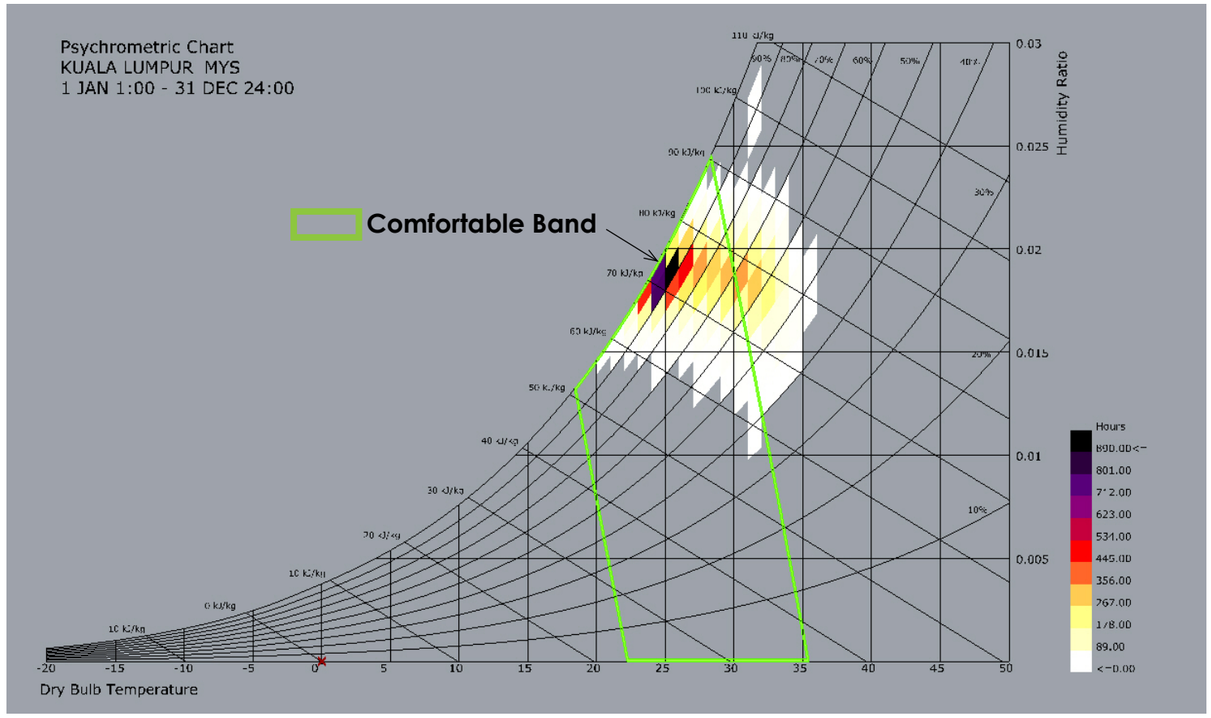
Thermal and Visual Comfort Maximization of an Unconditioned Space in Kuala Lumpur

753 Final Project | Rong, Shengliang

Temp. & RH Range of Outdoor Uncomfortable Hours



Psychrometric Chart Parameter:

- Clothing Level: 0.5, 0.8, 1
- Humidity Ratio Upper Bound: 0.03, Assuming Local People Could Tolerant 100% Humidity

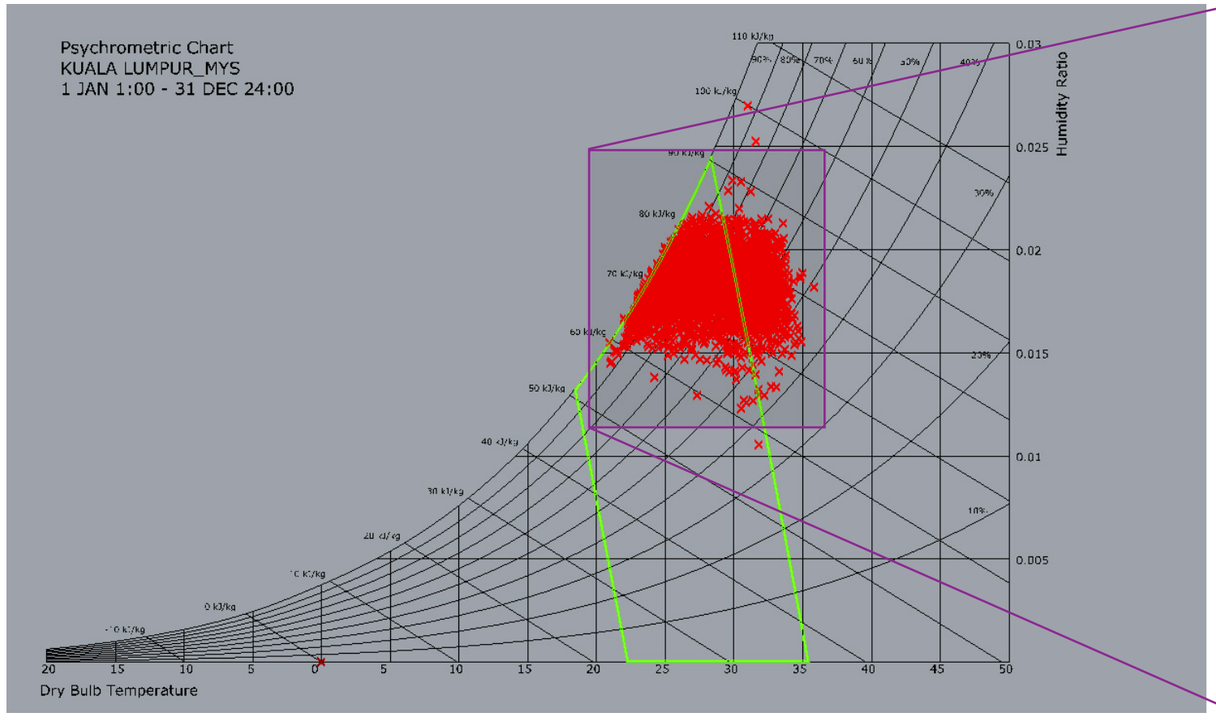
Uncomfortable Hours Percentage: 21%

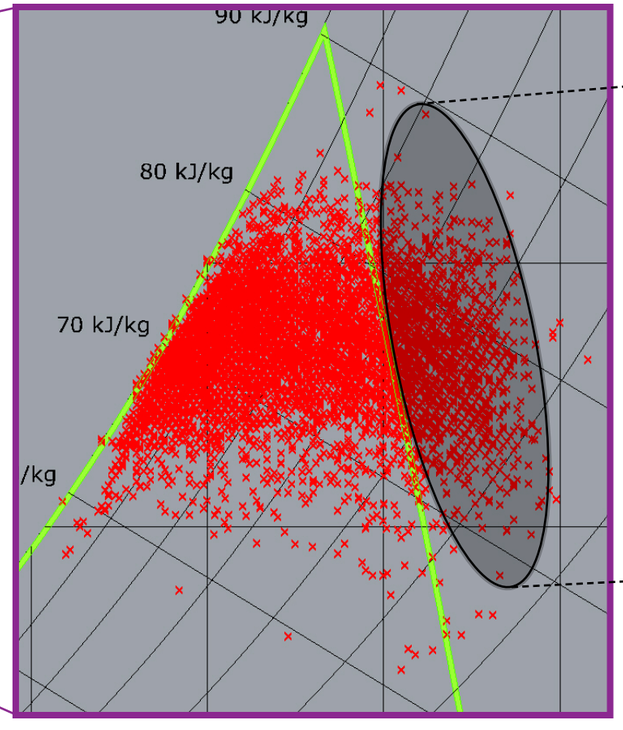
Define Uncomfortable Hours Temp. & RH Range

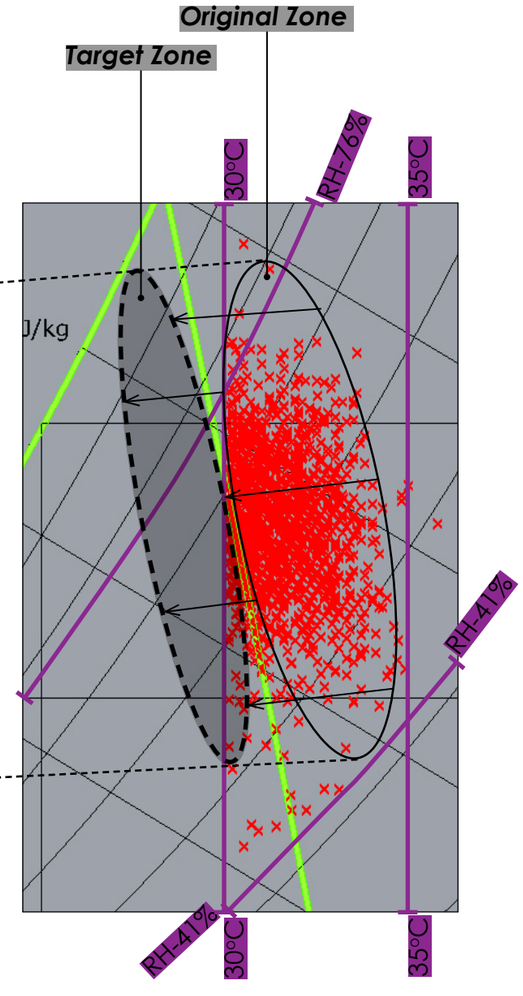
- 30°C<Temp.<35°C
- 41%<RH<76%
- **2084 Hours Fall in This Range, 23.7% of Total Hours**

Basic Concept to Achieve Indoor Comfort

- ***Overheat is the main Cause of Uncomfortable***
- First, when outdoor is comfortable, make sure indoor is as comfort as outdoor condition
- Second, when outdoor is uncomfortable, try to bring the hours from Original zone into Target Zone so that indoor is comfort.



