

# SUSTAINABILITY DESIGN ANALYSIS

**SHIV NADAR**  
UNIVERSITY  
CHENNAI

ACADEMIC BLOCK  
@ KELAMBAKKAM  
CHENGALPATTU, TAMILNADU  
February 2023



IN PARTNERSHIP WITH EARTHONOMICS



# 1.INTRODUCTION

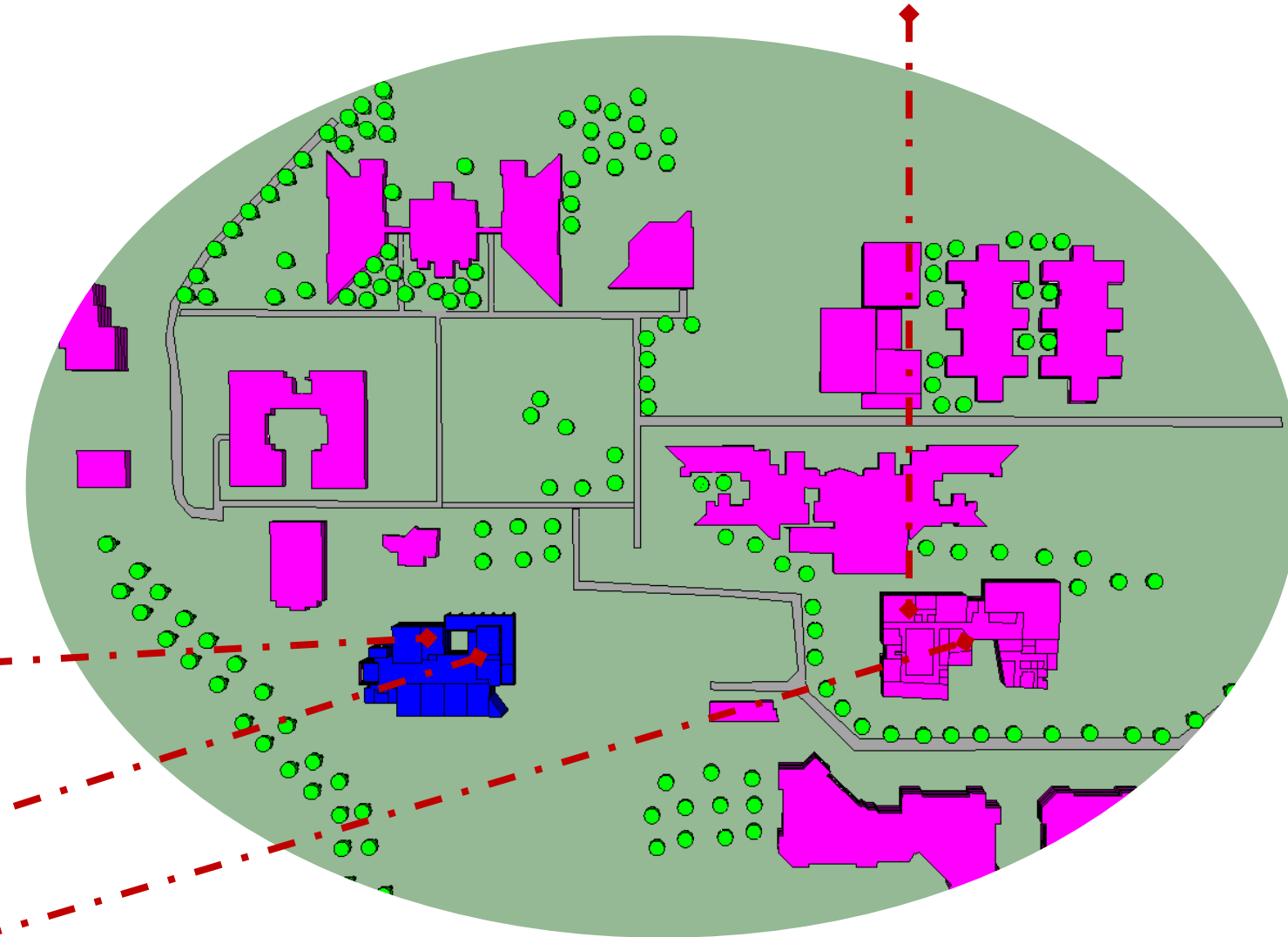
Passive Design Analysis is performed for Shiv Nadar University, Kelambakkam which falls under warm and humid category under the ECBC 2017.

Simulation Analysis is performed for SNU academic Building with a Built-up Area of 8,753 Sq.m.



Site location

Academic Building



Proposed Building

Research Building



**SSN**  
**ACADEMIC  
BLOCK**

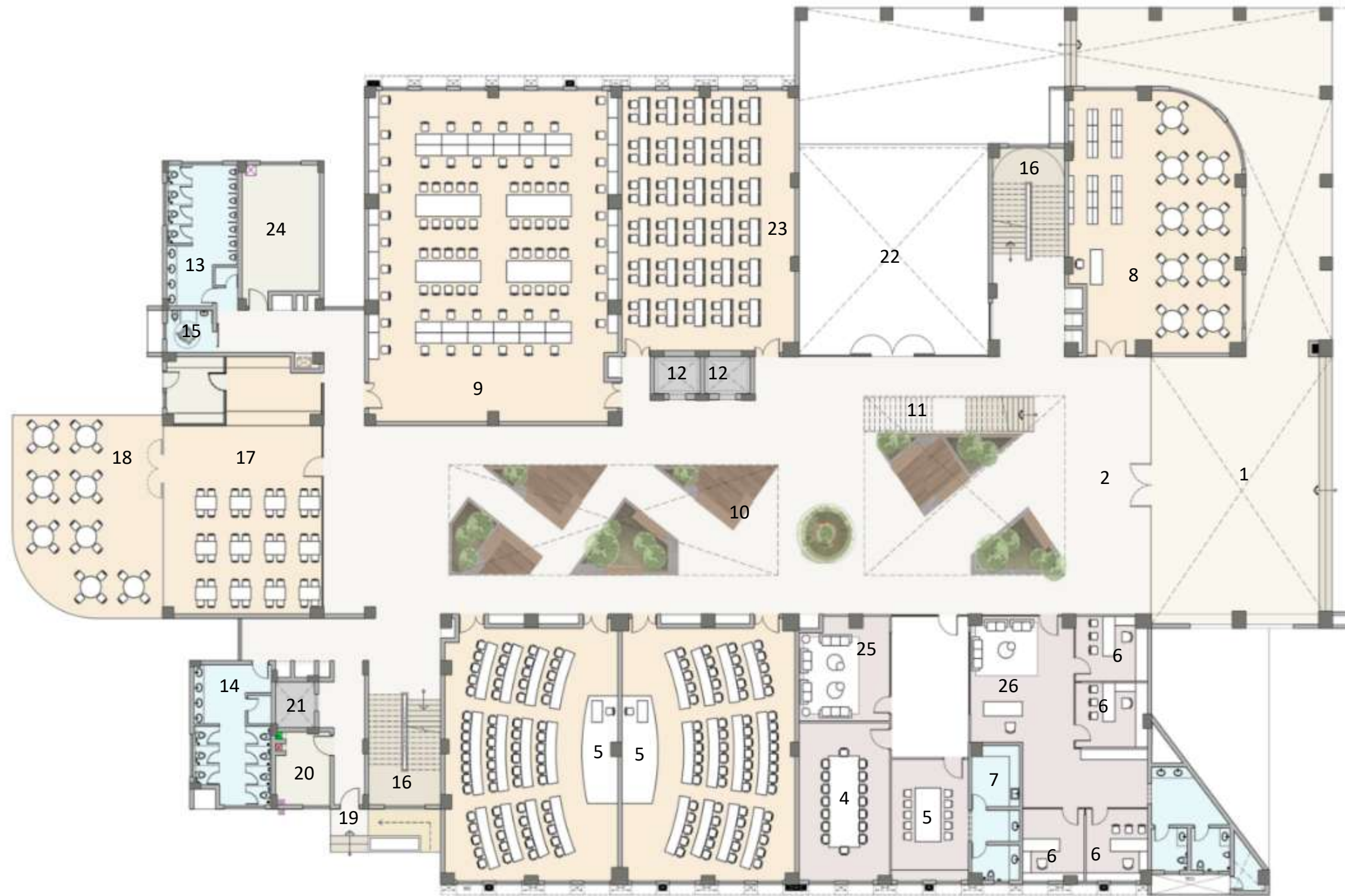
## SITE PLAN

### LEGEND :

1. Vehicular drive way
2. Vehicular drop-off
3. Main entrance
4. Pedestrian footpath
5. Services drop-off
6. Internal courtyard seating
7. Existing Storm water drain



# GROUND FLOOR PLAN



## LEGEND :

1. Verandah
2. Entrance lobby
3. Admin offices
4. Conference room
5. Lunch room
6. HOD Cabins
7. Pantry & Toilets
8. Library
9. Physics laboratory
10. Central Atrium
11. Main Staircase
12. Passenger lift
13. Gents Toilet
14. Ladies Toilet
15. PWD Toilet
16. Staircase
17. Cafeteria
18. Outdoor Cafeteria
19. Serive entrance
20. Store room

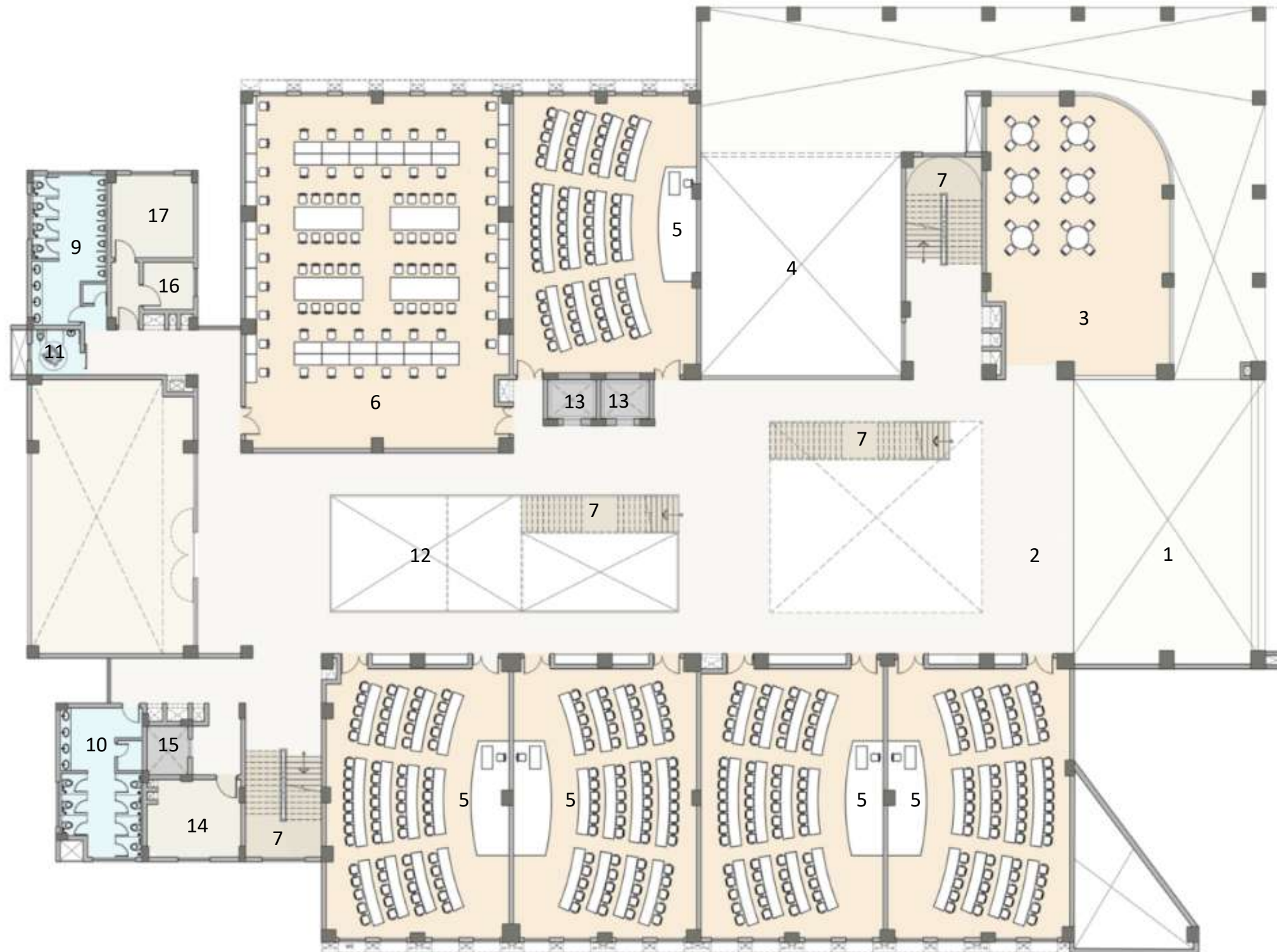
## LEGEND :

21. Service lift
22. Open to Sky Courtyard
23. Language laboratory
24. Electrical room
25. VIP waiting lounge
26. Common lounge room

# FIRST FLOOR PLAN

## LEGEND :

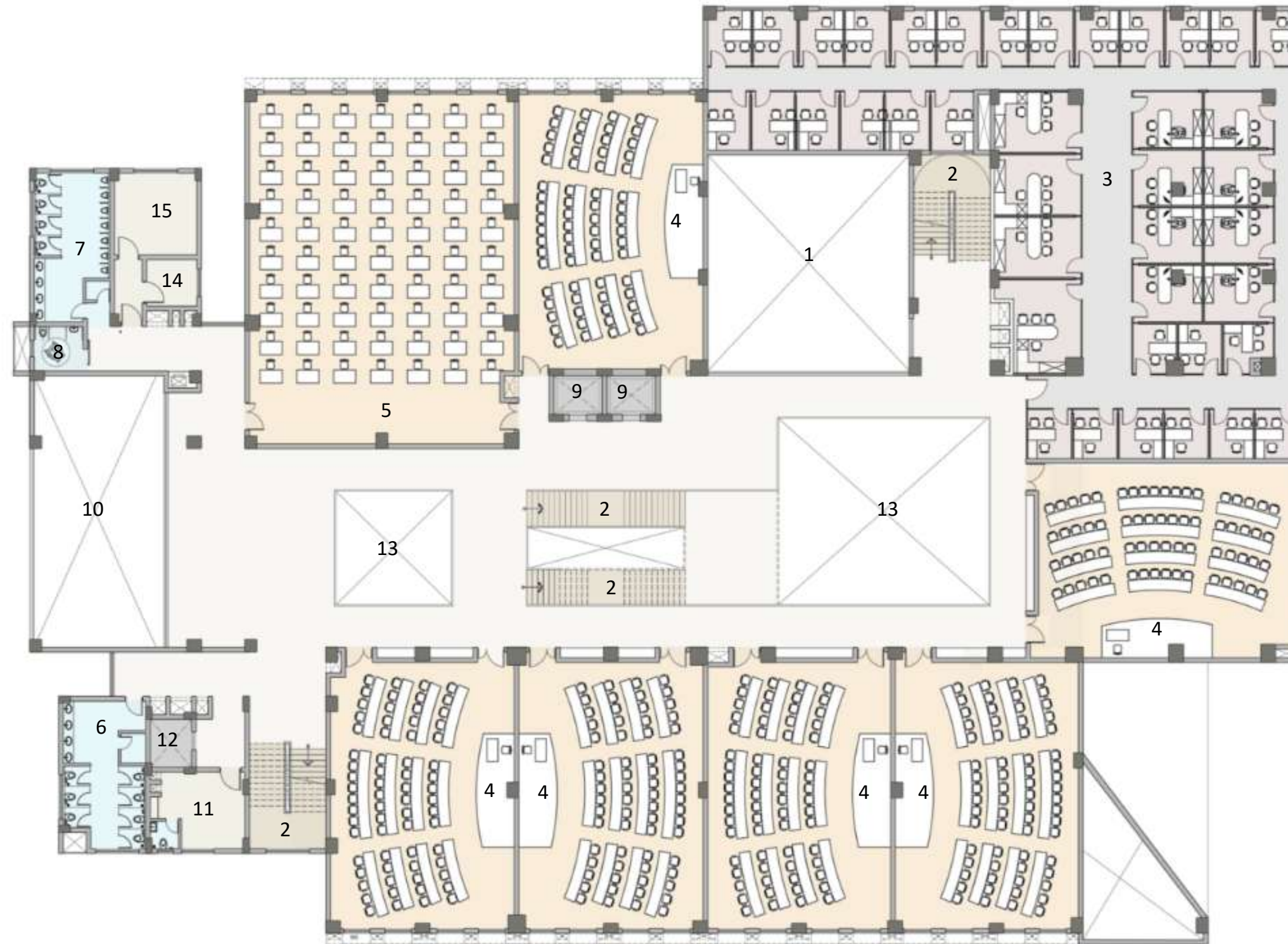
1. Double height verandah
2. Student lounge area
3. Sitout terrace
4. Open to Sky courtyard
5. 67 seater Classroom
6. Chemistry Laboratory
7. Staircase
8. Double height lecture theater
9. Gents toilet
10. Ladies toilet
11. PWD Toilet
12. Cut - out to Atrium space
13. Passenger lift
14. Sick room
15. Service lift
16. Electrical room
17. Server room



## SECOND FLOOR PLAN

### LEGEND :

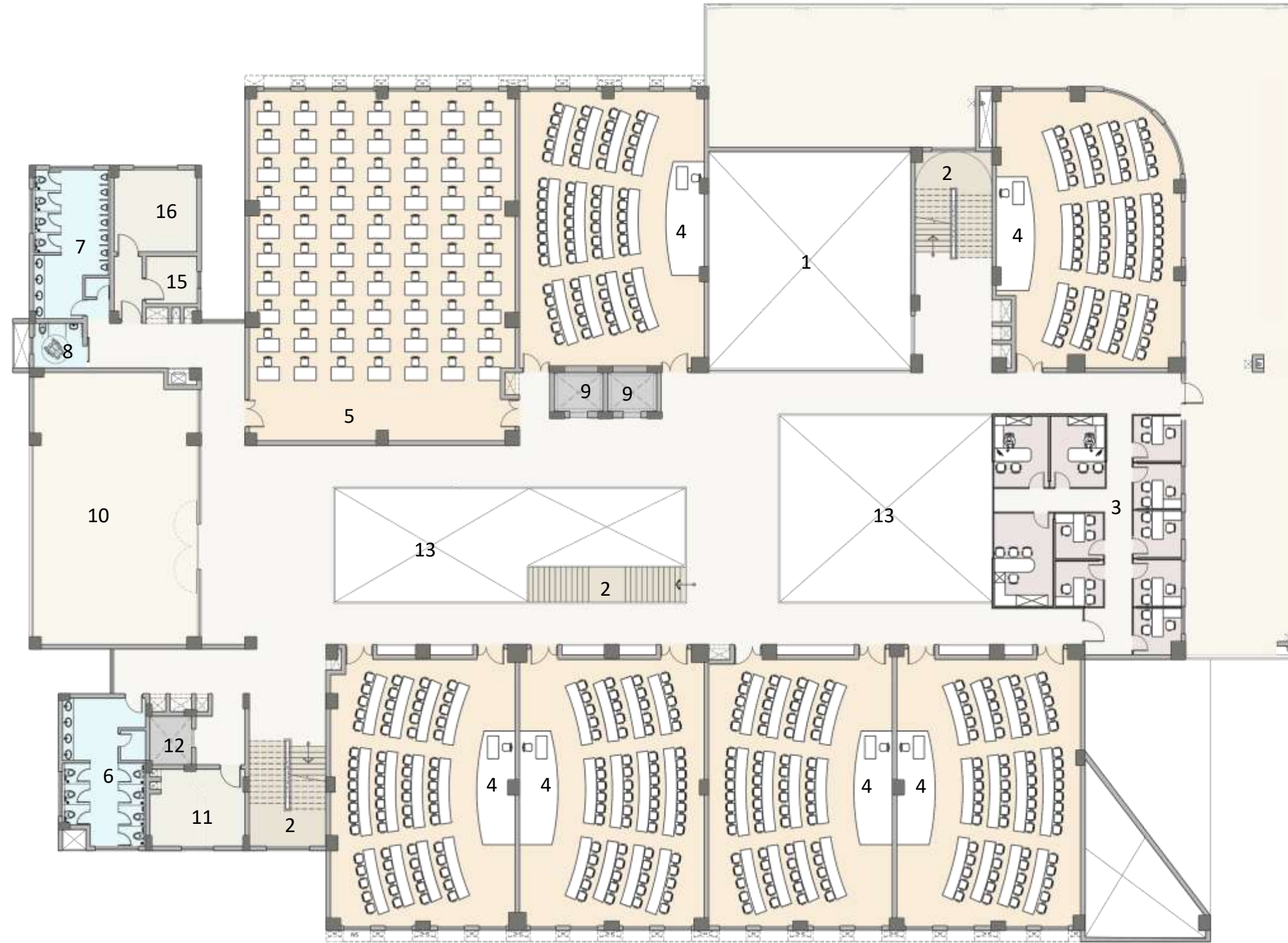
1. Open to Sky courtyard
2. Staircase
3. Faculty cabins
4. 67 seater Classroom
5. Drawing hall
6. Ladies toilet
7. Gents toilet
8. PWD Toilet
9. Passenger lift
10. Open terrace
11. Non teaching Staff room
12. Service lift
13. Cut out to Atrium space
14. Electrical room
15. Server room



## THIRD FLOOR PLAN

### LEGEND :

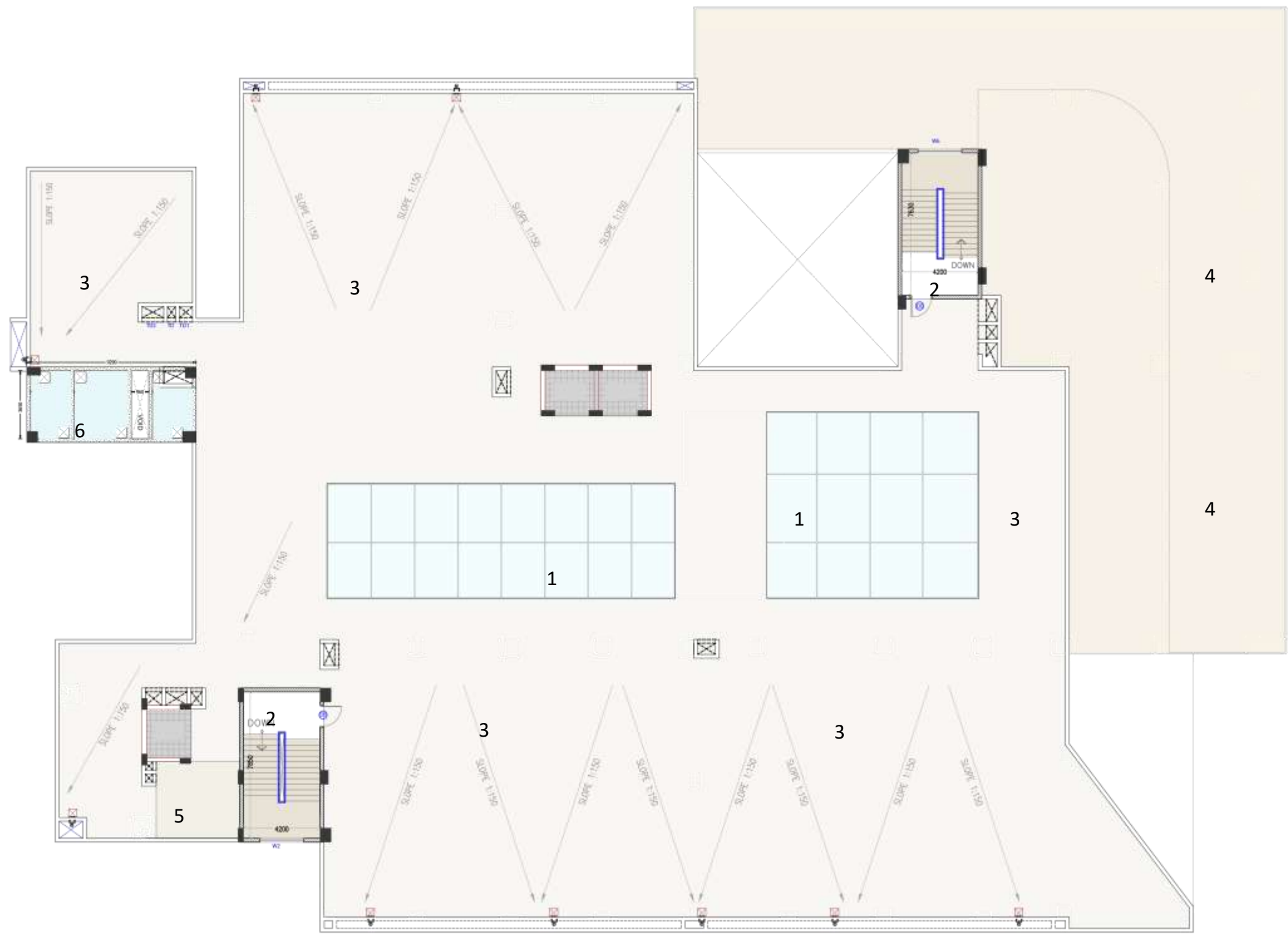
1. Open to Sky courtyard
2. Staircase
3. Faculty cabins
4. 67seater Classroom
5. Drawing hall
6. Ladies toilet
7. Gents toilet
8. PWD Toilet
9. Passenger lift
10. Over looking terrace
11. CCTV and control room
12. Service lift
13. Cut out to Atrium space
14. Student lounge area
15. Electrical room
16. Server room



# TERRACE FLOOR PLAN

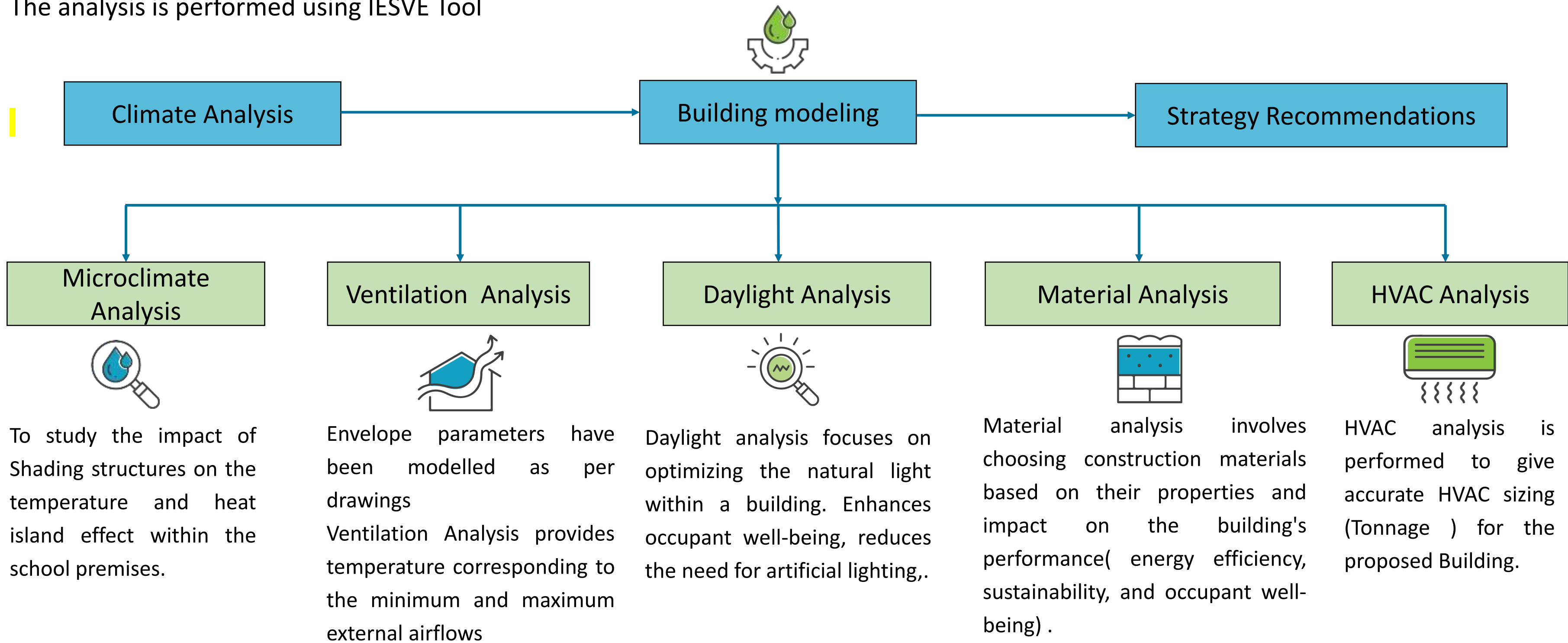
LEGEND :

- 1. OTS Courtyard
- 2. Staircase
- 3. Open terrace
- 4. Lower terrace
- 5. RO Plant
- 6. OHT
- 7. Skylight courtyard

