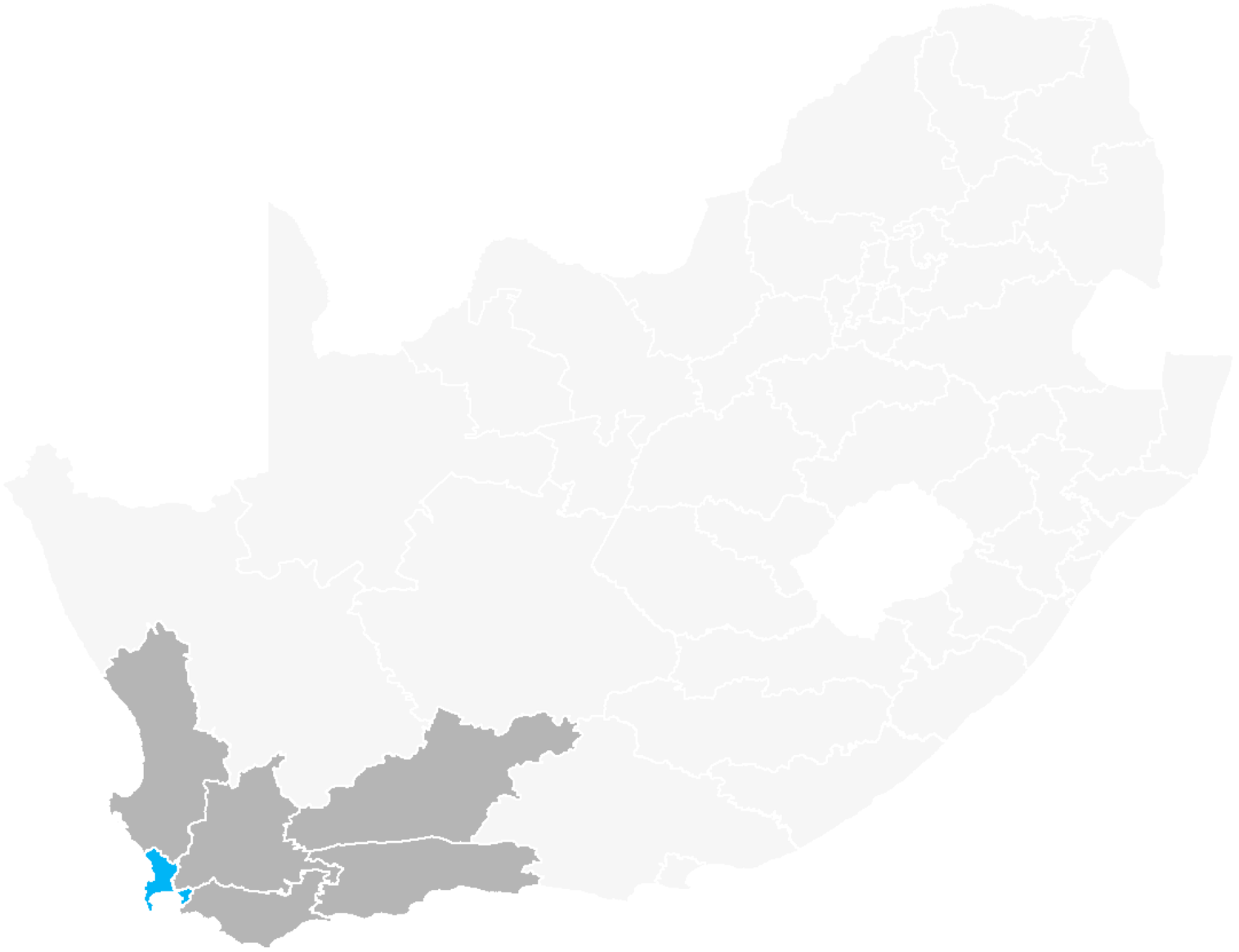
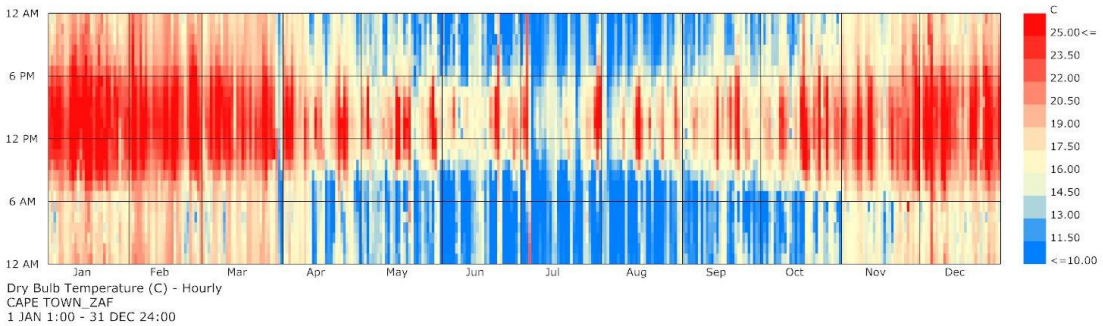
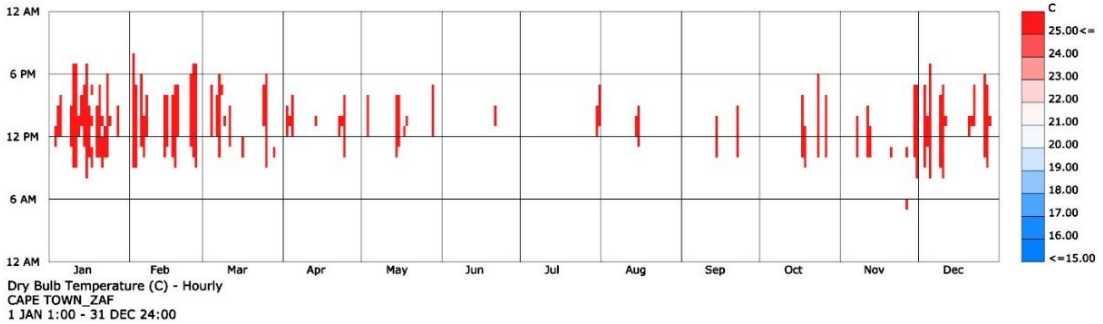
Cape Town, South Africa (33.9253° S, 18.4239° E)



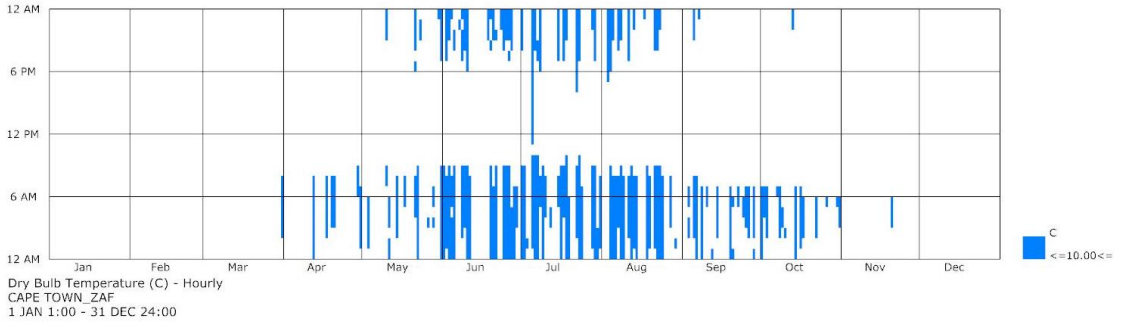
Temperature and Relative humidity



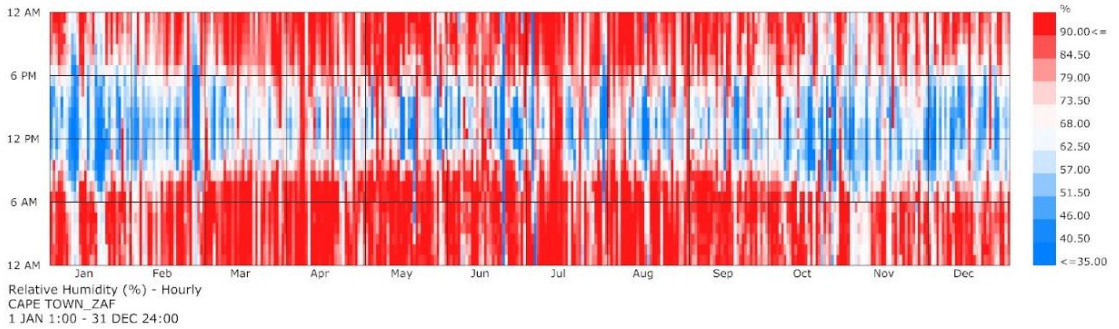
(Fig 1.1) The annual temperature graph of Cape Town indicating the average annual temperature range



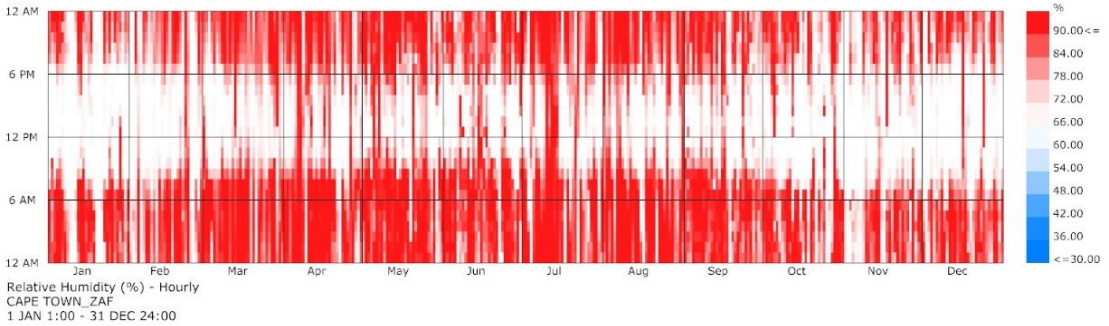
(Fig 1.2) Graph indicating the times of the year when the temperature falls higher than 25°



