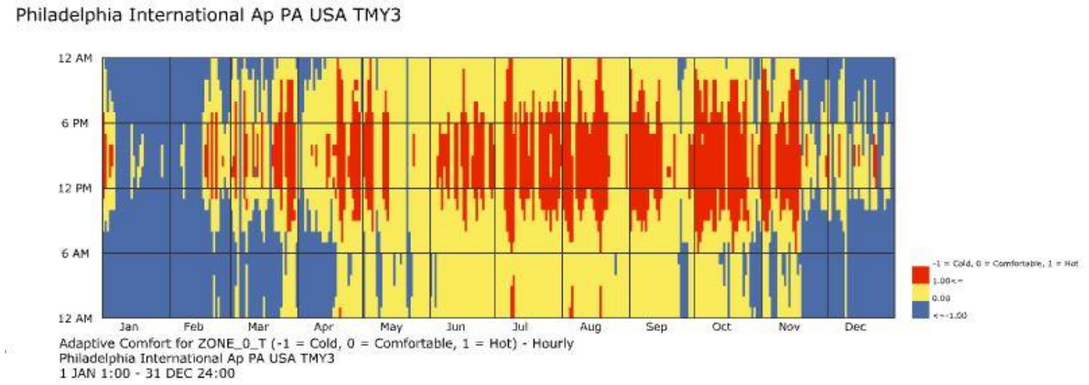










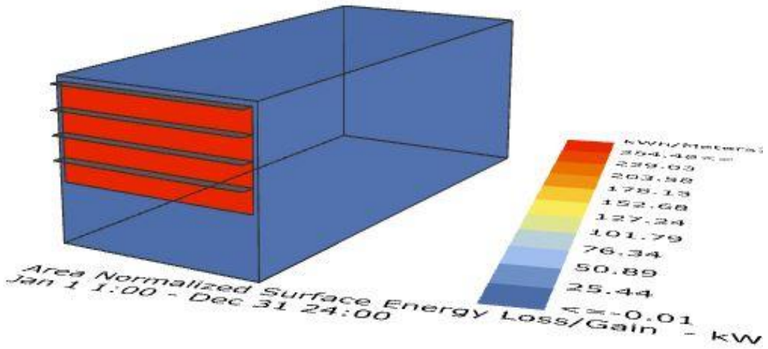


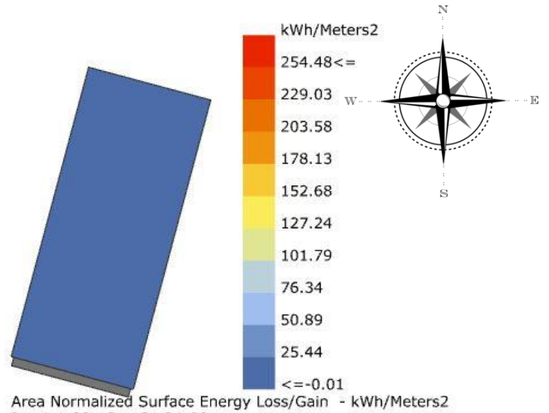
Trial and Error for a Better Thermal Comfort

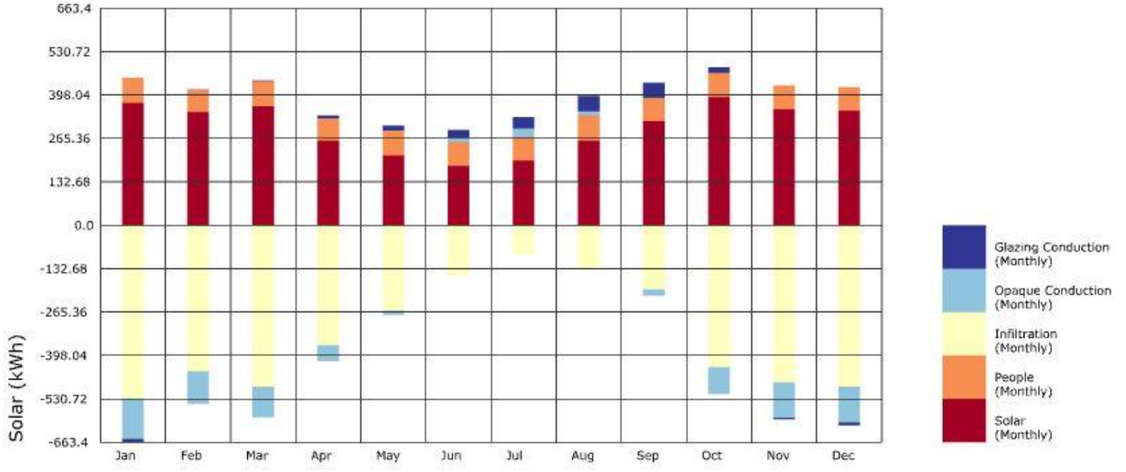
Setting a Higher Fraction for Glazing Area Operable