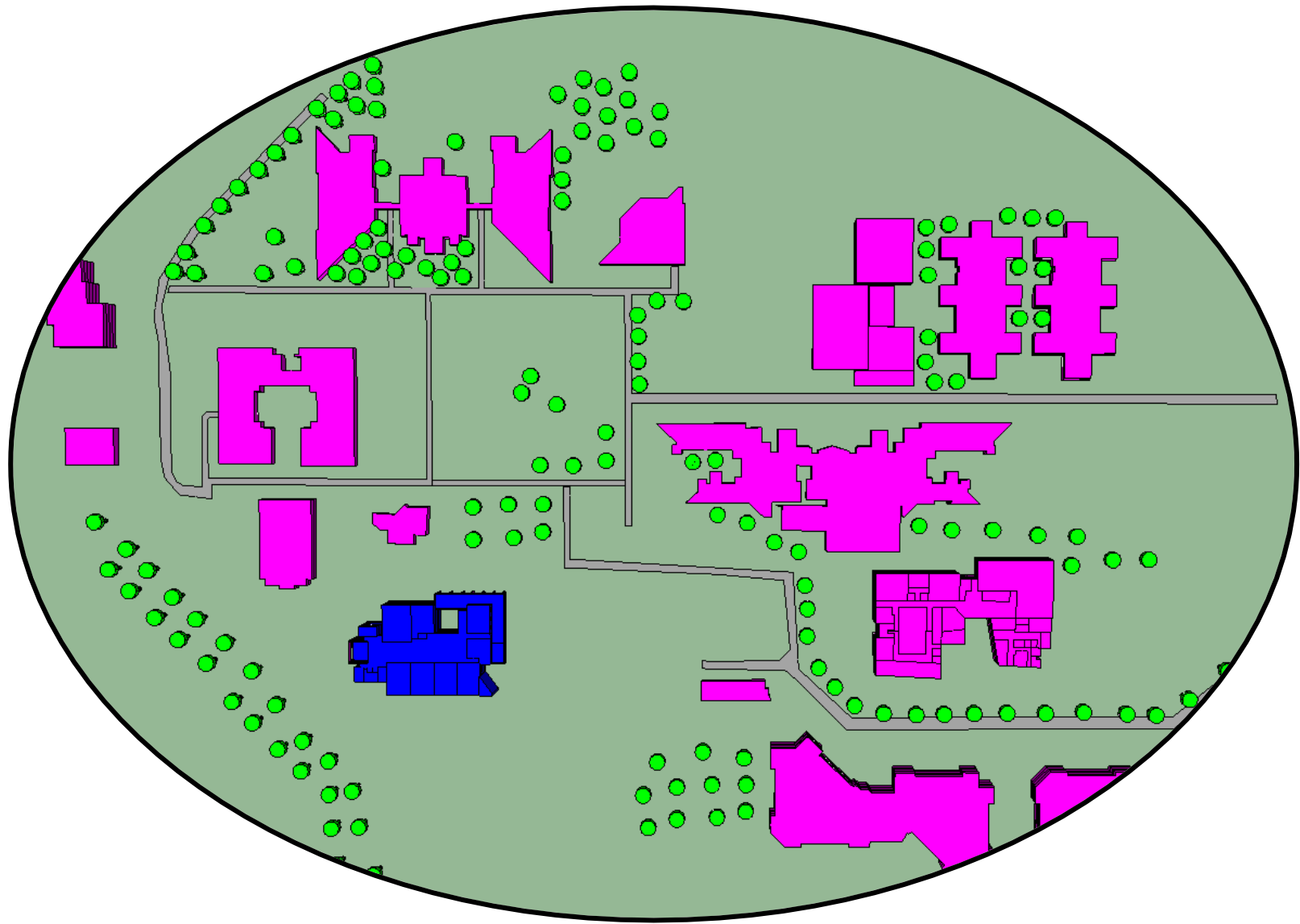


## 2.SCOPE OF WORK

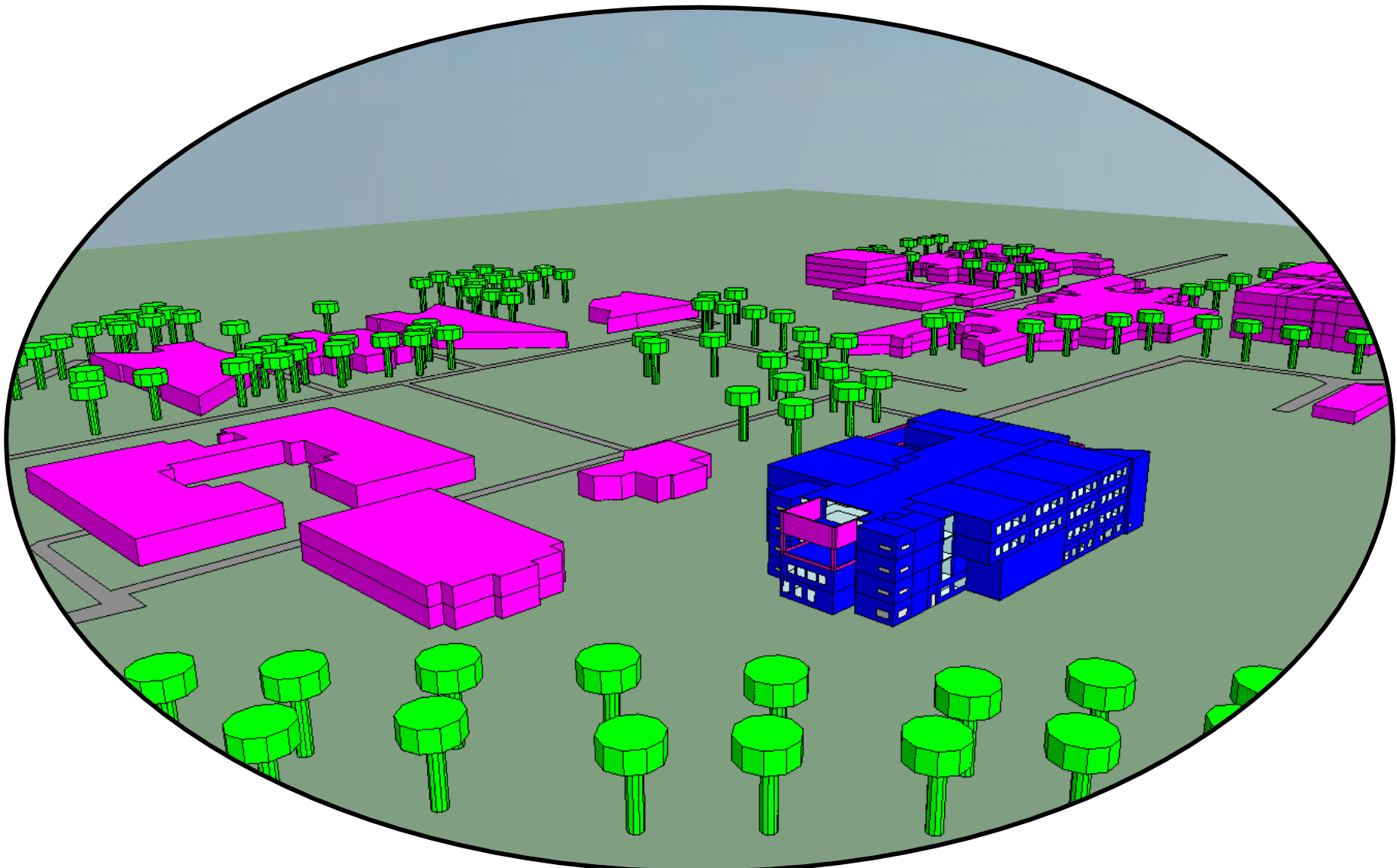
The following analysis have been performed for SNU project for better building performance and facilitate climate adaptive strategies .  
The analysis is performed using IESVE Tool