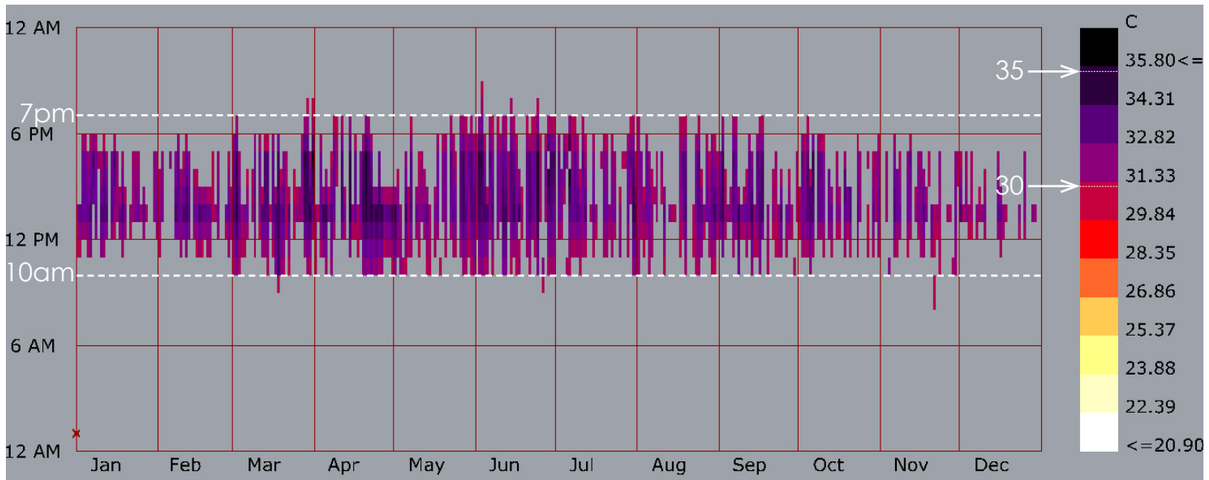




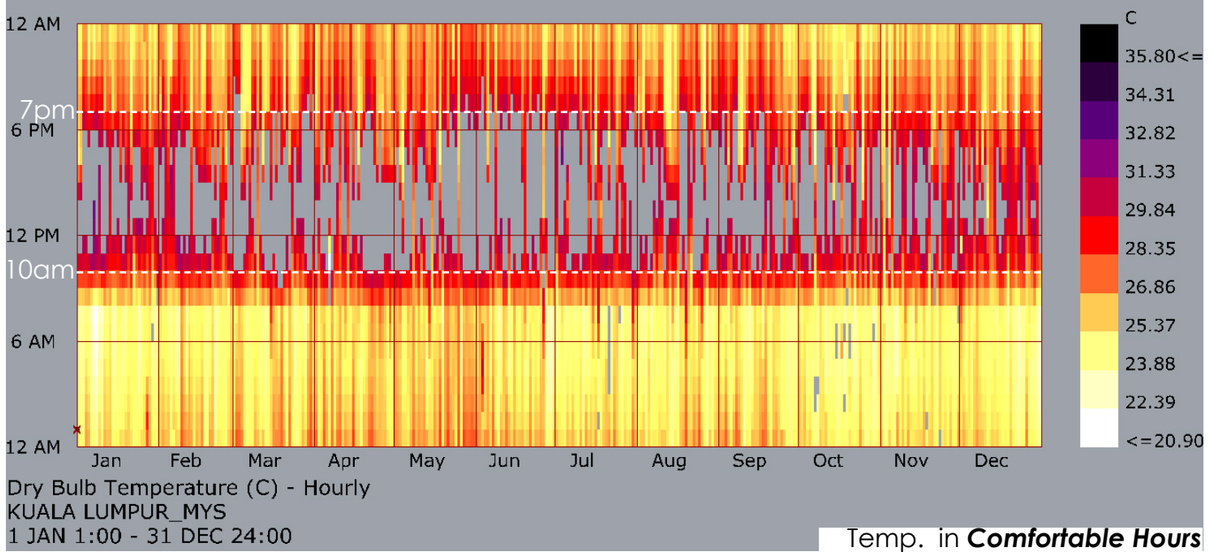
Climate Analysis

Time Range of Outdoor Uncomfortable Hours and Passive Strategy

Conditional Statement: ***Hours Uncomfortable & 30°C<Temp.<35°C & 41%<RH<76%***

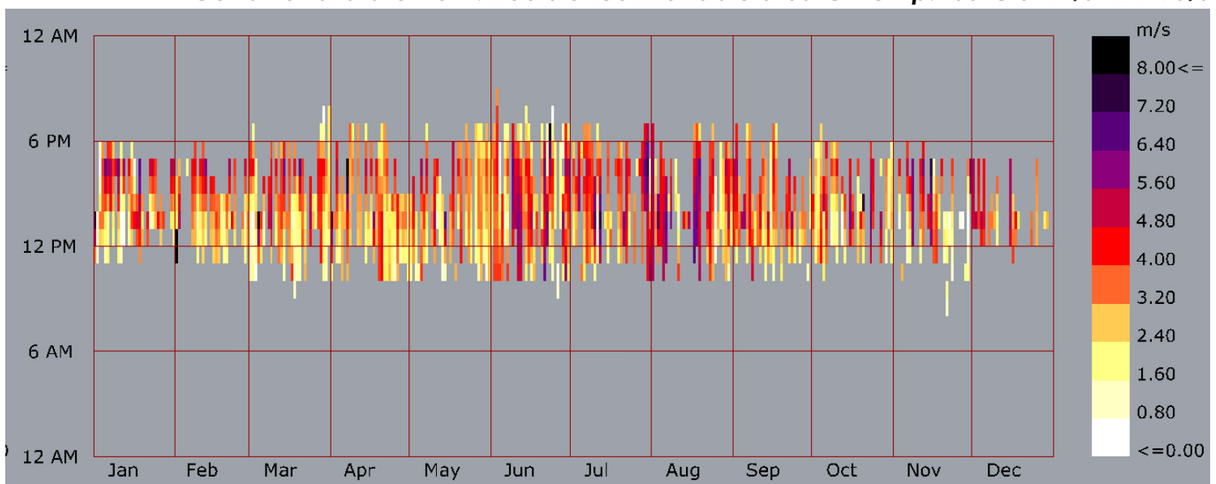


Temp. in ***Uncomfortable Hours***

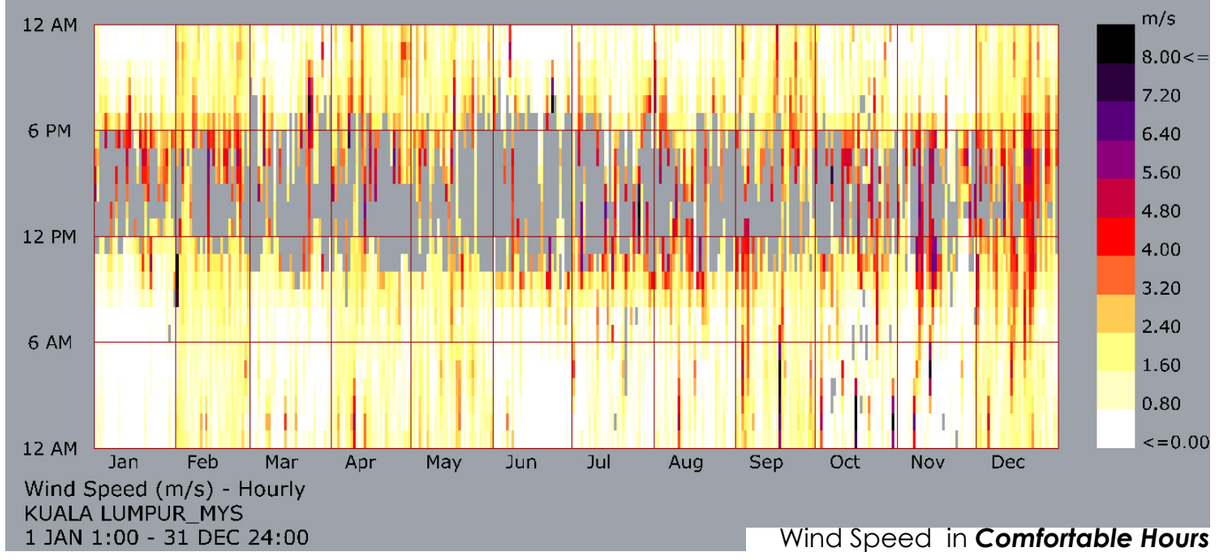


Temp. in ***Comfortable Hours***

- There is Strong corelation between High Temperature and Uncomfortable Hours, and also those uncomfortable hours are concentrated in the time period of 10am- 7pm. This could be caused by high diffuse horizontal radiation during day time.
- According to Traditional Malaysian Architecture, we could **raise the building above the ground**, **use lighter thiner materials** and **increase building surface area** in order to increase the heat transfer between building and outside Environment.