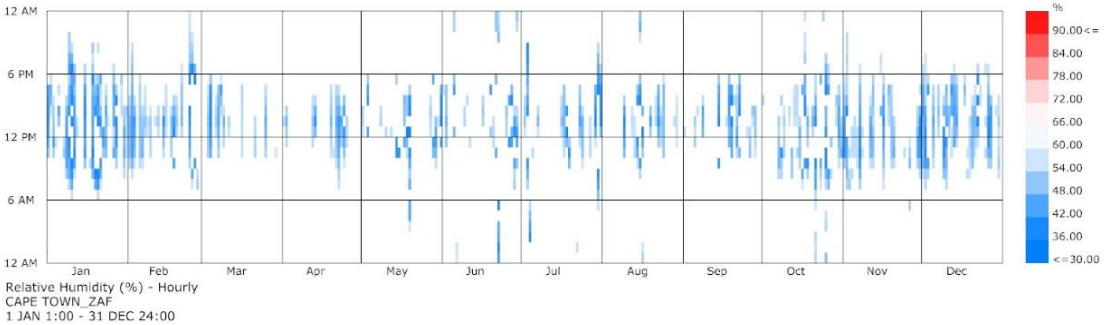
(Fig 1.3) Graph indicating the times of the year when the temperature falls lower than comfortable (15°)*



(Fig 2.1) The annual relative humidity graph of Cape Town indicating the average relative humidity range

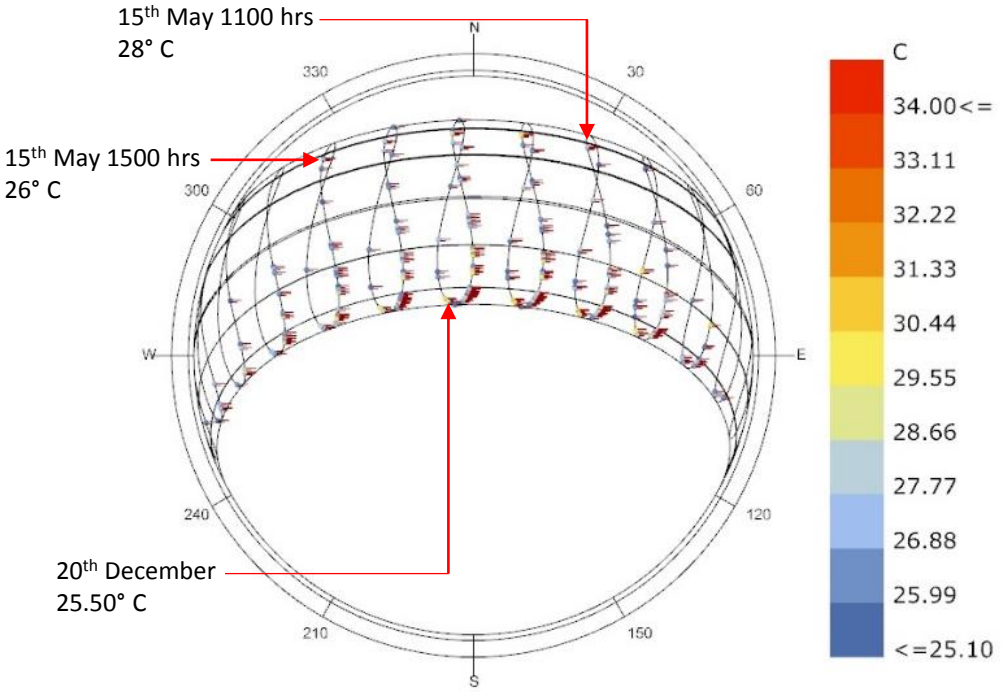


(Fig 2.2) Relative humidity graph of Cape Town indicating the relative humidity higher than 60%

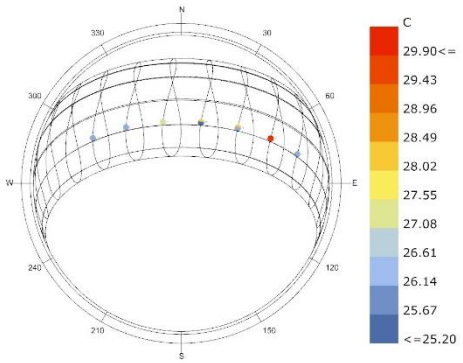


(Fig 2.4) Relative humidity graph of Cape Town indicating the relative humidity within the range of comfort*

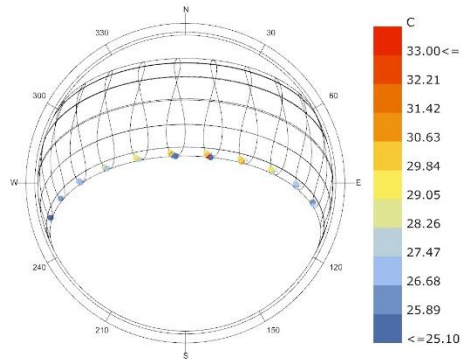
Sun path



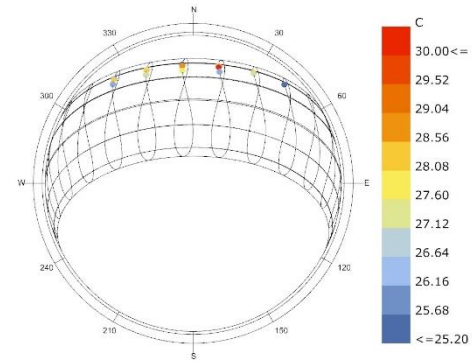
Sun-Path Diagram - Latitude: -33.98
Hourly Data: Dry Bulb Temperature (C)
CAPE TOWN_ZAF
... ...
Conditional Selection Applied:
Dry Bulb Temperature>25
272.0 hours of total 3012.0 sun up hours(9.03%).



Sun-Path Diagram - Latitude: -33.98
Hourly Data: Dry Bulb Temperature (C)
CAPE TOWN_ZAF
... ...
Conditional Selection Applied:
Dry Bulb Temperature>25
10.0 hours of total 252.0 sun up hours(3.97%)



Sun-Path Diagram - Latitude: -33.98
Hourly Data: Dry Bulb Temperature (C)
CAPE TOWN_ZAF
... ...
Conditional Selection Applied:
Dry Bulb Temperature>25
42.0 hours of total 294.0 sun up hours(14.29%)

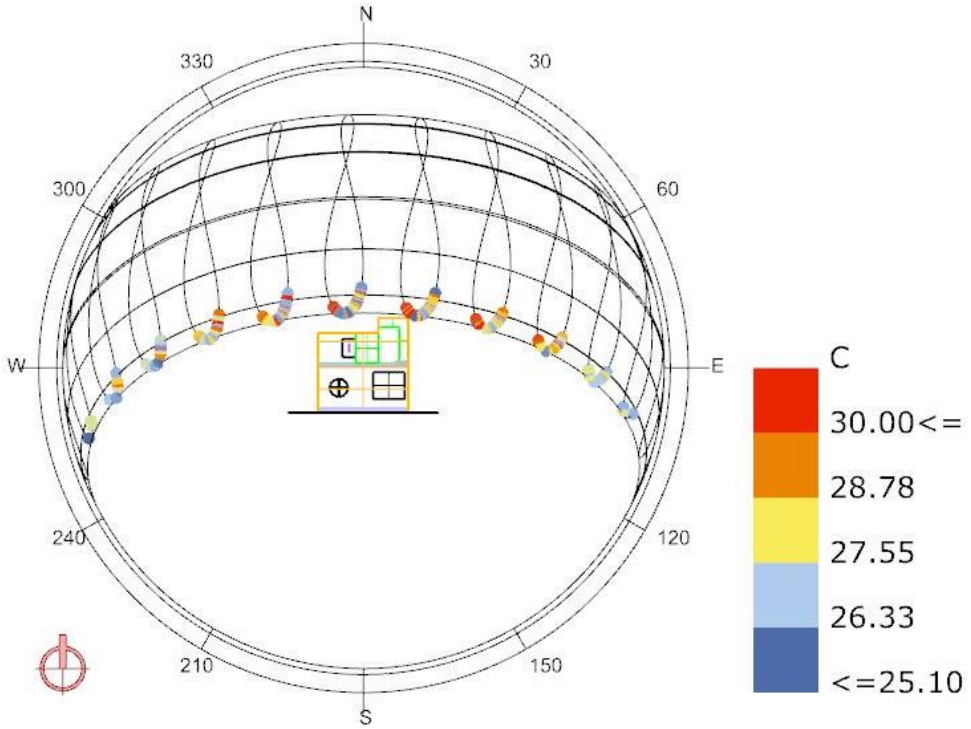


Sun-Path Diagram - Latitude: -33.98
Hourly Data: Dry Bulb Temperature (C)
CAPE TOWN_ZAF
... ...
Conditional Selection Applied:
Dry Bulb Temperature>25
17.0 hours of total 211.0 sun up hours(8.06%).