# 3.MODEL SNAPSHOTS

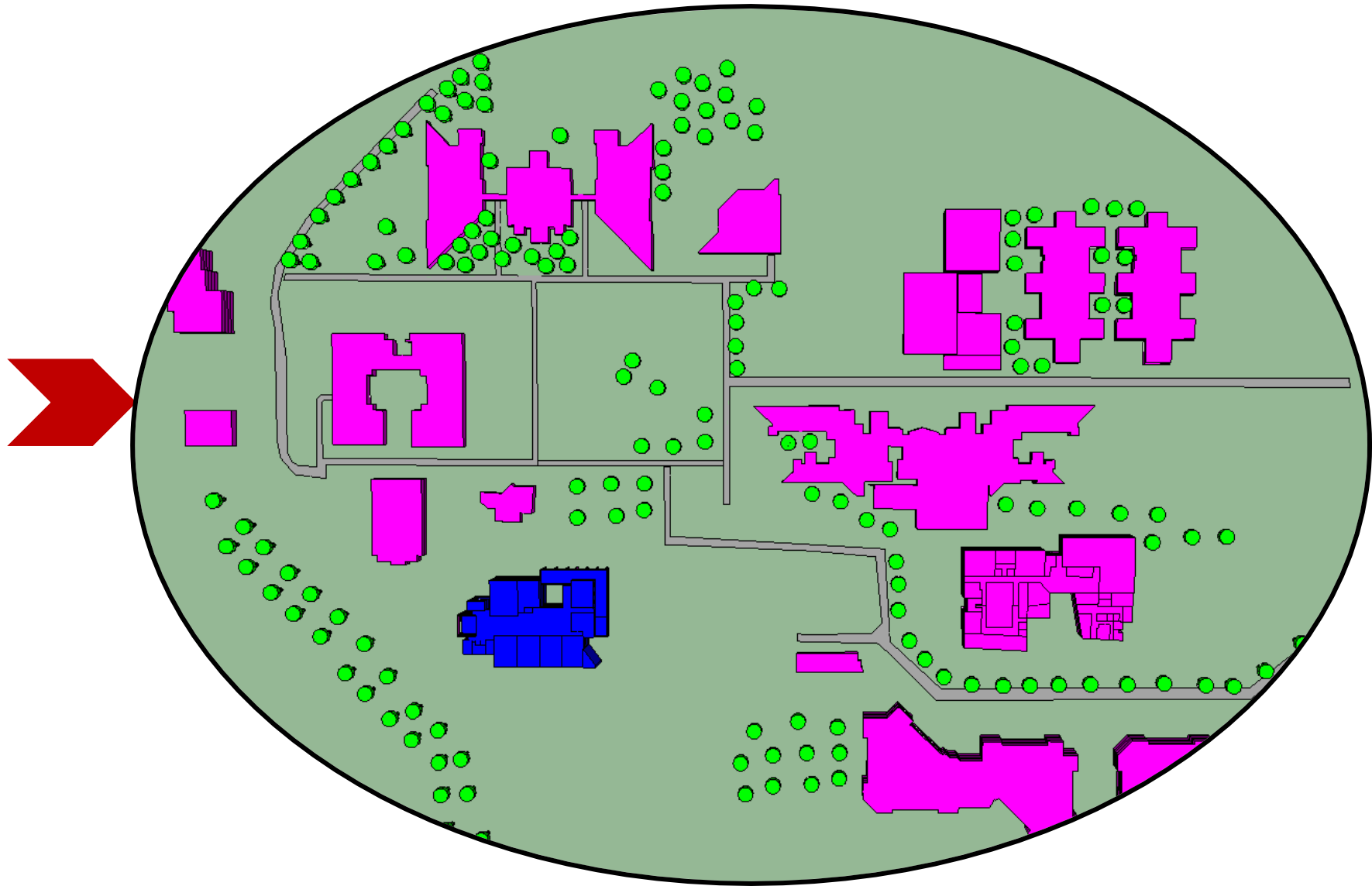


Site Model

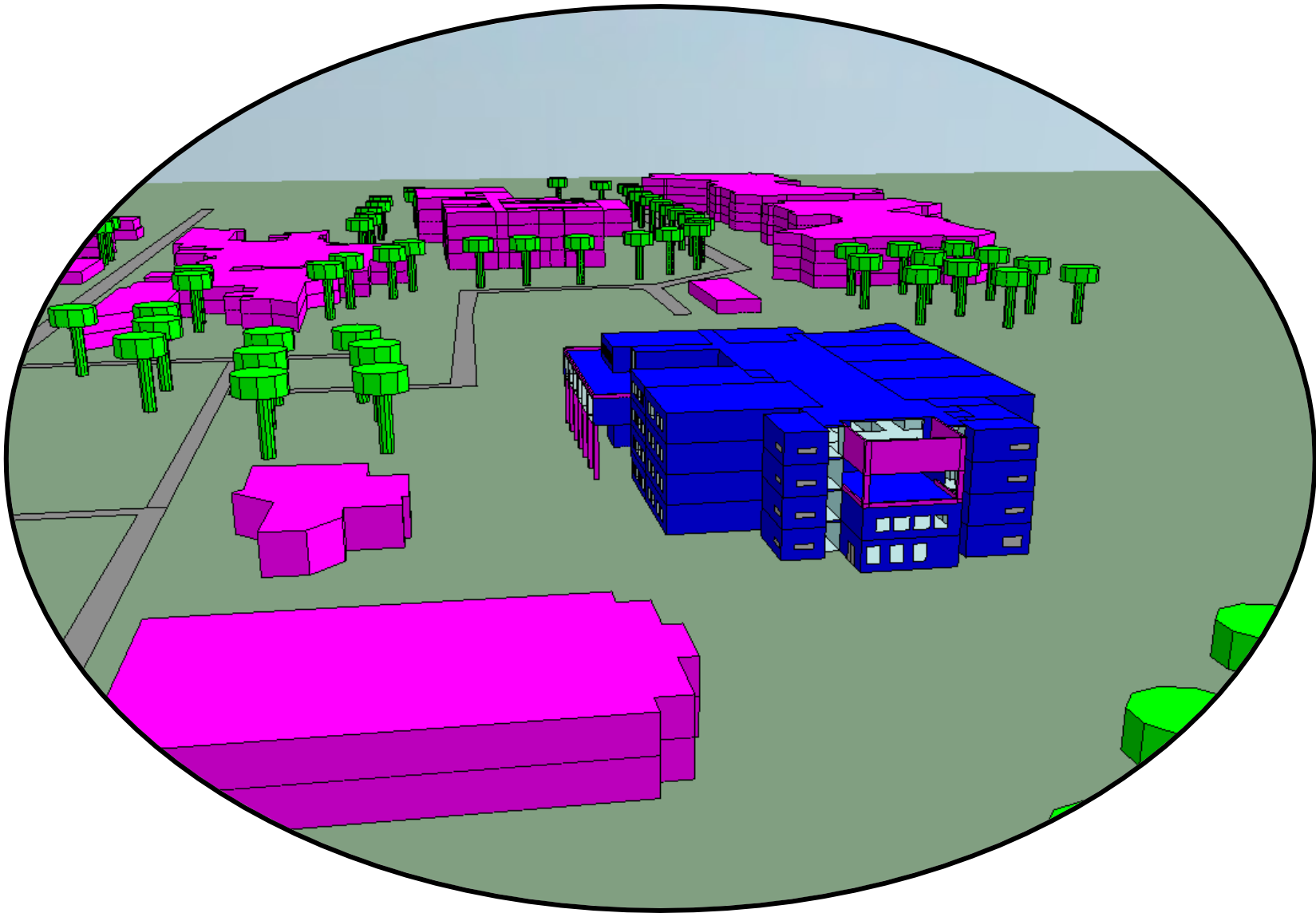


View from South direction

# 3.MODEL SNAPSHOTS

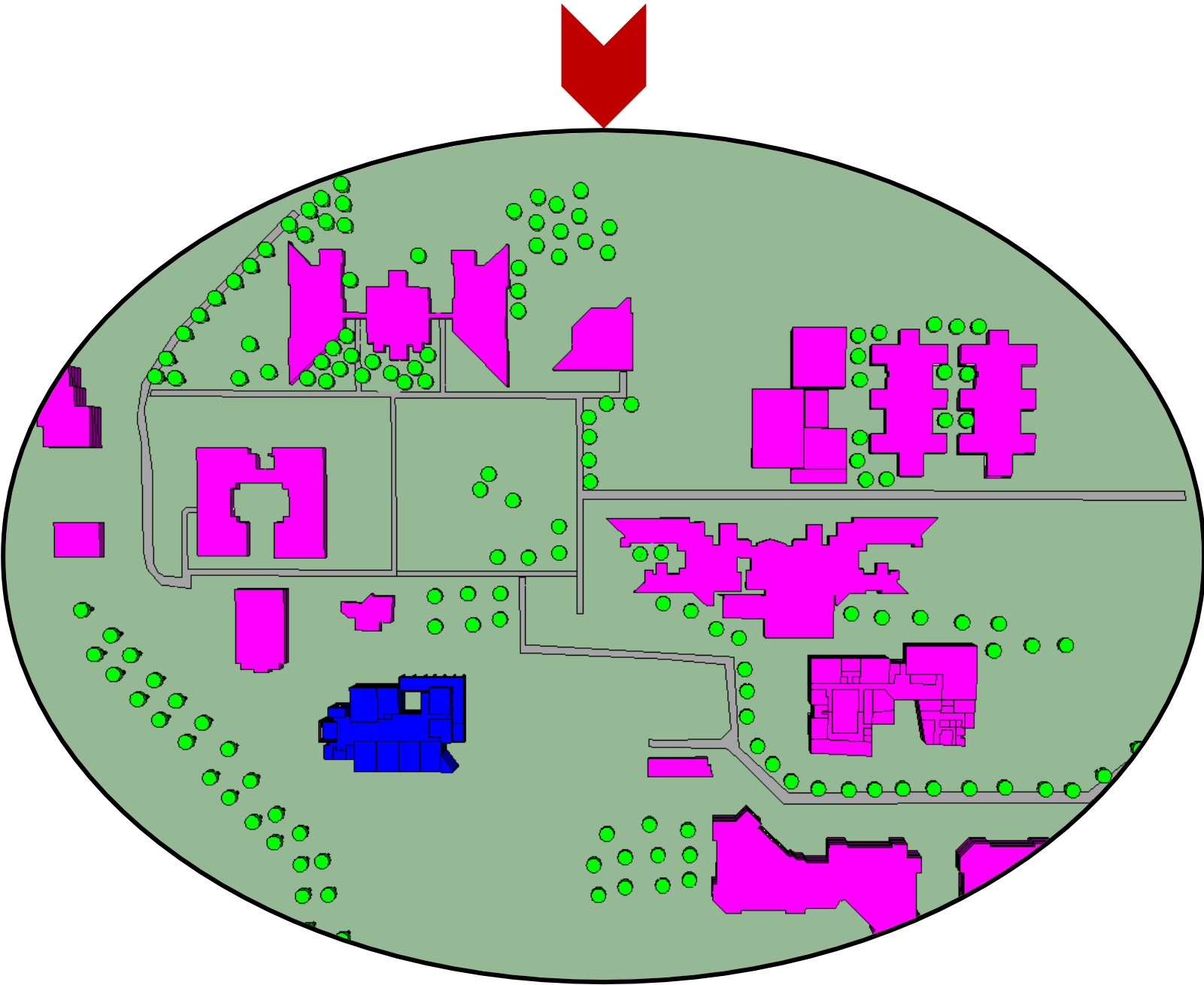


Site Model

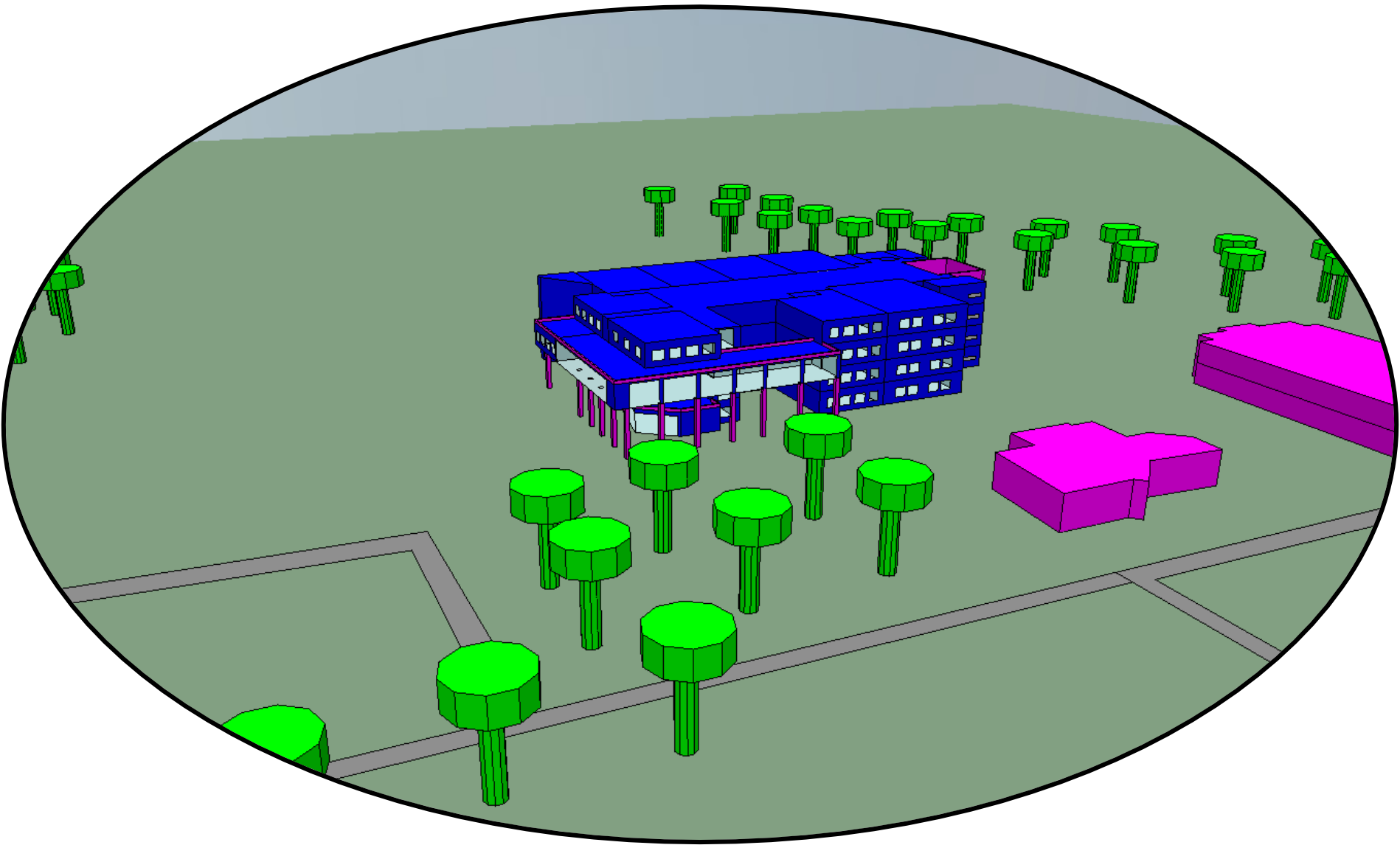


View from West direction

# 3.MODEL SNAPSHOTS

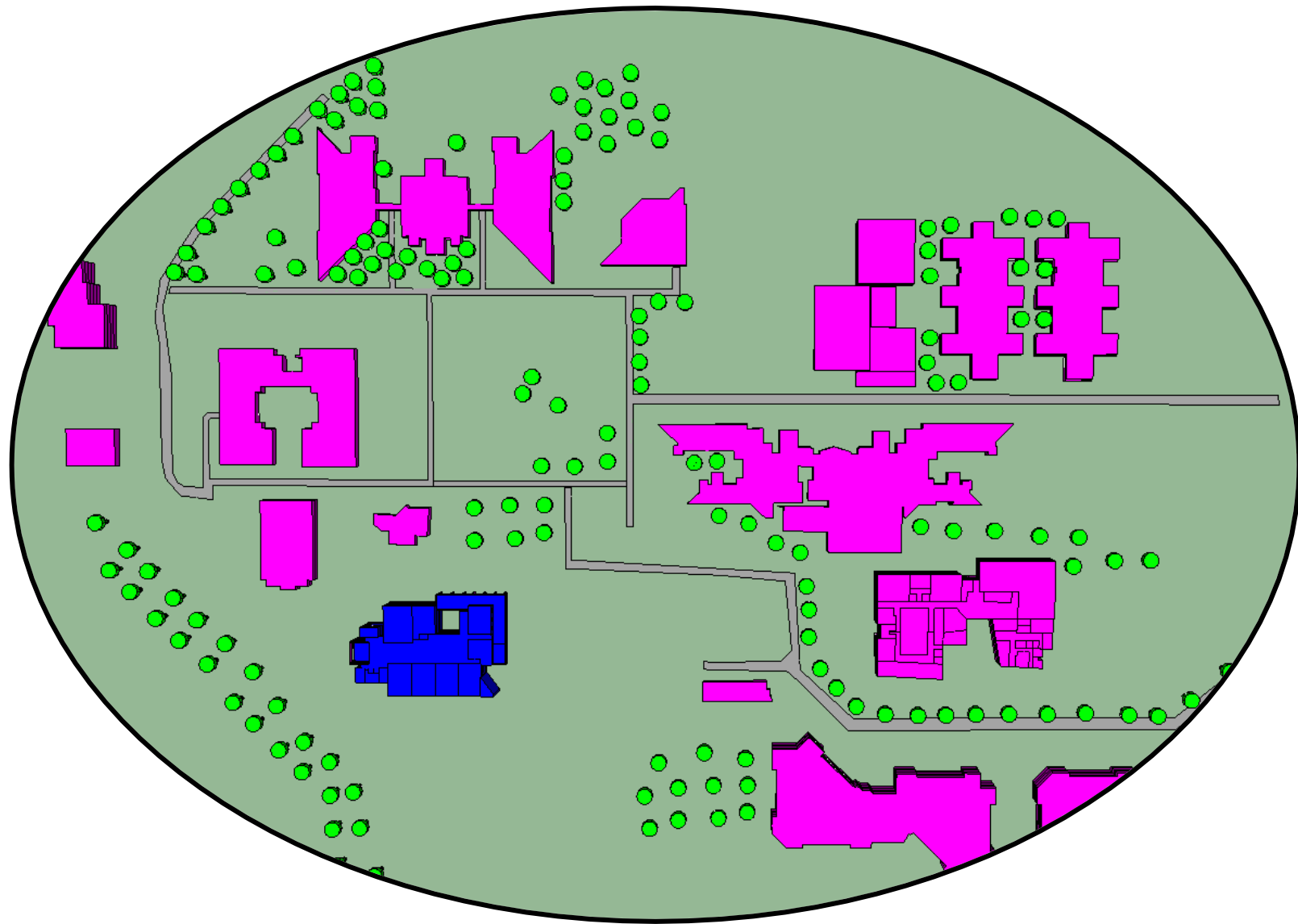


Site Model

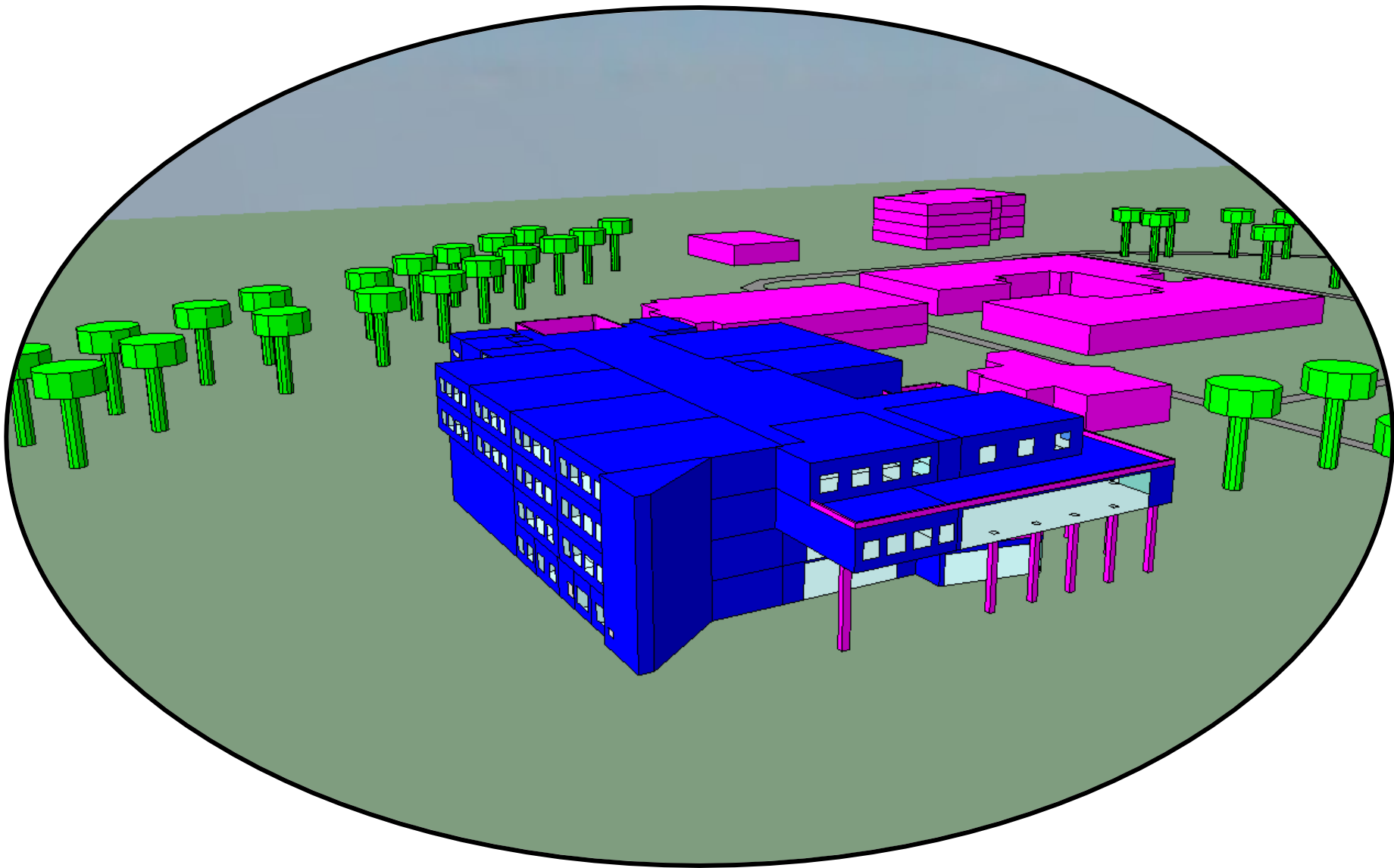


View from North direction

# 3.MODEL SNAPSHOTS

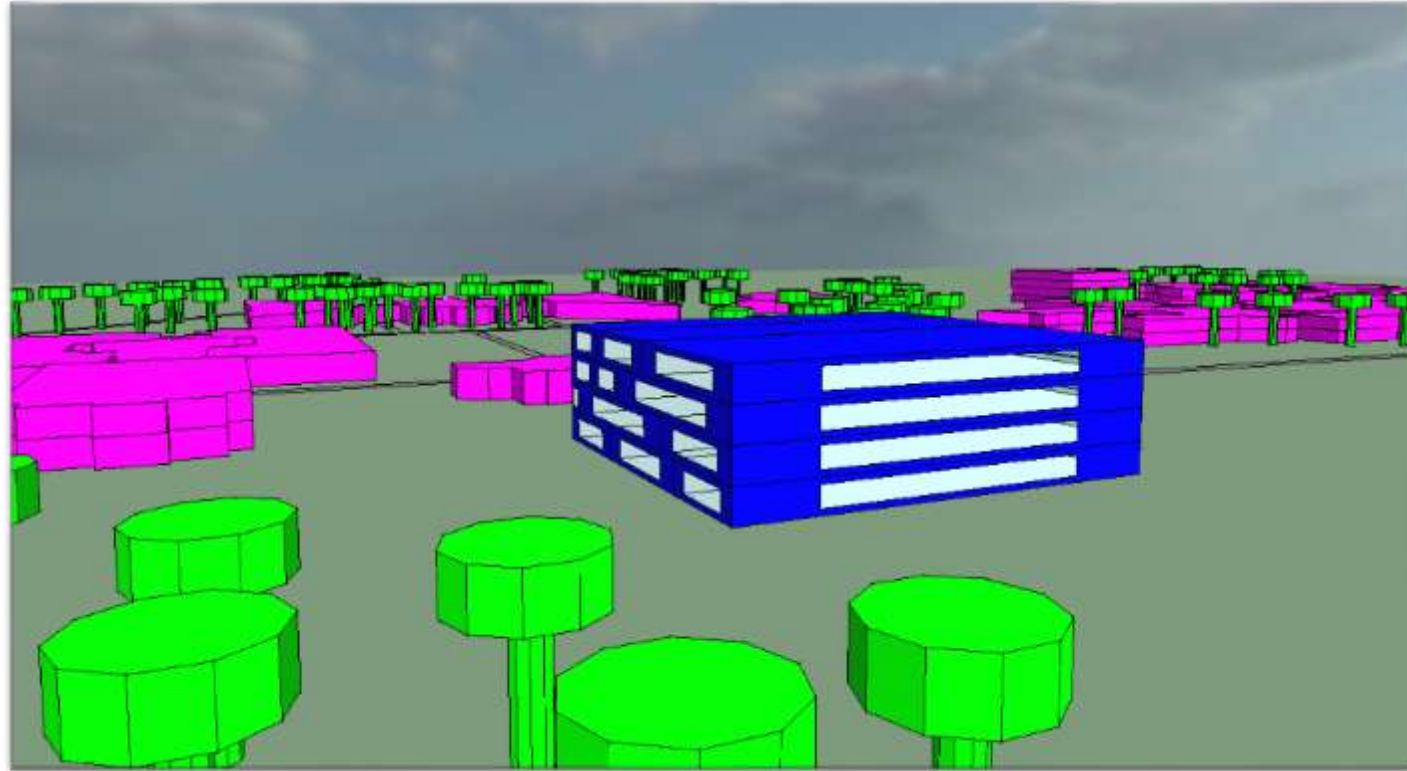


Site Model

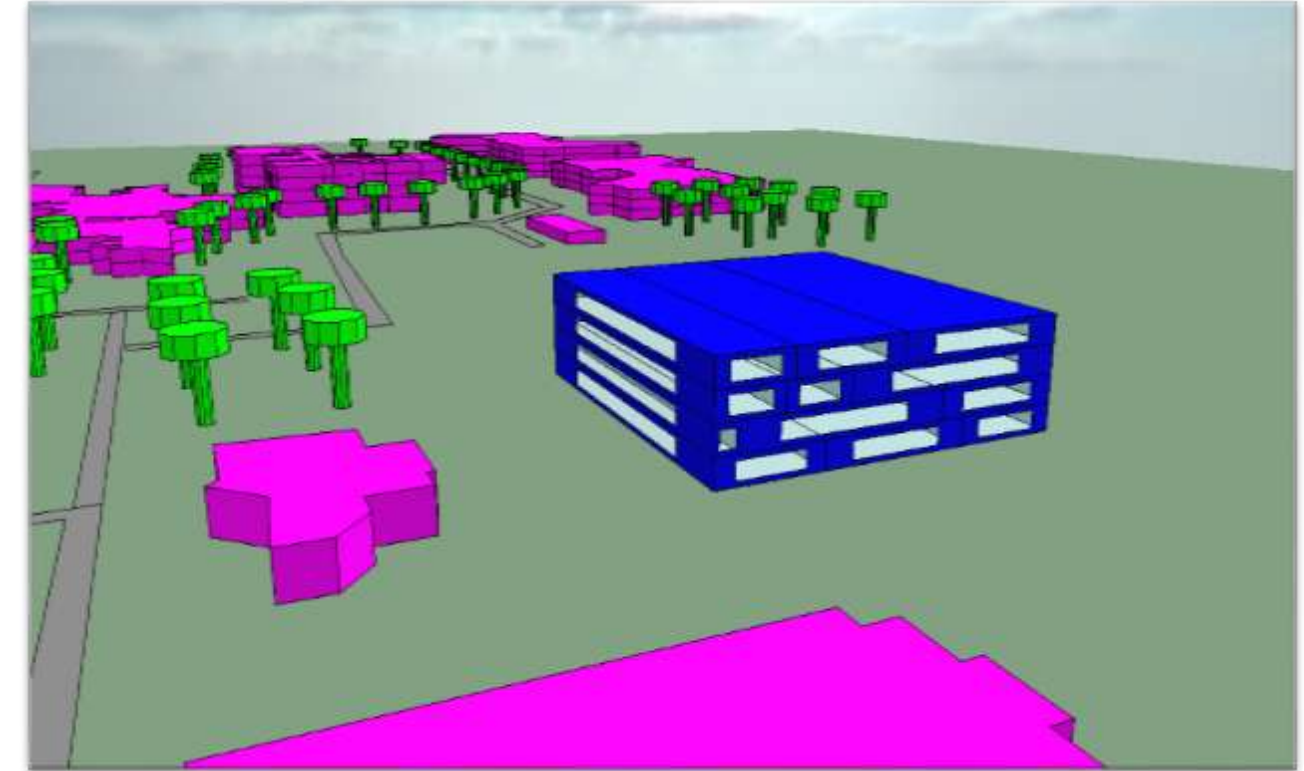


View from East direction

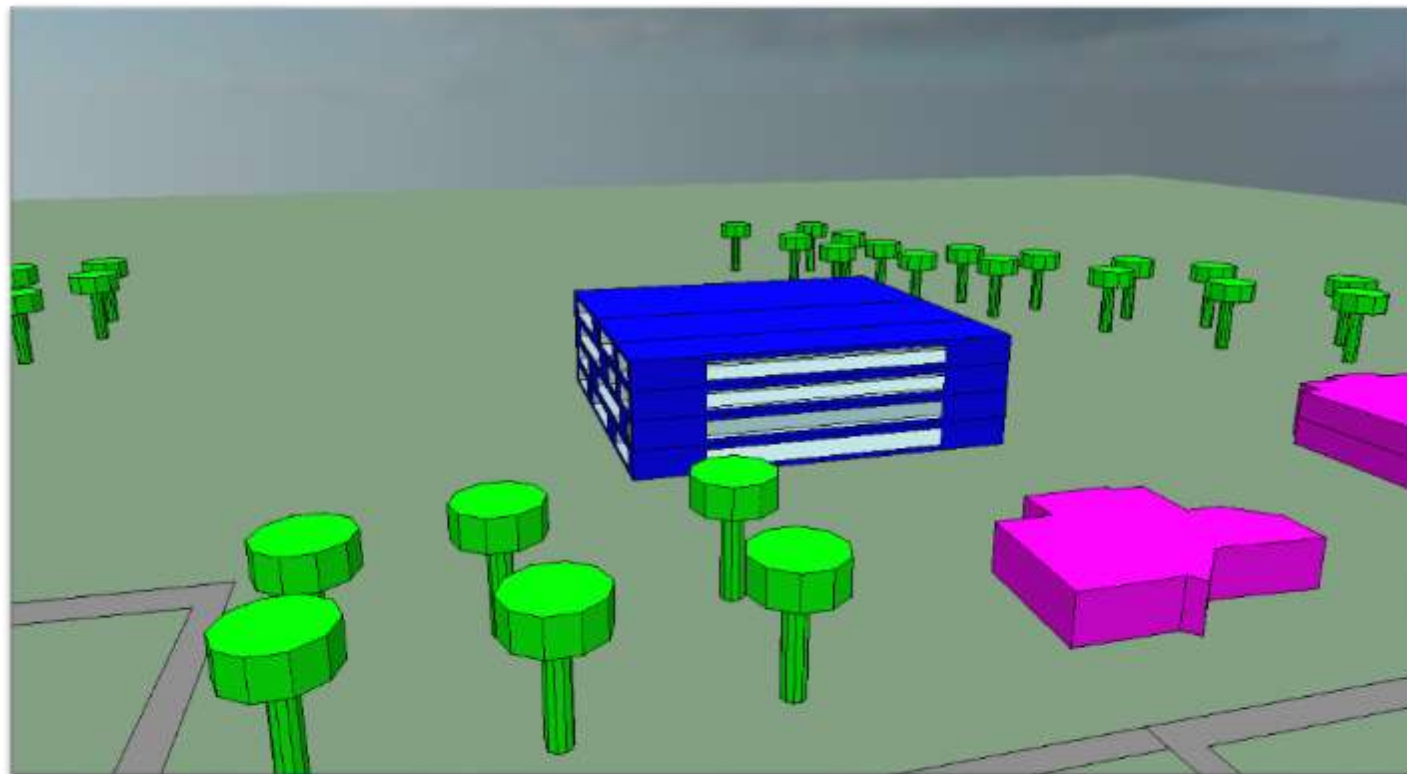
### 3.MODEL SNAPSHOTS



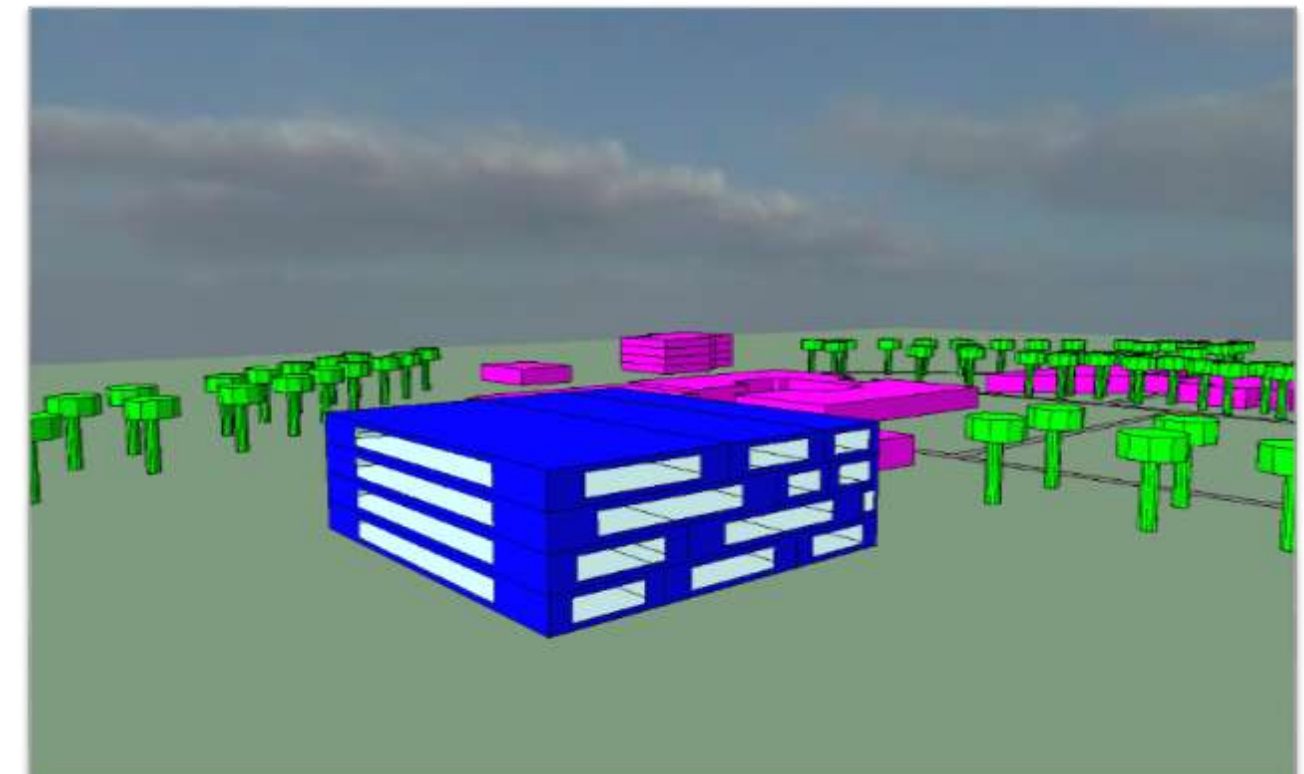
South Elevation



West Elevation

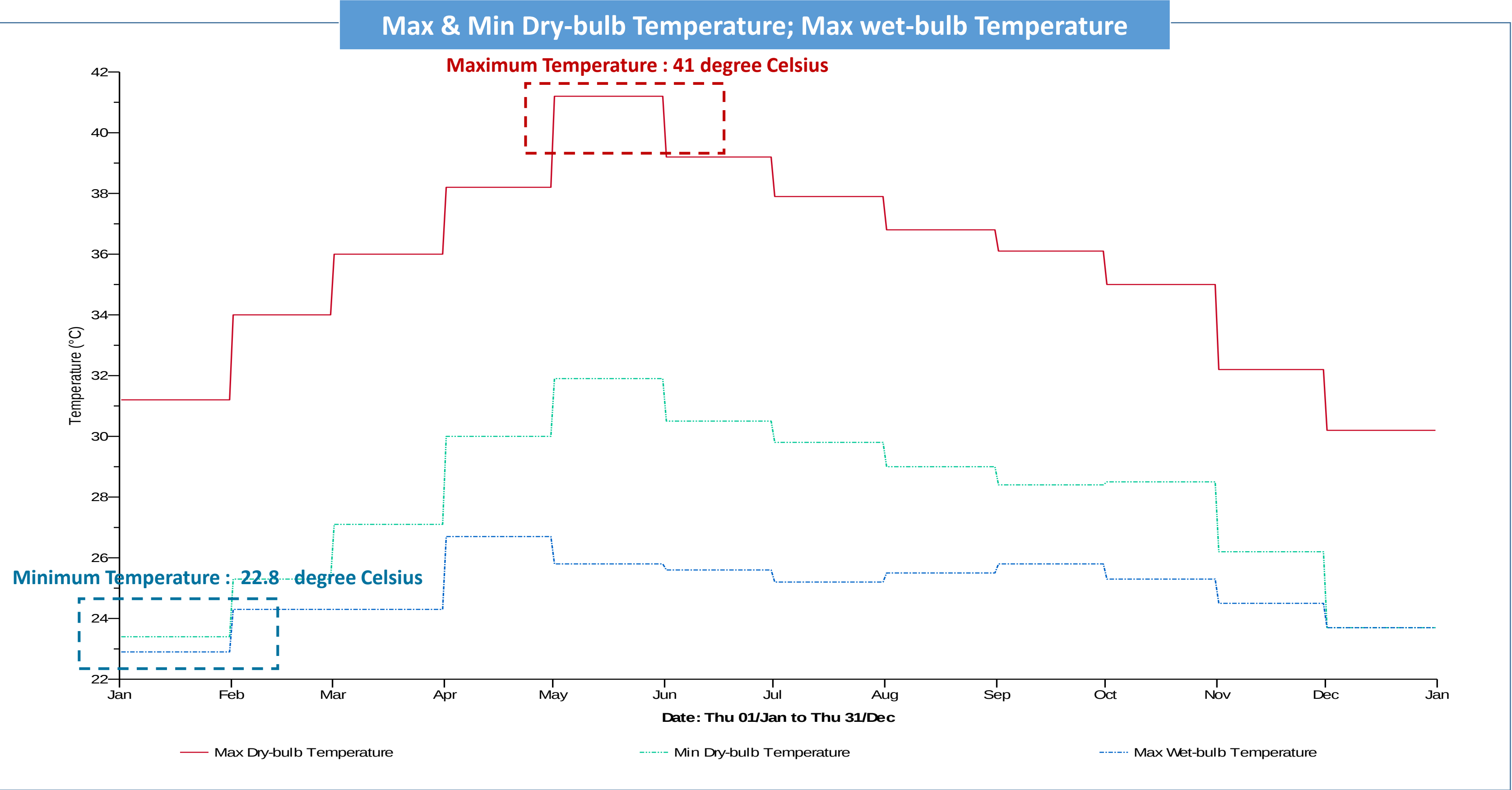


North Elevation



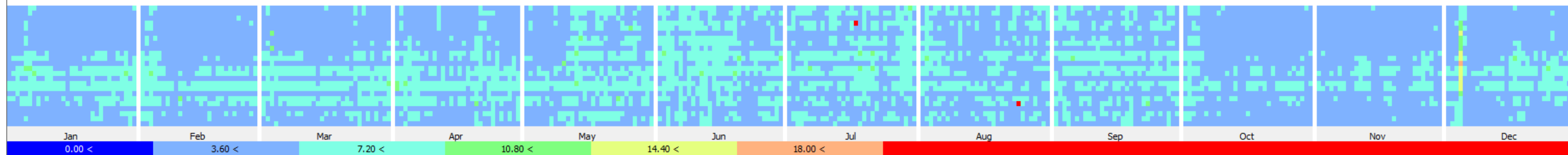
East Elevation

# 4.CLIMATE ANALYSIS

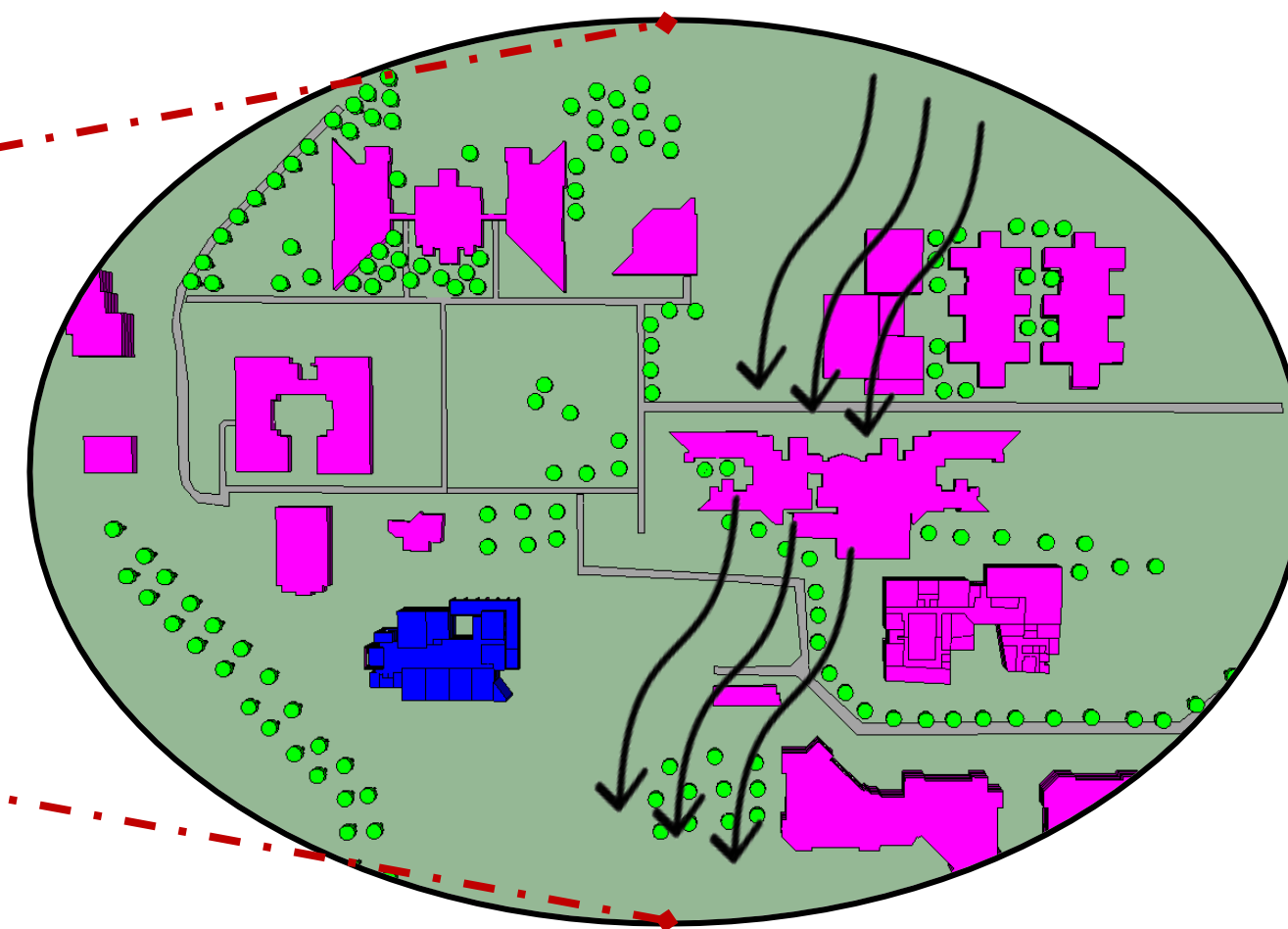
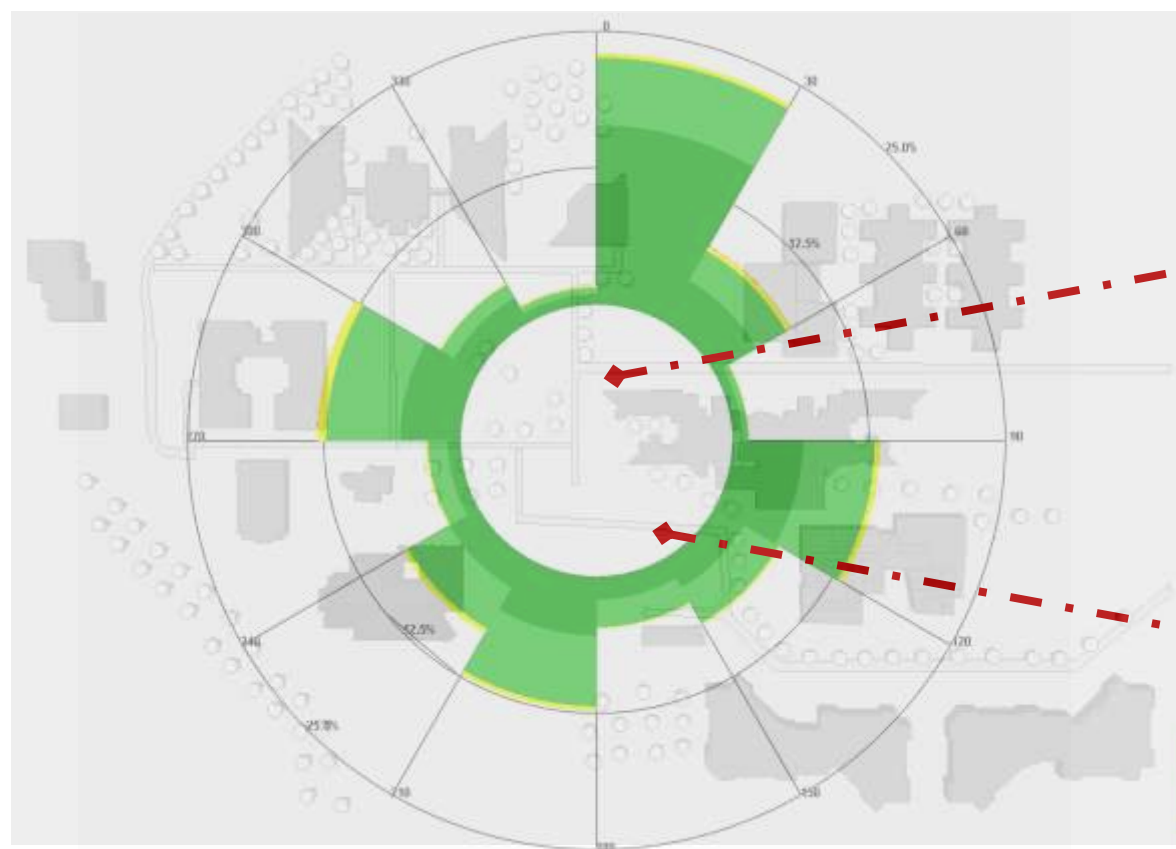


Wind Speed [Max- 25.4 m/s @ 17th July 4AM; Min- 0m/s @ 1st Jan 1AM]

Wind speed: (IND\_Chennai\_432790\_ssn 1.epw) - m/s



### Windrose diagram – Annual

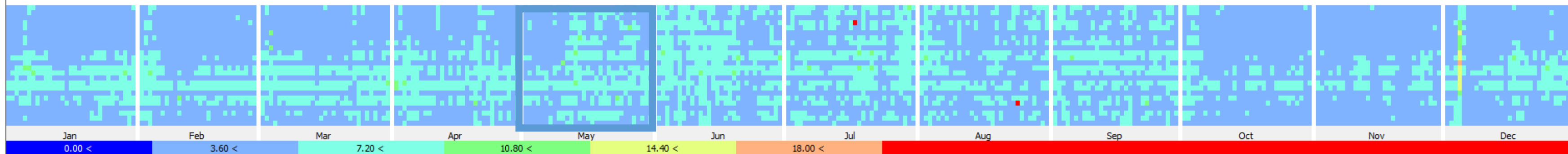


The predominant wind direction is from North-East to South -West

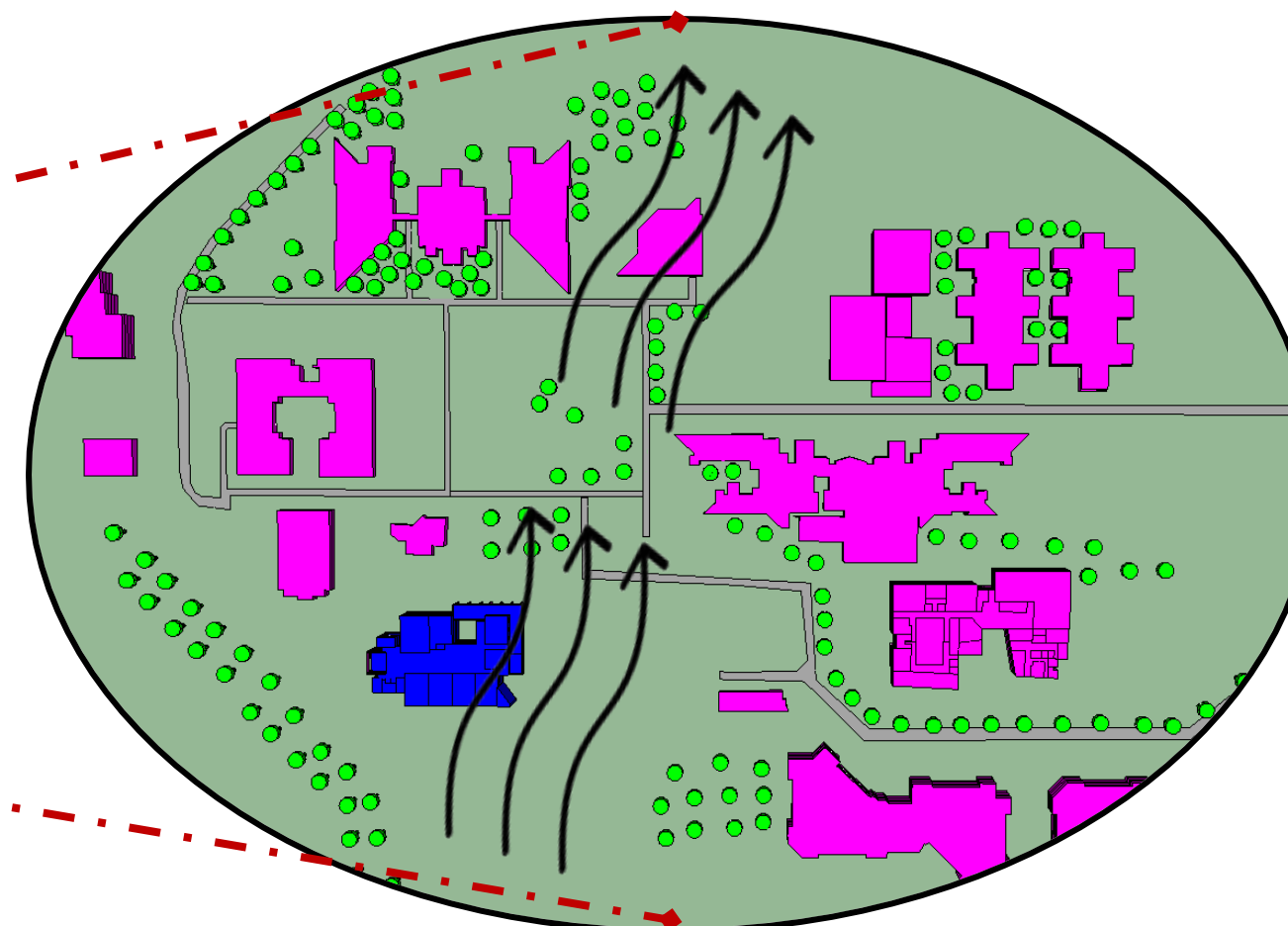
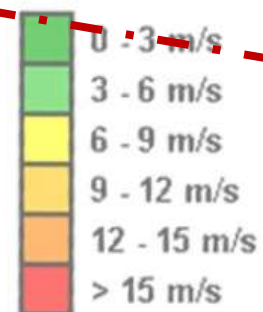
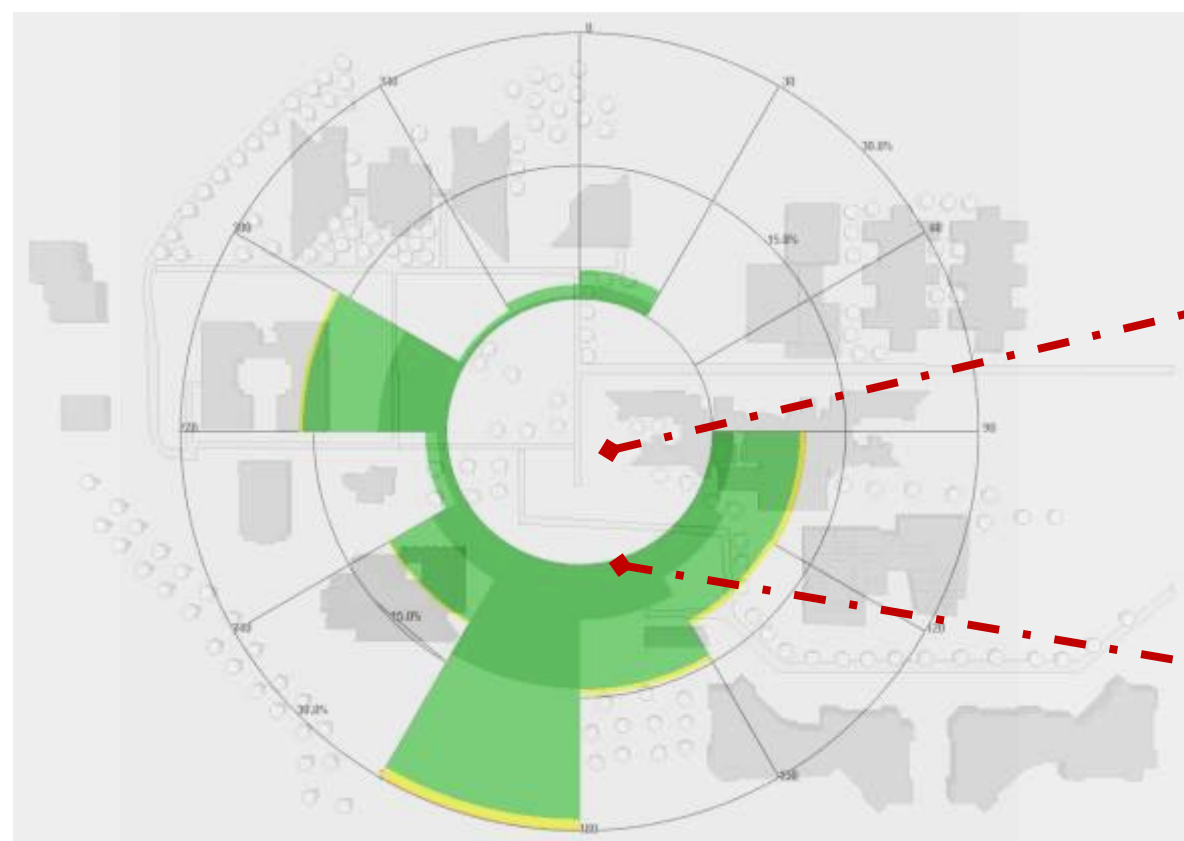


Wind Speed [Max- 25.4 m/s @ 17th July 4AM; Min- 0m/s @ 1st Jan 1AM]

Wind speed: (IND\_Chennai\_432790\_ssn 1.epw) - m/s



Windrose diagram – MAY

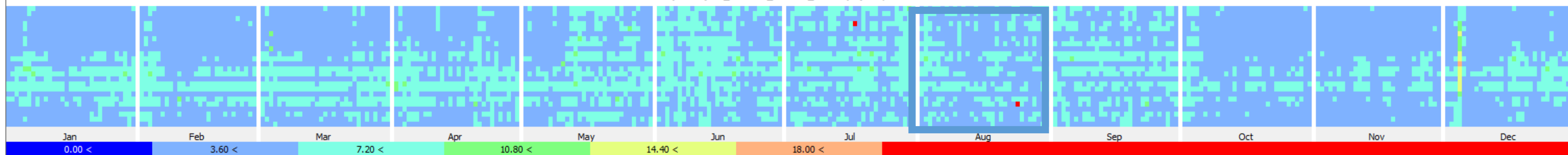


Hottest Month  
-MAY  
44.2°C  
48.2% RH

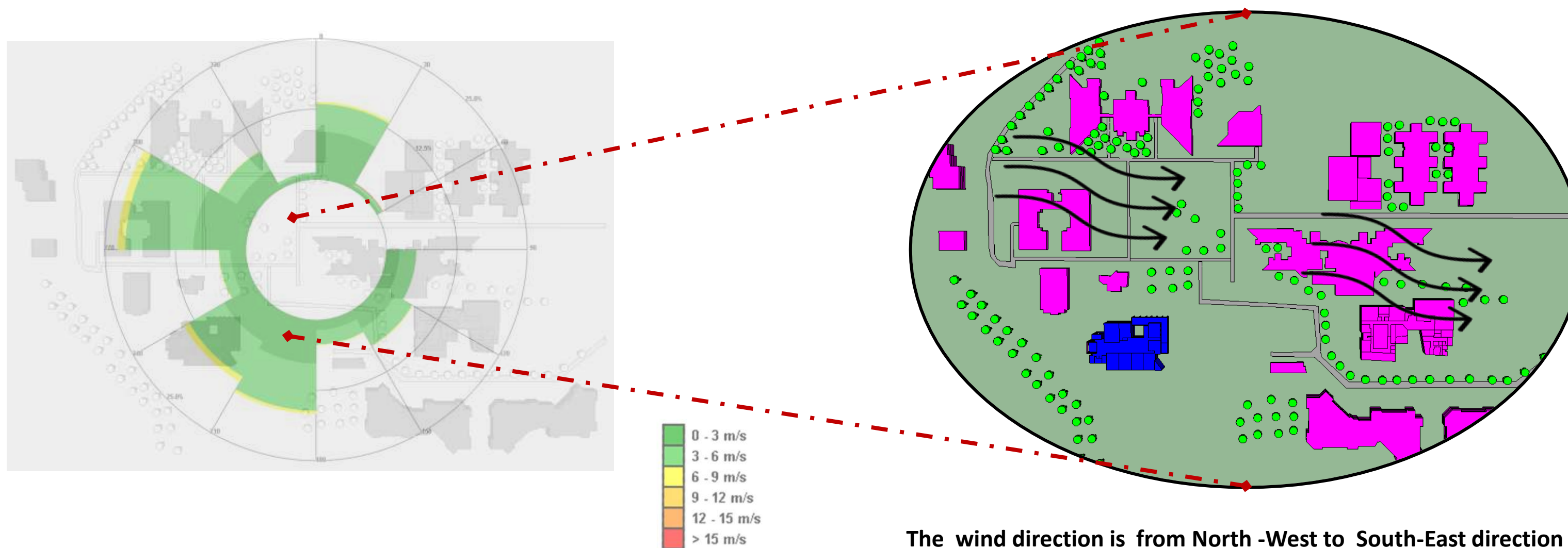
The wind direction is from South to North direction

Wind Speed [Max- 25.4 m/s @ 17th July 4AM; Min- 0m/s @ 1st Jan 1AM]