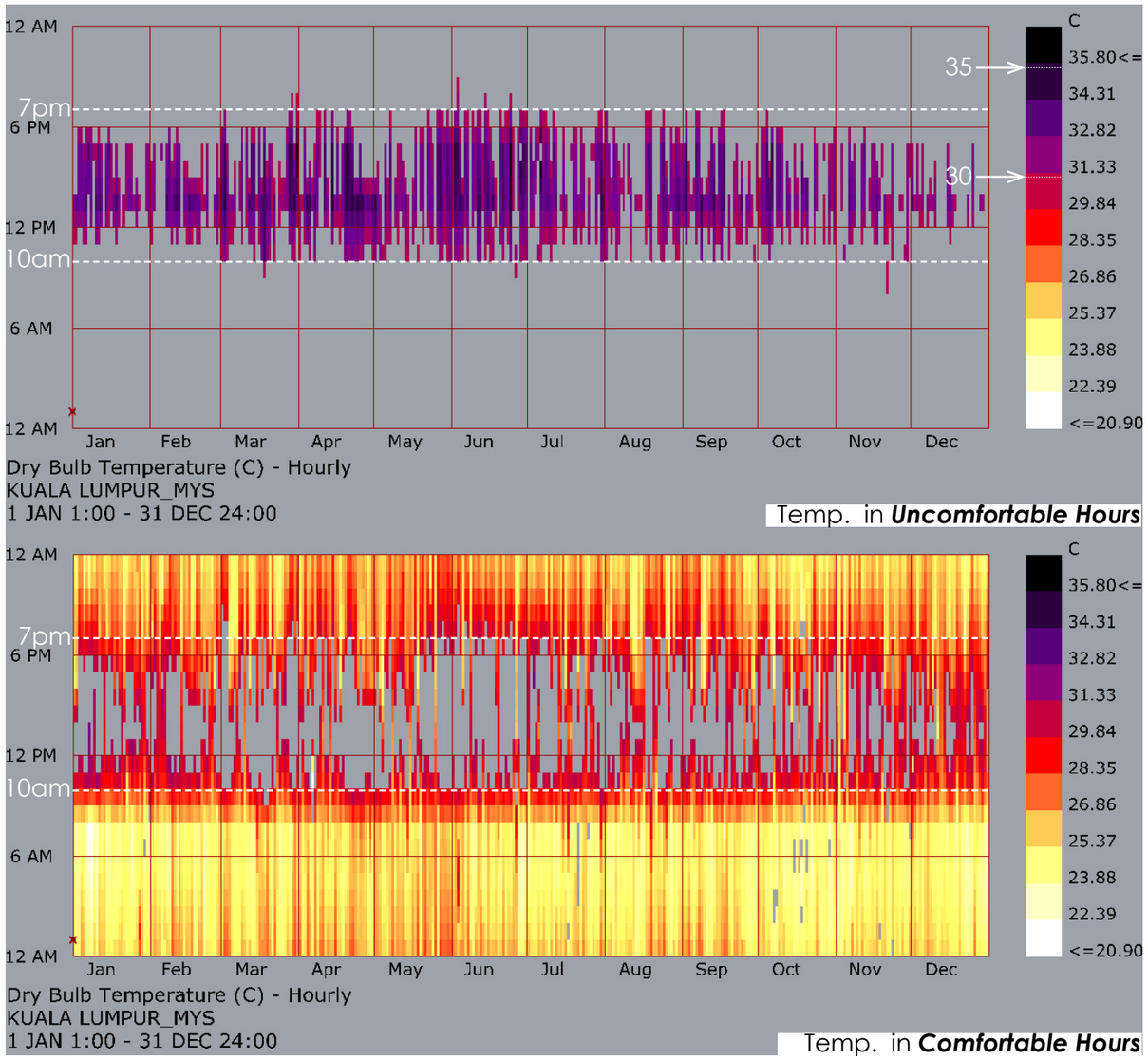
Wind Speed in ***Uncomfortable Hours***



Wind Speed in ***Comfortable Hours***

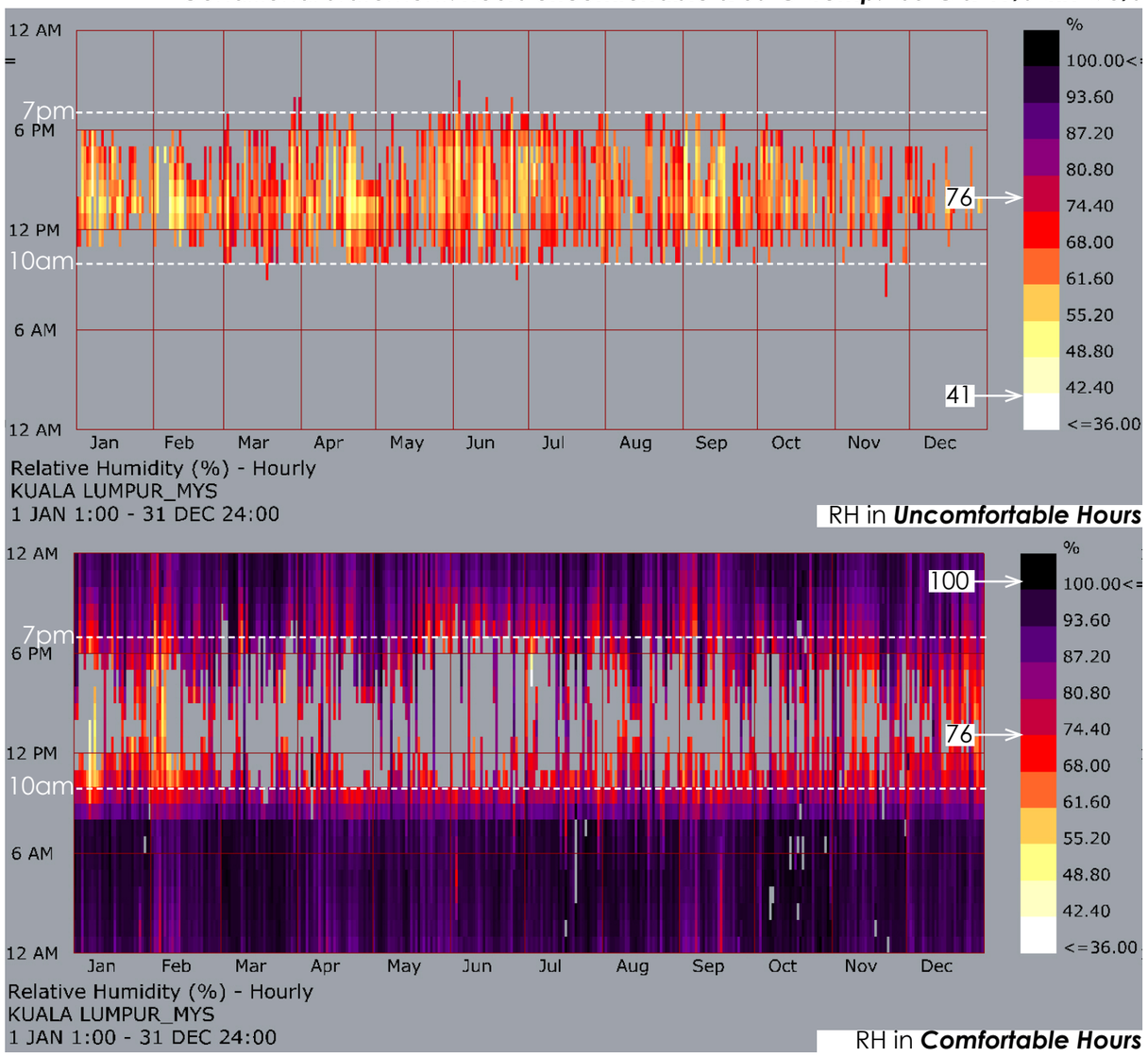
- Wind Speed at 10Meters is between 0-10 m/s, and Wind Speed during 10am-7pm is generally faster than the rest of the day through the whole year.
- **Use Cross Natural Ventilation during the whole day to bring down Indoor Temperature.**

Conditional Statement: ***Hours Uncomfortable & 30°C<Temp.<35°C & 41%<RH<76%***



Temp. in ***Uncomfortable Hours***

Temp. in ***Comfortable Hours***

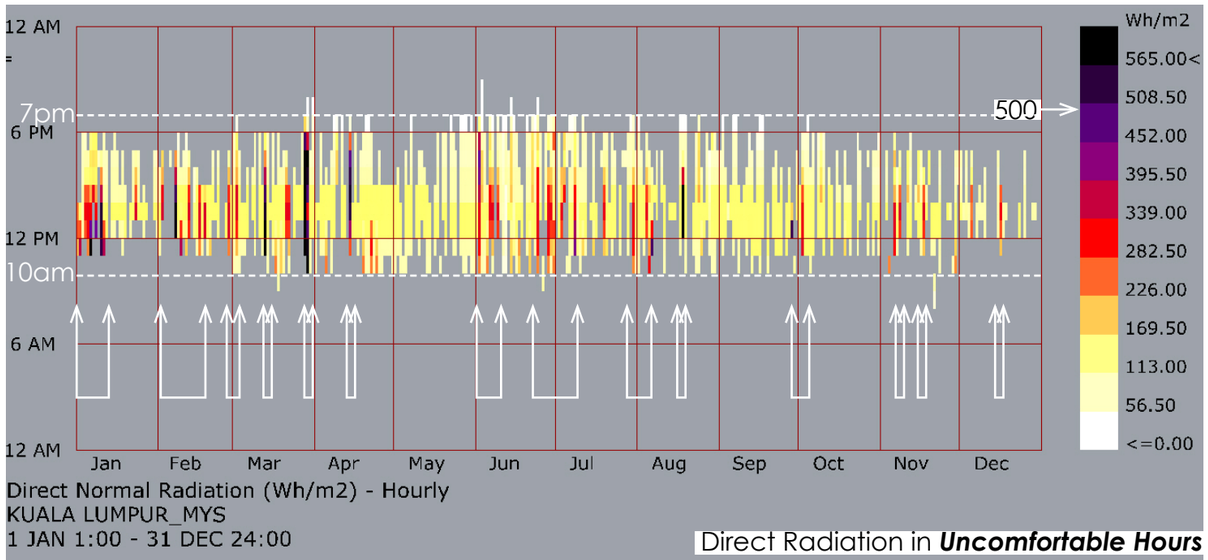


RH in ***Uncomfortable Hours***

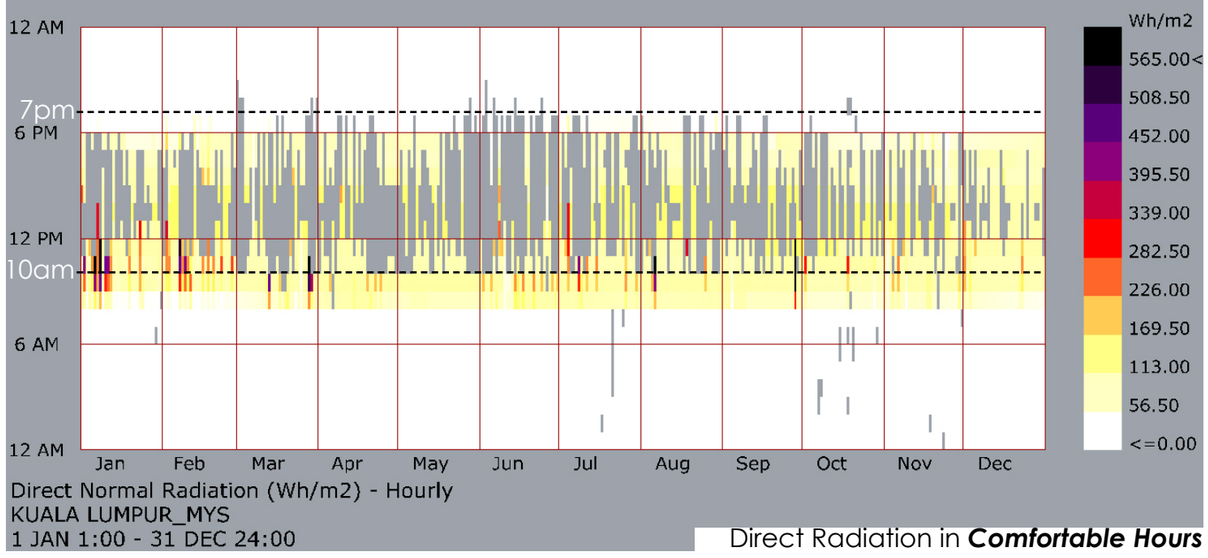
RH in ***Comfortable Hours***

- Given the RH during 10am-7pm is relatively low through the whole year, thus we could use **Green Roof** and **Roof Ponds** in order to increase evaperative cooling during daytime.

Conditional Statement: ***Hours Uncomfortable & 30°C<Temp.<35°C & 41%<RH<76%***

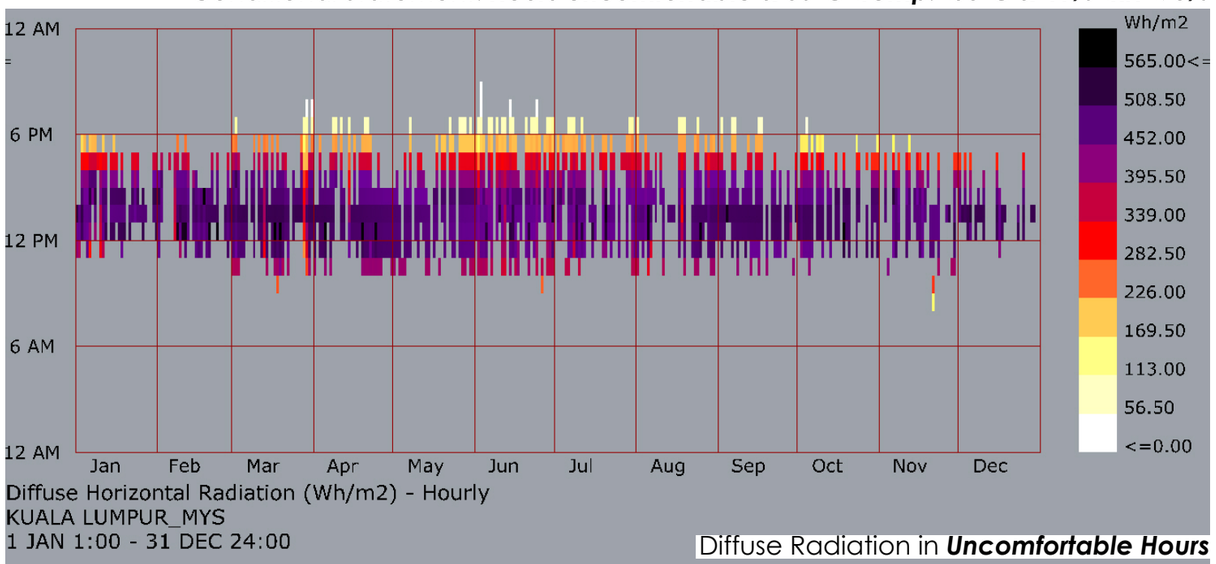


Direct Radiation in ***Uncomfortable Hours***

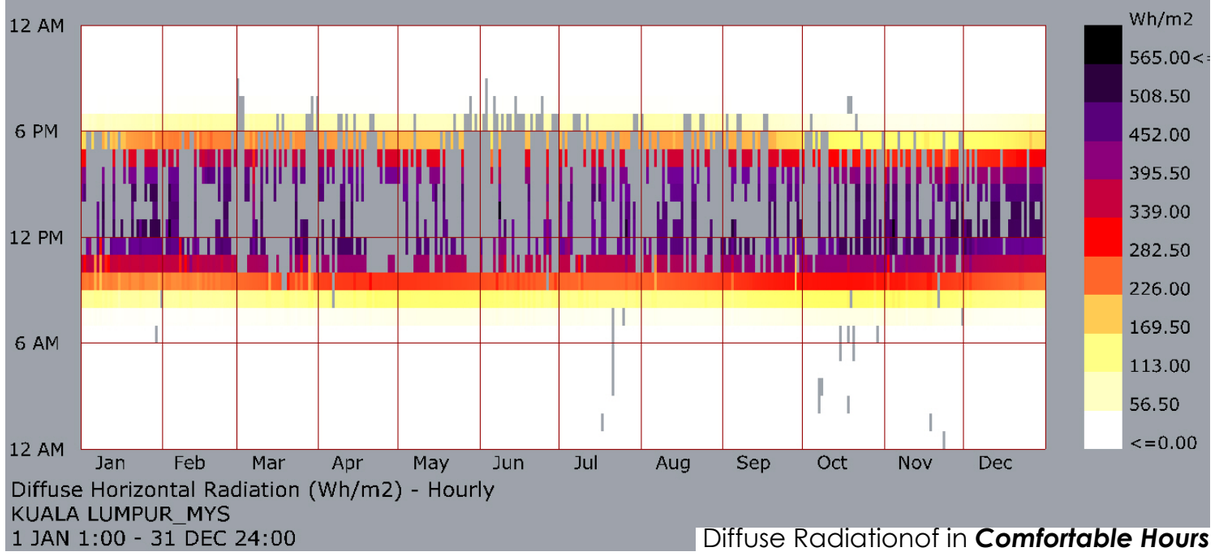


Direct Radiation in ***Comfortable Hours***

- Kuala Lumpur has low Direct Normal Radiation(DNR), there is no obvious corelation between DNR and High Temperature Uncomfortable Hours.
- However, some hours with higher direct radiation could have contribution to High Temperature Uncomfortable Hours from 10am to 7pm.
- **Thus, Could use shading for Sun Vectors with Direct Radiation of 500wh/m² and above.**