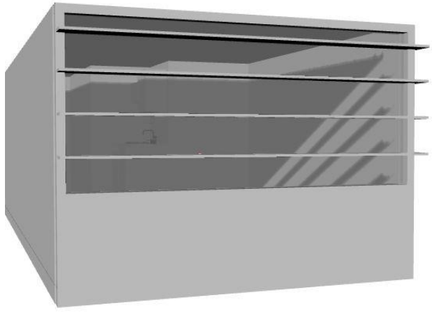
Higher Fraction of Glazing Area became operable and thus, the better natural ventilation happened. So the percentage of comfortable hours reached to almost 53 which is a good percentage with regards to no conditioning set for the room.

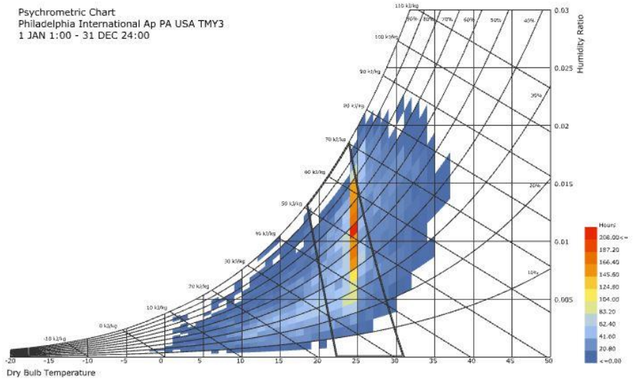
Percentage of Comfortable Hours : 53.04 %
Percentage of Hot hours : 16.26 %
Percentage of Cold hours : 30.71 %
Depth and Number of Blinds : 0.3 & 4
R value for Wall : 34.4
R value for Window : 0.7
R value for Roof : 34.4
Thermal Mass : 4 inch concrete
Air Change hour : 2
Min Indoor Temperature for Natural Ventilation : 25
Min Outdoor Temperature for Natural Ventilation : 15
Fraction of Glazing Area Operable : 0.8

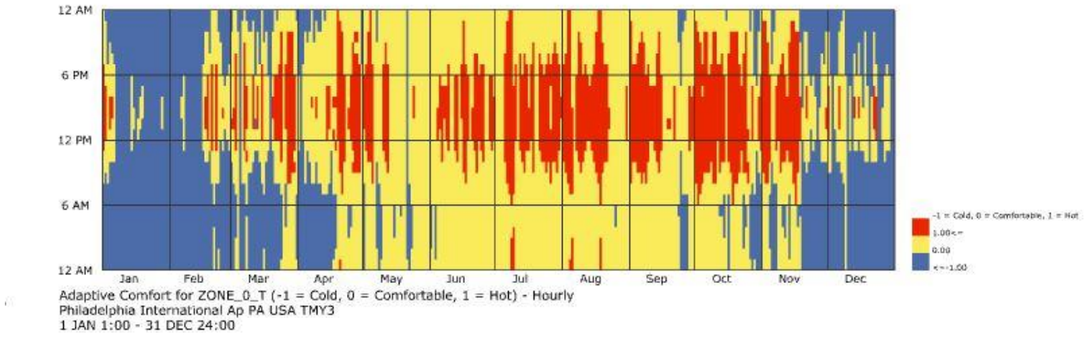










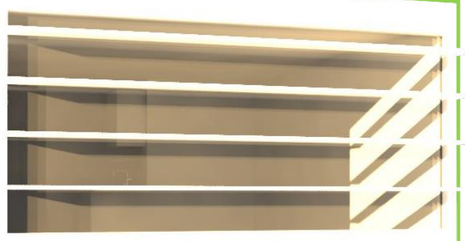


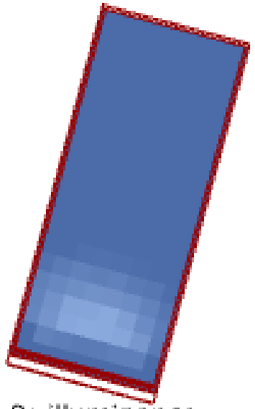
Final Design Proposal

Final Design Analysis

Point in Time Daylighting Analysis for Final Design Solution

Glare seem to be just a slight problem in March noon and afternoon time which can be acceptable due to the desire for enough penetration of light into the room.