Wind speed: (IND\_Chennai\_432790\_ssn 1.epw) - m/s



Windrose diagram –AUGUST

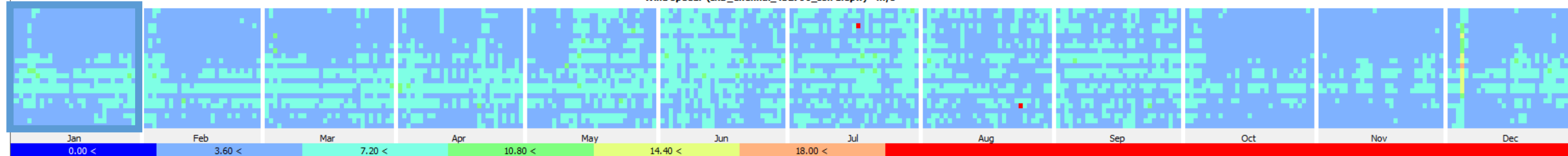


Most hot-humid  
month-AUGUST  
33.5 °C  
52.4% RH

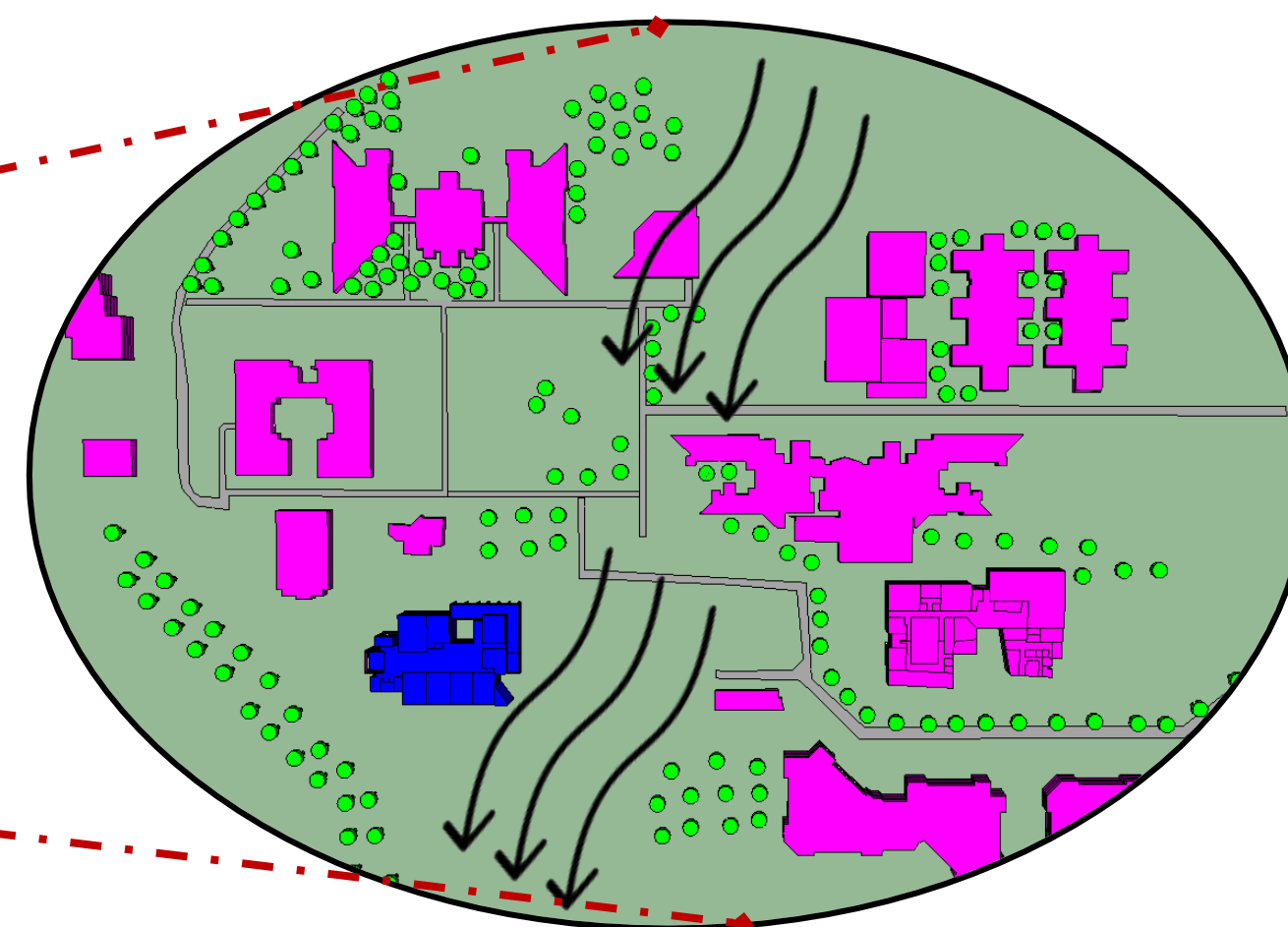
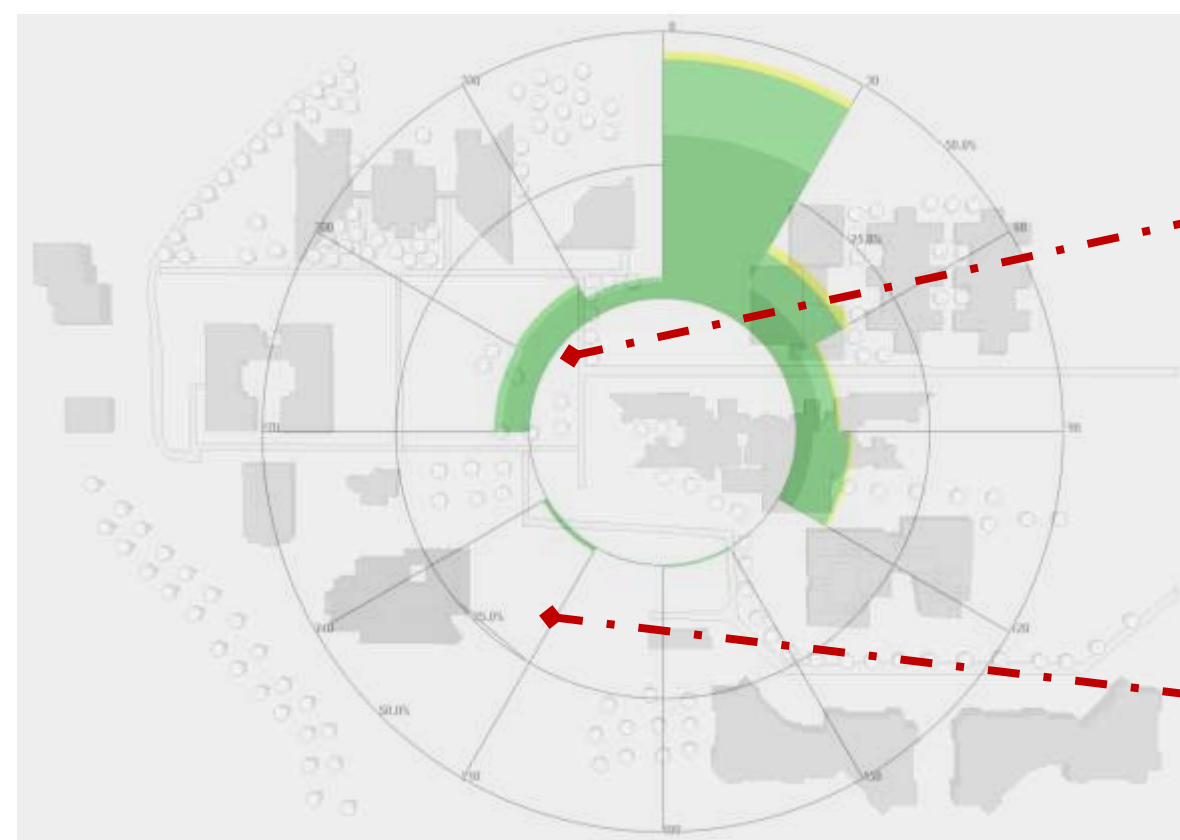


Wind Speed [Max- 25.4 m/s @ 17th July 4AM; Min- 0m/s @ 1st Jan 1AM]

Wind speed: (IND\_Chennai\_432790\_ssn 1.epw) - m/s



### Windrose diagram – JANUARY



Coldest Month -  
JANUARY  
31 °C  
51.7% RH

The wind direction is from North to South



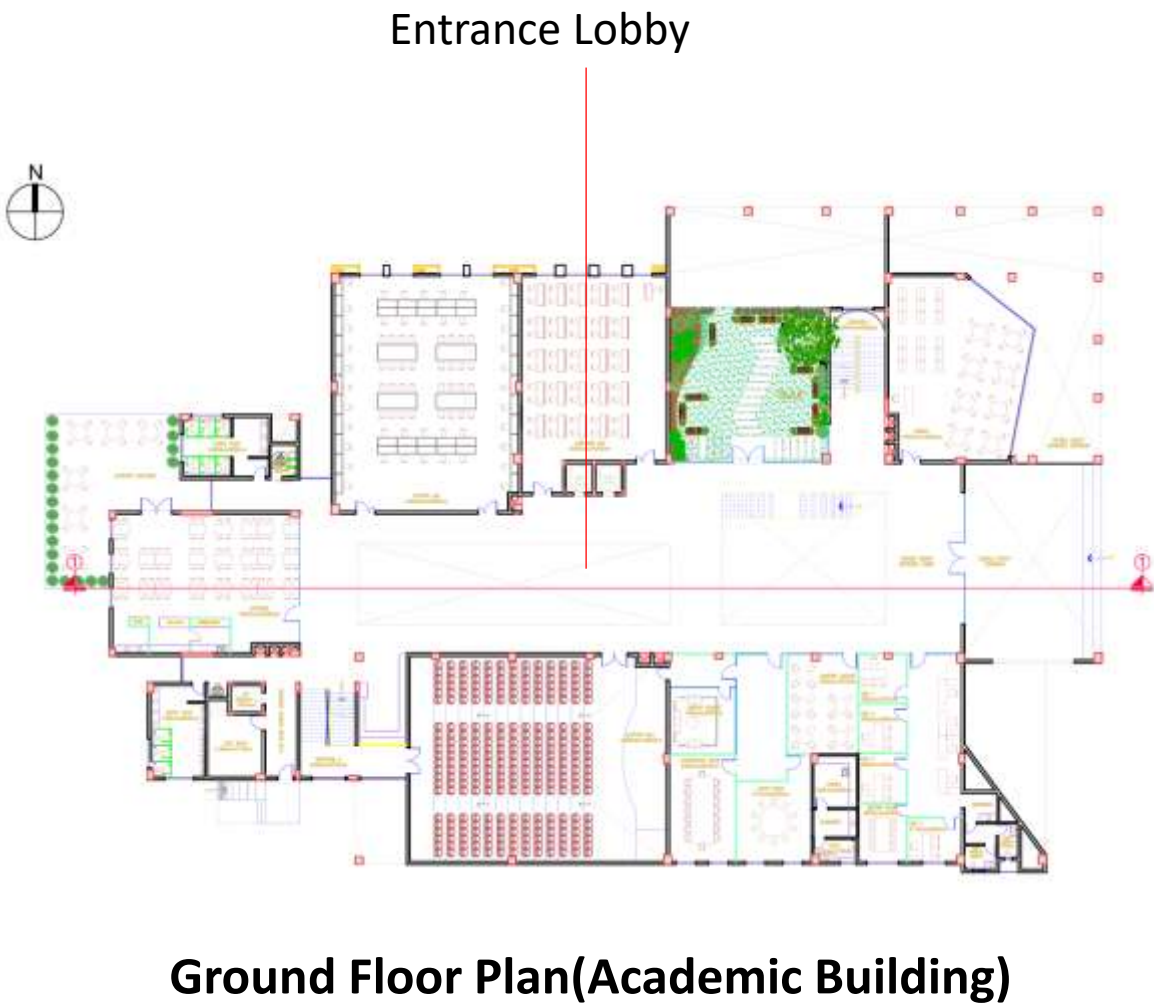
## VENTILATION ANALYSIS

- Ventilation Analysis is performed for Non Airconditioned spaces in Academic Buildings.
- The simulation is performed by considering 50 % Operable windows in all Non-Air-conditioned Areas.
- The Annual air flow rate and peak room temperature is determined from the ventilation Analysis.

|                           |                         |
|---------------------------|-------------------------|
| Project Name              | : Shiv Nadar University |
| Site Location             | : Kelambakkam ,Chennai  |
| Built-up Area             | : 8,752 Sq.m            |
| Academic Building AC Area | : 5,546 Sq.m            |
| Key Description           | : Educational Facility  |
| Geographical Location     | : 12.75° N , 80.20° E   |
| Climate Zone              | : Warm & Humid          |

RESULTS

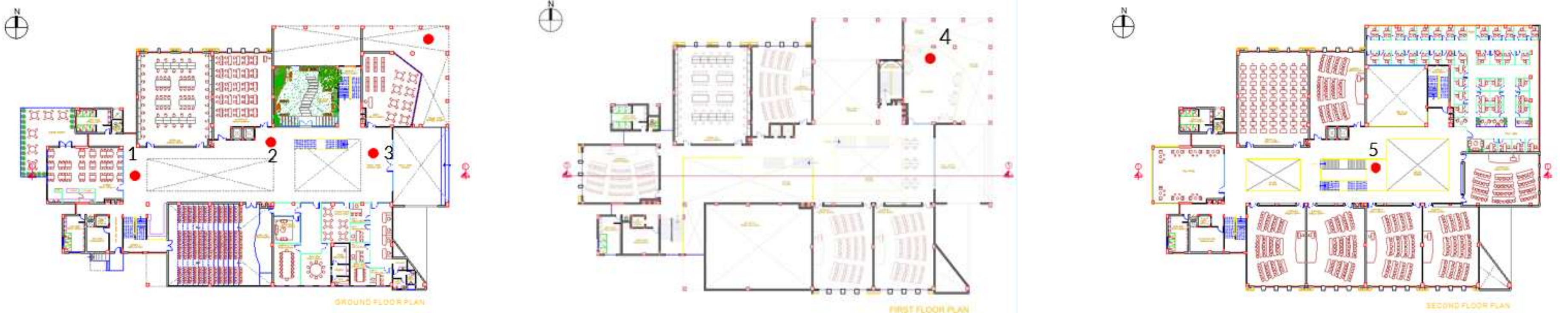
The Non-Air conditioned regularly occupied spaces are taken from the analysis



| Room Spaces    | Air Temperature(Deg C) in degree Celsius for construction options<br>External temperature condition: 41.40degC on May 28 <sup>th</sup> 2024 |           |               |           |             |       |                          |                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|-----------|-------------|-------|--------------------------|-------------------------------|
|                | Baseline( Box model)                                                                                                                        | Red Brick | Fly Ash Brick | AAC Brick | Cavity Wall | EIFS  | EIFS With High SRI Paint | AAC Brick With High SRI Paint |
| ENTRANCE LOBBY | 43.54                                                                                                                                       | 40.41     | 40.38         | 40.34     | 40.39       | 40.29 | 39.88                    | 39.91                         |

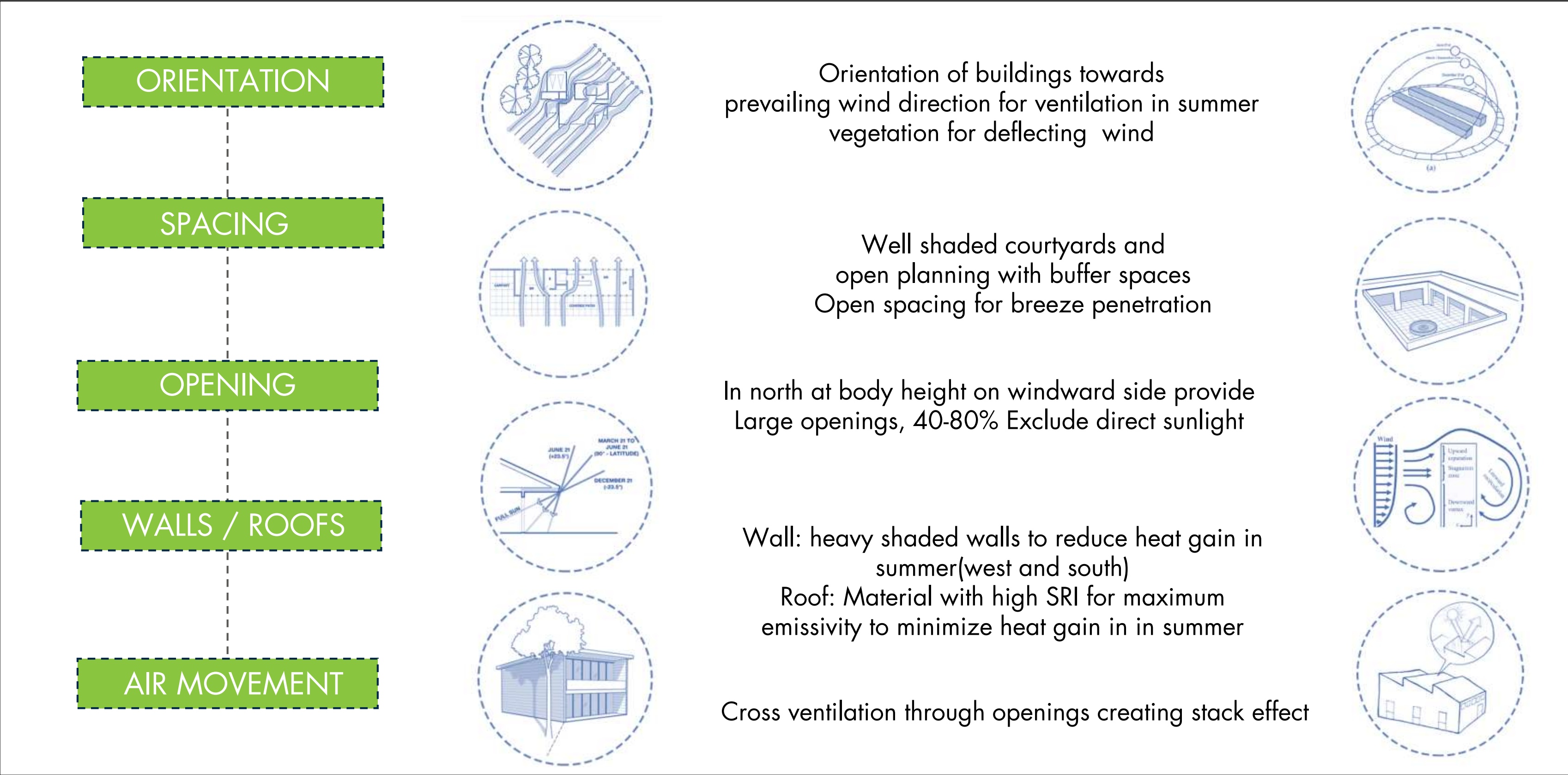
| Room Spaces    | Air change rate(ACH) in degree Celsius for construction options<br>External temperature condition: 41.40degC on May 28 <sup>th</sup> 2024 |           |               |           |             |      |                          |                               |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|-----------|-------------|------|--------------------------|-------------------------------|
|                | Baseline( Box model)                                                                                                                      | Red Brick | Fly Ash Brick | AAC Brick | Cavity Wall | EIFS | EIFS With High SRI Paint | AAC Brick With High SRI Paint |
| ENTRANCE LOBBY | 5.36                                                                                                                                      | 7.69      | 7.58          | 7.38      | 7.62        | 7.19 | 8.96                     | 8.75                          |

# AIR VELOCITY AND ACH AT MARKED POINTS

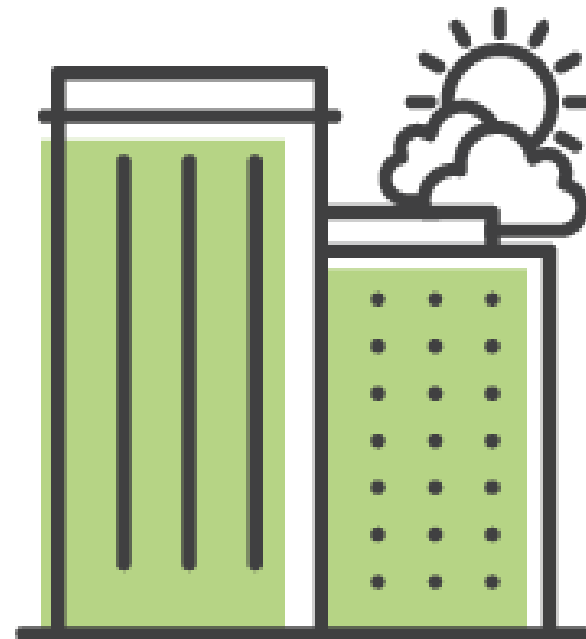


| Space Name     | Floor  | ACH(Peak Humidity Day) | ACH(Peak Dry Bulb Temperature Day) | ACH(Peak Wind speed Day) | Annual ACH(Mean) |
|----------------|--------|------------------------|------------------------------------|--------------------------|------------------|
| Lobby zone 1   | Ground | 16.25                  | 17.99                              | 14.04                    | 16.17            |
| Lobby zone 2   |        | 10.61                  | 11.30                              | 11.71                    | 11.56            |
| Lobby zone 3   |        | 14.51                  | 16.91                              | 15.02                    | 15.72            |
| Open Terrace 4 | First  | 150.93                 | 142.04                             | 145.65                   | 153.57           |
| Lobby zone 5   | Second | 14.18                  | 11.85                              | 14.50                    | 14.09            |