Diffuse Radiation in ***Uncomfortable Hours***



Diffuse Radiationof in ***Comfortable Hours***

- Kuala Lumpur has high Diffuse Horizontal Radiation(DHR), there is obivious corelation between DHR and High Temperature Uncomfortable Hours.
- DHR have much more contribution to High Ambient Temperature than DNR.
- **However, there is no Passive Strategies that I could think of to neutralize DHR's impact to Indoor Comfort.**

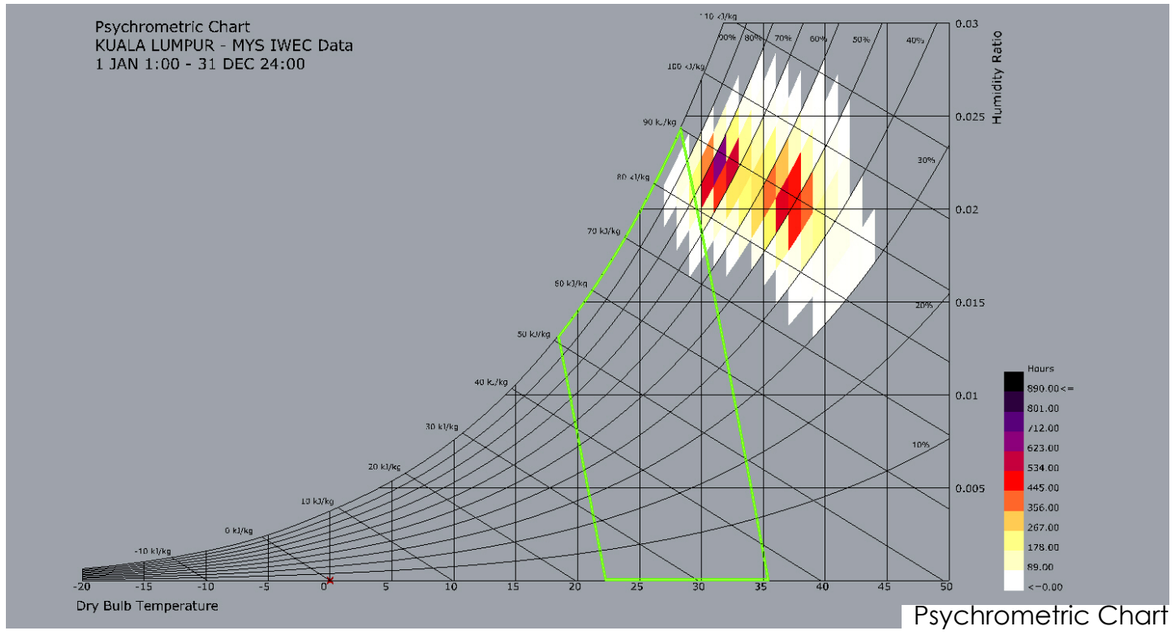
- Increase Heat Transfer to Cool Down-
  +Raise the Building Above the Ground,
  +Use Lighter and Thiner Materials
  +Increase Building Surface Area

- Increase Air Flow to Cool Down-
  +Cross Natural Ventilation during the whole day

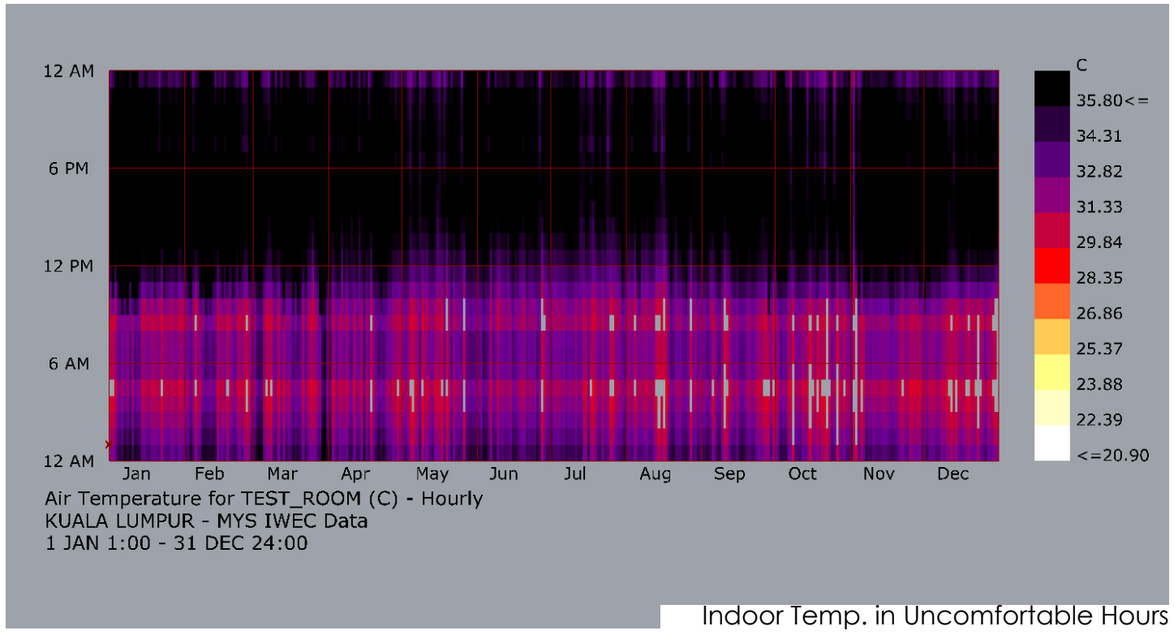
- Increase Evaporation to Cool Down-
  +Green Roof
  +Roof Ponds

- Neutralize Solar Gain to Cool Down-
  +Shading for Sun Vectors with Direct Radiation of 500wh/m^2 and above.

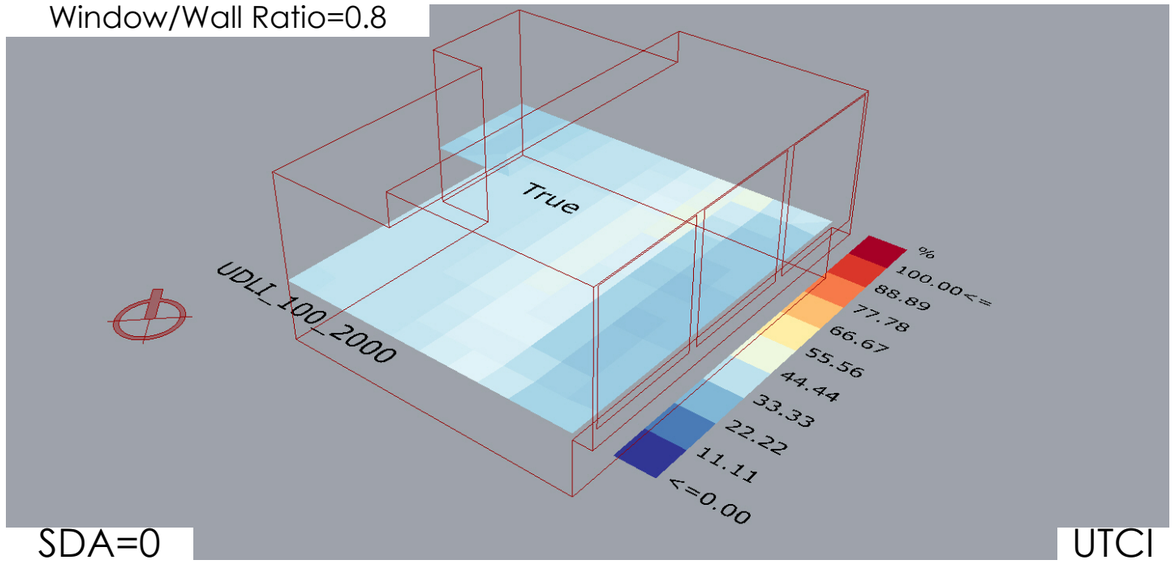
Base Case
Comfort & Daylight



Psychrometric Chart

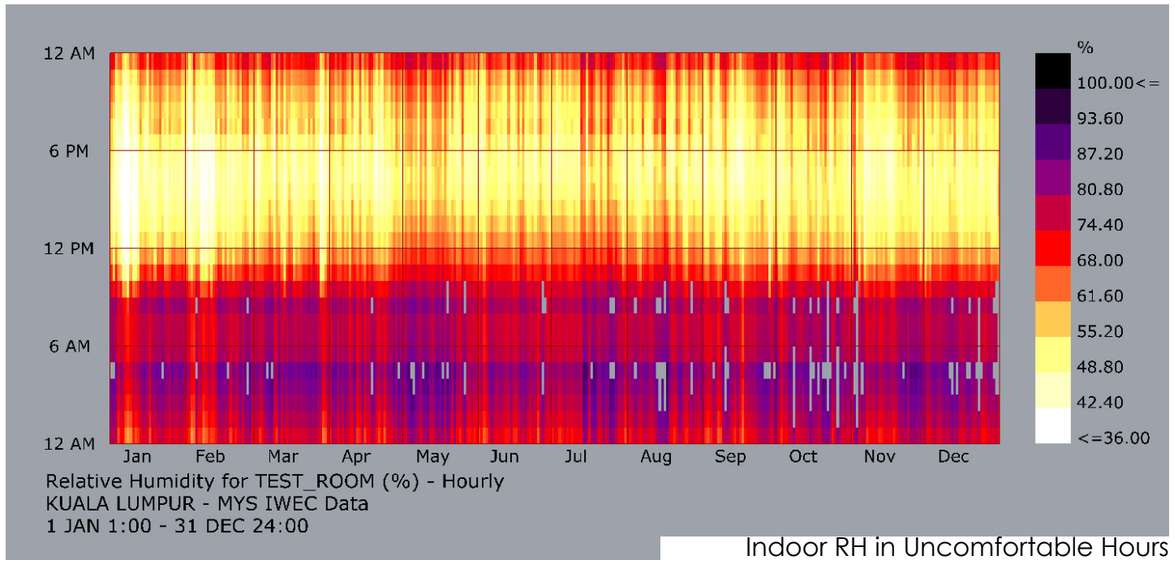


Indoor Temp. in Uncomfortable Hours



SDA=0

UTCI



Indoor RH in Uncomfortable Hours

Base Case Facts:

- SDA=0, Lighting Load= 1032 KWh ⟶
- Comfort Hours Percentage= 1.67% ⟶
- Indoor Temperature is much higher than Outside ⟶