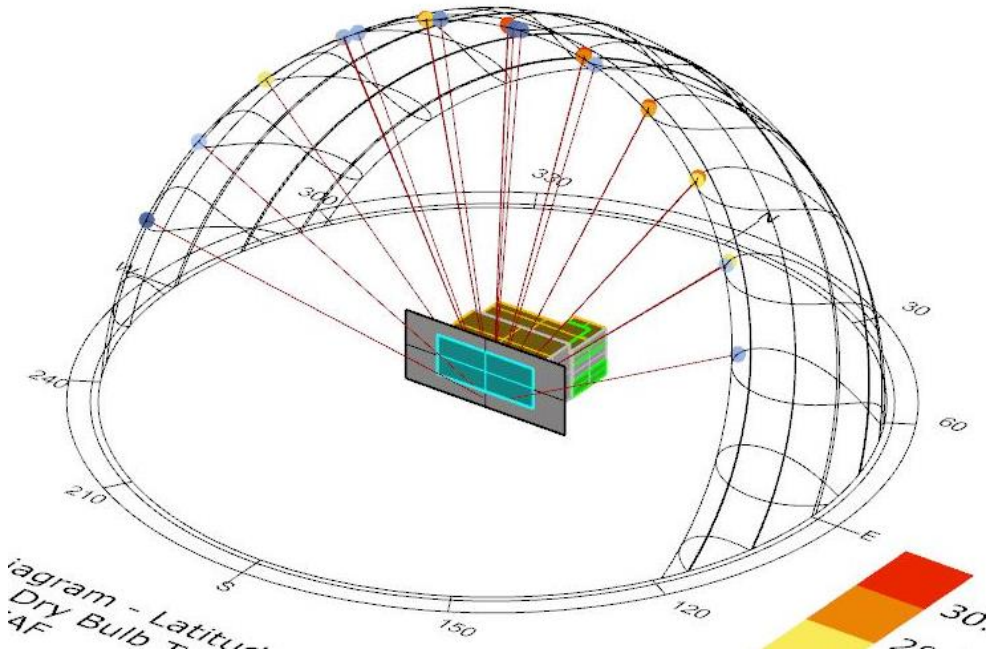
Observations:

- Strong sun (>25°) from 17th October from 1000 hrs to 1500 hrs through all days in December through 15th May from 1100 hrs to 1500 hrs.

Sun path



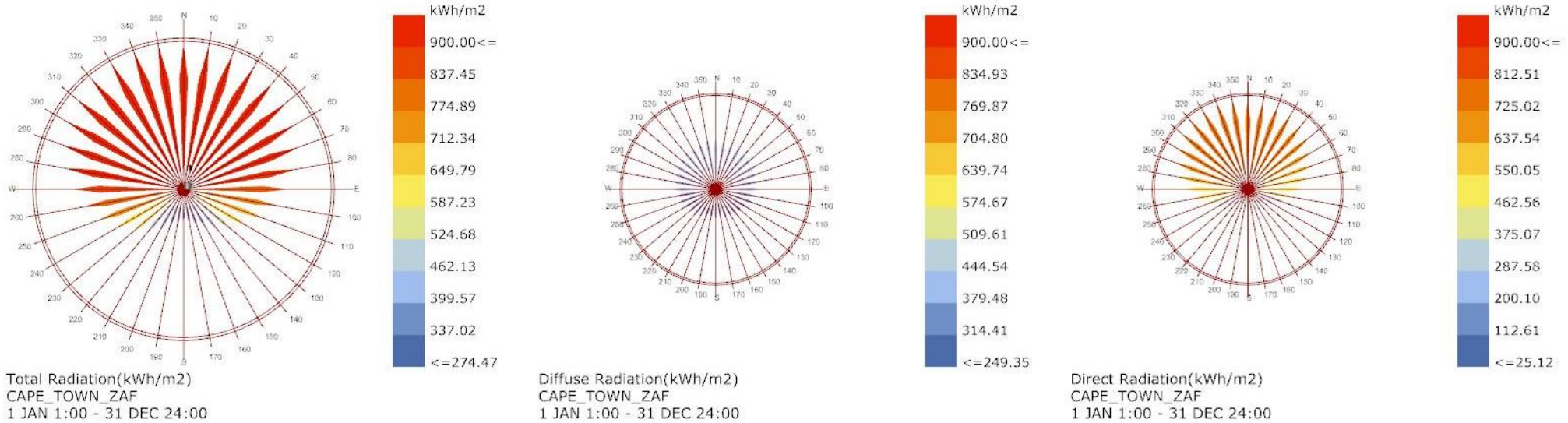
(Fig 4.1) Sun path of the hottest month – Nov-Feb



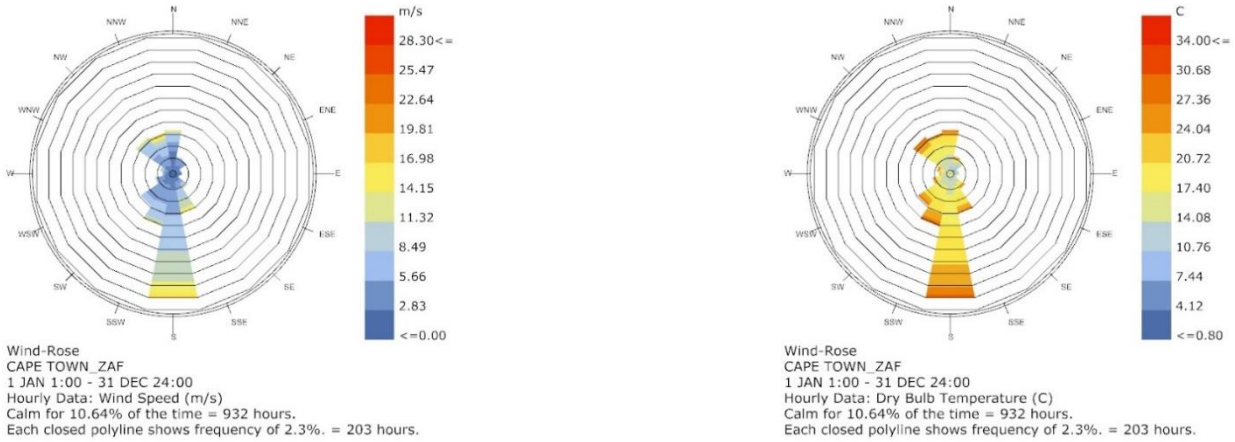
(Fig 4.2) December sun of radiant temp>25°C. Based on this, vertical fins on either side of glazing will be required.

"South orientation reduces direct hot sun through out the year except on Dec. 08, 0800 and between 1700 and 1800 hours

Wind-rose and Radiation

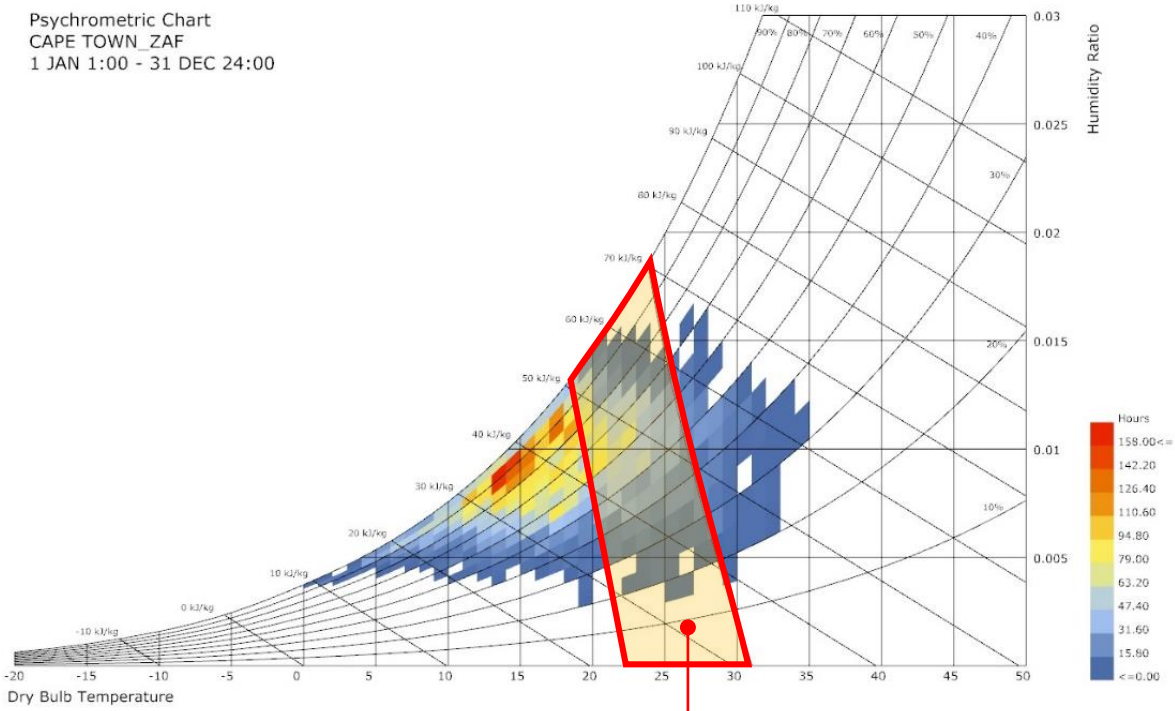


(Fig 5.1) Radiation rose indicates harsh radiation from due North.