# 5. DESIGN RECOMMENDATIONS FOR WARM AND HUMID CLIMATE

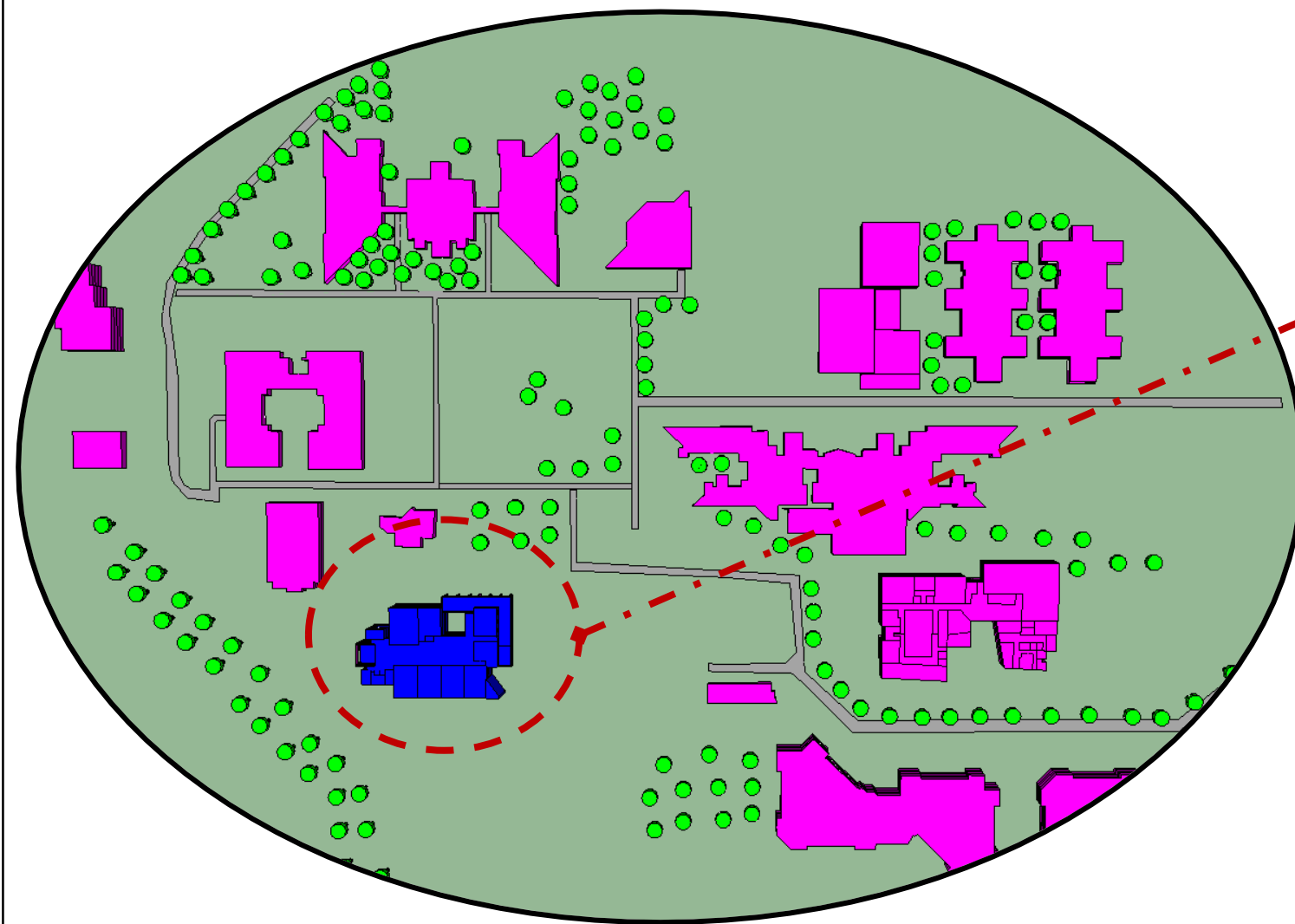


# SOLAR THERMAL ANALYSIS

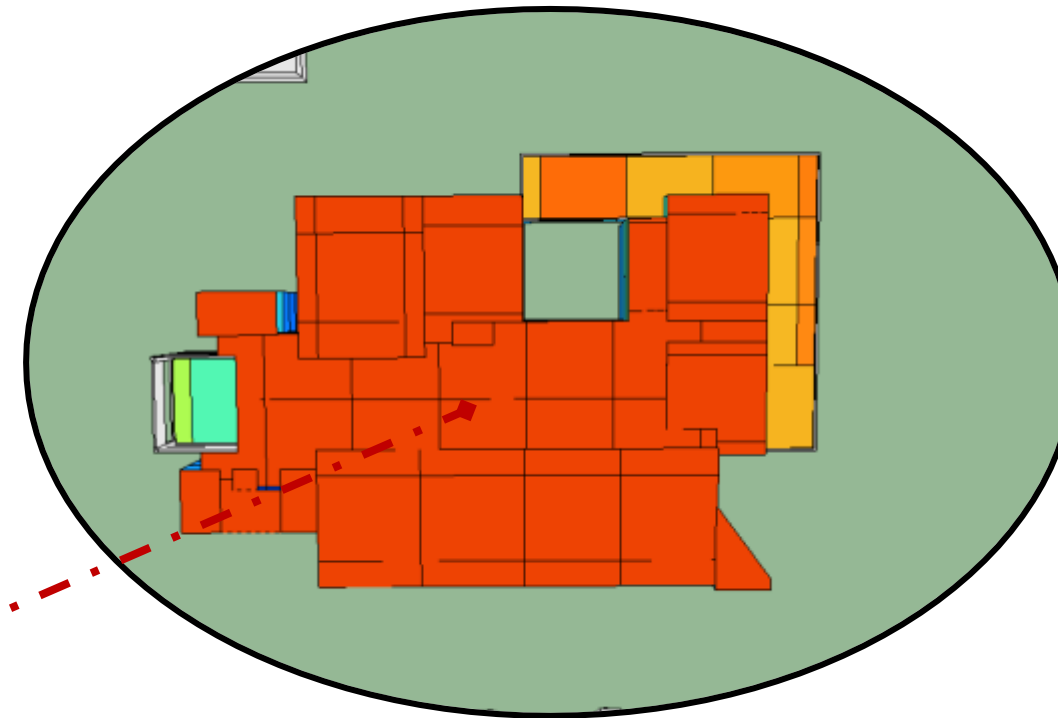


## SOLAR ANALYSIS -Annual

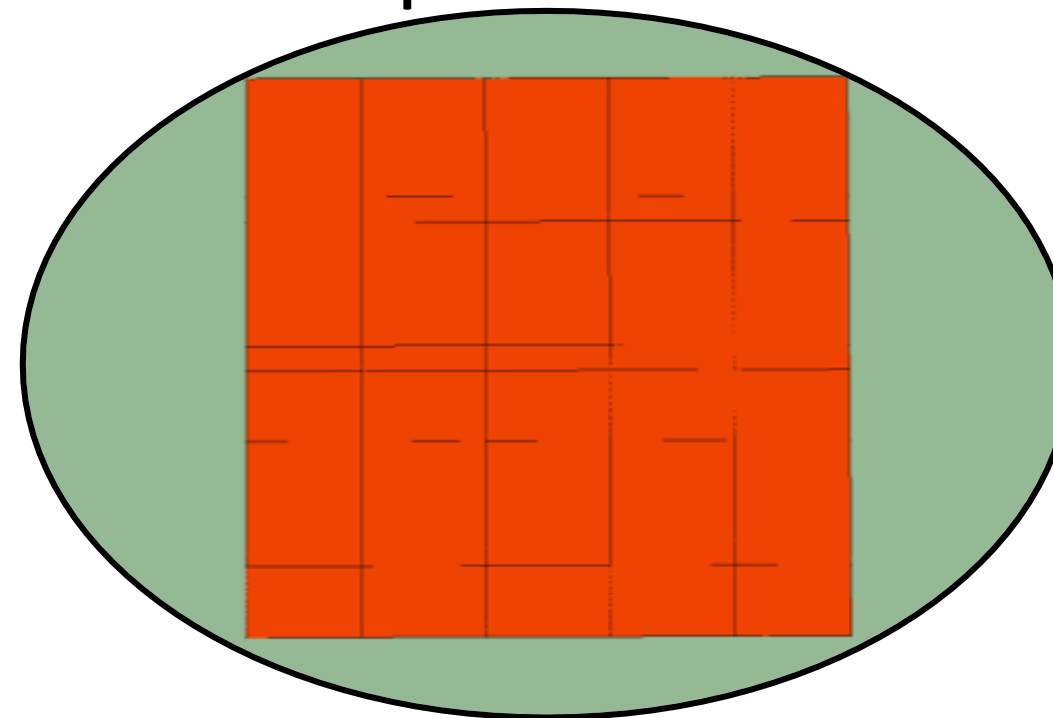
### Roof Radiant Heat Academic Building



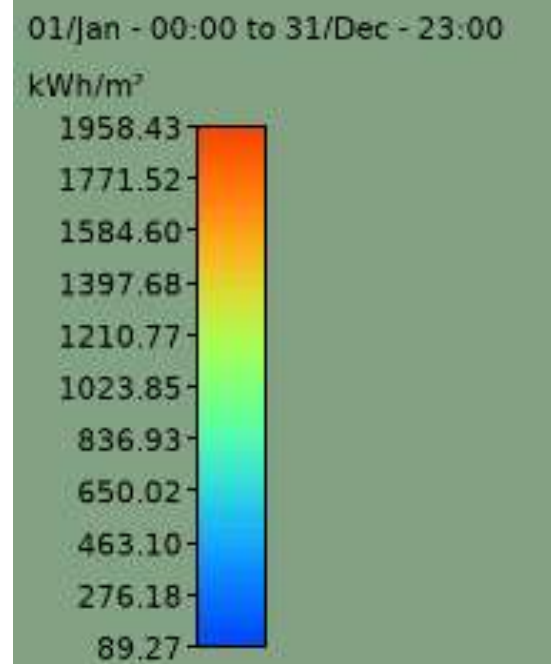
Key plan



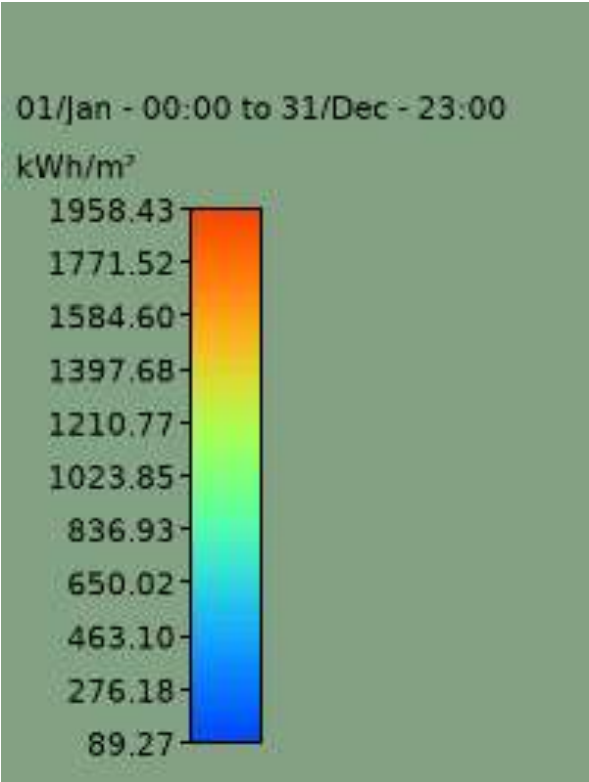
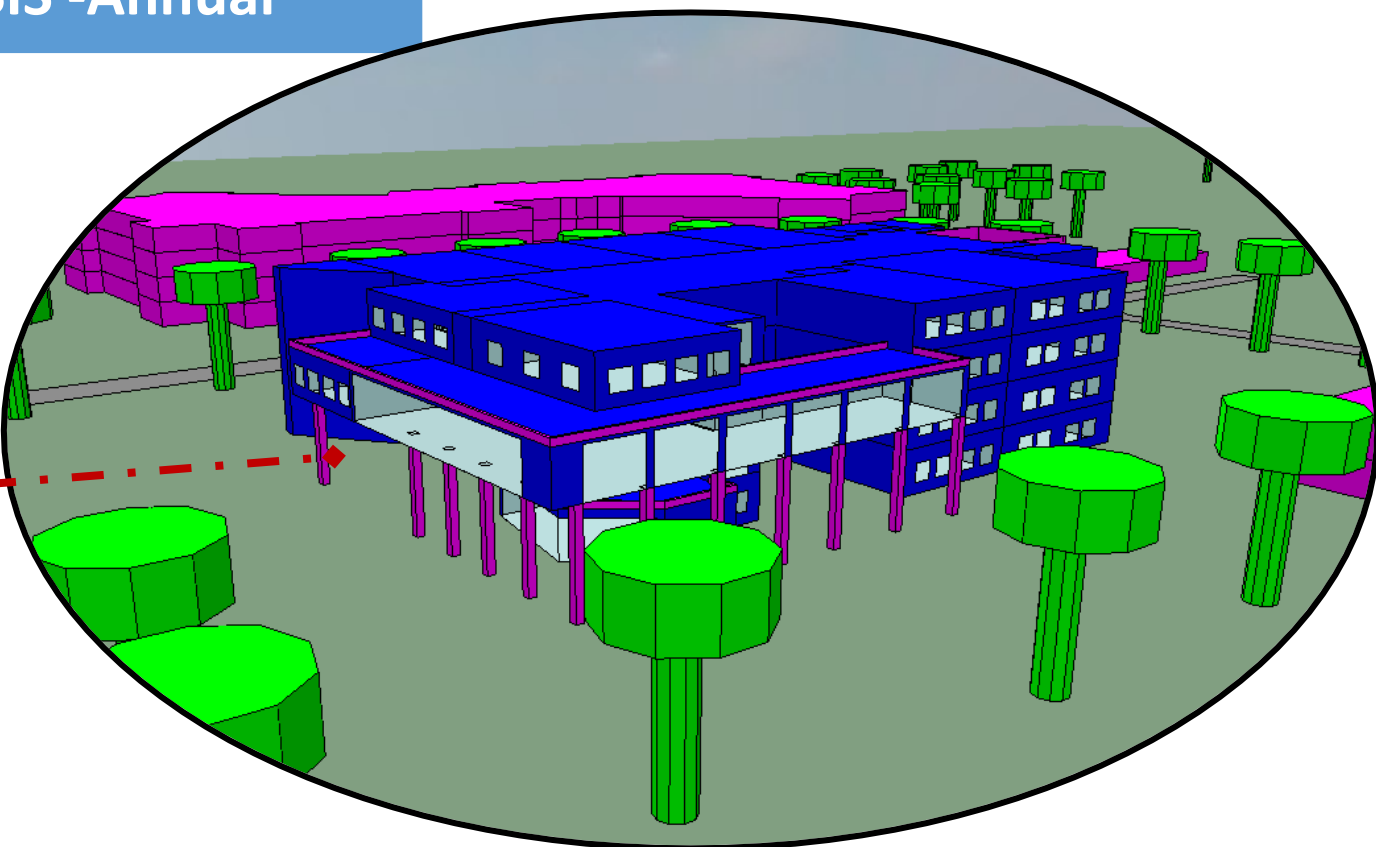
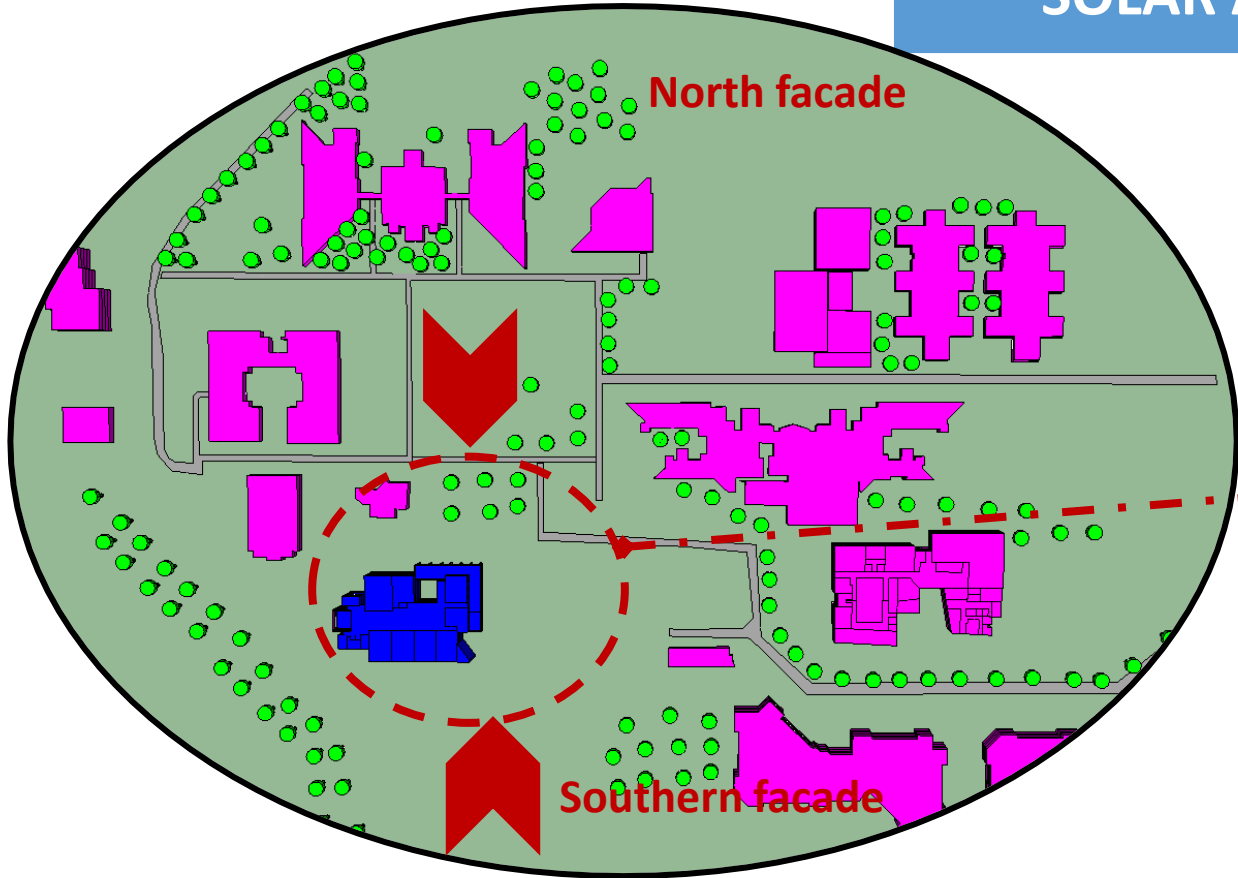
Proposed Model



Box Model

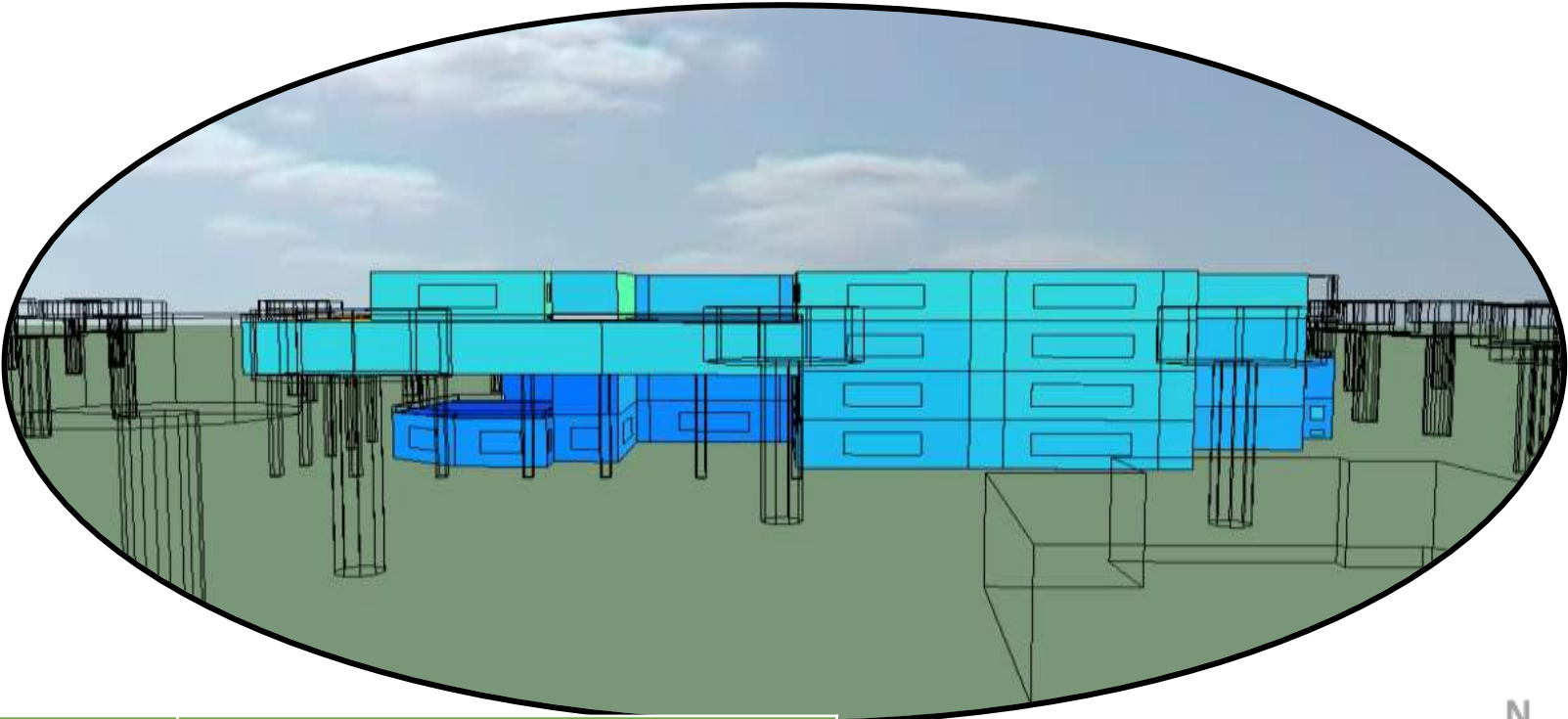
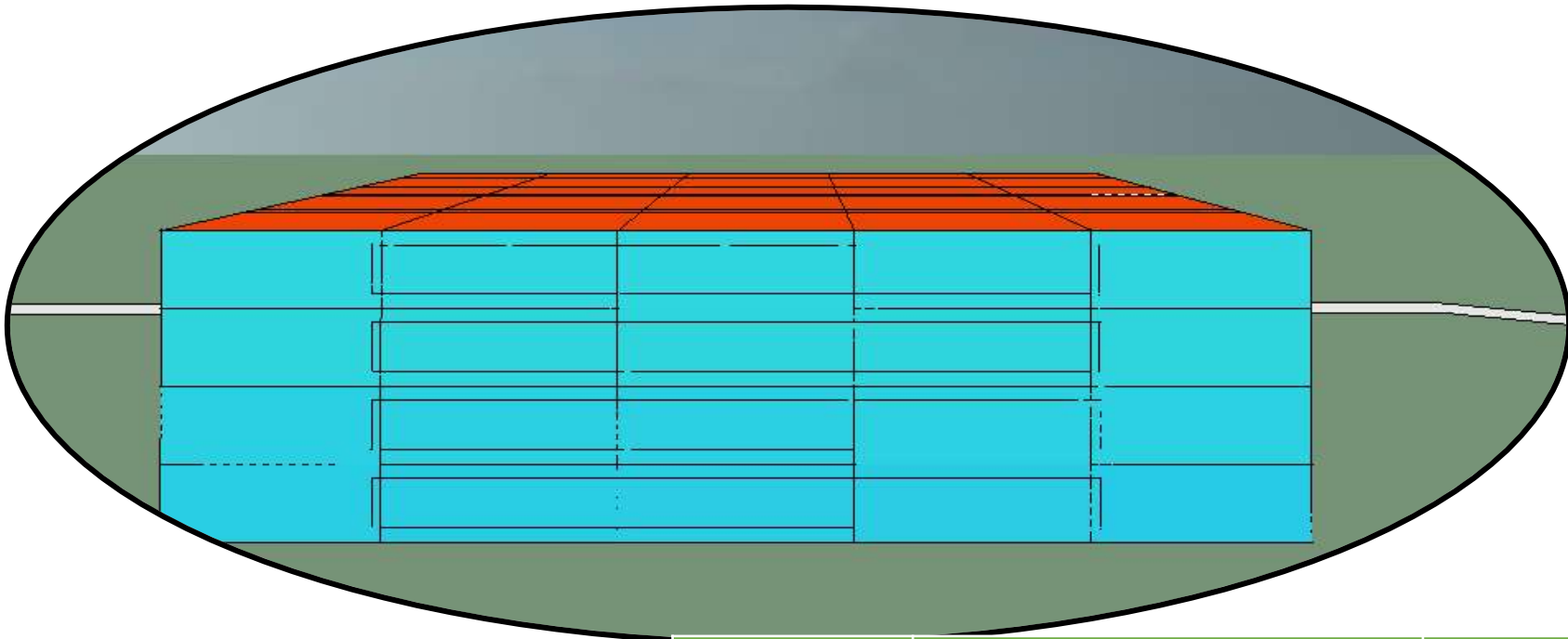


SOLAR ANALYSIS -Annual



Northern Facade Radiant heat(Box Model)

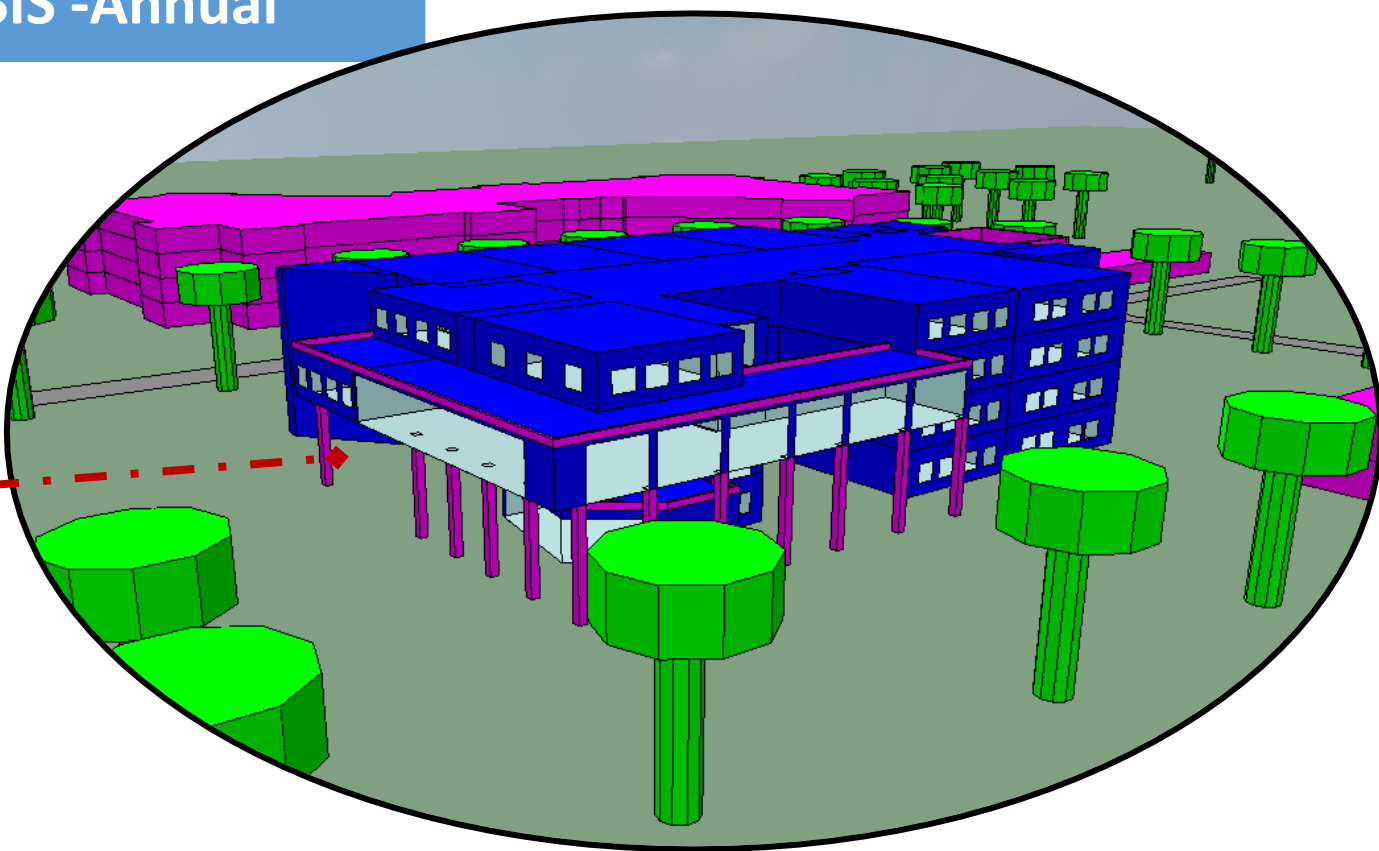
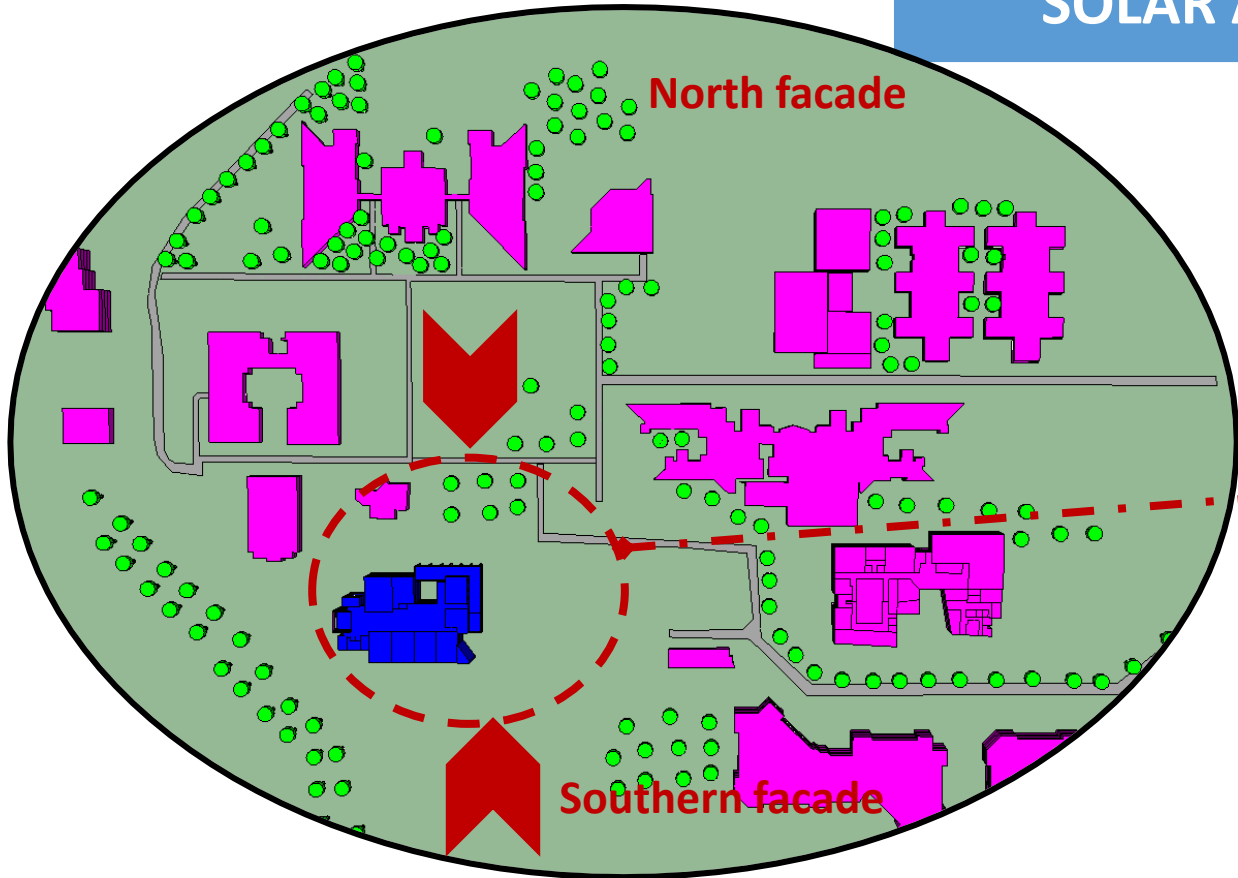
Northern Facade Radiant heat(Proposed Model)



| Facade | Baseline Design Solar Radiation(KWH/Sq.m) | Proposed Design Solar Radiation(KWH/Sq.m) | % Reduction In thermal Radiation |
|--------|-------------------------------------------|-------------------------------------------|----------------------------------|
| North  | 650                                       | 325                                       | 50%                              |

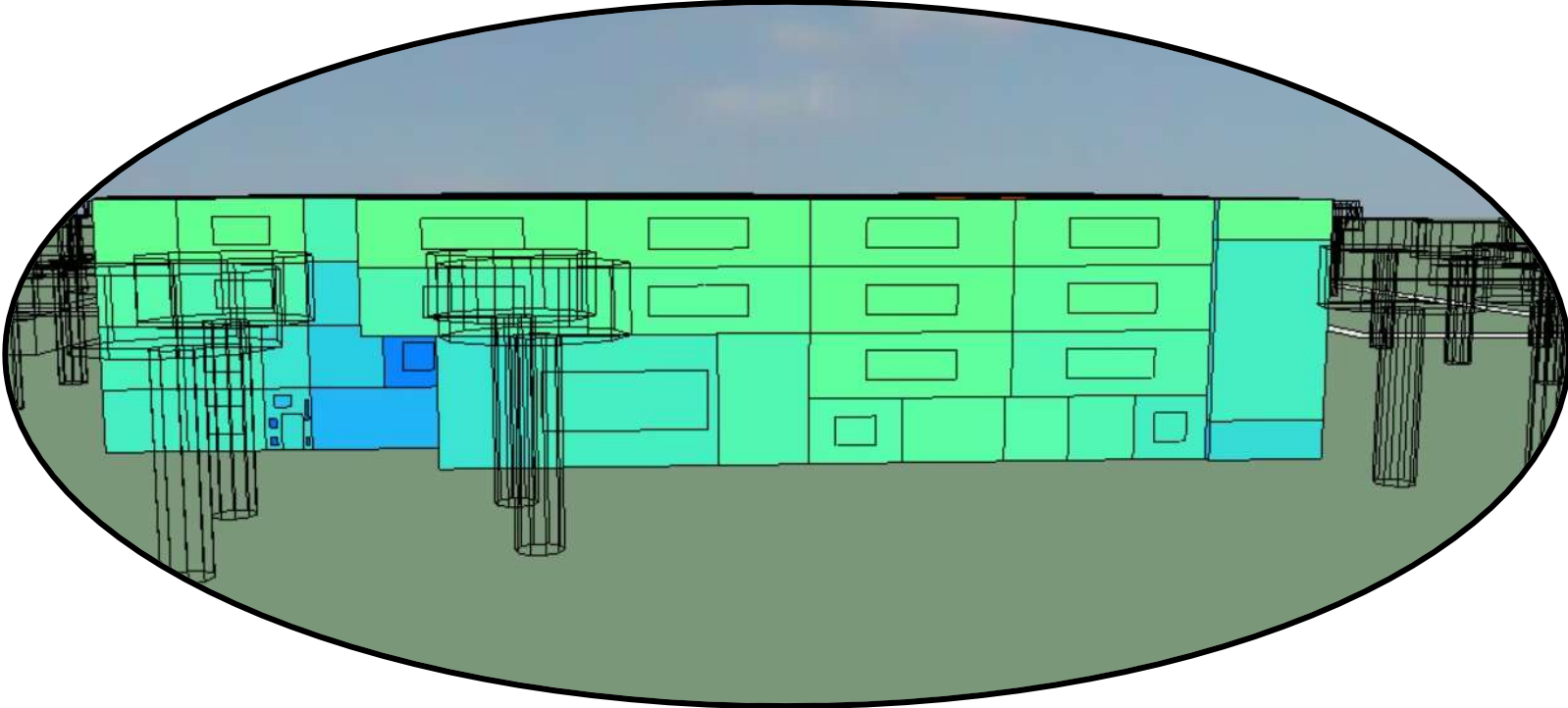
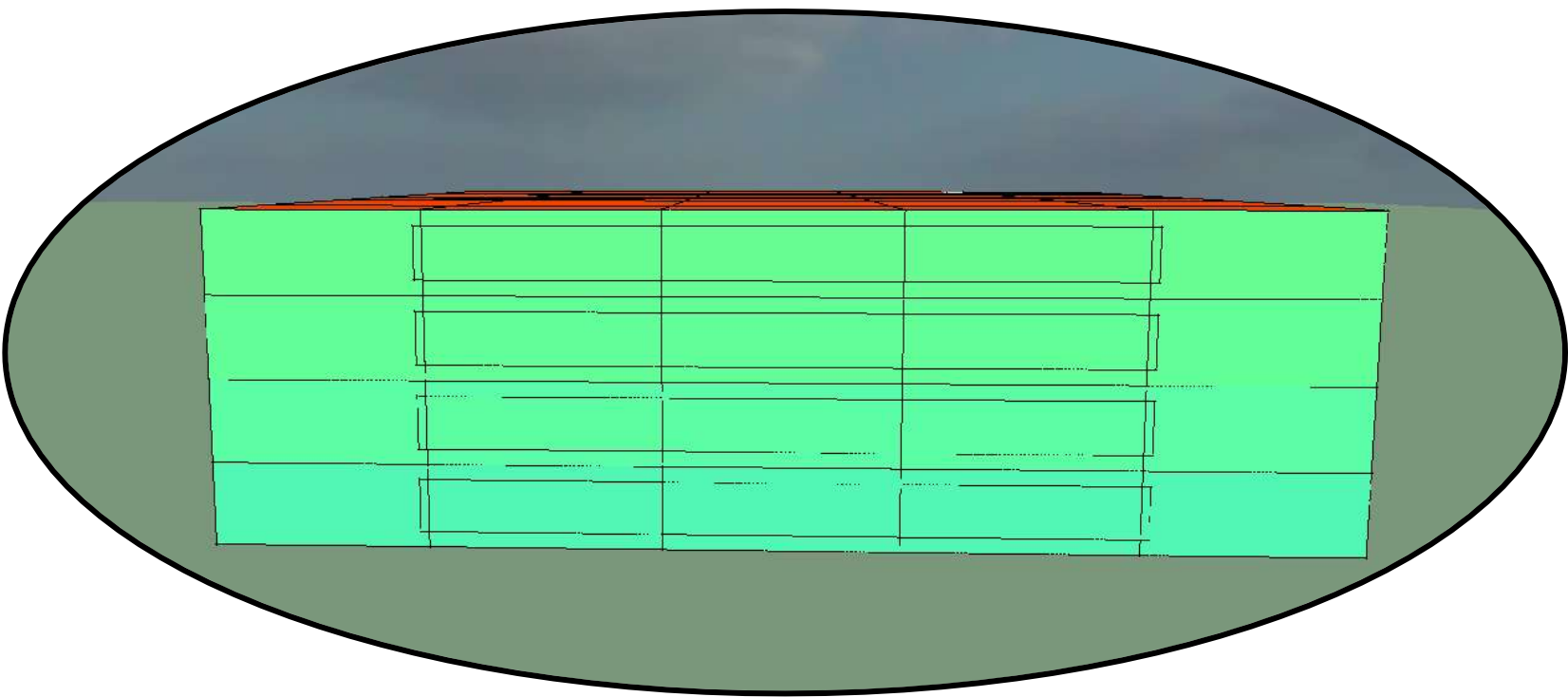


SOLAR ANALYSIS -Annual



Southern Facade Radiant heat(Box Model)

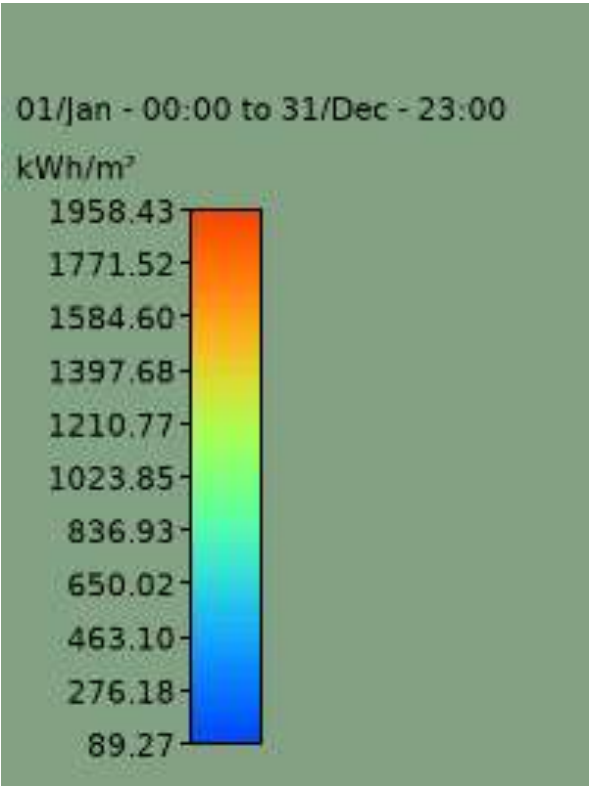
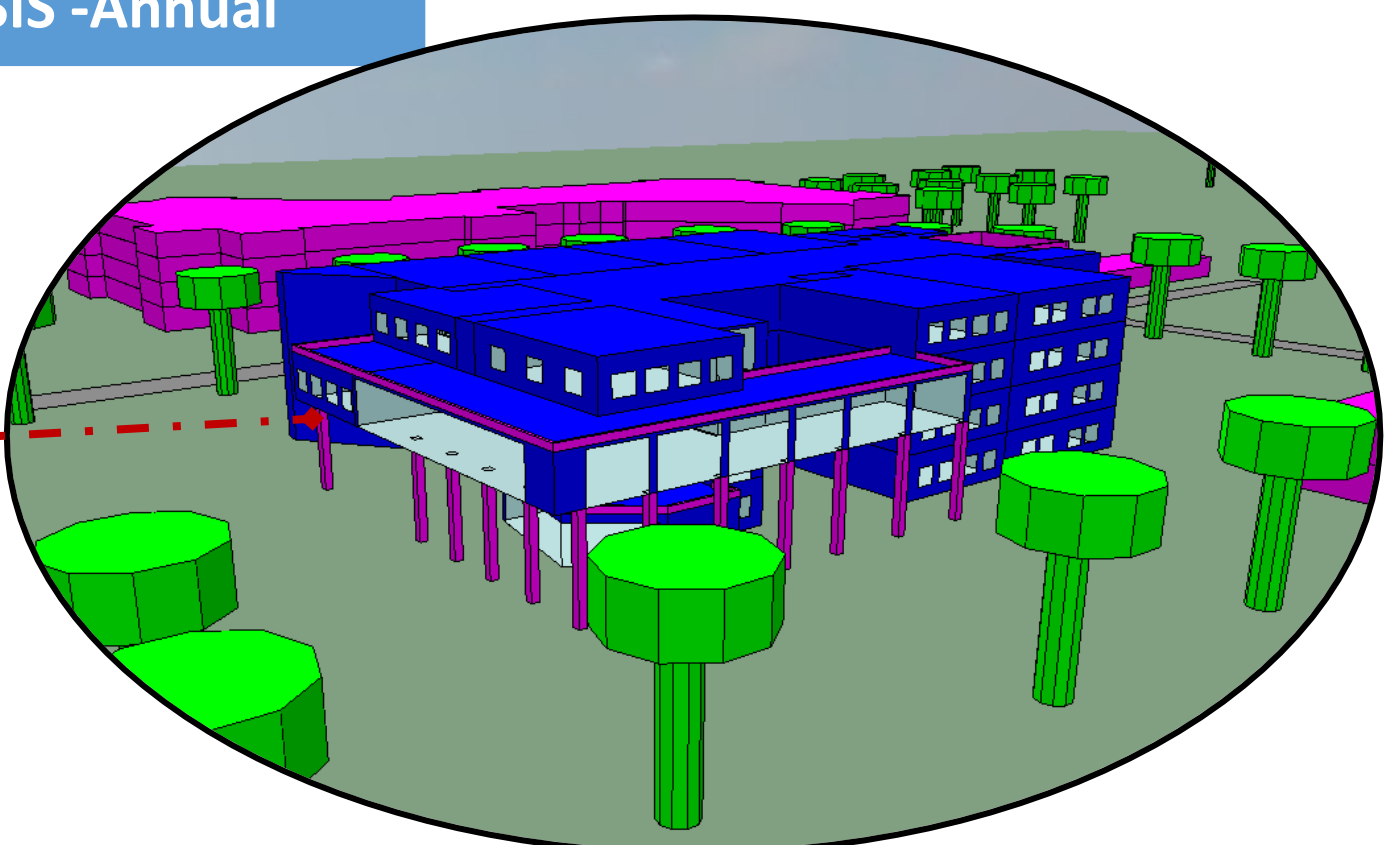
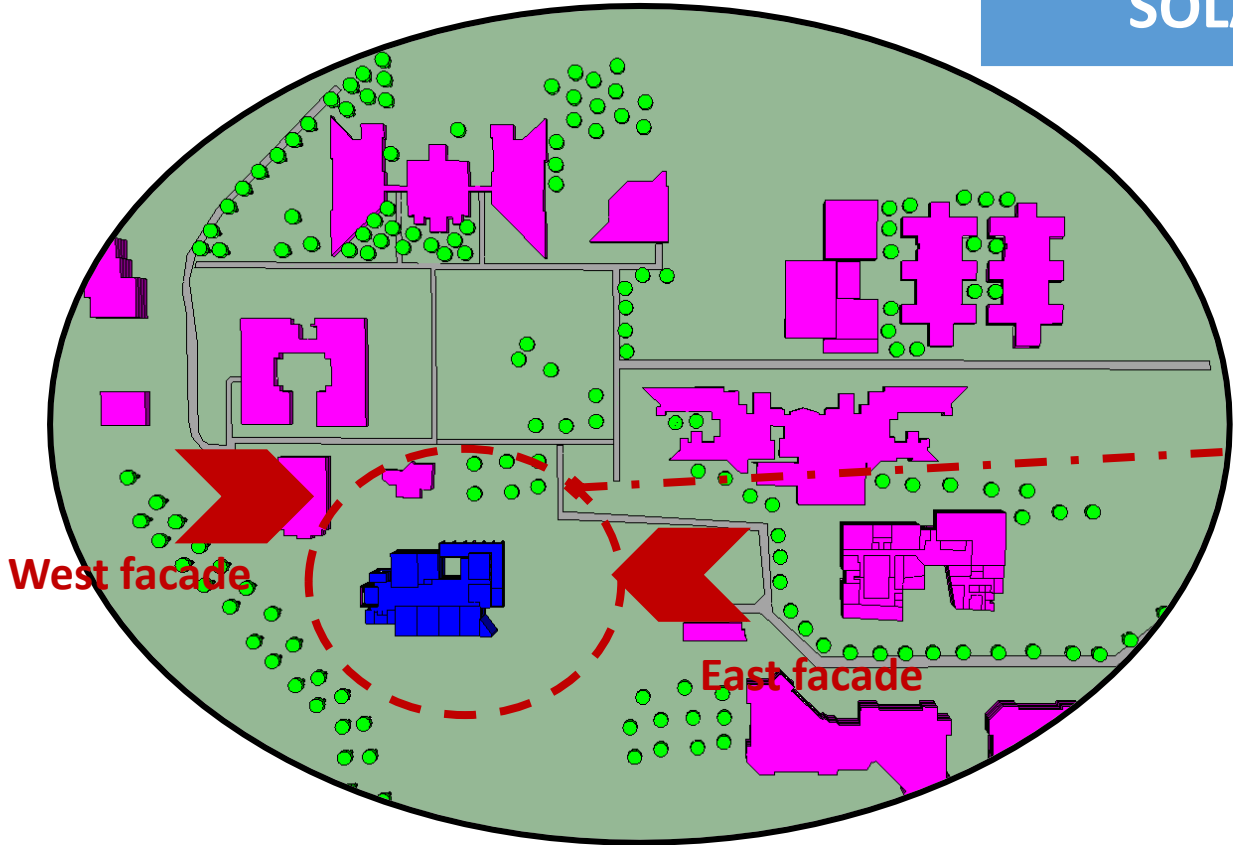
Southern Facade Radiant heat(Proposed Model)



| Facade | Baseline Design Solar Radiation(KWH/Sq.m) | Proposed Design Solar Radiation(KWH/Sq.m) | % Reduction In thermal Radiation |
|--------|-------------------------------------------|-------------------------------------------|----------------------------------|
| South  | 1000                                      | 550                                       | 55%                              |