Reasons Behind Facts:

- Diffuse Radiation is dominant Day-Light Source,
- ***Overheat is Main Cause of Uncomfort***
- Lack of ways to release Heat Out Lighting Internal Load generate Heat

Passive Strategies Could be Implement

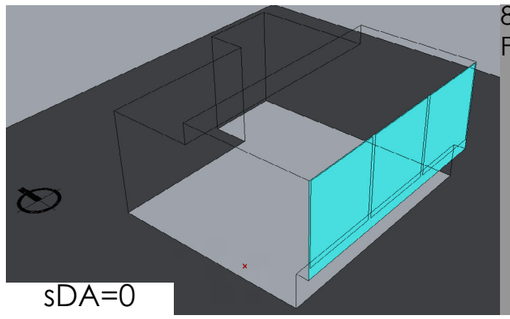
- ***Create more Openings*** to Allow More Light in
- Create Well Daylight Space to ***Reduce Lighting Heat***
- Orient Building According to Dominant Wind Direction, Fully Utilize ***Natural Ventilation*** & ***Stack Effect*** during All Time
- Use ***Roof Pond*** or ***Green Roof*** to Further Cool down Building
- Change Building Materials into ***Wood or Bamboo*** in order to Allow Heat Transfer Out

Daylight_Base Case Analysis

DLAIllumThresholds=100

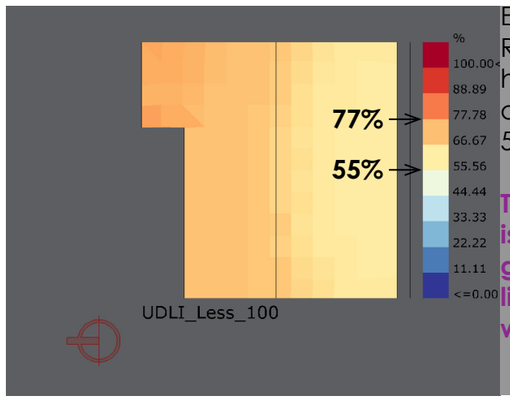
Base Case

Window/Wall Ratio=0.8



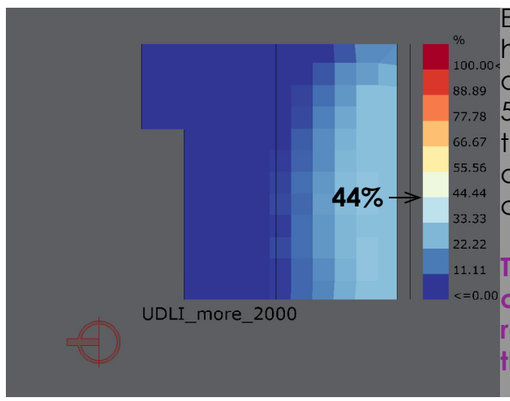
sDA=0

80% area of South Facade is window, without shading.



Even when W/W Ratio=80%, the hours of UDLI<100 are still more than 55% in one year , and sDA=0.

That means, there is no way I could get enough day-light only through window on south side.



Even when the hours of UDLI<100 are more than 50% in one year, the area near win-dow still have a fair chance to get too much daylight.

This could be caused by direct radiation, since there is no shading.

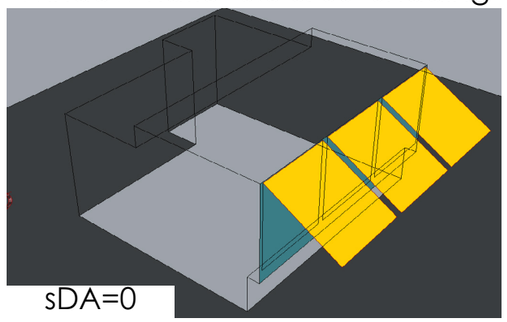
Based on the two conclusions made above, I have 2 steps:

First, do shading for South facing window, see if I could neu-tralize the portion of UDLI>2000.

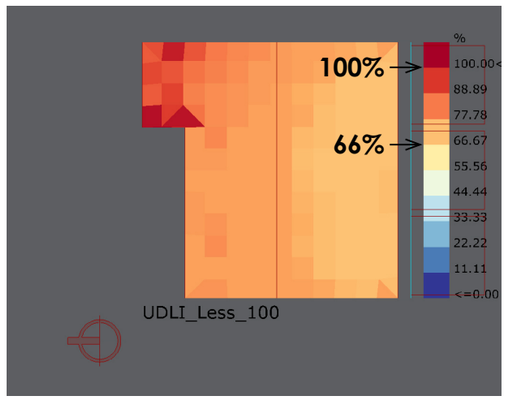
Second, start open windows on other walls, see if I could achieve a better daylight space.

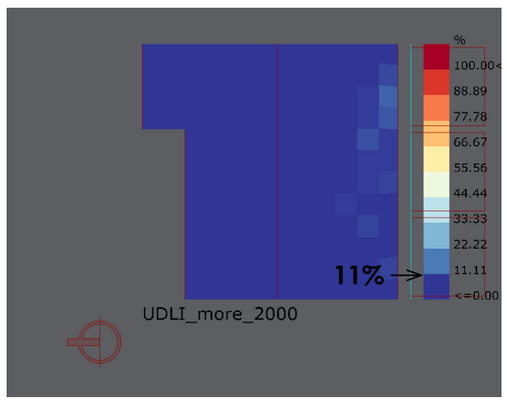
Test Case_0

Window Ratio=0.8 & 30° Shading



sDA=0





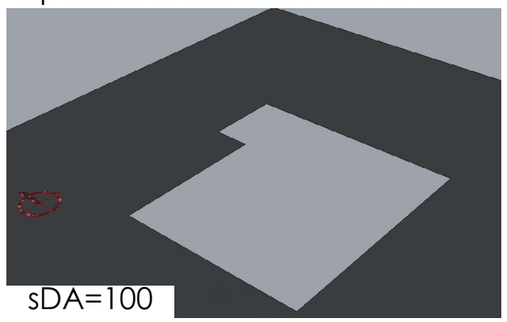
Based on Test Case_0:

The shading has to extend long enough to neutralize the portion of UDLI>2000, but UDLI<100 increase dramatically.

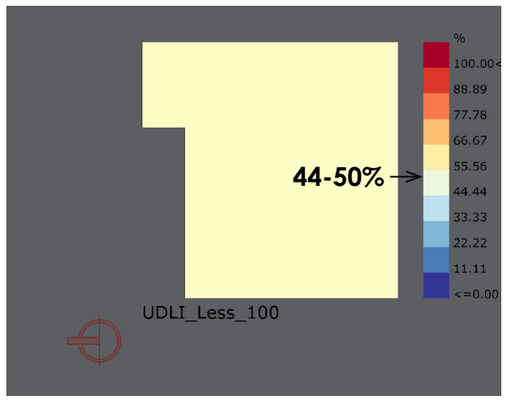
To fix this, I will setup windows on oth-er facade and see if I could bring the portion of UDLI<100 up to the portion of 100<UDLI<2000.

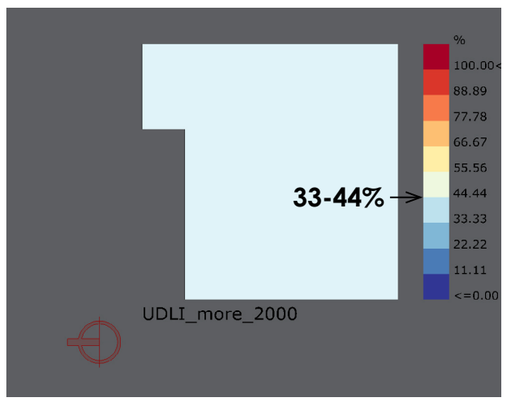
Test Case_1

Open Floor without Walls & Roofs



sDA=100





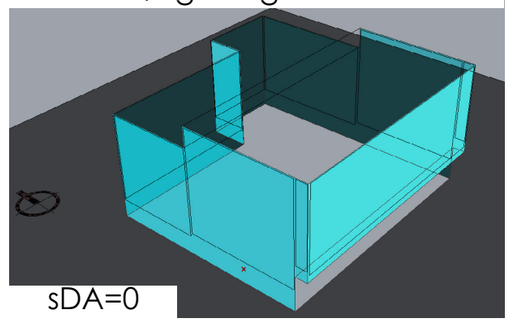
Based on Test Case_1:

Even in wide open space, I couldn't get enough daylight in nearly 44-50% time of one year, based on image of UDLI<100.

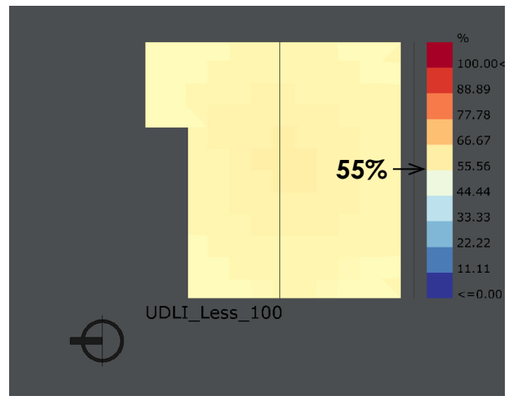
The other 33-44% time of one year, the space got too much daylight based on image of UDLI>2000.

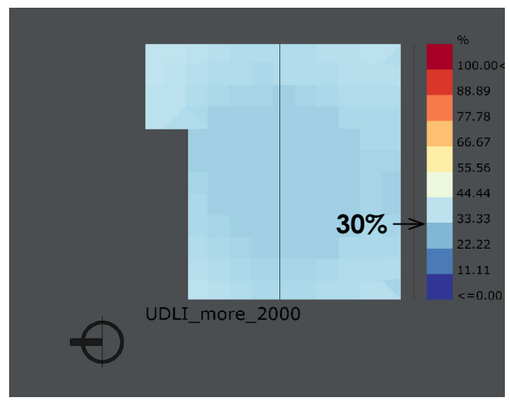
Test Case_2

90% glazing Facade



sDA=0





Based on Test Case_2:

Just by having 90% glazing area enve-lope and Roof, UDLI<100 run over 50%.

This means if I want to have a space with enough daylight, 90% glazing area on all facade is only choice.

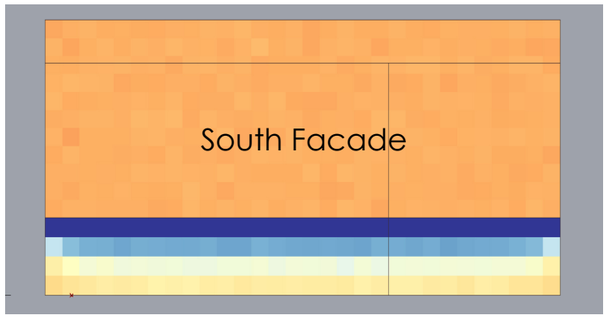
And since that, any shading I add in or-der to neutralize the portion of UDLI>2000 would cause increasing of the portion of UDLI<100.