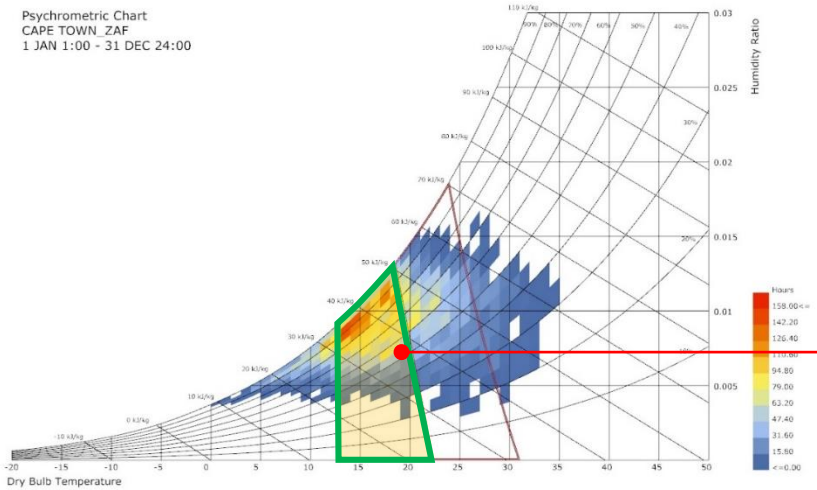


(Fig 6.1) The average wind speeds with directions and temperatures

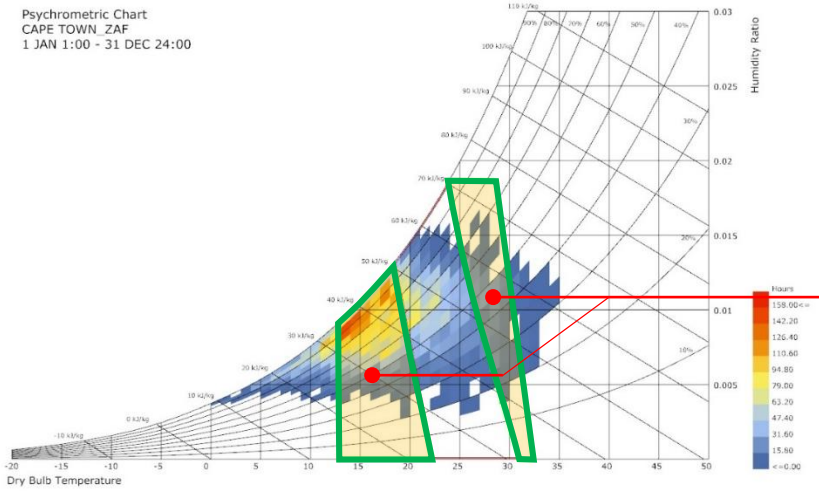
Psychrometric chart



Default comfortable hours – 23.88%



Internal Heat gain – 77%

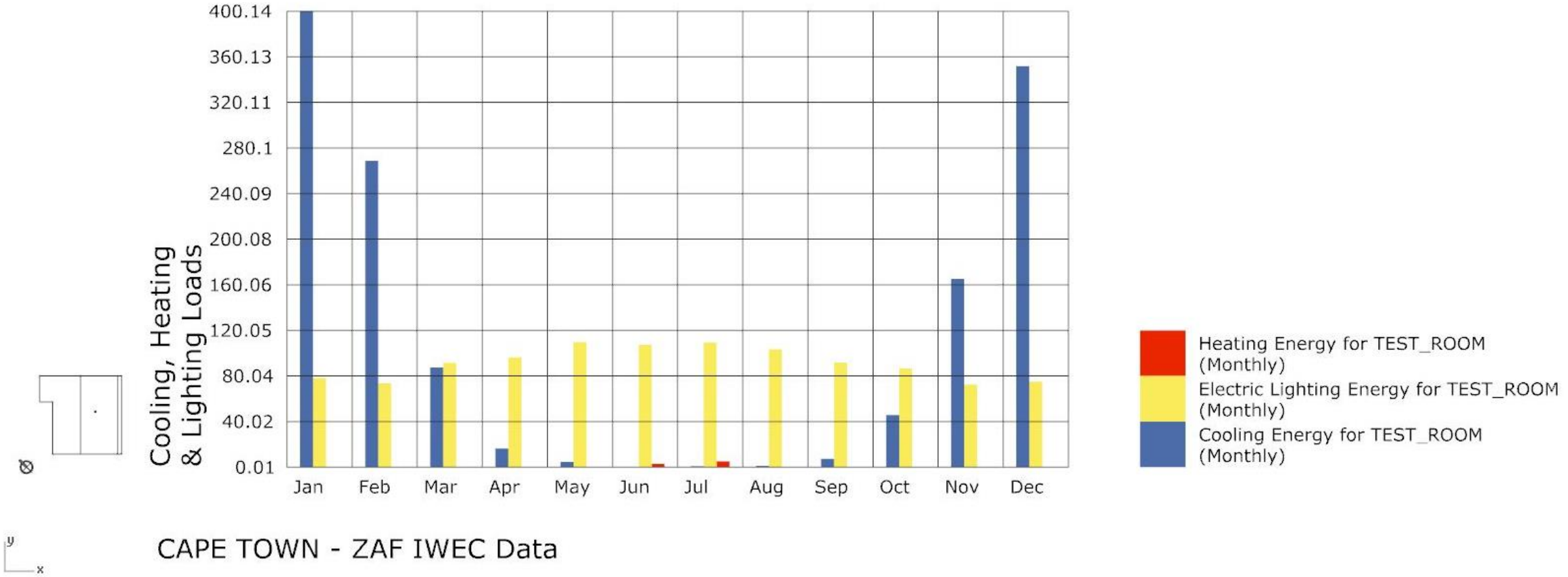


Heat gain + Fans – 79.3%

Observations:

- Cape town falls under the international zone-4 as per ASHRAE standard 90.1-2007. It experiences dry, warm summers and mild, humid winters. With internal heat gain, 77% of the hours in a building can fall within the comfort range.to cool down temperatures during the dry summers, induced ventilation by fans/ mechanical systems can be replaced with natural ventilation from the South winds whenever available.

Base case (assuming mechanical heating and cooling)

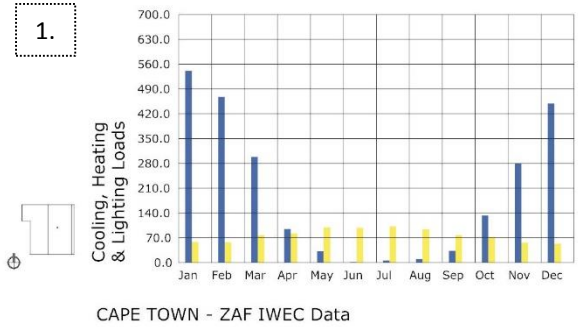


Total Cooling load: 1349.27
Total Heating load: 8.13
Total Lighting load: 1095.54
Total load: 2492.54

"The building needs to be cooled

Optimizing Orientation for the base case

1.

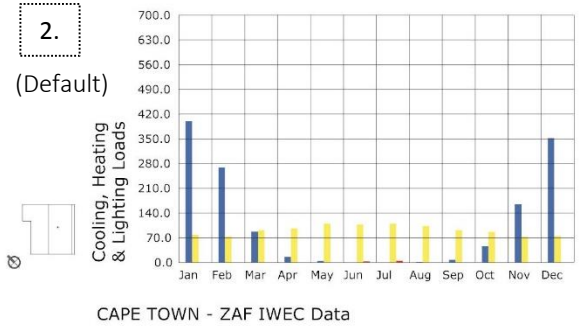


Total Cooling load: 2346.33
Total Heating load: 0.0
Total Lighting load: 929.89
Total load: 3276.22

PMV Comfort: 16.67%

2.

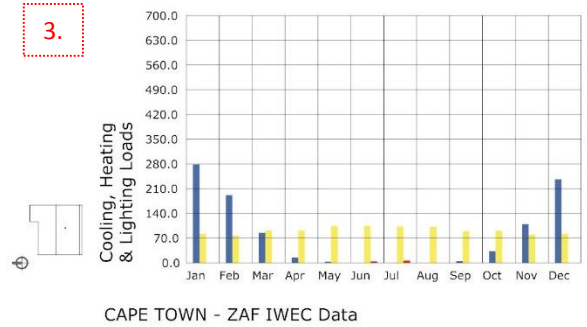
(Default)



Total Cooling load: 1349.27
Total Heating load: 8.13
Total Lighting load: 1095.54
Total load: 2492.54

PMV Comfort: 41.67%

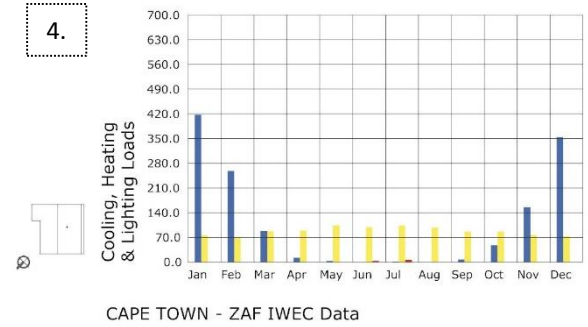
3.



Total Cooling load: 961.74
Total Heating load: 12.33
Total Lighting load: 1102.47
Total load: 2076.54

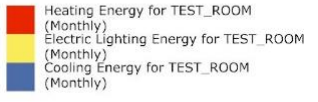
PMV Comfort: 50%

4.