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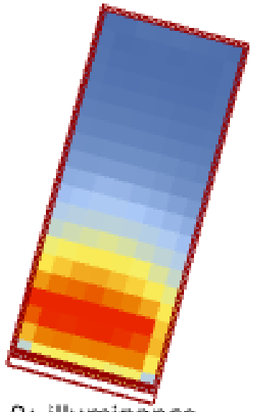

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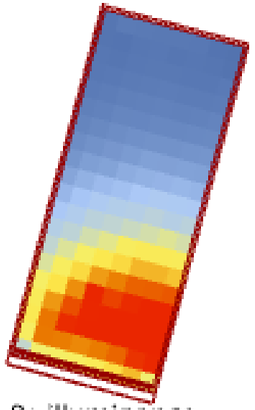

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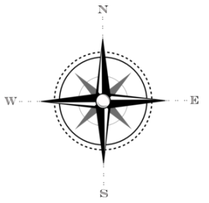

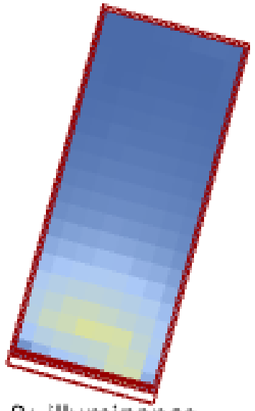

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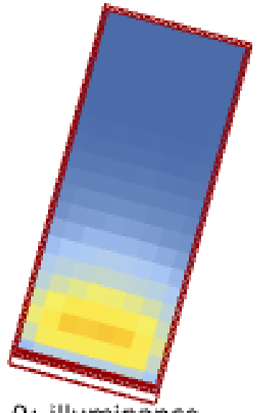

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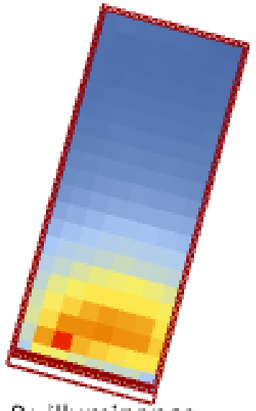

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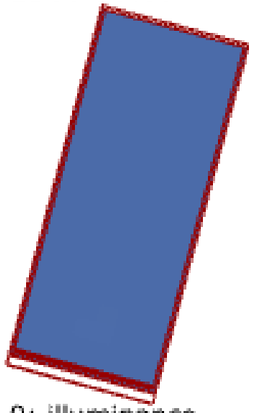

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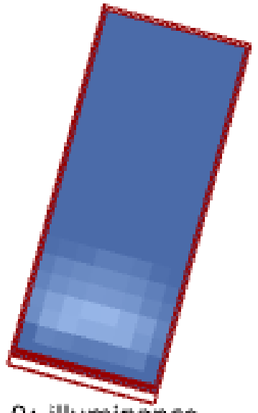

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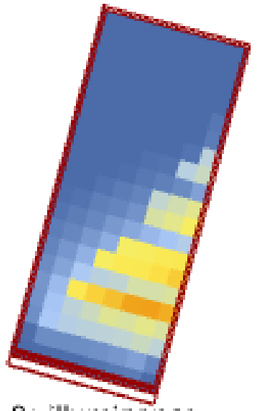
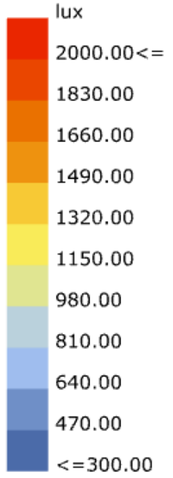