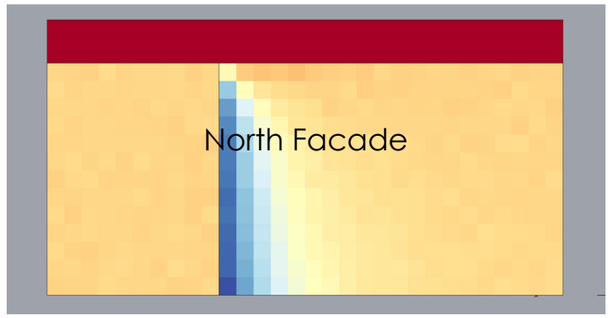
Daylight_Test Case_2 Analysis

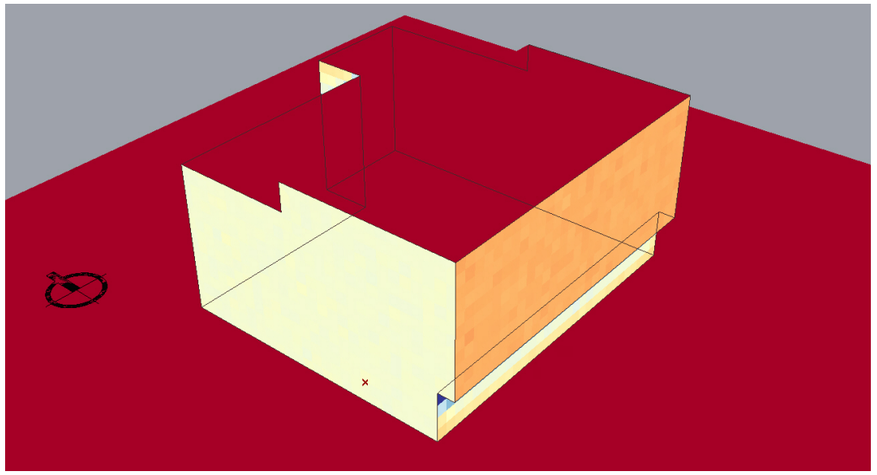
DLAIllumThresholds=100

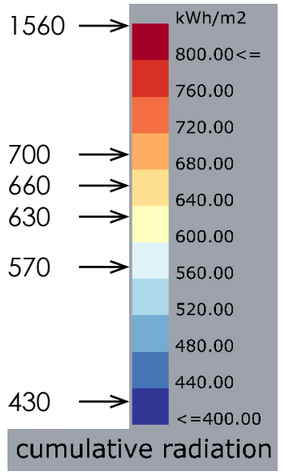
Radiation Map

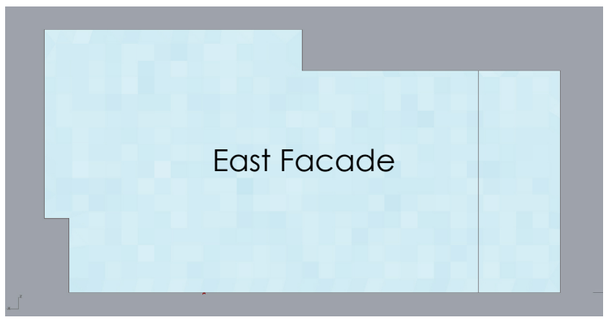
On all Surfaces

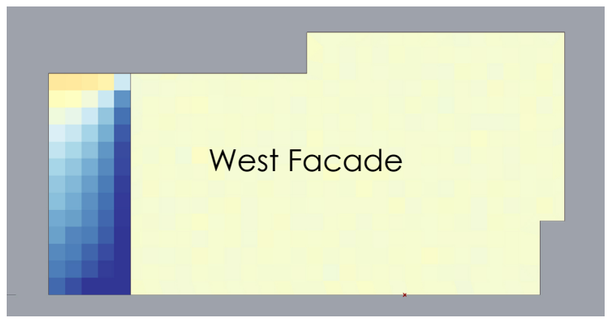












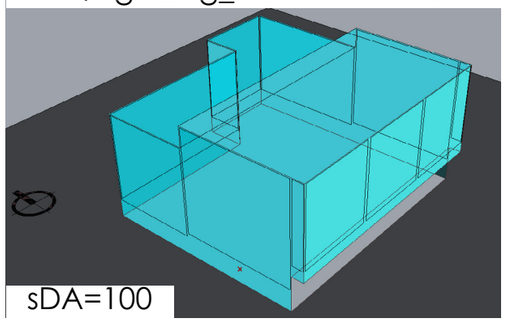
Based on Radiation Map:

Roof is the main source of radiation.

In order to get enough daylight, I would open up skylight and see if it works.

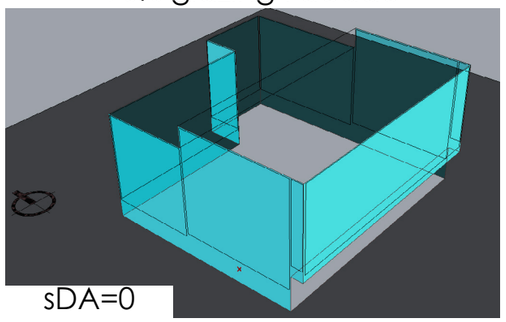
Test Case_3

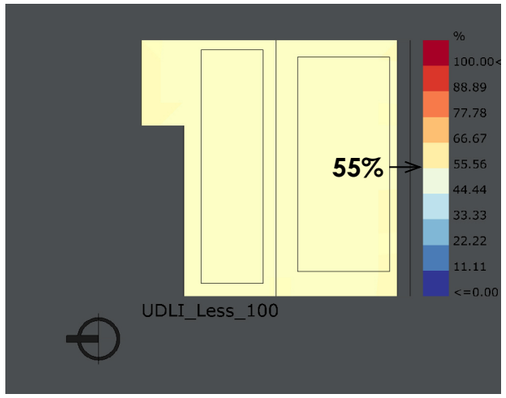
90% glazing_Facade & Roof

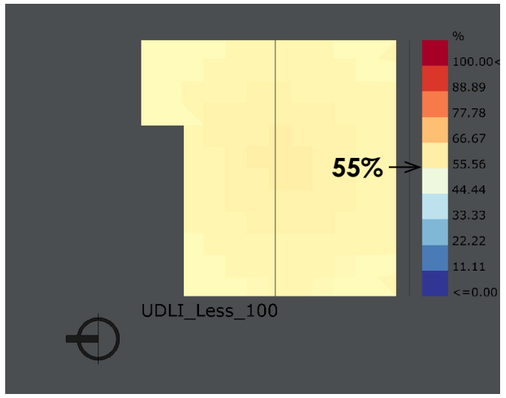


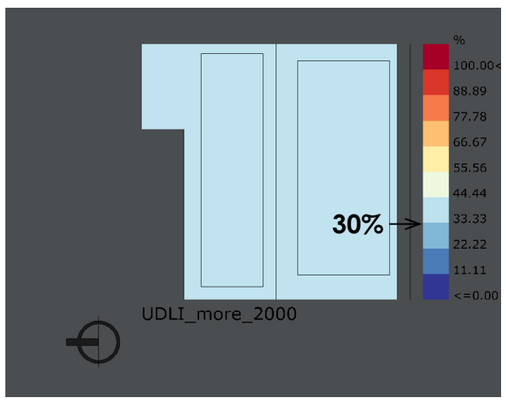
Test Case_2

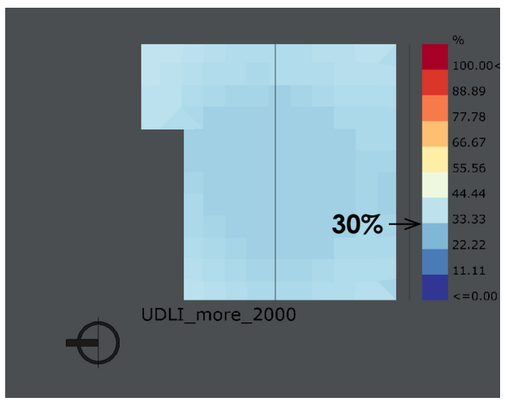
90% glazing Facade











Compare Test Case_2 and Test Case_3:

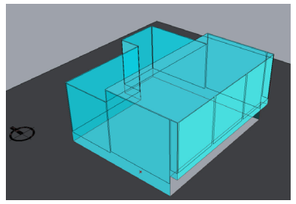
There is obvious change regarding on daylighting .

I would also further compare in terms of lighting energy and comfort.