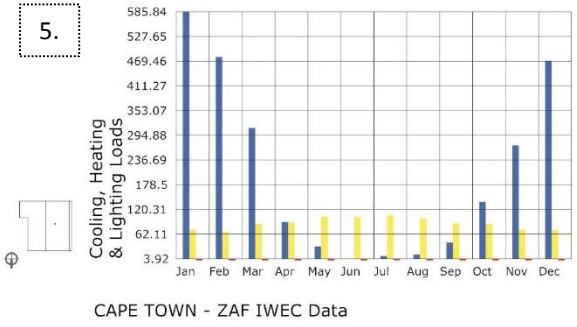


Total Cooling load: 1346.38
Total Heating load: 9.85
Total Lighting load: 1050.66
Total load: 2406.89

PMV Comfort: 33.33%



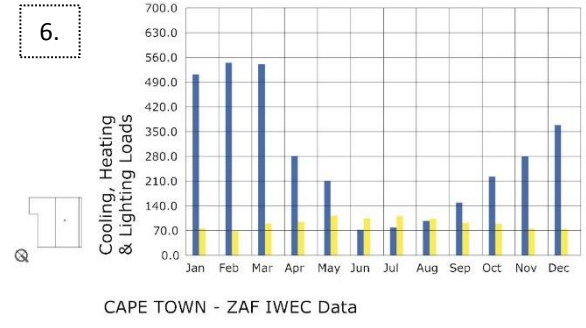
5.



Total Cooling load: 2451.79
Total Heating load: 0.20
Total Lighting load: 1045.27
Total load: 3497.26

PMV Comfort: 16.667%

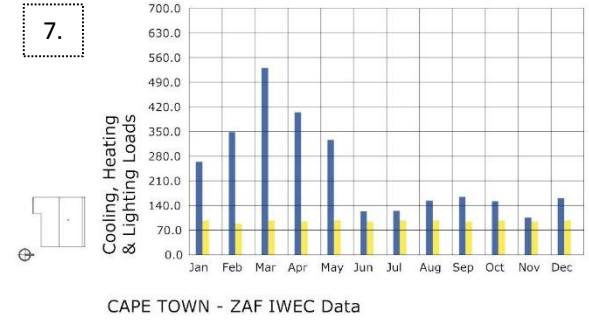
6.



Total Cooling load: 3360.10
Total Heating load: 0.0
Total Lighting load: 1093.27
Total load: 4453.37

PMV Comfort: 0%

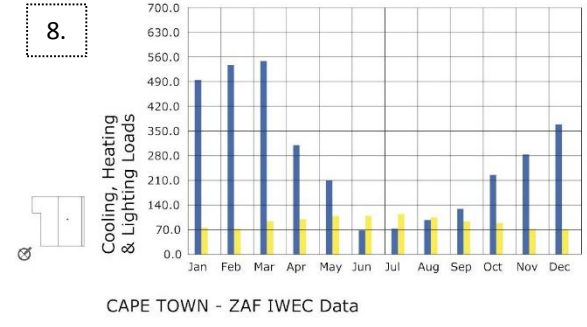
7.



Total Cooling load: 2744.18
Total Heating load: 0.0
Total Lighting load: 1138.32
Total load: 3882.5

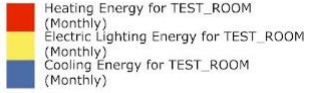
PMV Comfort: 0%

8.



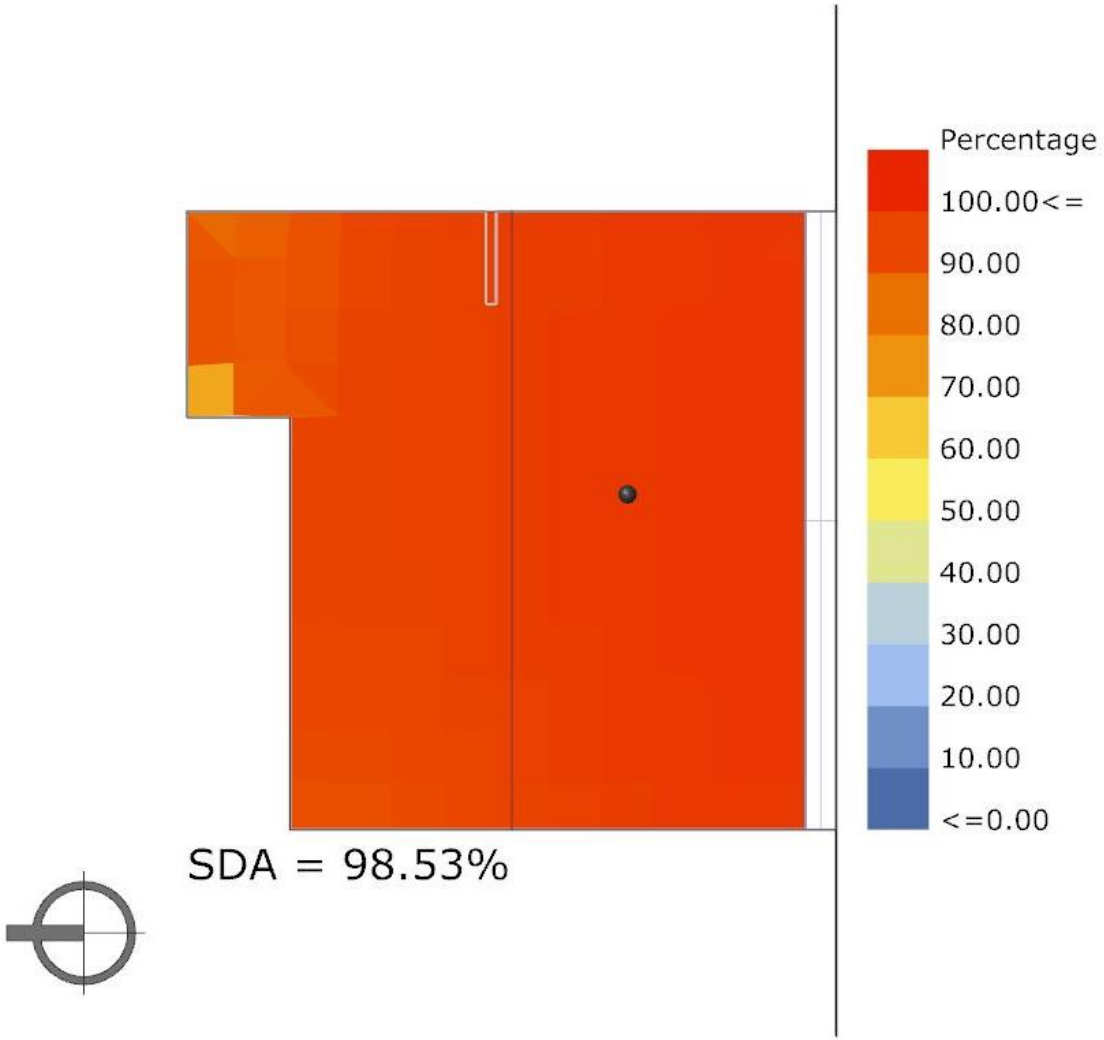
Total Cooling load: 3346.85
Total Heating load: 0.0
Total Lighting load: 1101.64
Total load: 4448.49

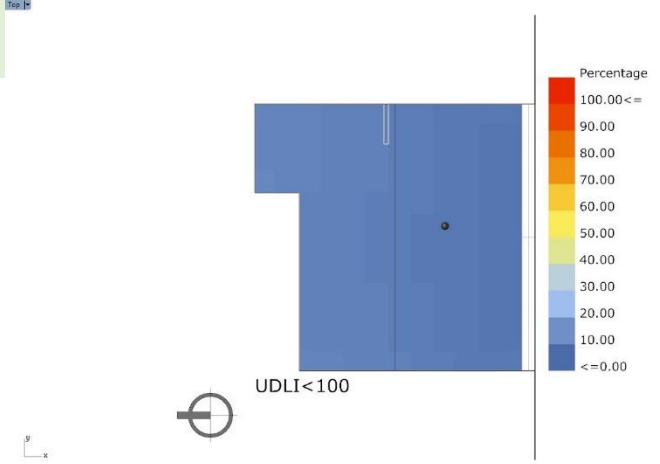
PMV Comfort: 0%

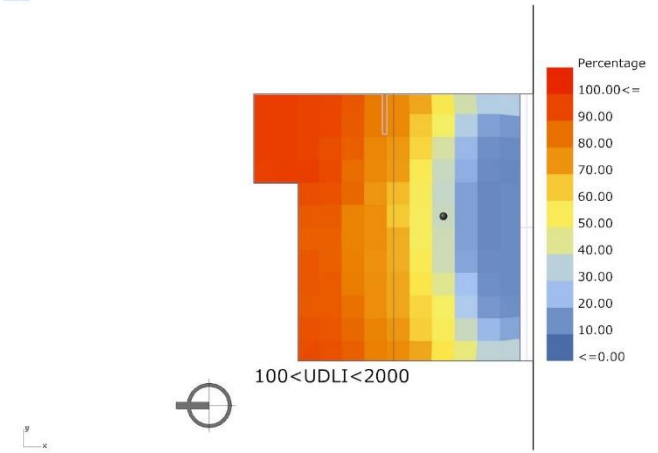


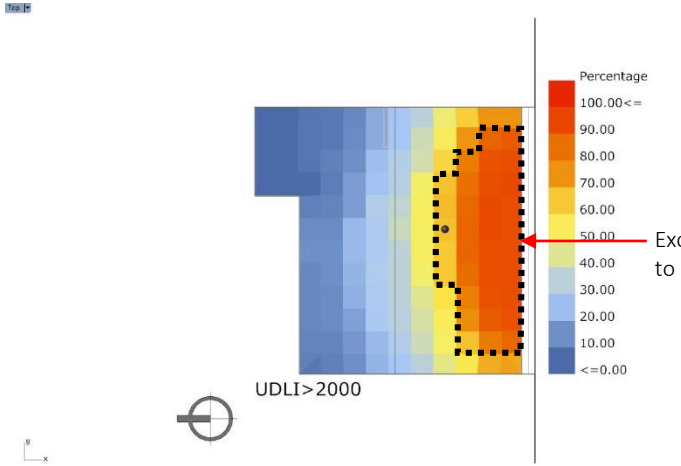
"Façade facing south is the least energy consuming. Daylight to be checked.