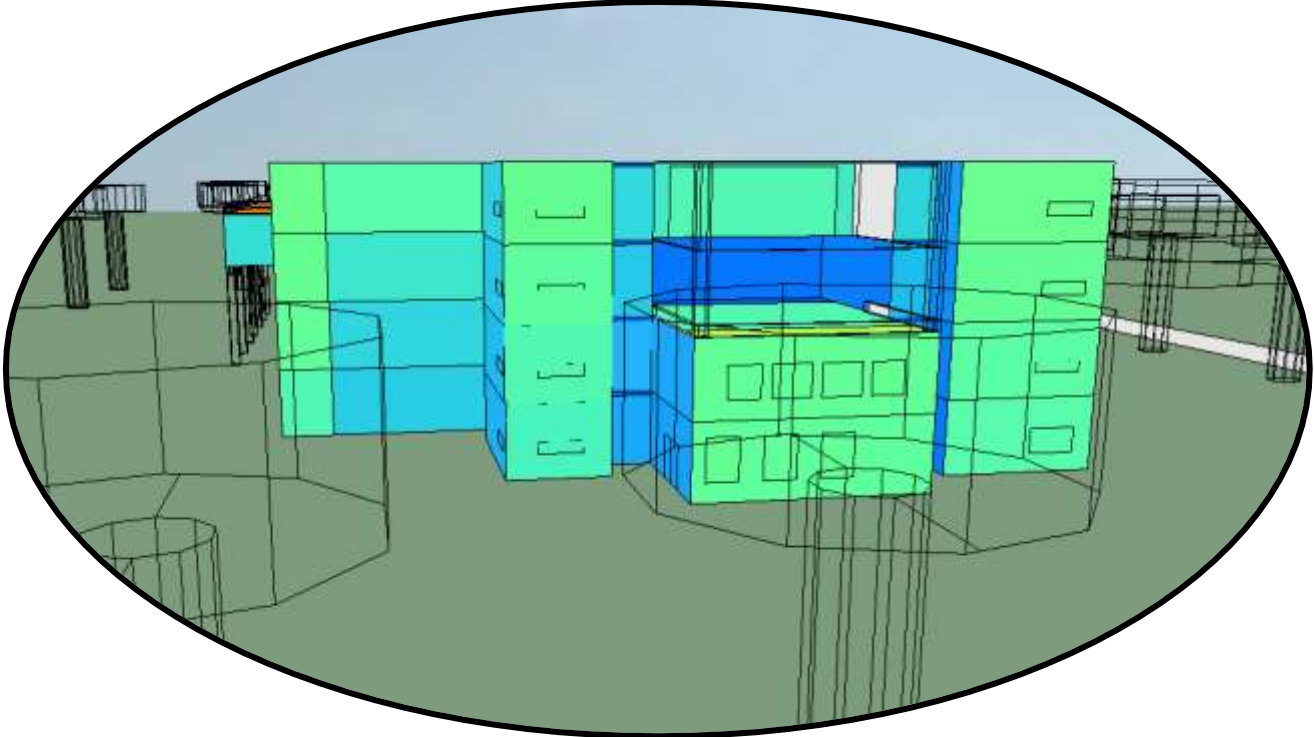
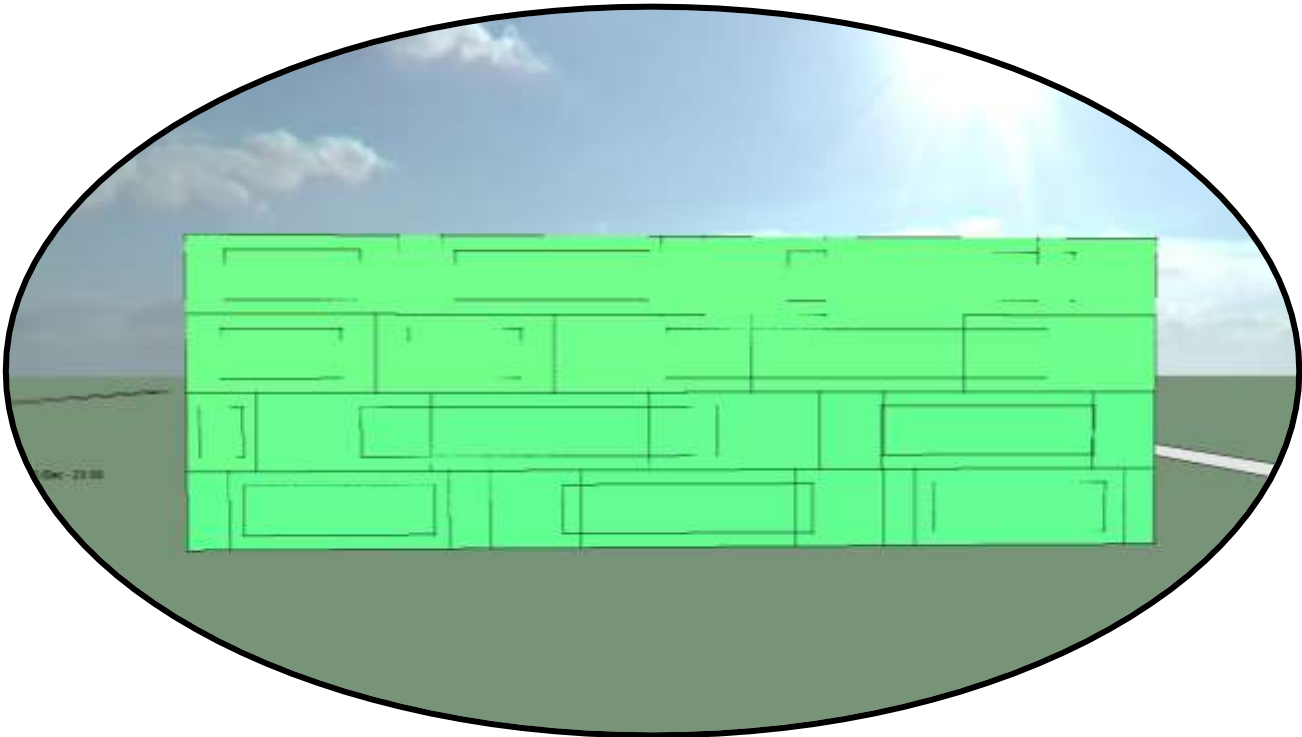


SOLAR ANALYSIS -Annual



Western Facade Radiant heat(Box Model)

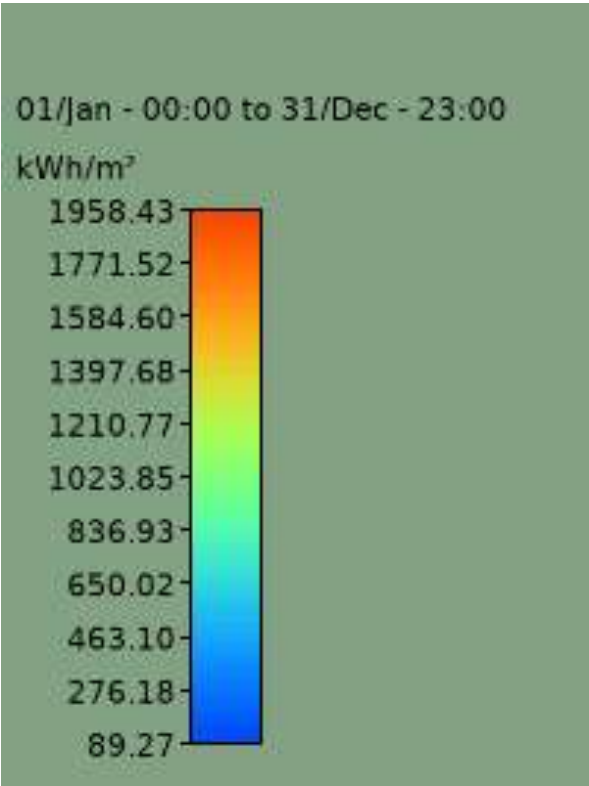
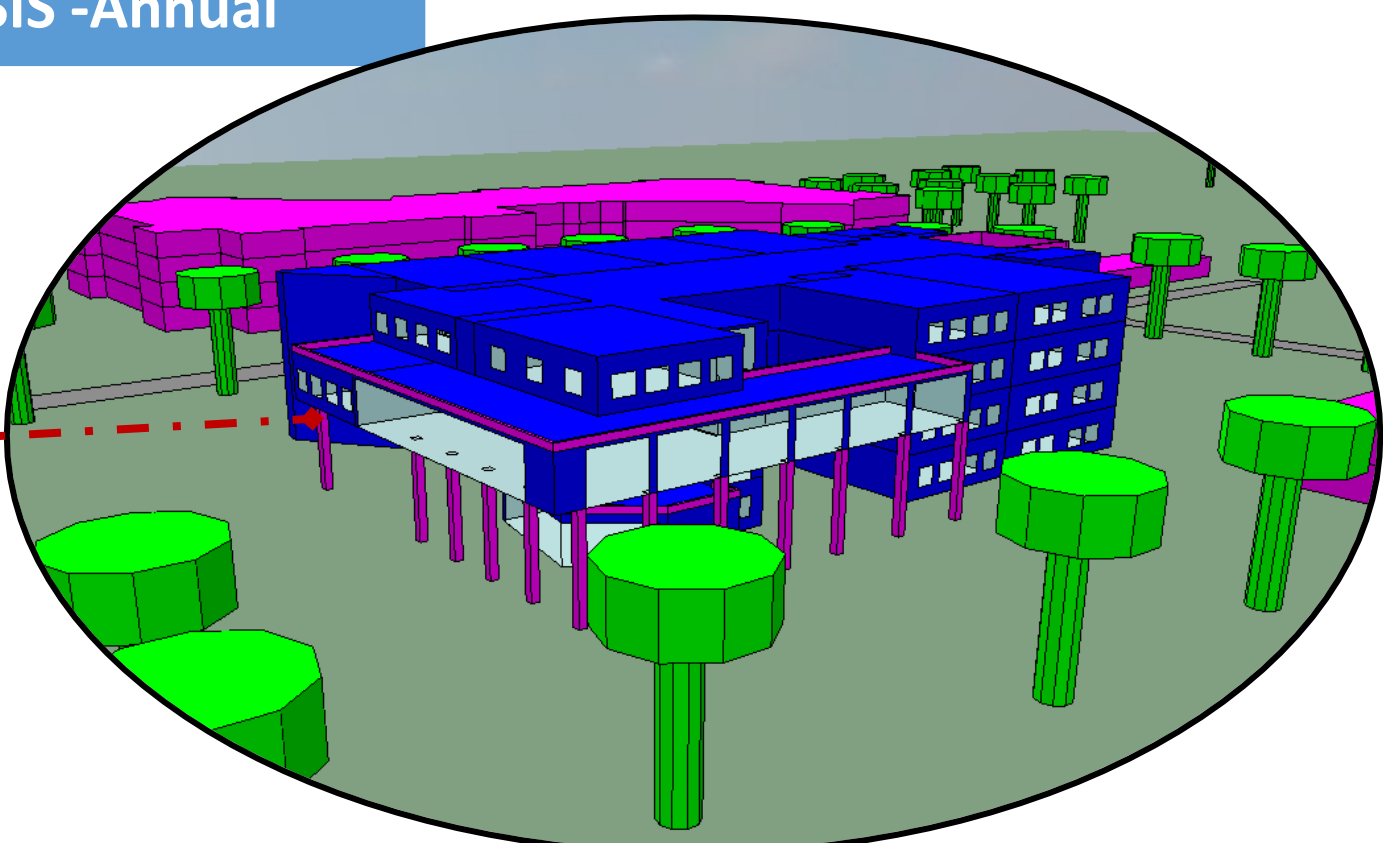
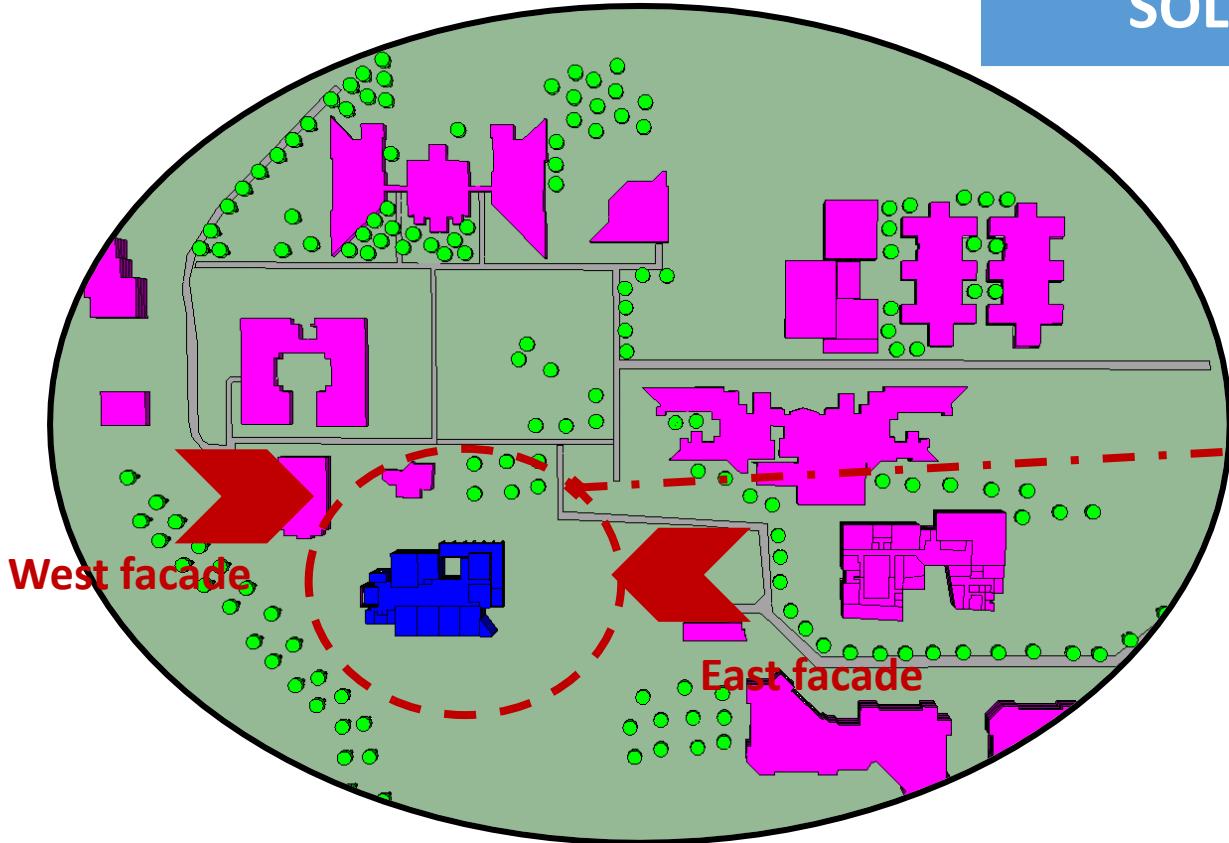
Western Facade Radiant heat(Proposed Model)



| Facade | Baseline Design Solar Radiation(KWH/Sq.m) | Proposed Design Solar Radiation(KWH/Sq.m) | % Reduction In thermal Radiation |
|--------|-------------------------------------------|-------------------------------------------|----------------------------------|
| West   | 1023                                      | 666                                       | 65%                              |

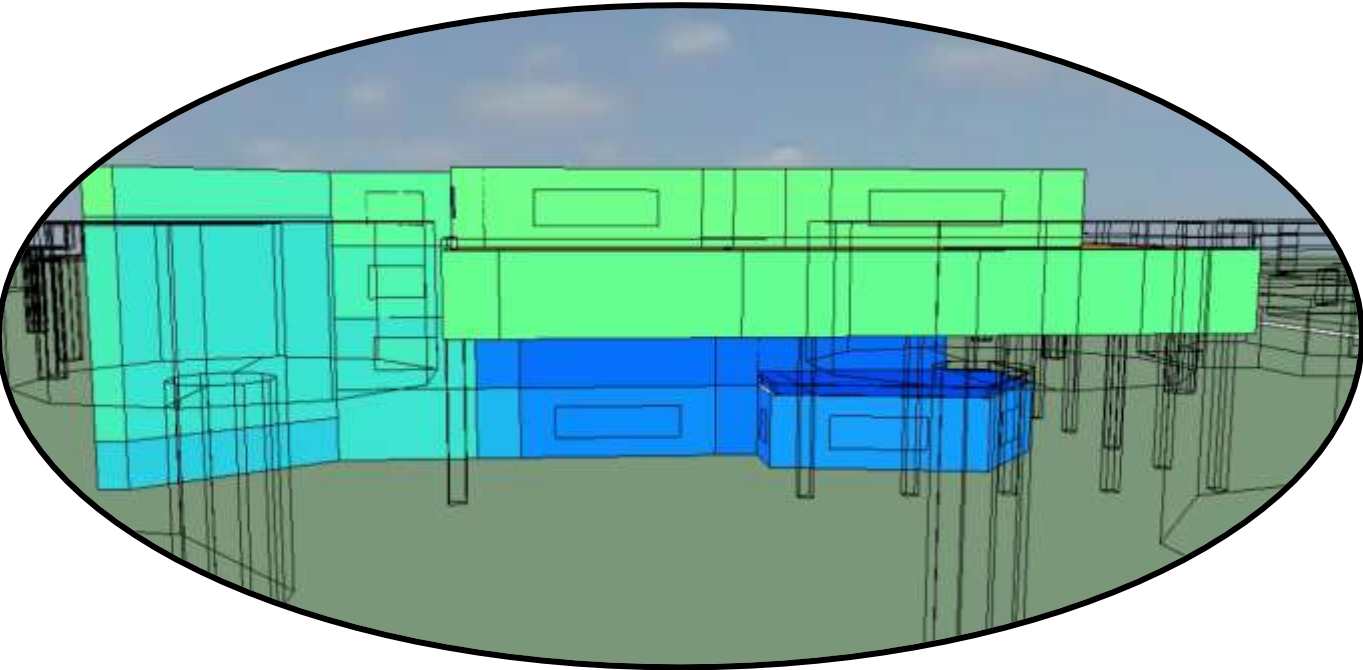
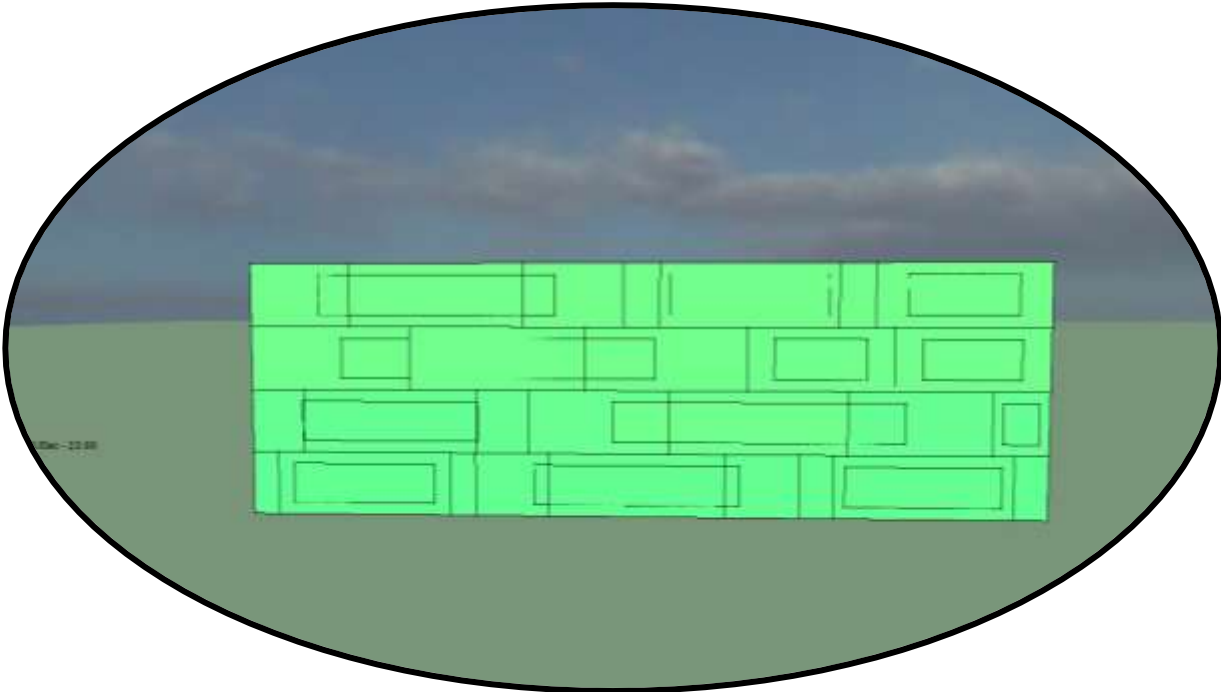


SOLAR ANALYSIS -Annual



Eastern Facade Radiant heat(Box Model)

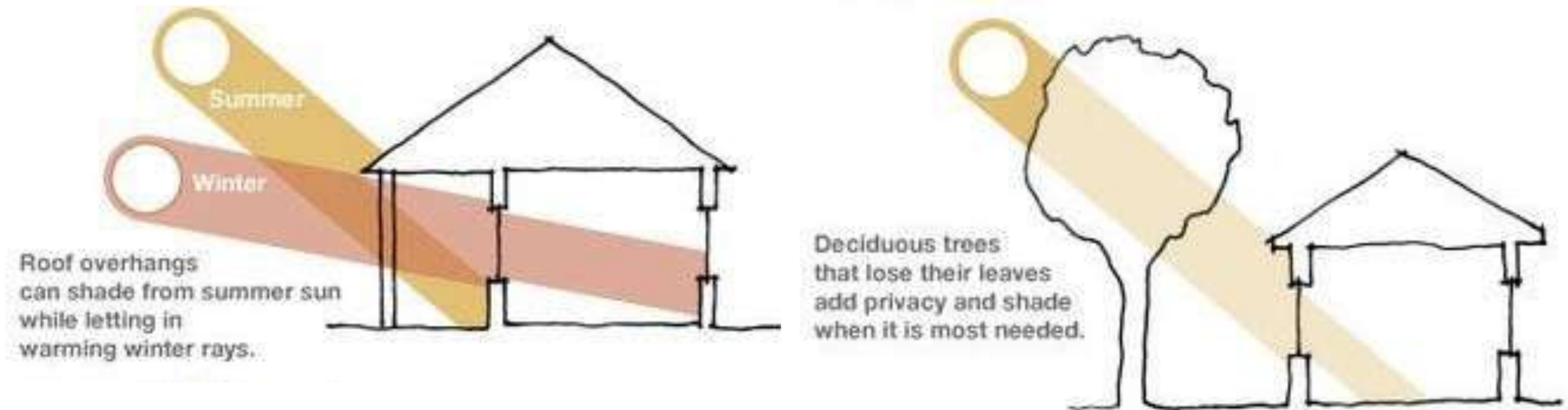
Eastern Facade Radiant heat(Proposed Model)



| Facade | Baseline Design Solar Radiation(KWH/Sq.m) | Proposed Design Solar Radiation(KWH/Sq.m) | % Reduction In thermal Radiation |
|--------|-------------------------------------------|-------------------------------------------|----------------------------------|
| East   | 1010                                      | 808                                       | 80%                              |



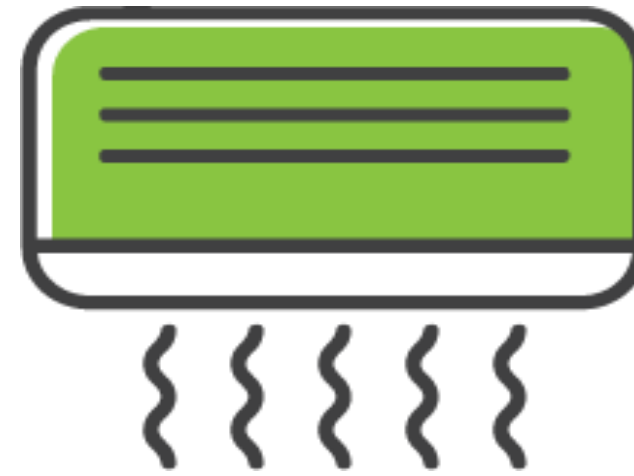
## SOLAR THERMAL ANALYSIS INFERENCE



| Facade | Baseline Design Solar Radiation(KWH/Sq.m) | Proposed Design Solar Radiation(KWH/Sq.m) | % Reduction In thermal Radiation |
|--------|-------------------------------------------|-------------------------------------------|----------------------------------|
| North  | 650                                       | 325                                       | 50%                              |
| South  | 1000                                      | 550                                       | 55%                              |
| West   | 1023                                      | 666                                       | 65%                              |
| East   | 1010                                      | 808                                       | 80%                              |

- Hot and Dry winds(41 °C and 30% RH) is observed from South and west directions in May, By planting Large foliage trees in Western and southern façade site temperature is substantially reduced.
- Deploying Shading Elements/Large canopy trees shall reduce façade temperature. Thus, Heat ingress through Building Envelope is reduced.
- It is also observed that the Southern ,Eastern and Western façade is exposed to High Radiation .