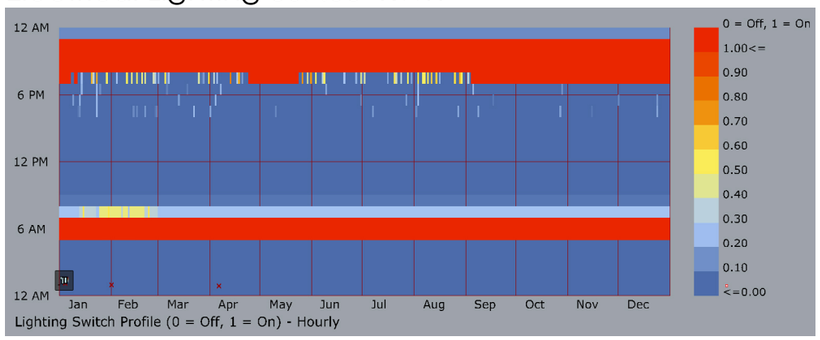
Daylight_Test Case_2 Analysis

Test Case_3

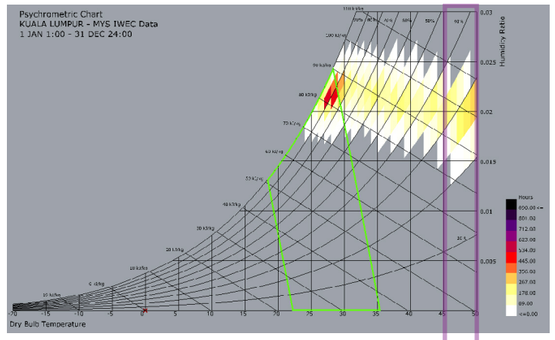
90% glazing_
all Facade & Roof



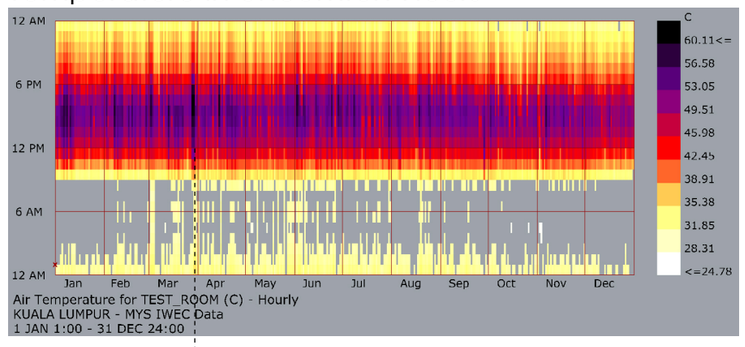
Electrical Lighting 807.58 KWh



Uncomfort Hours 70.82%

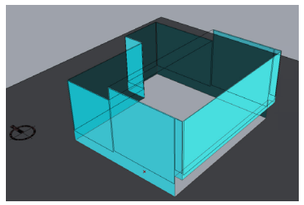


Temperature in Uncomfort Hours

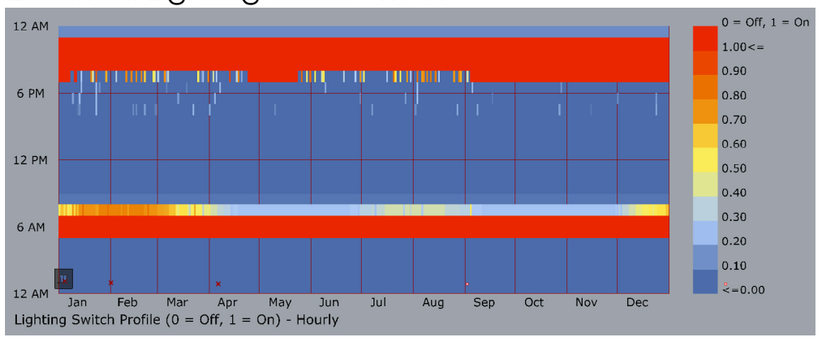


Test Case_2

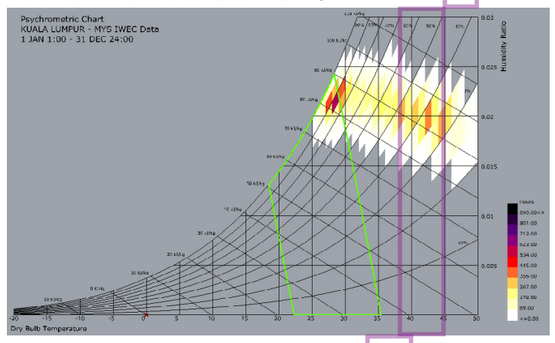
90%
glazing on all
Facade



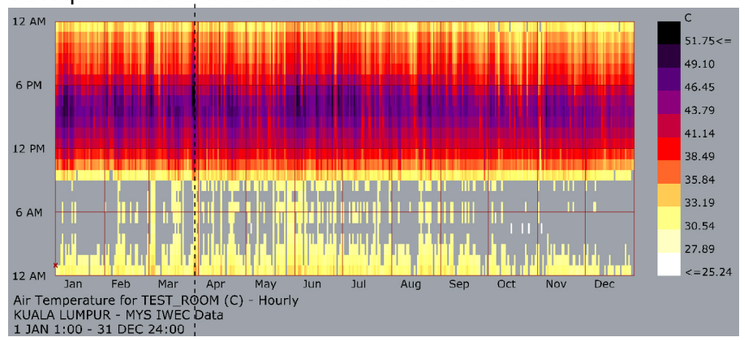
Electrical Lighting 831.09 KWh



Uncomfort Hours 76.9%

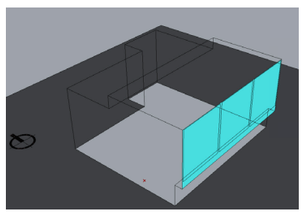


Temperature in Uncomfort Hours

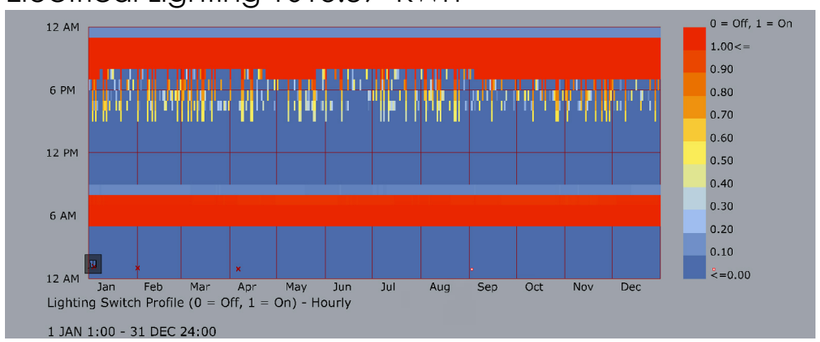


Base Case

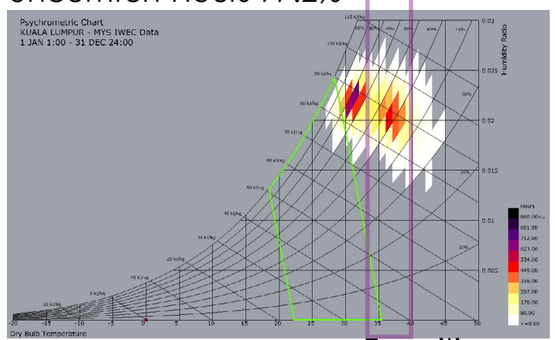
80%
glazing on South
Facade



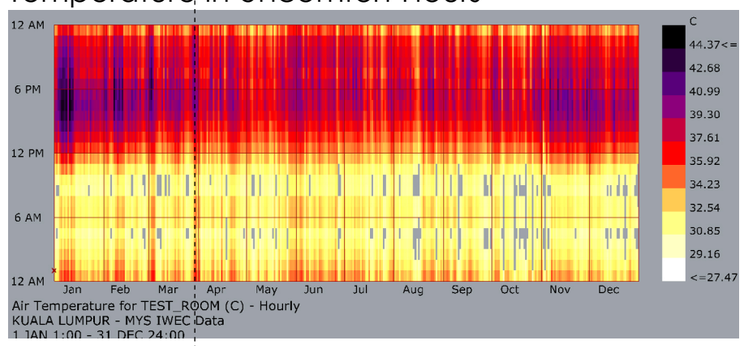
Electrical Lighting 1013.89 KWh



Uncomfort Hours 97.2%

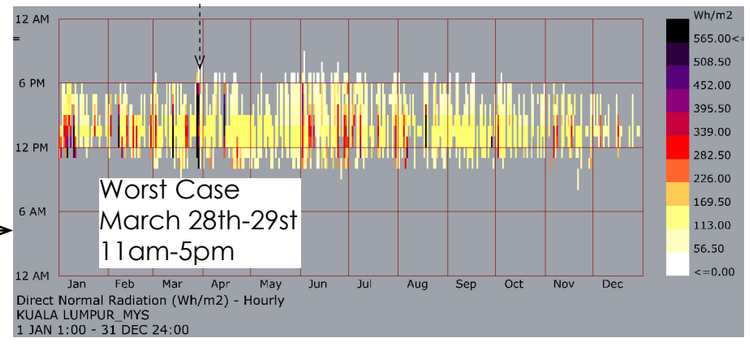


Temperature in Uncomfort Hours



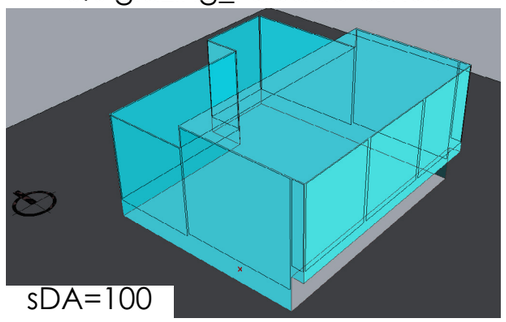
Compare Test Case_2 and Test Case_3 and Base Case:
Test Case_3 is better than Test Case_2 in terms of Lighting Energy and Comfortable as well.
Reasons for Improve:
More Glazing Surface Area, Better for Heat Transfer Out,
Better Daylighting, Less Internal gain generated by Electrical Lighting
Reasons for Transition of Heat:
More Direct Solar gain, Peak Temperature corelate with Direct Radiation Diagram

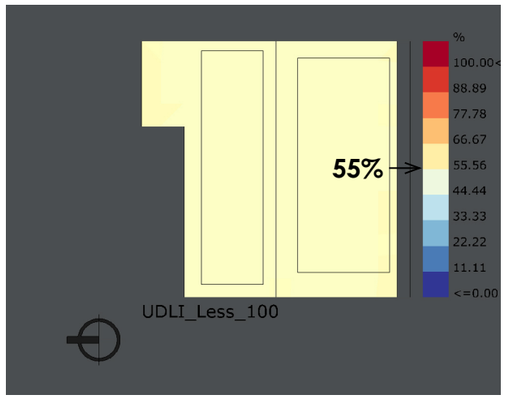
Transition of Heat

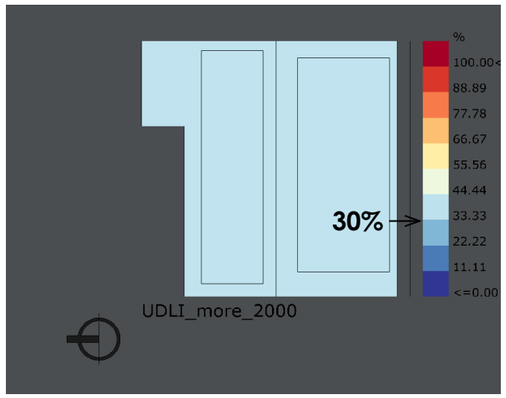


Design Shading for Test Case_3

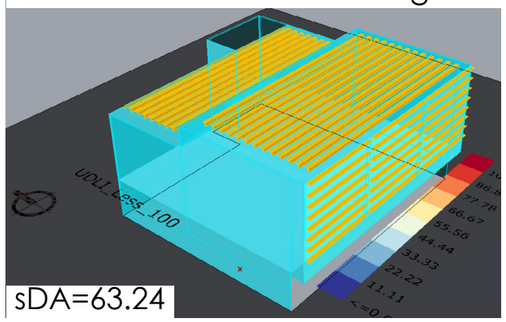
Test Case_3
90% glazing_Facade & Roof

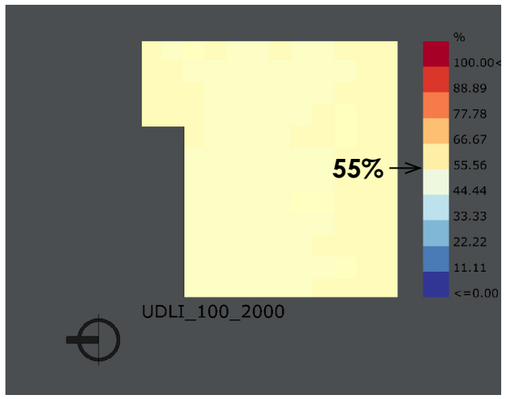


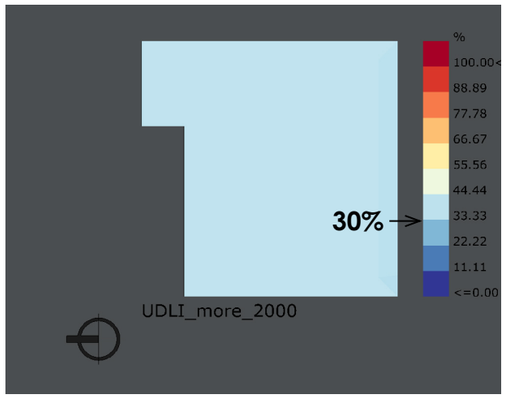




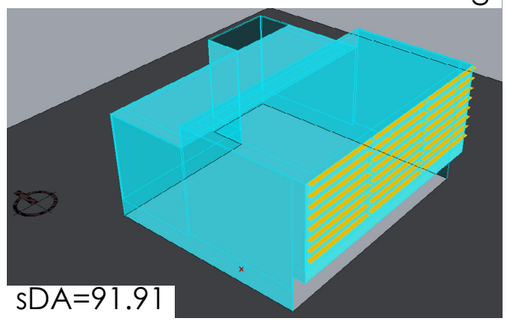
Test Case_4
Test Case3 with Shading

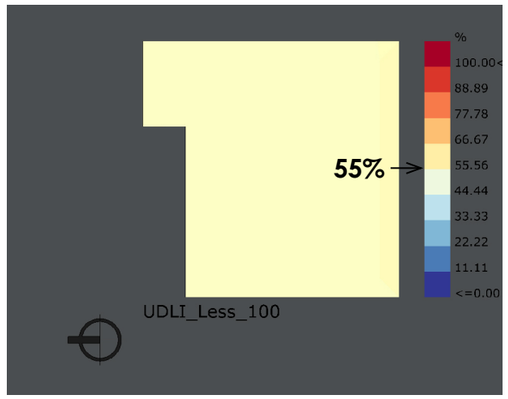


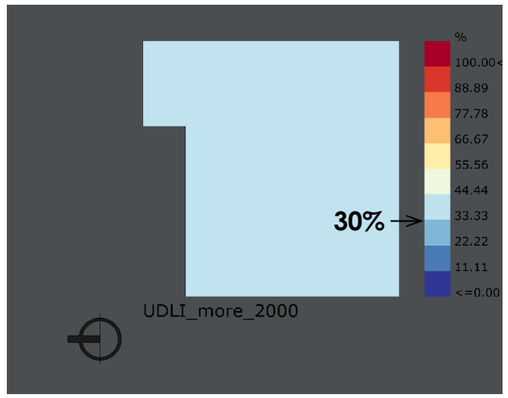




Test Case_5
Test Case3 with facade Shading





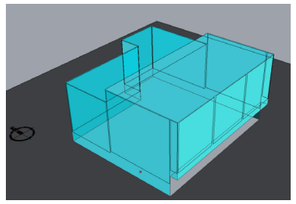


Compare Test Case_3 and Test Case_4/5:
Both Test Case_4 and Test case_5 doesn't Change much on Comfort.
TestCase_4 daylighting level Drops too much in terms of sDA, since Roof Shading Block too much light.