Daylighting for the base case

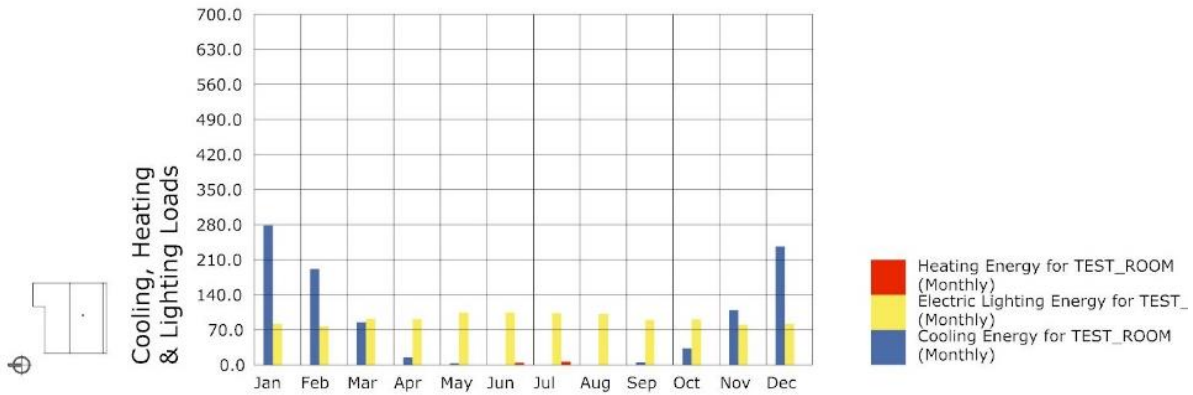








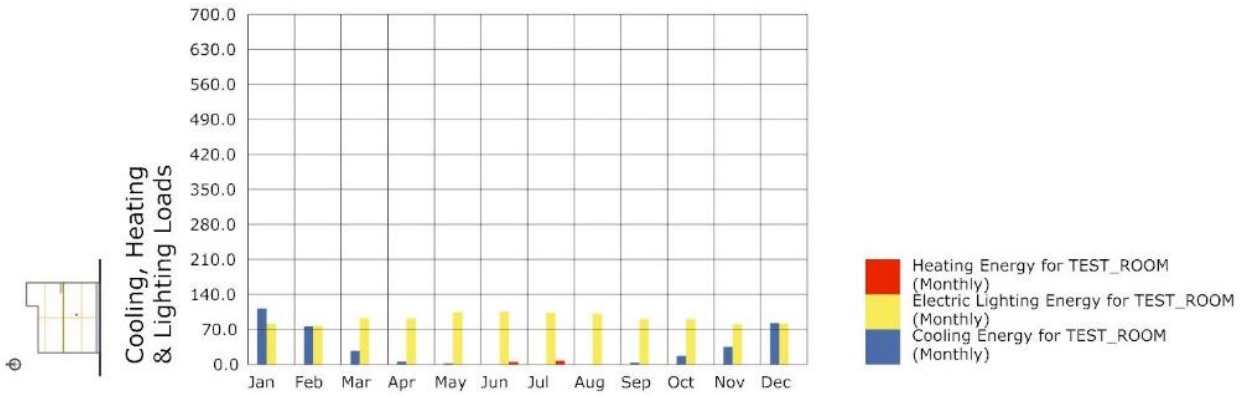
Natural ventilation for the base case



Total Cooling load: 961.74
Total Heating load: 12.33
Total Lighting load: 1102.47
Total load: 2076.54

PMV Comfort: 50%

Predicted Mean Vote without natural ventilation	
Jan	24.130108
Feb	22.221277
Mar	17.759555
Apr	9.928756
May	5.510932
Jun	6.839324
Jul	6.968423
Aug	5.000035
Sep	7.78615
Oct	11.920636
Nov	18.693702
Dec	24.291295



Total Cooling load: 362.95
Total Heating load: 14.13
Total Lighting load: 1102.47
Total load: 1479.55

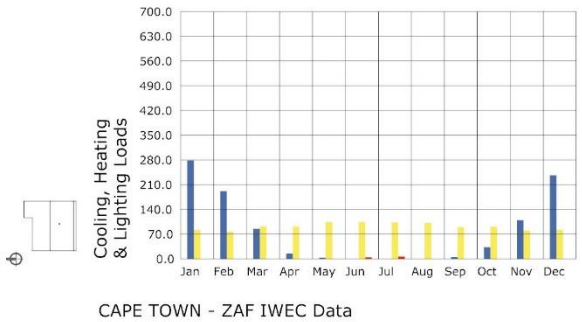
PMV Comfort: 58.33%

Predicted Mean Vote with natural ventilation	
Jan	6.483681
Feb	5.783032
Mar	5.005769
Apr	7.036377
May	10.6163
Jun	15.59338
Jul	15.37391
Aug	12.51079
Sep	9.042309
Oct	6.719571
Nov	5.067242
Dec	5.760595

Observations:

- Without natural ventilation, Annual Predicted Mean Vote comfort is 50%
- With natural ventilation, Annual Predicted Mean Vote comfort is 66.67%
- Greater percentage of people uncomfortable from November to February (see chart).

Ventilation options for the Optimized case



Base case – No ventilation

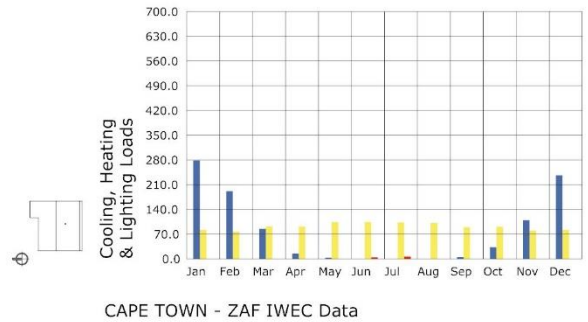
Total Cooling load: 961.74
Total Heating load: 12.33
Total Lighting load: 1102.47
Total load: 2076.54

PMV Comfort: 50%

Min. indoor: 15°C, Min. outdoor: 20°C, Max. Outdoor: 24°C

Total Cooling load: 362.95
Total Heating load: 14.13
Total Lighting load: 1102.47
Total load: 1479.55

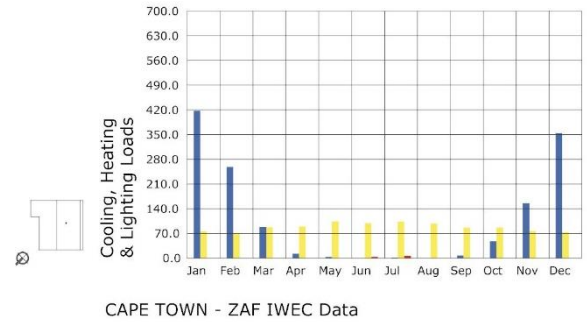
PMV Comfort: 58.33%



Min. indoor: 18°C, Min. outdoor: 24°C, Max. Outdoor: 28°C

Total Cooling load: 2081.14
Total Heating load: 12.33
Total Lighting load: 1102.47
Total load: 3196.95

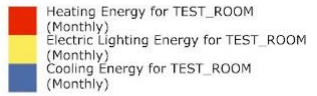
PMV Comfort: 50%



Min. indoor: 12°C, Min. outdoor: 22°C, Max. Outdoor: 25°C

Total Cooling load: 476.18
Total Heating load: 12.67
Total Lighting load: 1102.47
Total load: 1591.33

PMV Comfort: 50%



Min. indoor: 12°C, Min. outdoor: 20°C, Max. Outdoor: 24°C

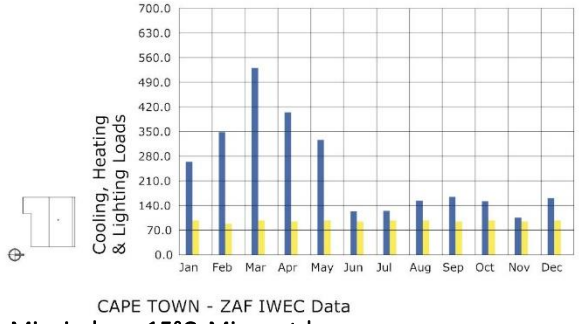
Total Cooling load: 362.95
Total Heating load: 14.13
Total Lighting load: 1102.47
Total load: 1479.55

PMV Comfort: 58.33%

Min. indoor: 0°C, Min. outdoor: 20°C, Max. Outdoor: 24°C

Total Cooling load: 362.95
Total Heating load: 14.13
Total Lighting load: 1102.47
Total load: 1479.55