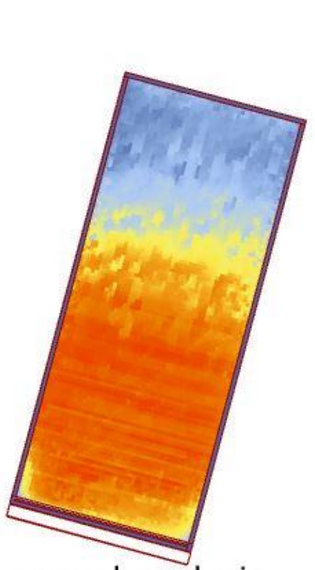
0: illuminance
21 DEC 15:00



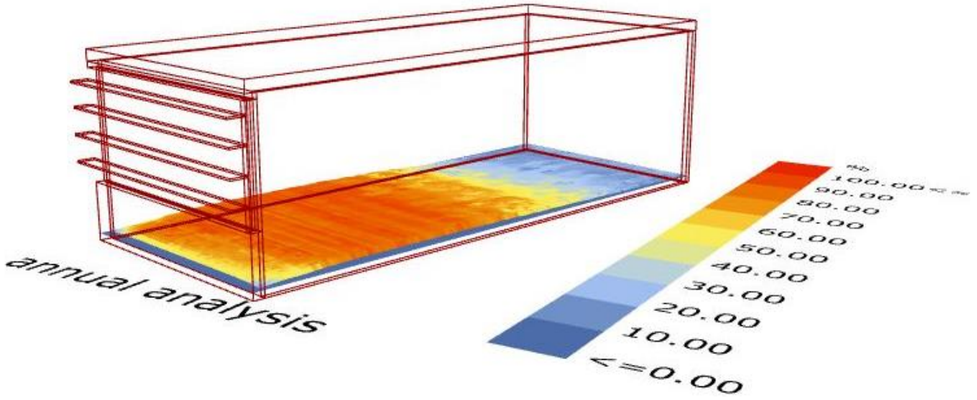
Final Design Analysis

Annual Daylighting Analysis (UDLI) for Final Design Solution

The percentage of time room is well daylit is a really good amount and the result seem to be satisfying. Those parts with less percentage of UDLI are just corridors and closed spaces.



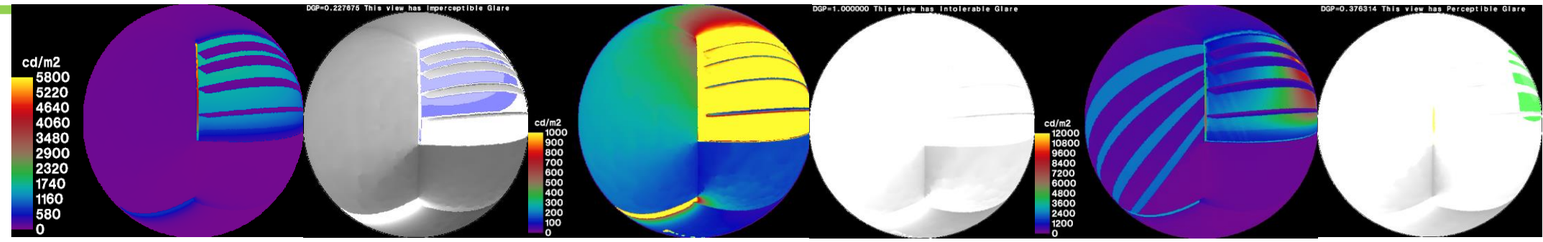
annual analysis
UDLI
Percentage of Time Between 100-2000