# HVAC ANALYSIS



## HVAC ANALYSIS

- HVAC Analysis is performed for Academic Building.
- The Project has used efficient HVAC system which minimizes HVAC ODP and GWP.
- Implementing Efficient HVAC system shall achieve significant Energy savings.

|                           |                         |
|---------------------------|-------------------------|
| Project Name              | : Shiv Nadar University |
| Site Location             | : Kelambakkam ,Chennai  |
| Built-up Area             | : 8,753 Sq.m            |
| Academic Building AC Area | : 5,546 Sq.m            |
| Key Description           | : Educational Facility  |
| Geographical Location     | : 12.75° N , 80.20° E   |
| Climate Zone              | : Warm & Humid          |

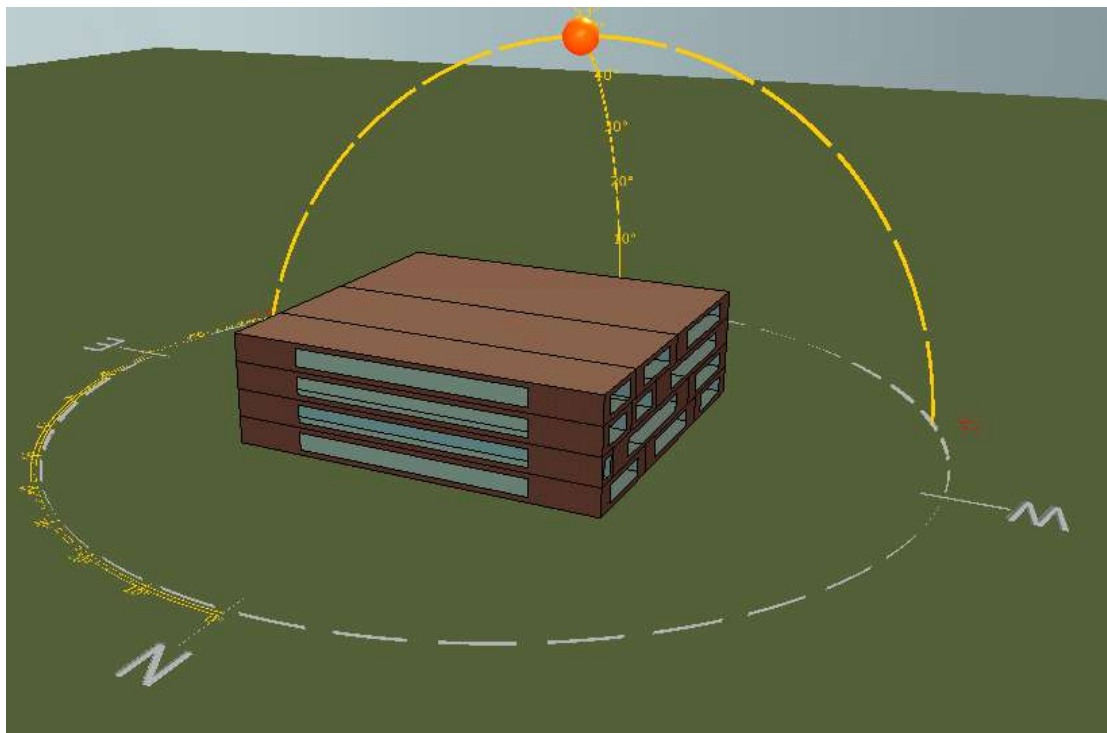
PARAMETERS CONSIDERED FOR SIMULATION

| Parameters                       | Red Brick<br>(Base Box<br>Model) | Red Brick<br>U<br>Value(W/sq.mk) | Fly Ash Brick<br>U<br>Value(W/sq.mk) | AAC<br>U Value<br>\(W/sq.mk) | Cavity Wall<br>U Value(W/sq.mk) | EIFS U<br>Value(W/sq.mk) |
|----------------------------------|----------------------------------|----------------------------------|--------------------------------------|------------------------------|---------------------------------|--------------------------|
| External<br>Wall(W/sq.m k)       | 3.28                             | 3.28                             | 2.31                                 | 0.98                         | 1.35                            | 0.25                     |
| Roof(W/sq.m k)                   | 3.41(Roof -<br>Concrete)         | 3.41(Roof -<br>Concrete)         | 0.26(Roof with Rock Wool Insulation) |                              |                                 |                          |
| SRI ( Solar<br>Reflective Index) | 53                               | 53                               | 53                                   | 100                          | 53                              | 100                      |
| External<br>Window(W/sq.m k)     | 5.5                              |                                  |                                      |                              |                                 |                          |
| SHGC                             | 0.37                             |                                  |                                      |                              |                                 |                          |
| VLT                              | 0.23                             |                                  |                                      |                              |                                 |                          |

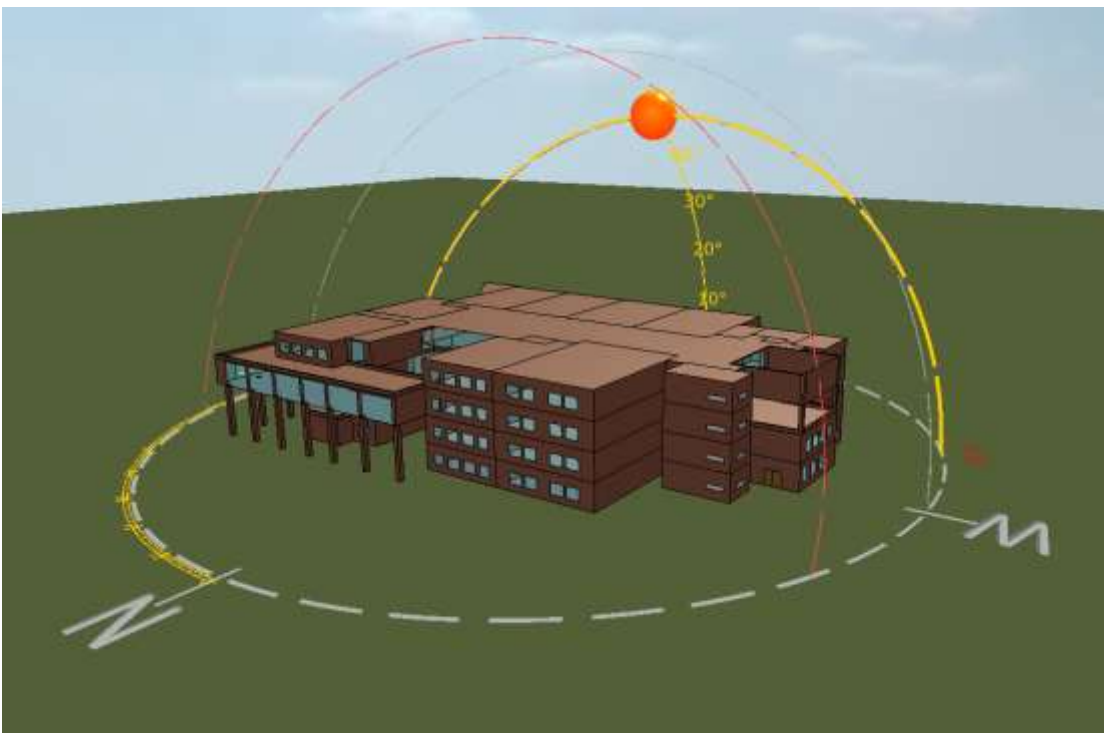
# PARAMETERS DATA CONSIDERED FOR SIMULATION

| Parameters                | Base case (Actual) case |
|---------------------------|-------------------------|
| Internal Lighting(W/sq.m) | 12.92                   |
| People load(Sq.m/Person)  | 15.51                   |
| Equipment Load (W/sq.m)   | 5.38                    |
| Primary HVAC System type  | Split system system     |
| HVAC Cooling Set point    | 24°C                    |
| Fresh air                 | As per ASHRAE 62.1 2016 |
| Timing Profile            | 8AM to 6 PM             |

# HVAC ANALYSIS SUMMARY-ACADEMIC BUILDING



Box Model



Proposed Model

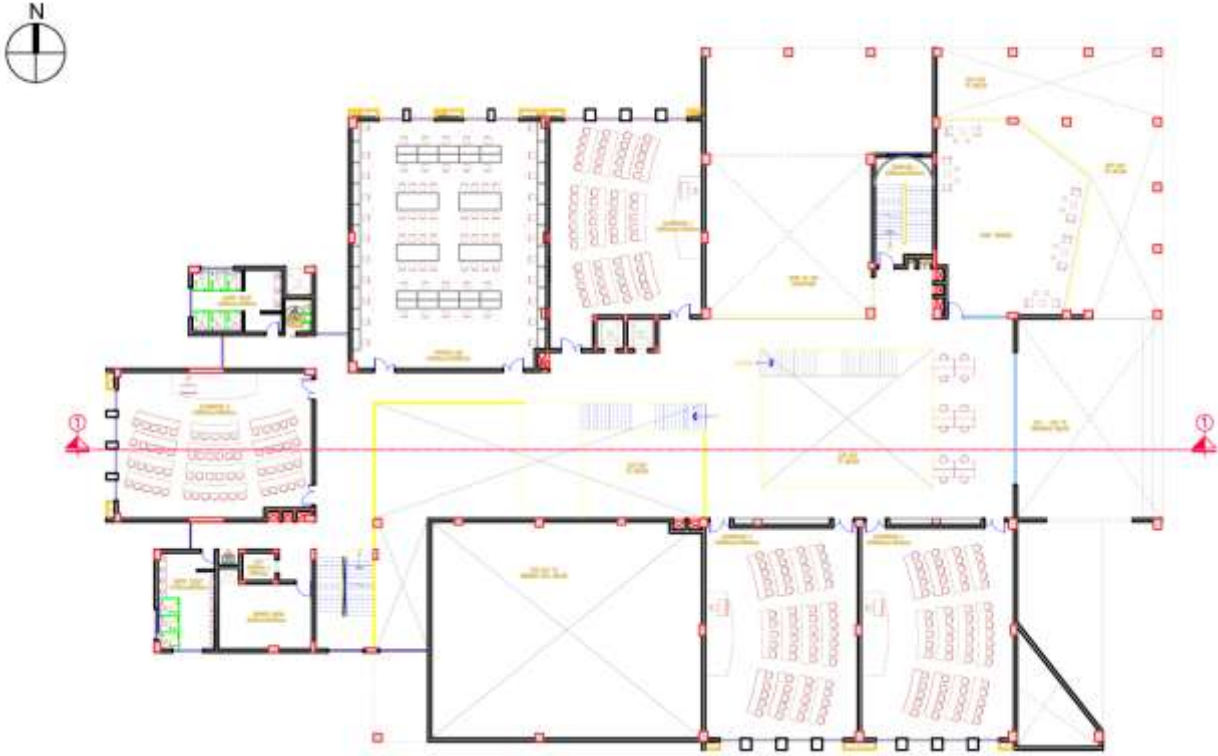
| PARAMETRS                          | Red Brick<br>(Box Model) | Red Brick | Proposed<br>case(AAC) | Fly ash<br>Brick | Cavity Wall | EIFS | Proposed case(AAC<br>with High SRI) | Proposed<br>case(EIFS with<br>High SRI) |
|------------------------------------|--------------------------|-----------|-----------------------|------------------|-------------|------|-------------------------------------|-----------------------------------------|
| Peak Load(TR)                      | 179                      | 157       | 145                   | 152              | 149         | 140  | 142                                 | 136                                     |
| HVAC<br>Consumption(M<br>WH)       | 946                      | 834       | 781                   | 813              | 792         | 770  | 765                                 | 754                                     |
| Drop in Cooling<br>Capacity (%)    | 24.02%                   |           |                       |                  |             |      |                                     |                                         |
| Drop in Cooling<br>Consumption (%) | 20.29%                   |           |                       |                  |             |      |                                     |                                         |

# DAYLIGHTING ANALYSIS

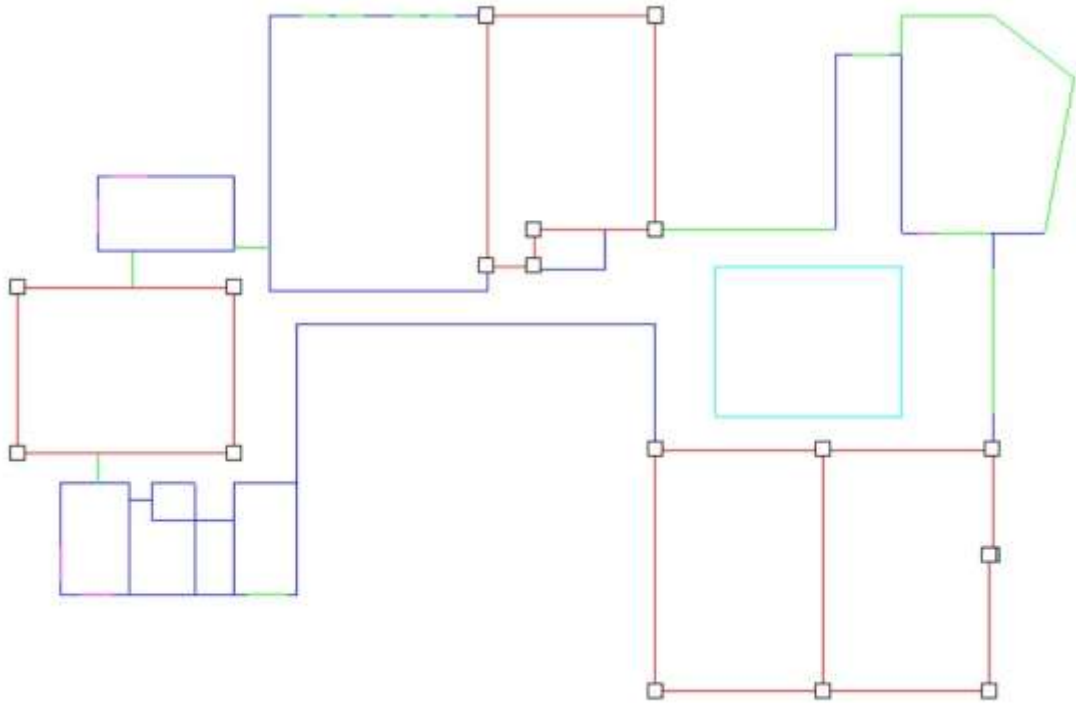


# DAYLIGHT ANALYSIS

## Regularly occupied spaces considered for simulation - Academic Building



First Floor Plan

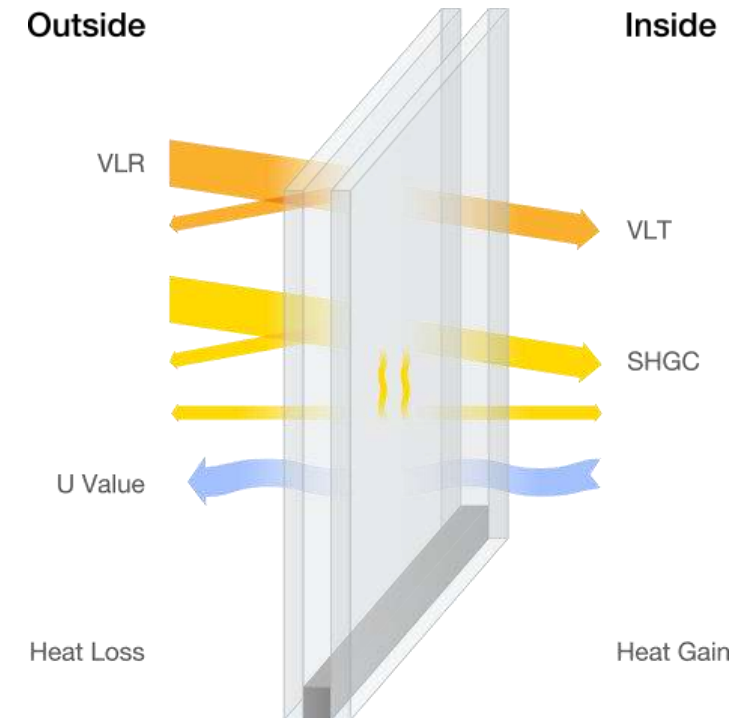
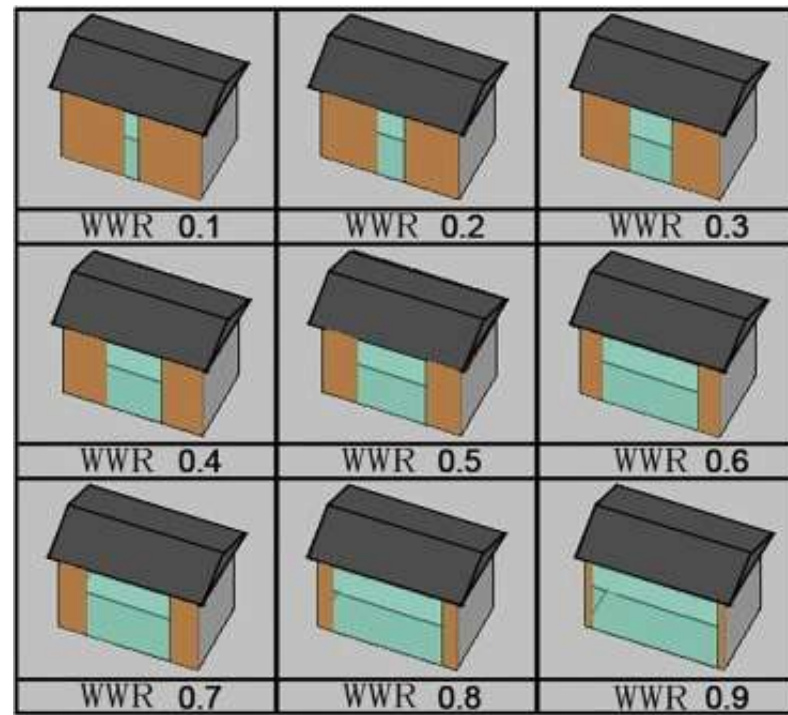


Regularly occupied spaces

### Regularly occupied First floor Room Spaces

|               |
|---------------|
| F-CLASSROOM 1 |
| F-CLASSROOM 2 |
| F-CLASSROOM 3 |
| F-CLASSROOM 3 |

# DAYLIGHT ANALYSIS INFERENCE



**BEST**  
43% VLT\*



**BETTER**  
50% VLT\*



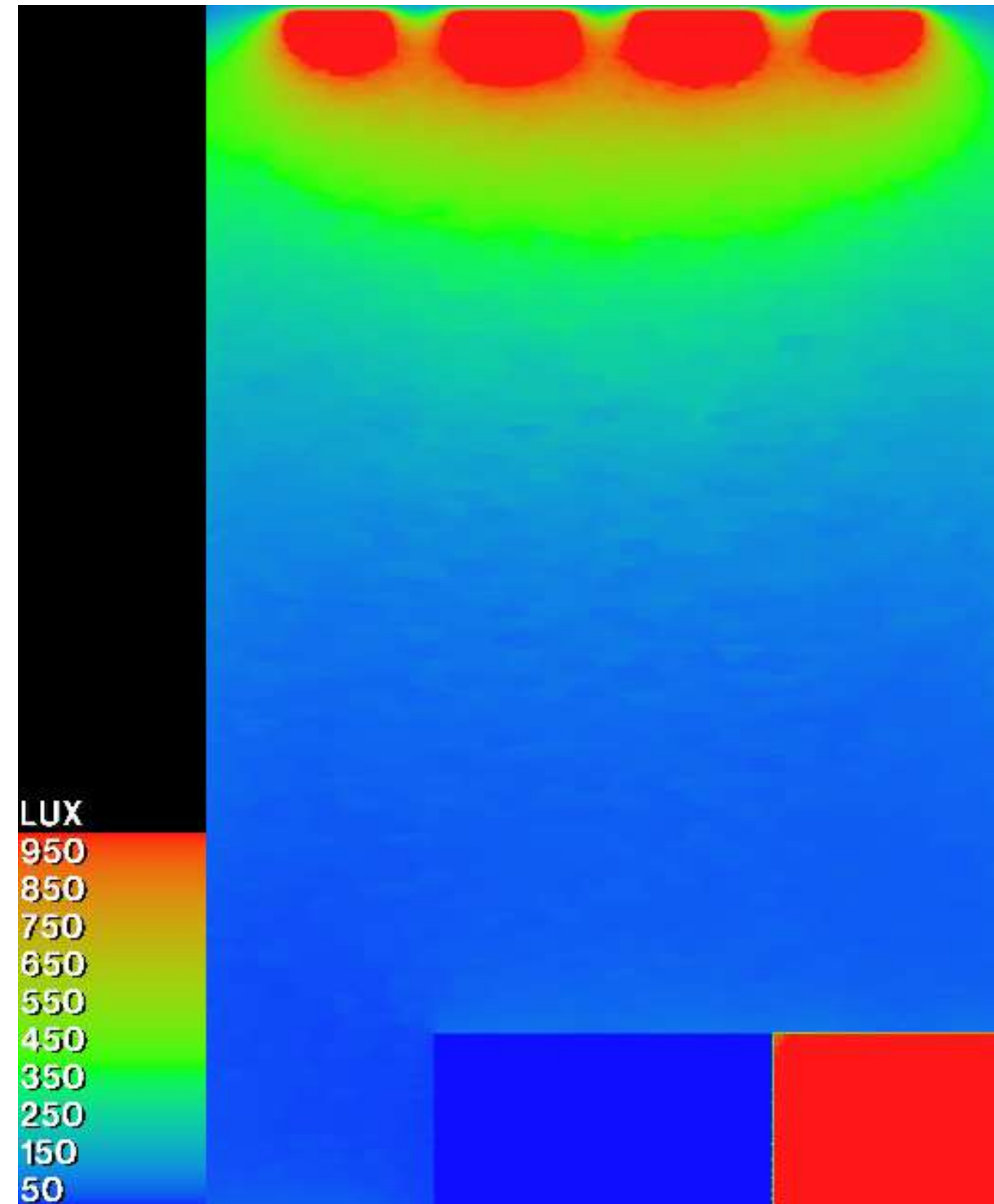
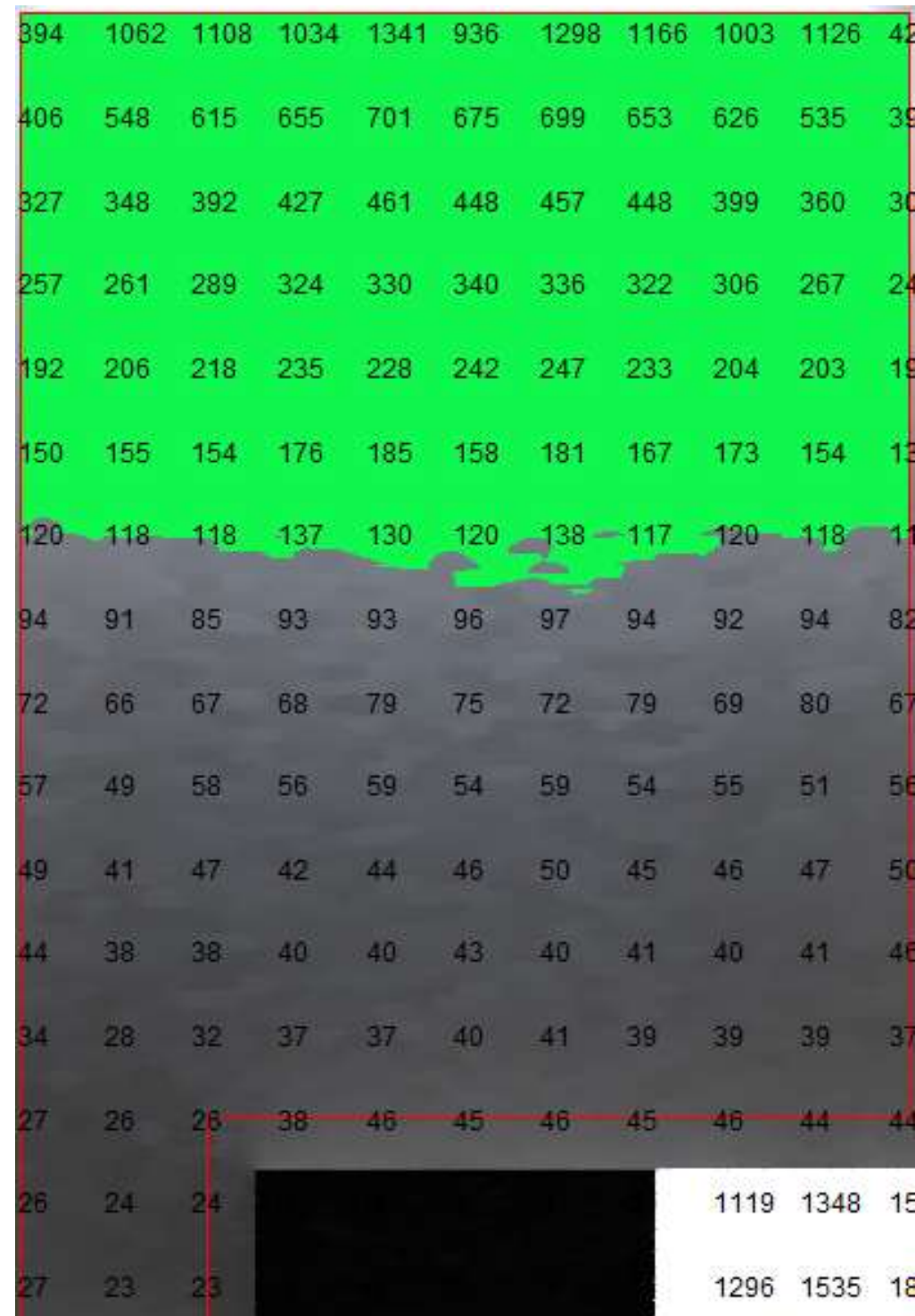
**GOOD**  
69% VLT\*



| S.NO | SPACE NAME               | BASELINE DAYLIGHT PERCENTAGE(%) | PROPOSED(WITH LIGHT SHELVES) DAYLIGHT PERCENTAGE(%) |
|------|--------------------------|---------------------------------|-----------------------------------------------------|
| 1    | Class Room 1(North)      | 46.88                           | 63.21                                               |
| 2    | Class Room 2(West)       | 51.01                           | 69.37                                               |
| 3    | Class Room 3(South)      | 45.91                           | 62.52                                               |
| 4    | Class Room 4(South west) | 45.7                            | 60.95                                               |

## Base case(Without Light shelves) - Academic class room 1 First floor

### Base case



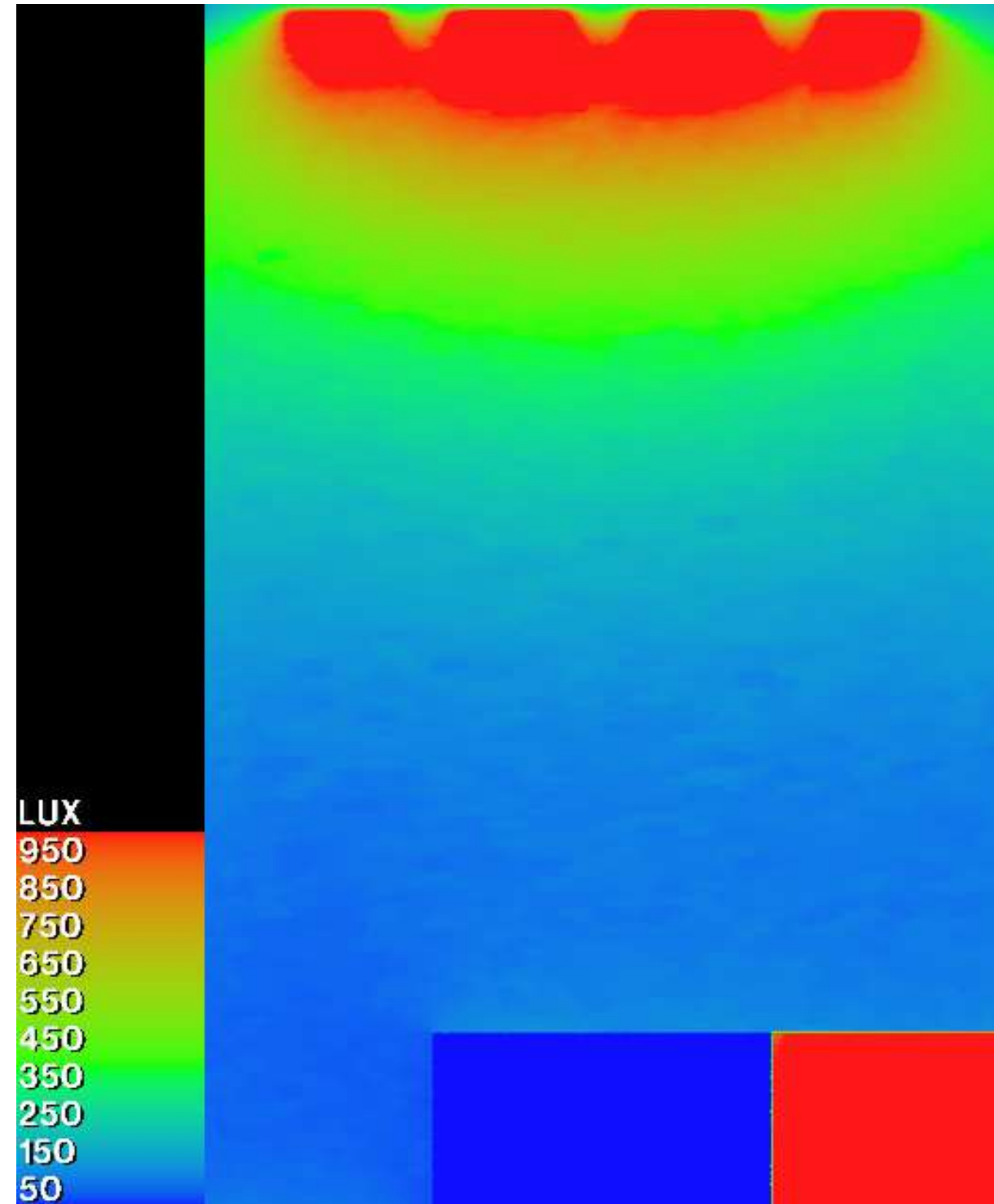
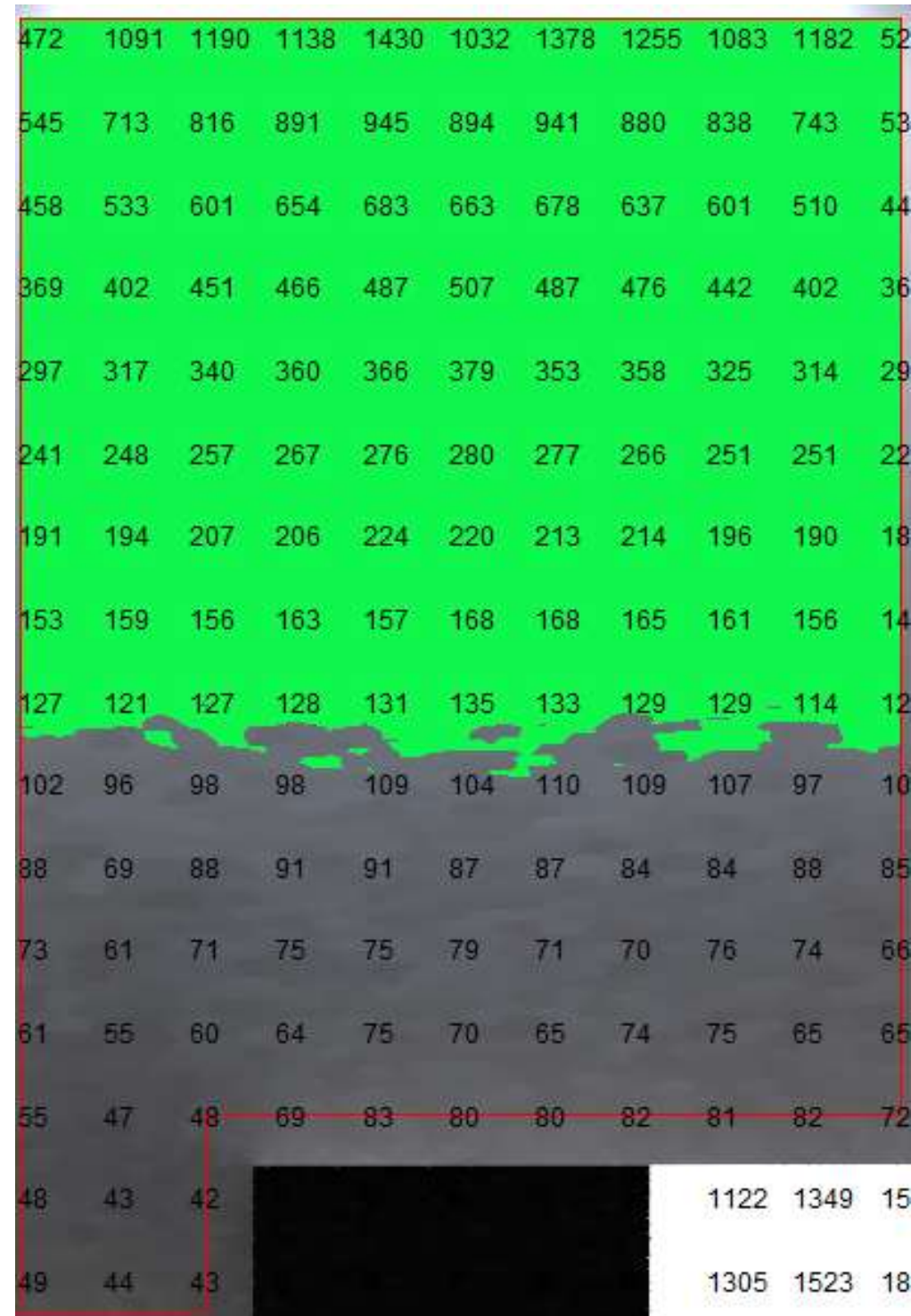
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 46.88 % ( 65.91 m²)