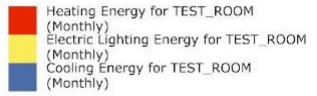
PMV Comfort: 58.33%



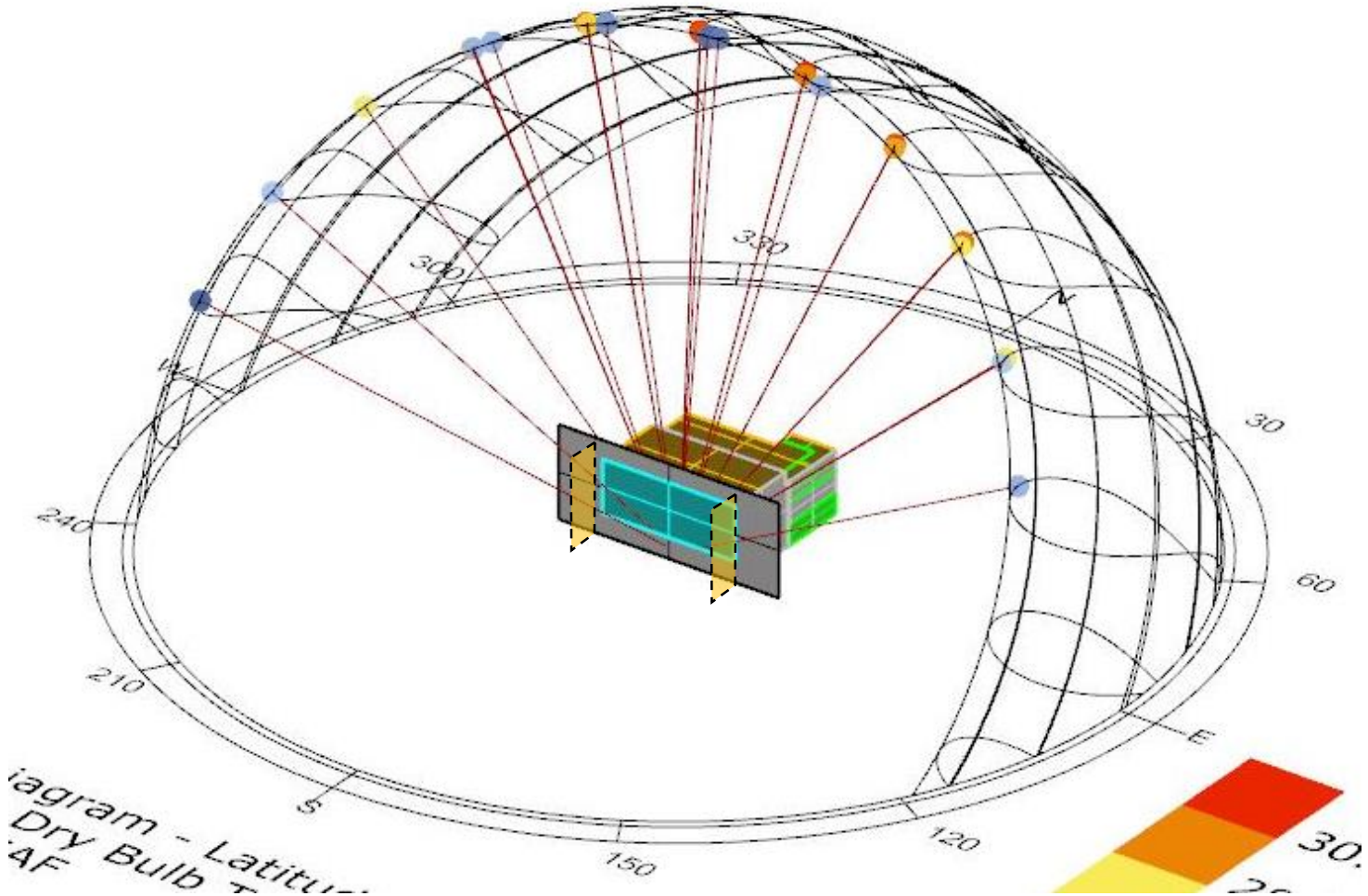
Min. indoor: 15°C, Min. outdoor: 18°C, Max. Outdoor: 24°C

Total Cooling load: 261.29
Total Heating load: 5223.30
Total Lighting load: 1102.47
Total load: 6587.07

PMV Comfort: 100%

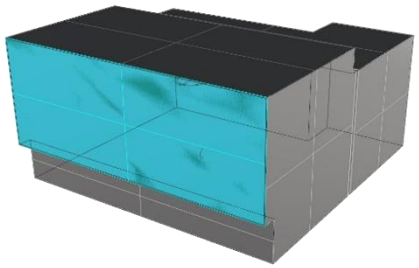


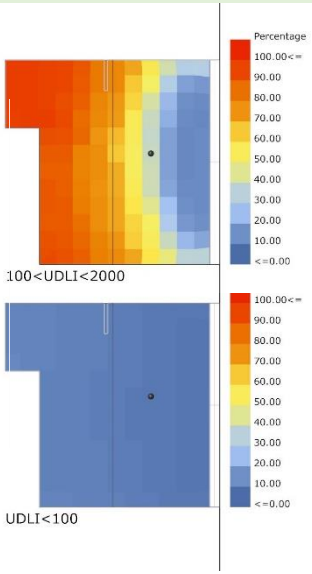
Potential shading strategy



Additive shading options and results

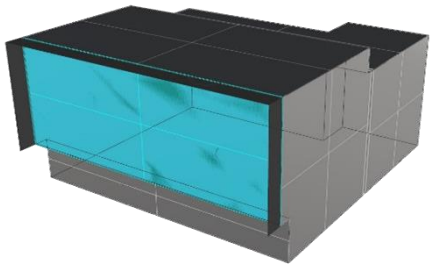
0.

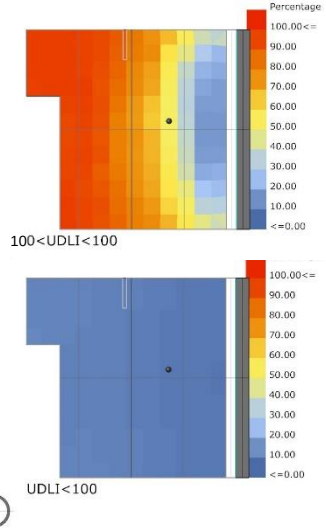




Base PMV Comfort: 33.33%
SDA: 98.3%

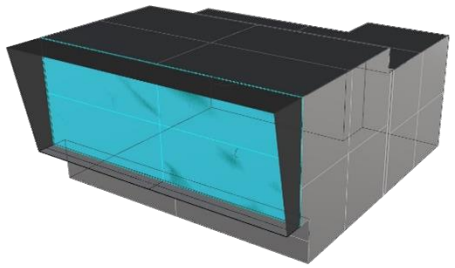
1.

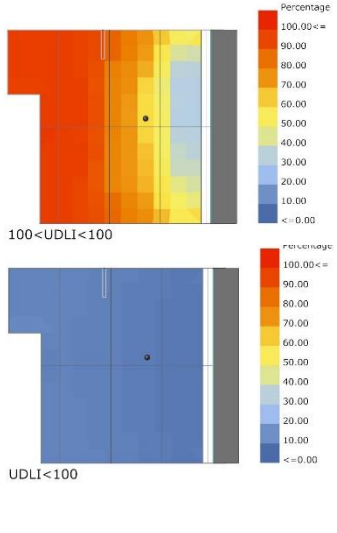




PMV Comfort: 41.67%
SDA: 100%

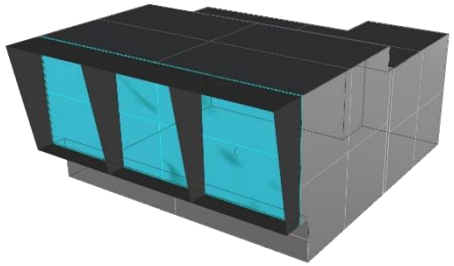
2.

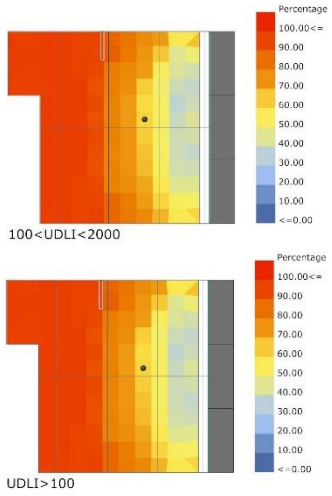




PMV Comfort: 41.67%
SDA: 97.06%

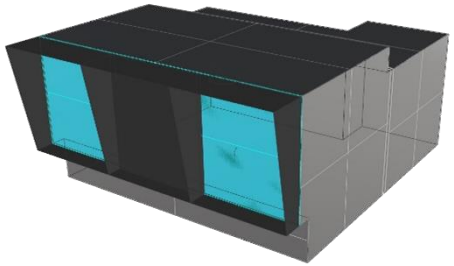
3.

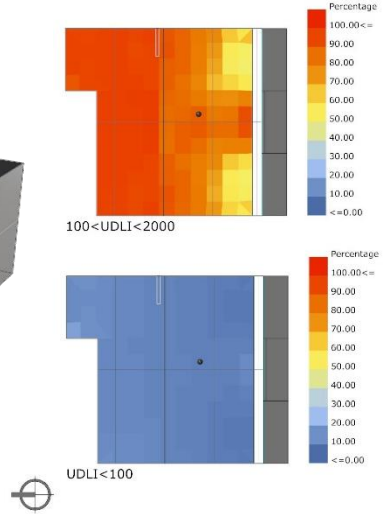




PMV Comfort: 50.0%
SDA: 97.79%

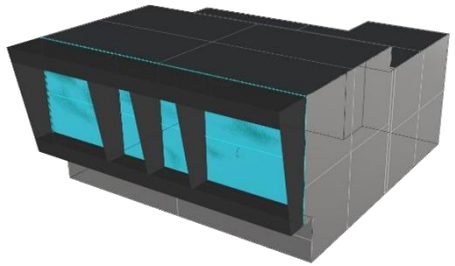
4.