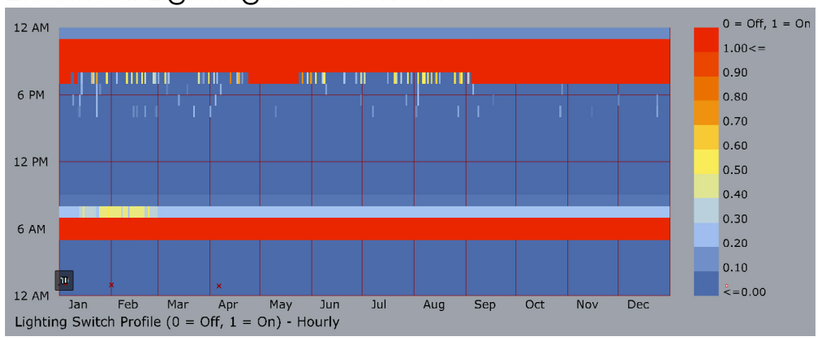
At last, I will go with the Test Case_3, because of its better Performace in daylighting and less Electrical Lighting use , also because we don't need to worry too much about glare since the cloud is already do the shading for us.

Test Case_3

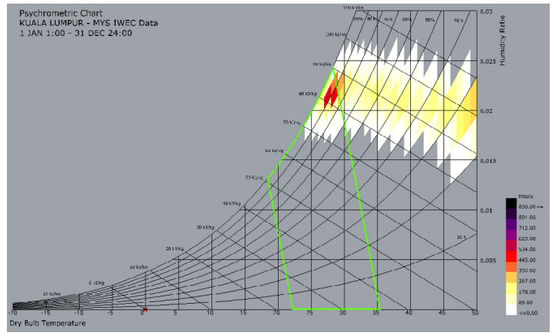
90% glazing_
all Facade & Roof



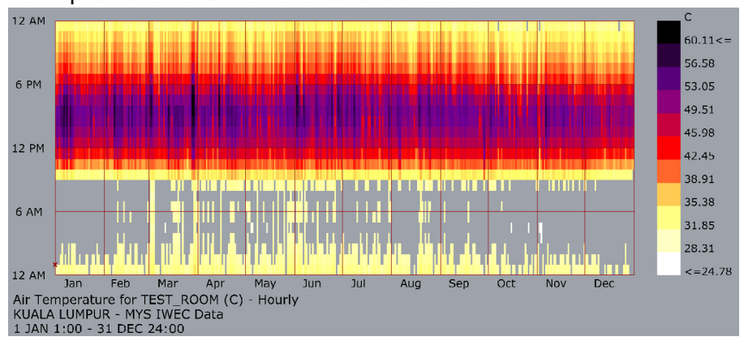
Electrical Lighting 807.58 KWh



Uncomfort Hours 70.82%



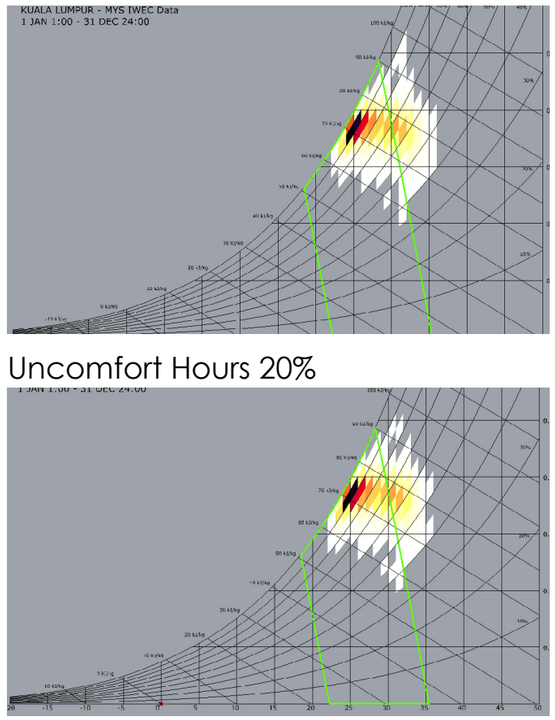
Temperature in Uncomfort Hours



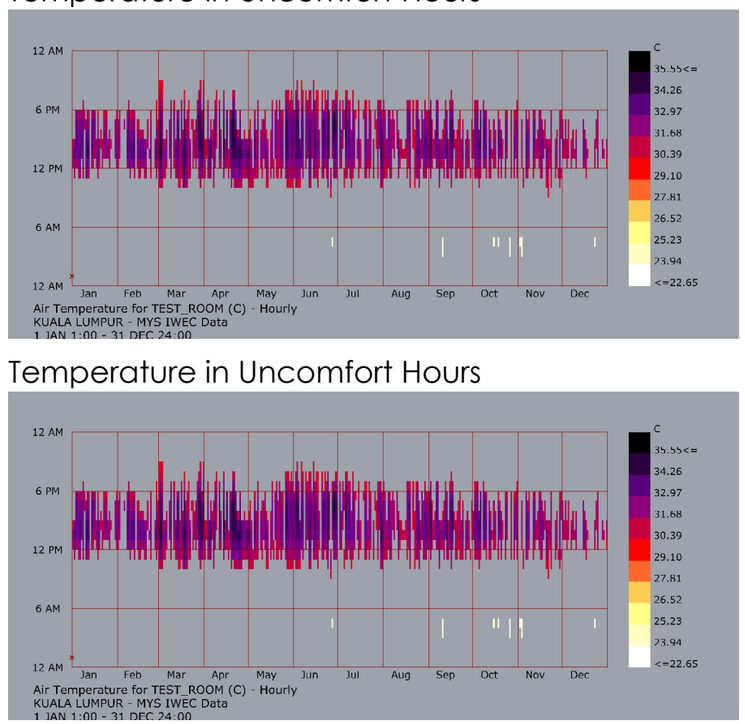
90% glazing_
all Facade & Roof
With Natural Ventilation

Minimum indoor Temp=24°C
Maximum Outdoor Temp= 40°C

Uncomfort Hours 20%



Temperature in Uncomfort Hours



90% glazing_
all Facade & Roof
With Natural Ventilation and Wood Frame and Roof

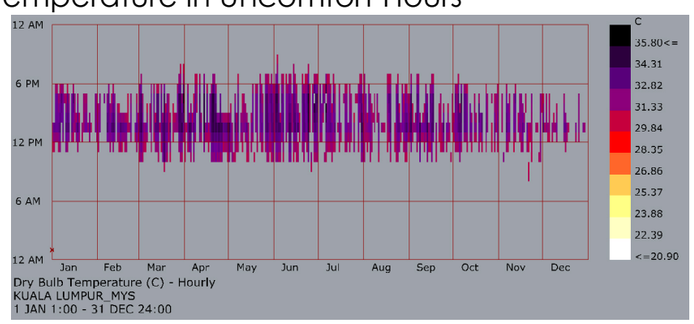
ASHRAE 189.1-2009 EXTWALL WOOD-FRAME CLIMATEZONE 1-4

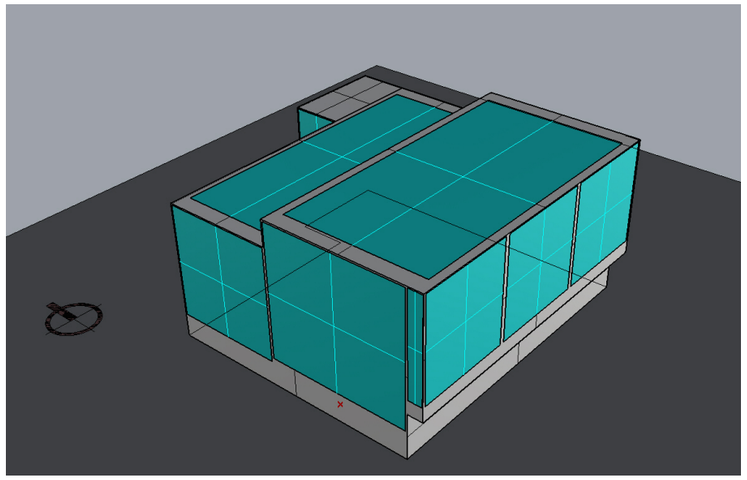
Uncomfort Hours 20%

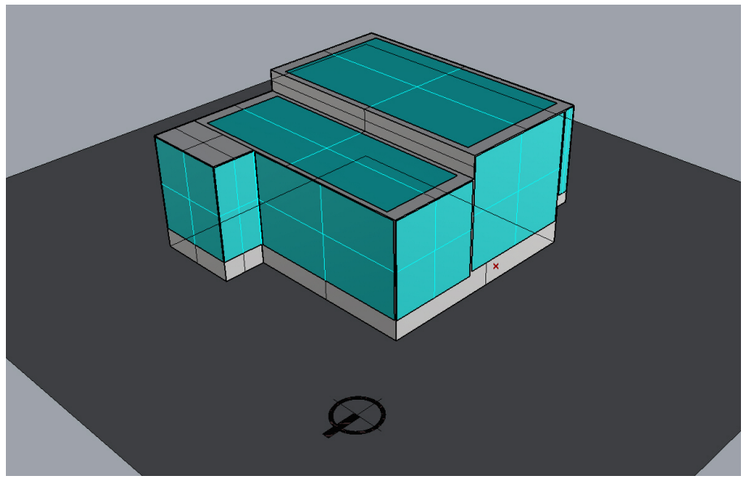
Temperature in Uncomfort Hours

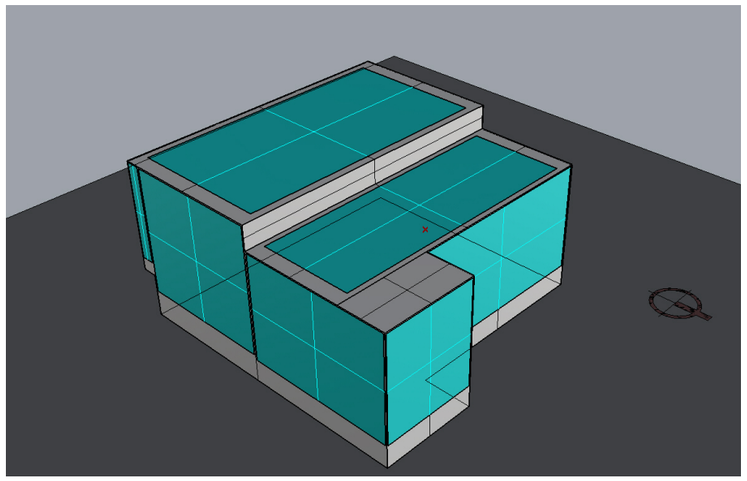
Outdoor Case

Temperature in Uncomfort Hours









Daylighting:

# sDA=100%,
DLAIllumThresholds=100

Comfort:

Comfort Time Percentage=80%,
with Natural Ventilation & Wood Frame

Be able to achieve indoor comfort, when outdoor is comfort.
However, not able to achieve a better comfort when outdoor temperature is too hot and uncomfortable.

By using Roof Pond_evaporate cooling, there might be a chance to achieve a better comfort level when outside is too hot. However, it will result in not enough daylight, if roof is covered.