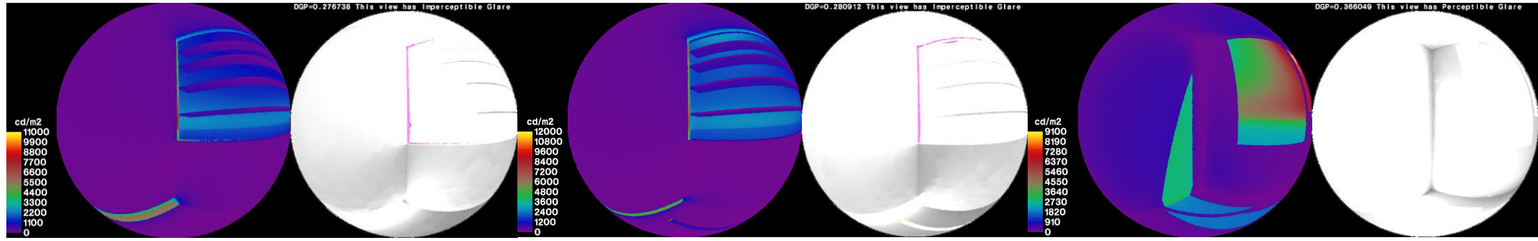
Final Design Analysis

Point in Time Glare Analysis for Final Design Solution

Almost all the time we have just imperceptible glare which is basically no glare and so we don't have any problem. Just in some cases same as the result is daylighting analysis we have glare issue which is acceptable if we want enough daylight.



21 March 9:00 | 21 March 12:00 | 21 March 15:00



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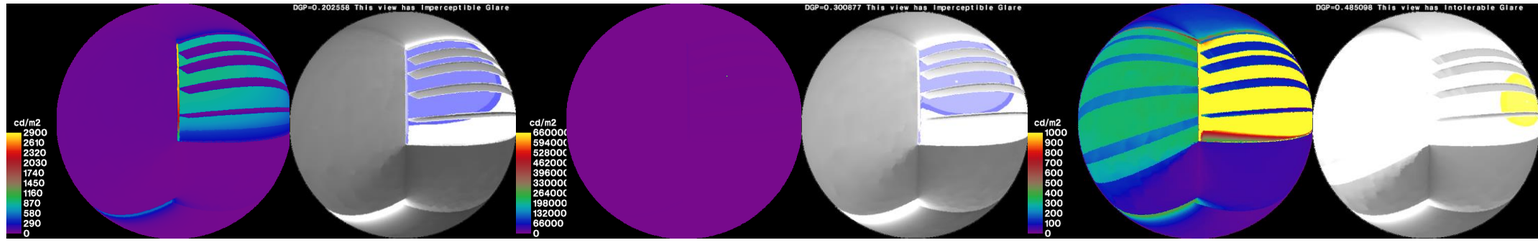


21 December 9:00 | 21 December 12:00 | 21 December 15:00

Final Design Analysis

The Best Percentage achieved is 50.04 and still percentage of cold hours is more than percentage of hot hours. That may be cause of natural ventilation and infilteration rate, but the overall achievement seems to be reasonable and acceptable.

Percentage of Comfortable Hours : 53.04 %

Percentage of Hot hours : 16.26 %

Percentage of Cold hours : 30.71 %

Depth and Number of Blinds : 0.3 & 4

R value for Wall : 34.4

R value for Window : 0.7

R value for Roof : 34.4

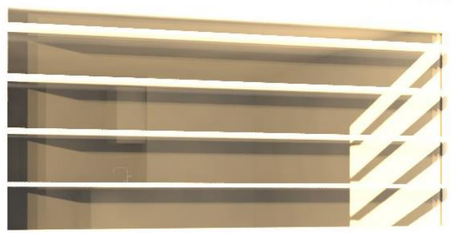
Thermal Mass : 4 inch concrete

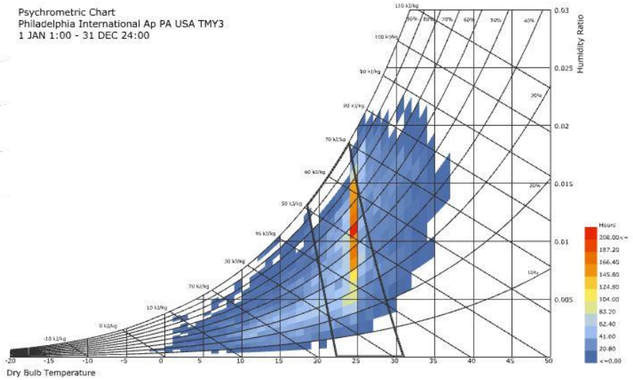
Air Change hour : 2

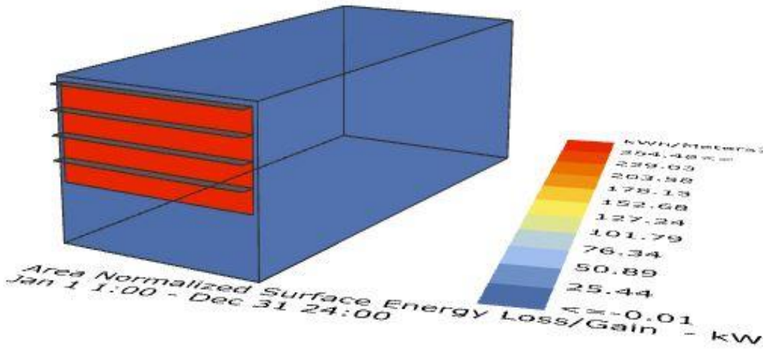
Min Indoor Temperature for Natural Ventilation : 25