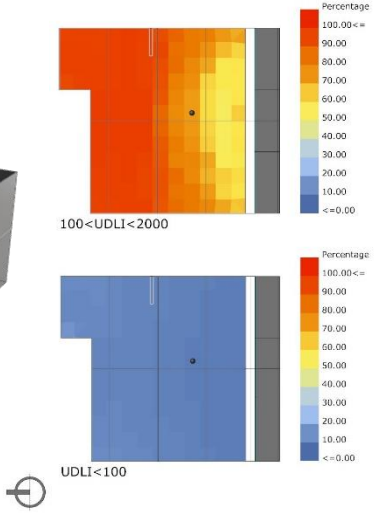




PMV Comfort: 50.0%
SDA: 82.35%

5.



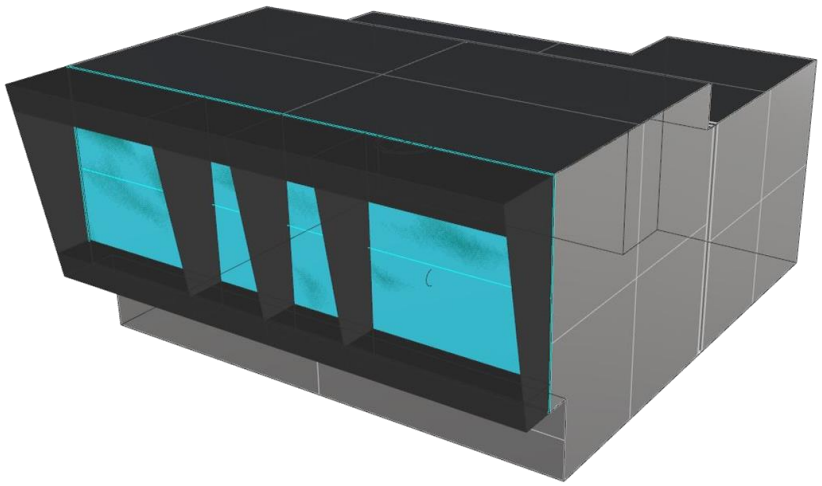


PMV Comfort: 66.67%
SDA: 87.5%

Observations:

- Glass facing due south affords complete glazing but creates zones where the UDLI exceeds 2000 lux.
- As studied in the Sun-Path, Direct sun with radiation greater than 25°C is only during the morning and late afternoon in December. Therefore, vertical fins are used in addition to a horizontal louver to diffuse light.

Material study for the finalized shading option



Default material
PMV Comfort: 66.67%
SDA: 87.5%

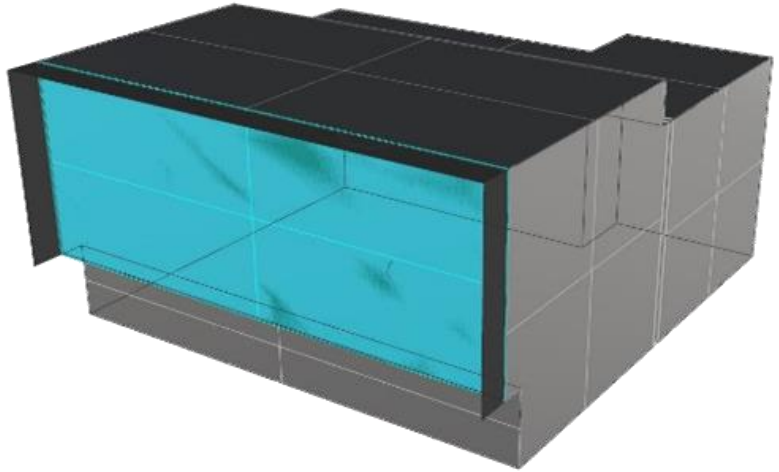
	Default	Material Option-1	Material Option-2	Material Option-3	Material Option-4
Walls	-	ASHRAE 90.1-2010 EXTWALL MASS CLIMATEZONE 1	ASHRAE 90.1-2010 EXTWALL MASS CLIMATEZONE 4	ASHRAE 90.1-2010 EXTWALL WOODFRAME CLIMATEZONE 1	ASHRAE 90.1-2010 EXTWALL MASS CLIMATEZONE 4
Floor	-	DEFAULT	ASHRAE 90.1-2010 EXTROOF IEAD CLIMATEZONE 2-8	ASHRAE 90.1-2010 EXTROOF IEAD CLIMATEZONE 2-8	DEFAULT
Roof	-	DEFAULT	ASHRAE 90.1-2010 ATTICROOF CLIMATEZONE 2-7	ASHRAE 90.1-2010 ATTICROOF CLIMATEZONE 2-7	DEFAULT
Glass	-	DEFAULT CLEAR	DEFAULT CLEAR	DEFAULT CLEAR	LOW_E
PMV comfort	66.67%	58.33%	66.67%	58.33%	8.98%

Observations:

- Materials with greater thermal mass are better suitable for the external surfaces. Materials did not increase the comfort levels but using materials too thick such as Zone-1 External wall or Zone-4 wood-frame wall reduces comfort.

Comparison of annual PMV comfort between option 1 and 5

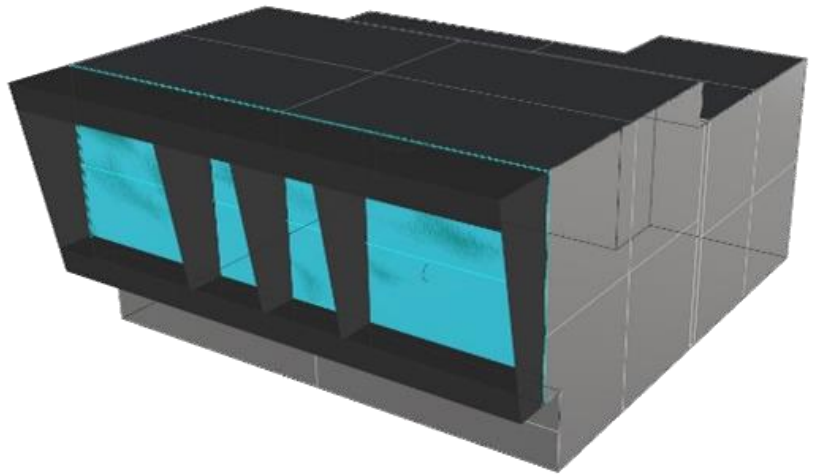
1.



PMV Comfort: 41.67%
SDA: 100%

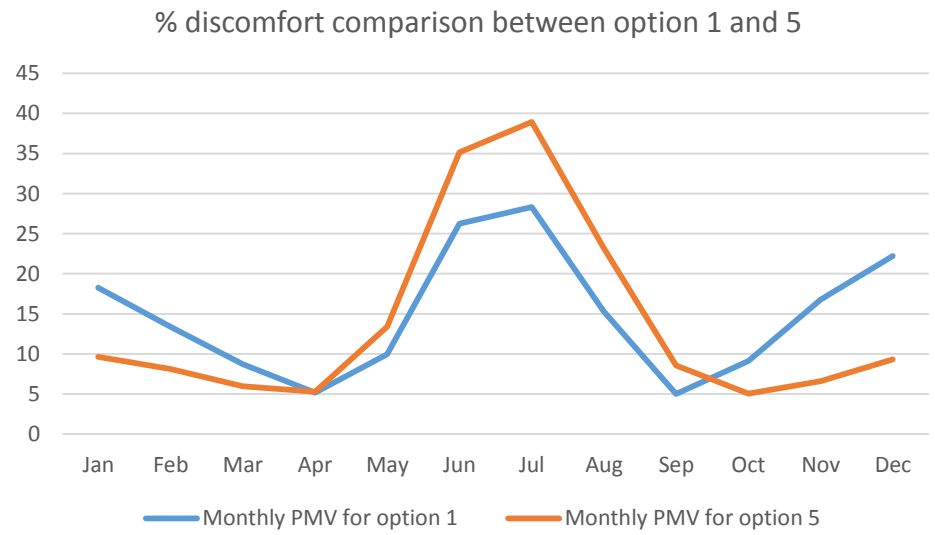
	Monthly PMV for option 1
Jan	18.269073
Feb	13.406969
Mar	8.738198
Apr	5.181595
May	9.97228
Jun	26.263198
Jul	28.334266
Aug	15.287809
Sep	5.001555
Oct	9.130797
Nov	16.801032
Dec	22.224934

5.



PMV Comfort: 66.67%
SDA: 87.5%

	Monthly PMV for option 5
Jan	9.64411
Feb	8.134949
Mar	5.971332
Apr	5.299757
May	13.385286
Jun	35.130745
Jul	38.937306
Aug	23.202968
Sep	8.541169
Oct	5.035705
Nov	6.585352
Dec	9.32263



Observations:

- Shading helps control the indoor temperature during the warm summer months i.e. from September till March.
- But the added comfort in summer due to shading comes at the cost of colder indoor temperatures during winter. Therefore, excessive shading reduces comfort. **This tradeoff makes it unfeasible to achieve 100% comfort through shading.**
- Since cooling is the primary criteria considering the base case, ventilation improves the average PMV comfort. Analysis period plugin in the HB Air Flow component would make it possible to decide which months and days can the window be completely closed to avoid ventilation. As observed in the previous slide, Natural ventilation increases discomfort from May to September.