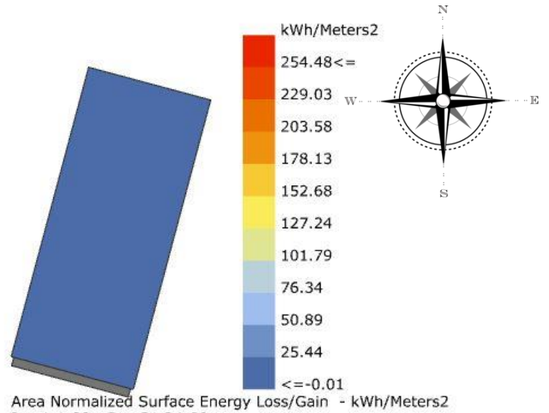
Min Outdoor Temperature for Natural Ventilation : 15

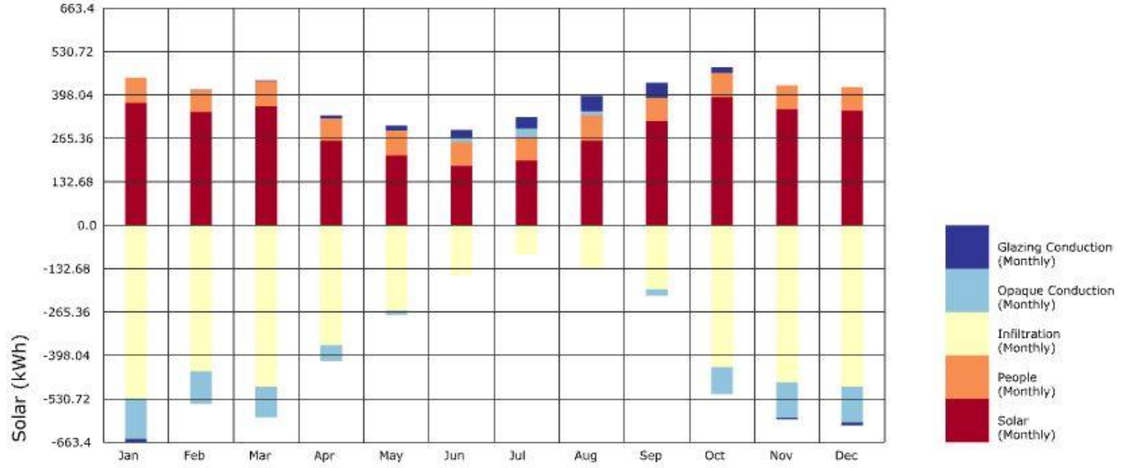
Fraction of Glazing Area Operable : 0.8











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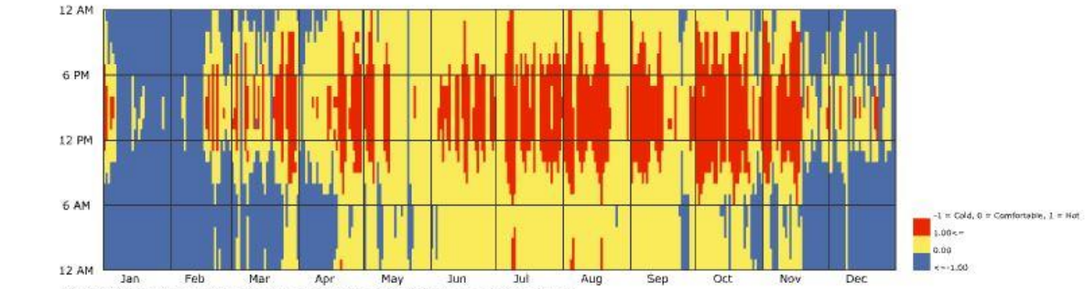

Thank You