## Proposed case(With Light shelves) - Academic class room 1 First floor

### Proposed case



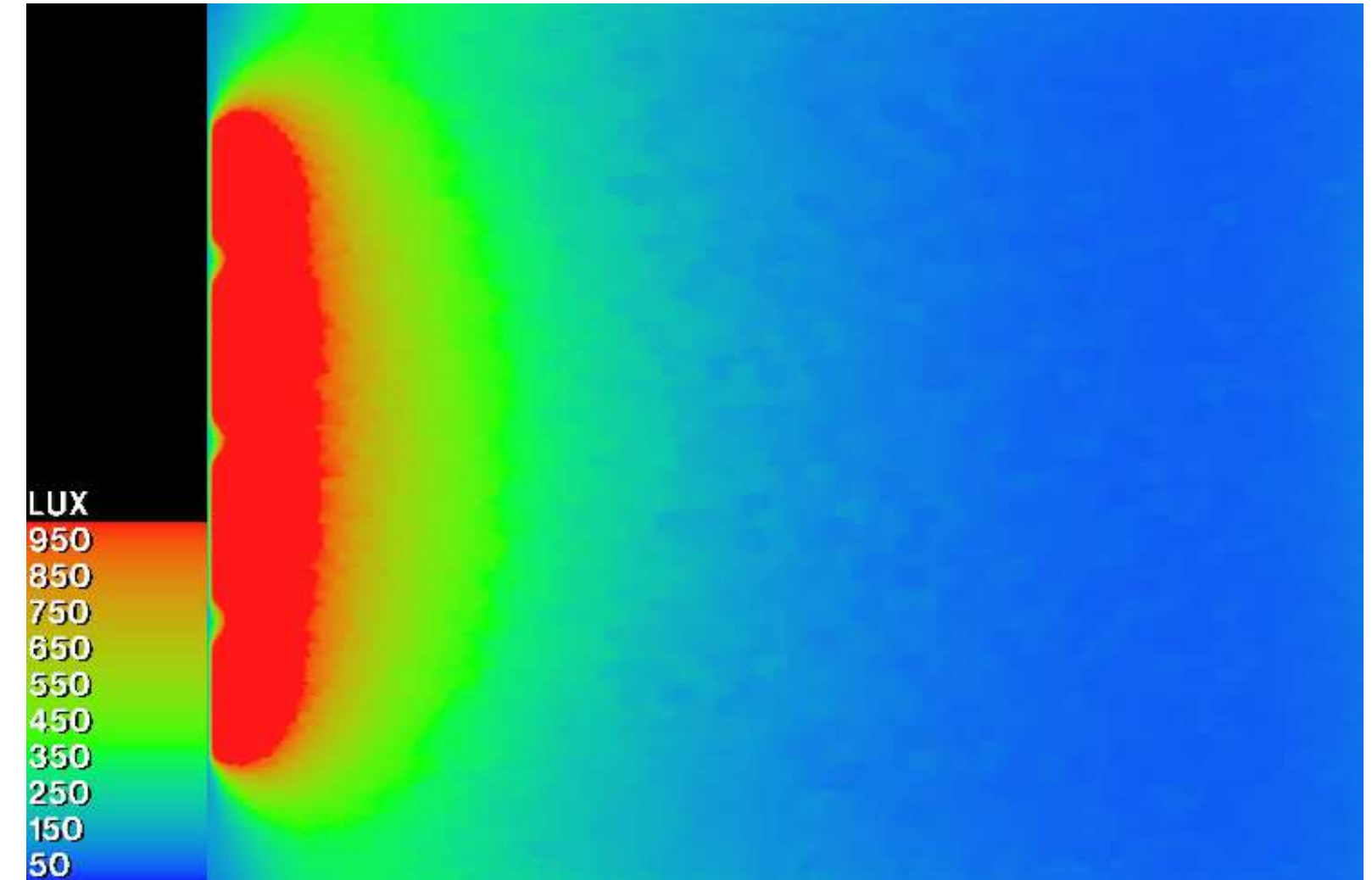
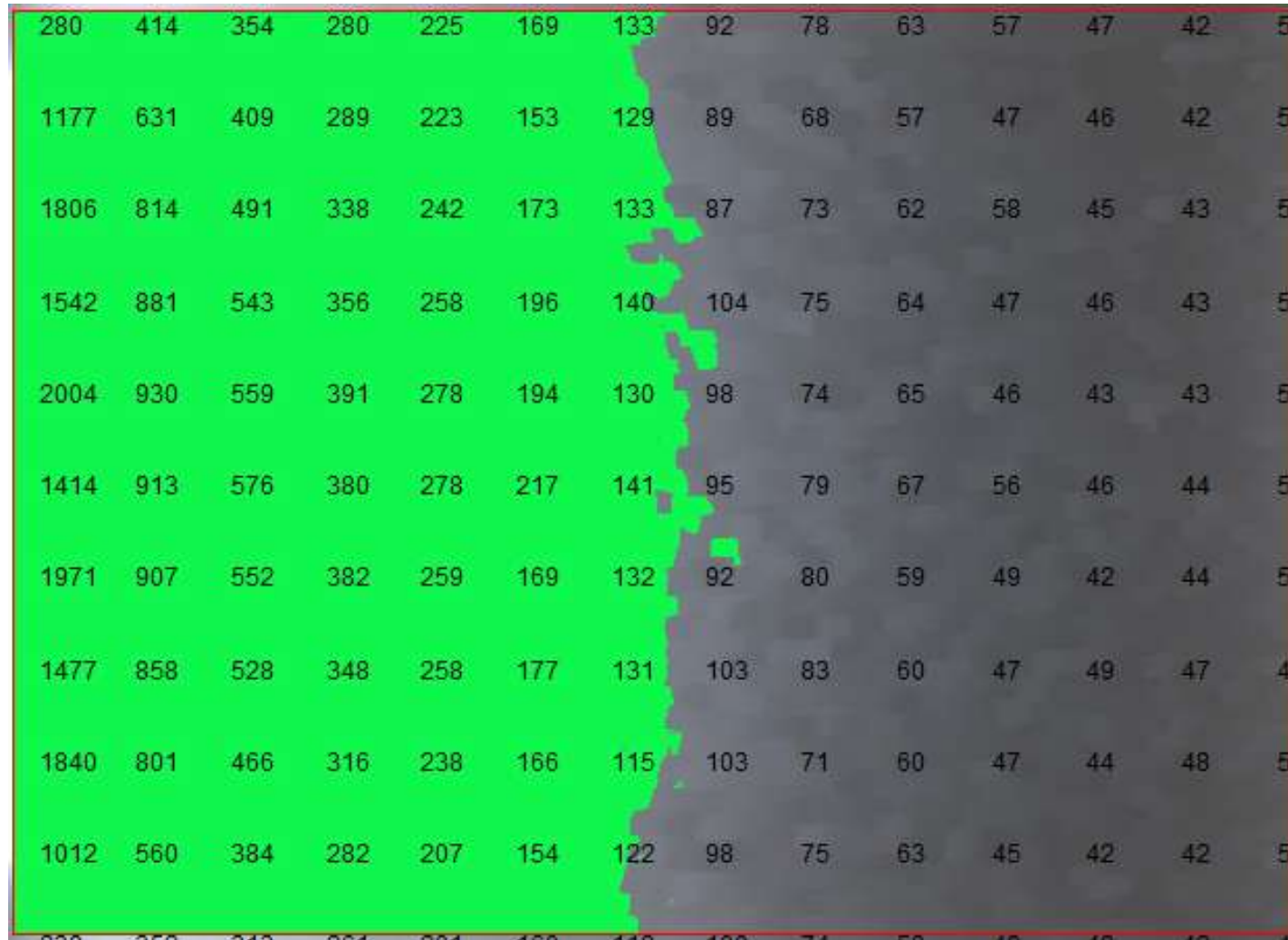
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 63.21 % ( 88.86 m²)

## Base case(Without Light shelves) - Academic class room 2 First floor

### Base case



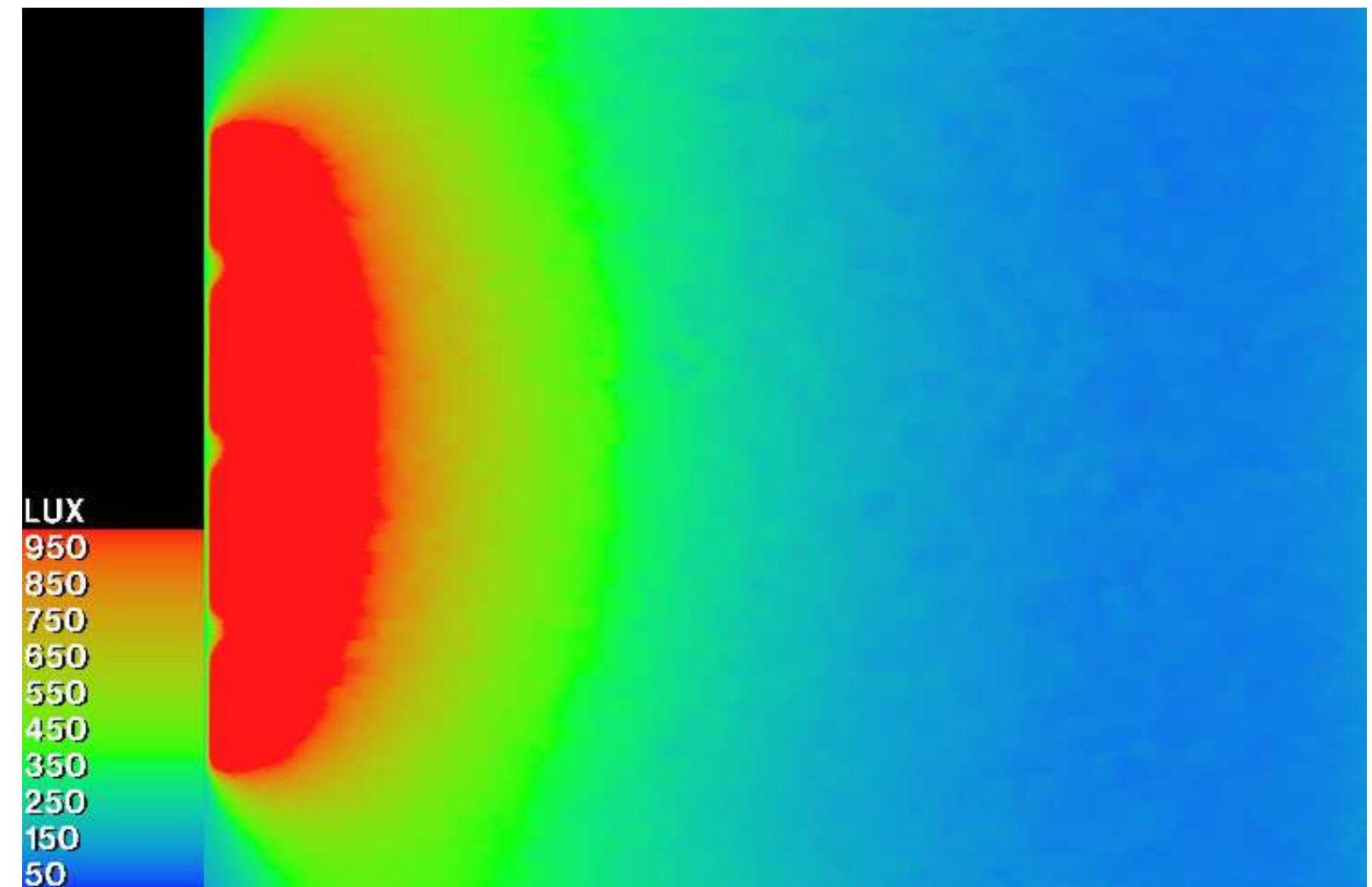
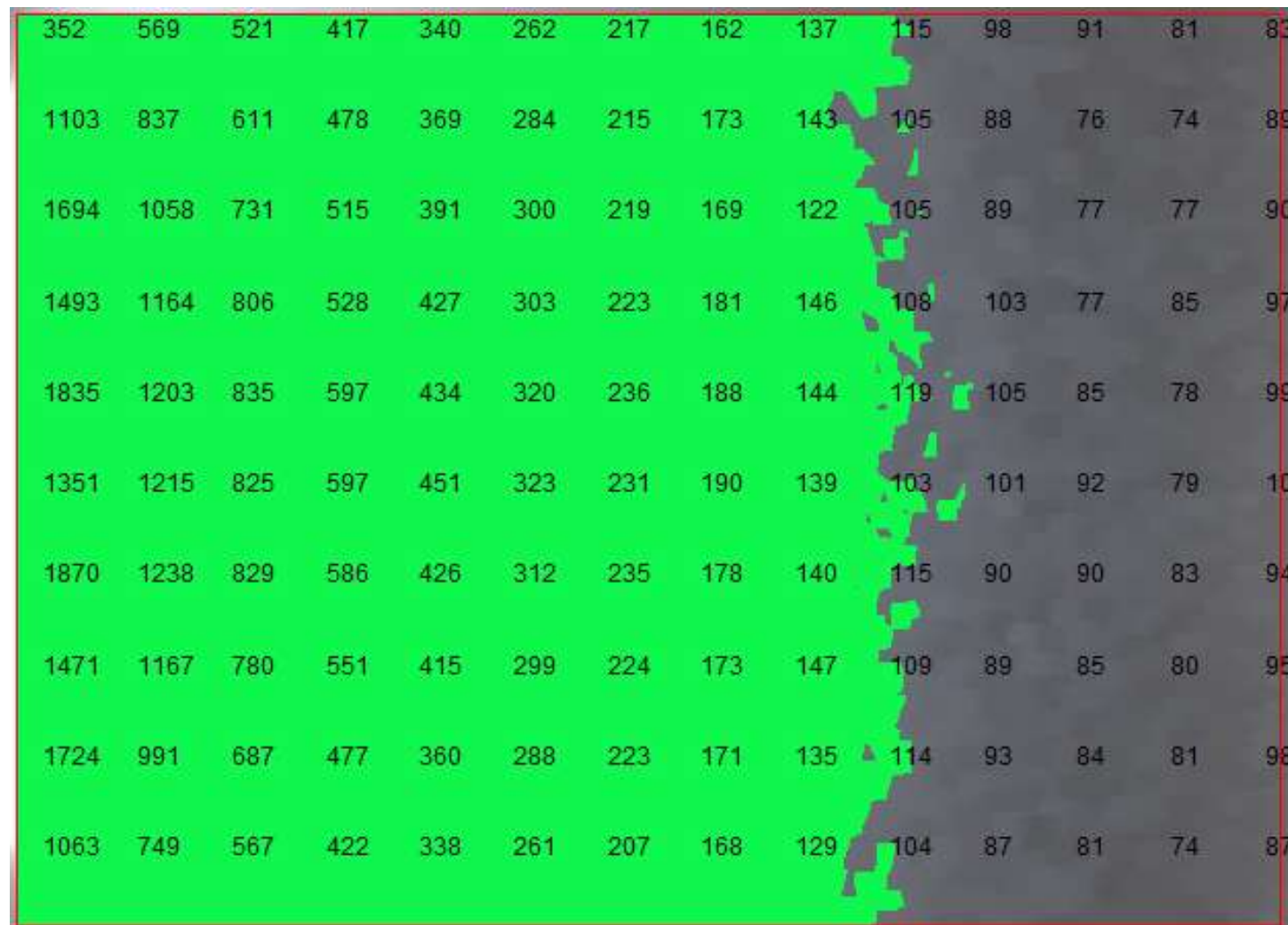
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 51.01 % ( 68.72 m<sup>2</sup>)

## Proposed case(With Light shelves) - Academic class room 2 First floor

### Proposed case



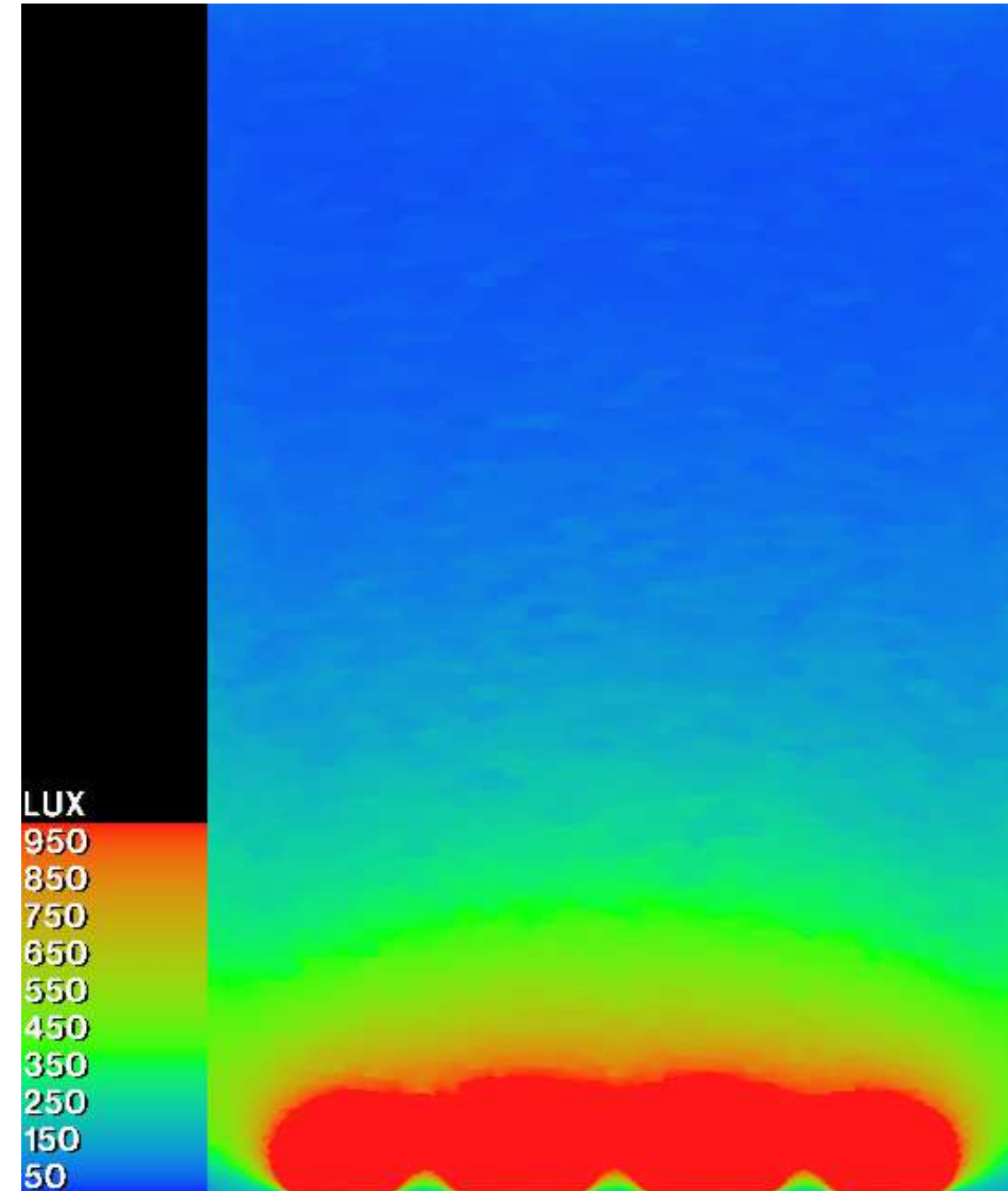
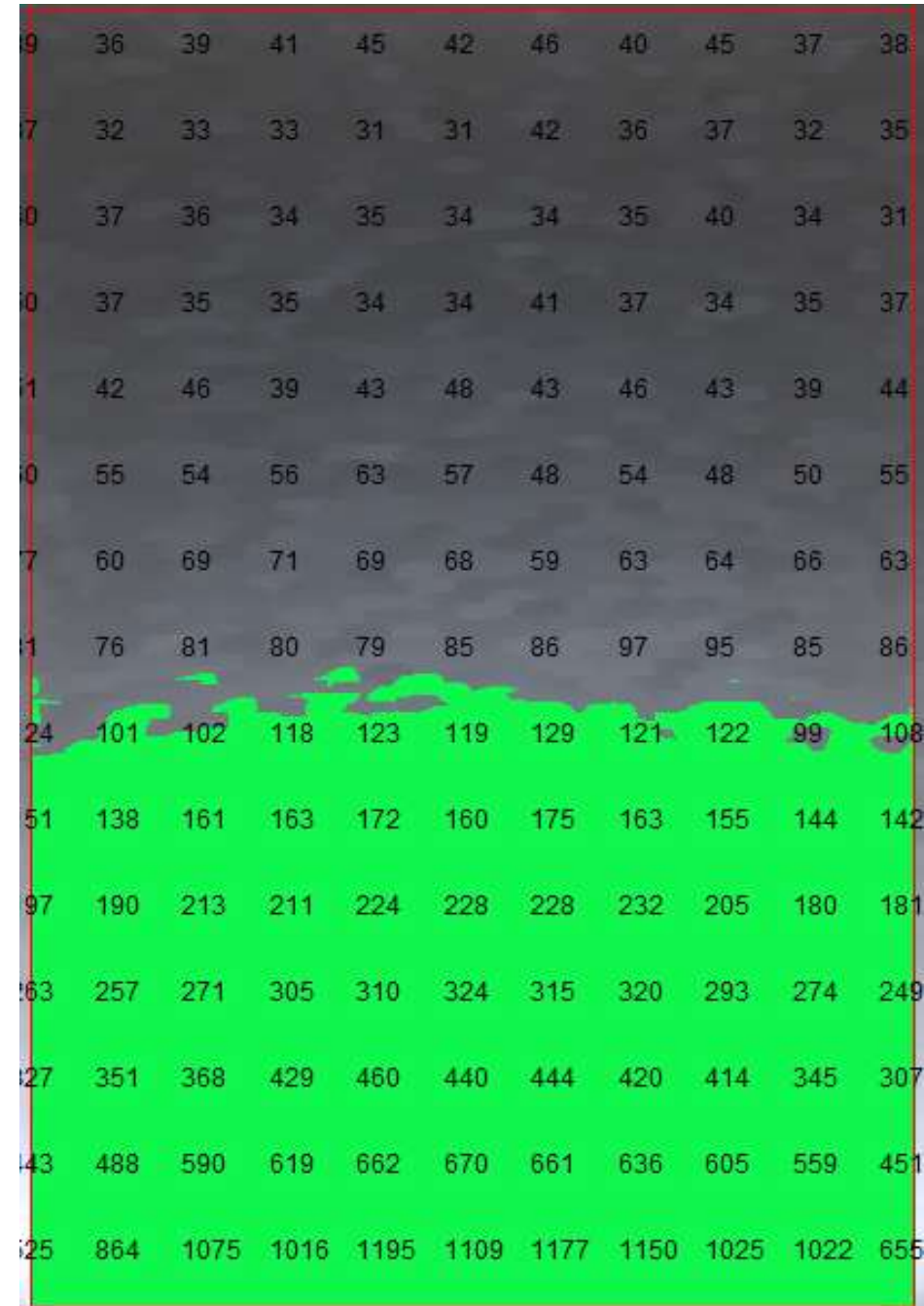
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 69.37 % ( 93.46 m<sup>2</sup> )

## Base case(Without Light shelves) - Academic class room 3 First floor

### Base case



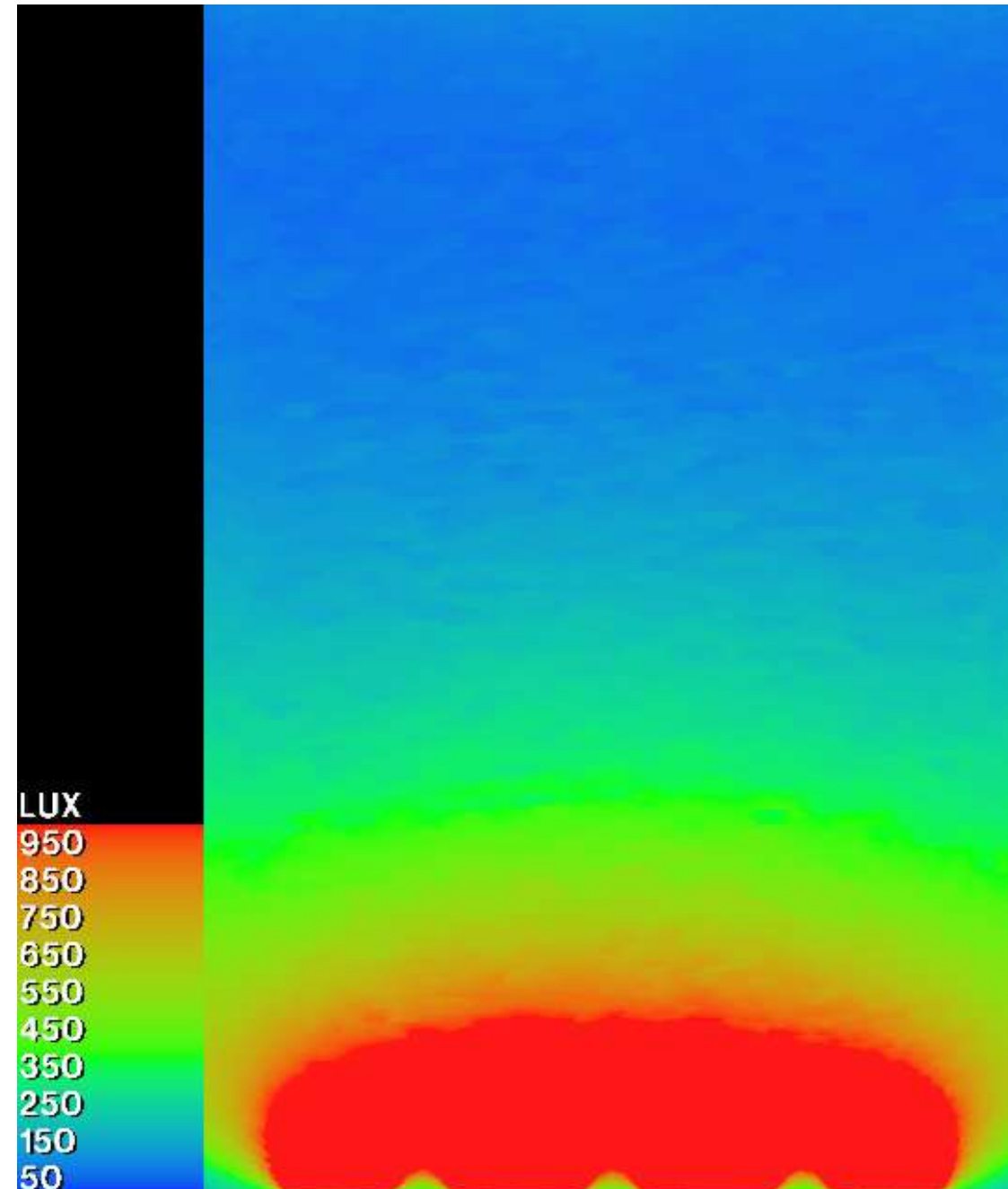
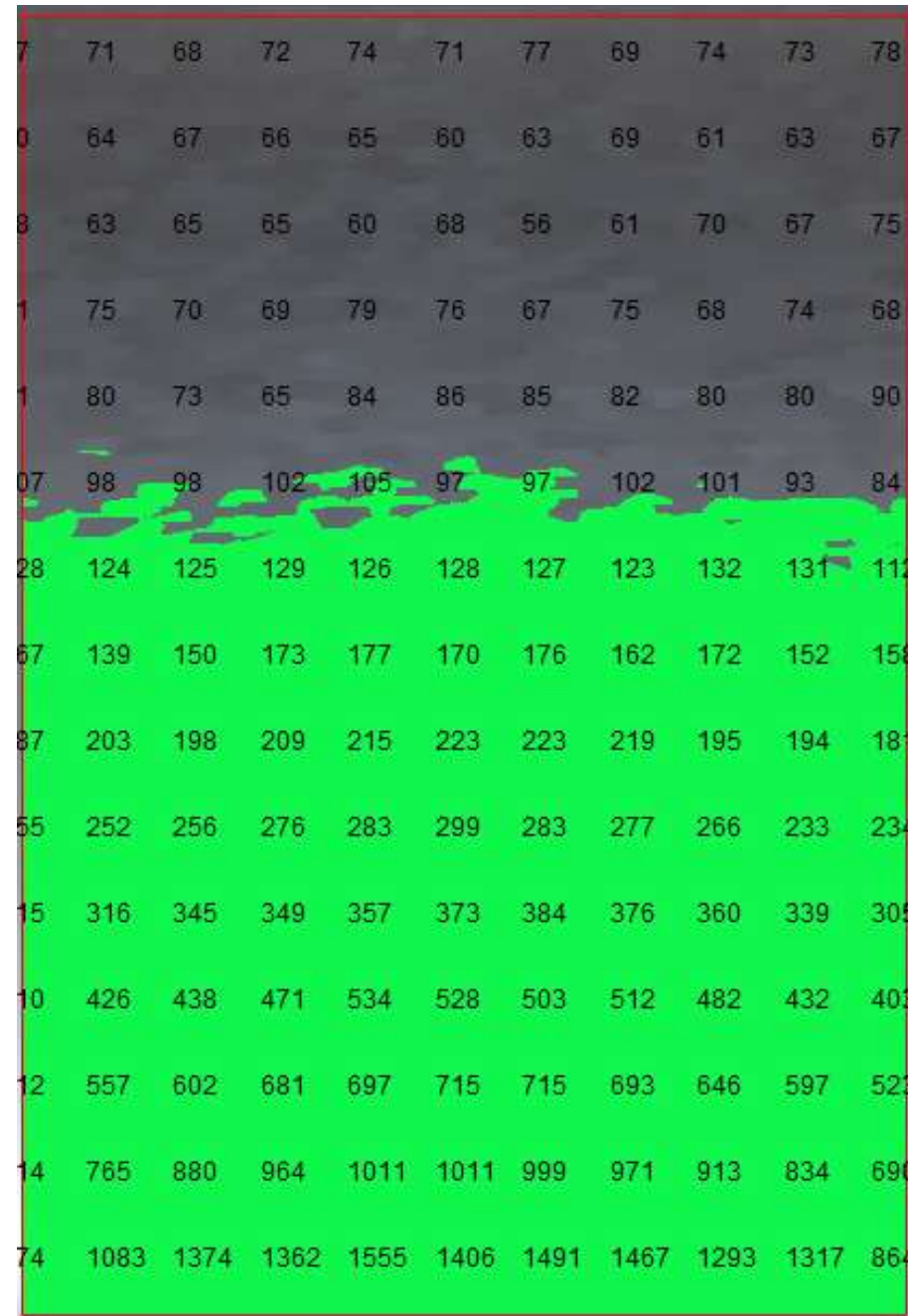
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 45.91 % ( 70.23 m²)

## Proposed case(With Light shelves) - Academic class room 3 First floor

### Proposed case



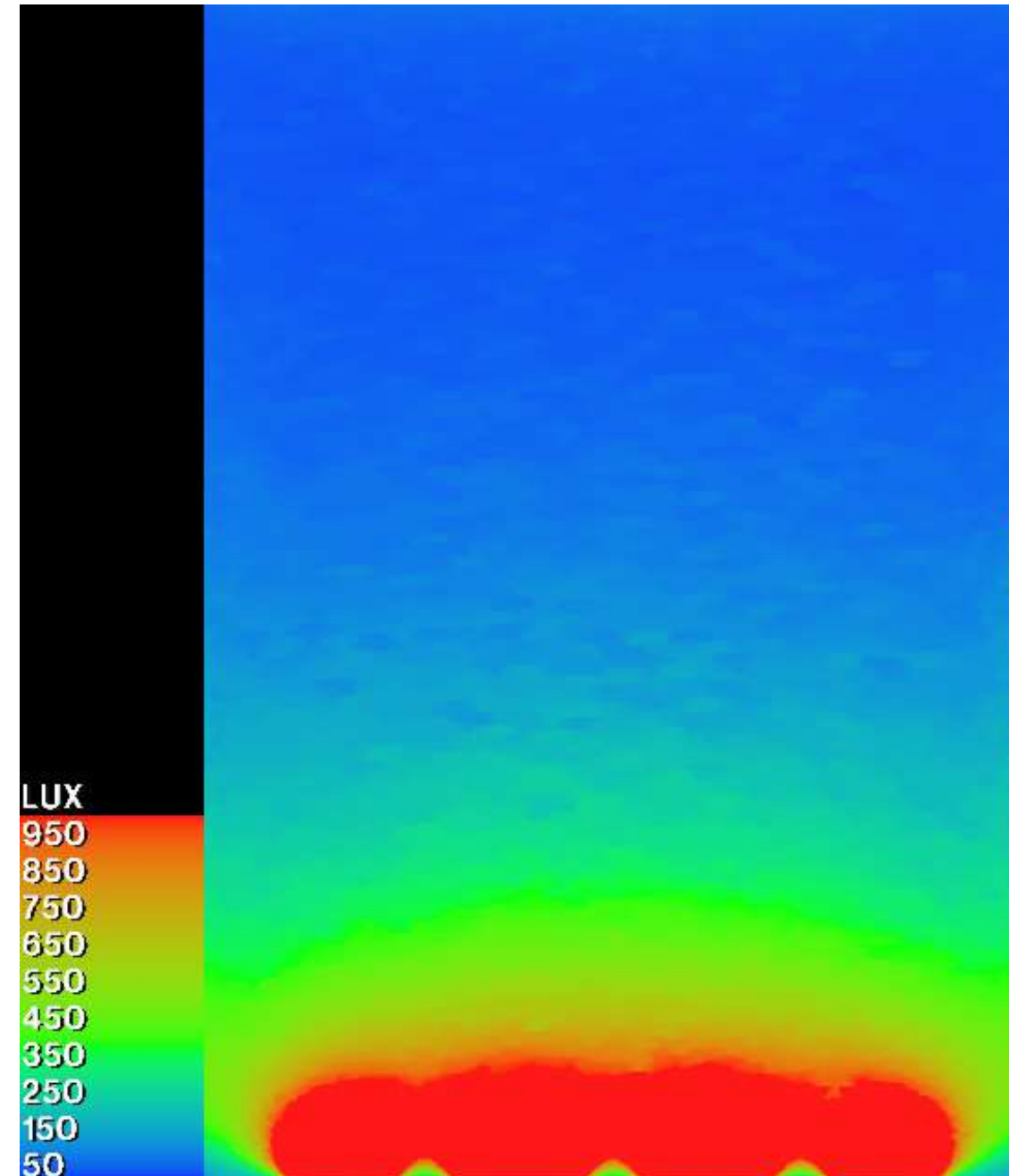
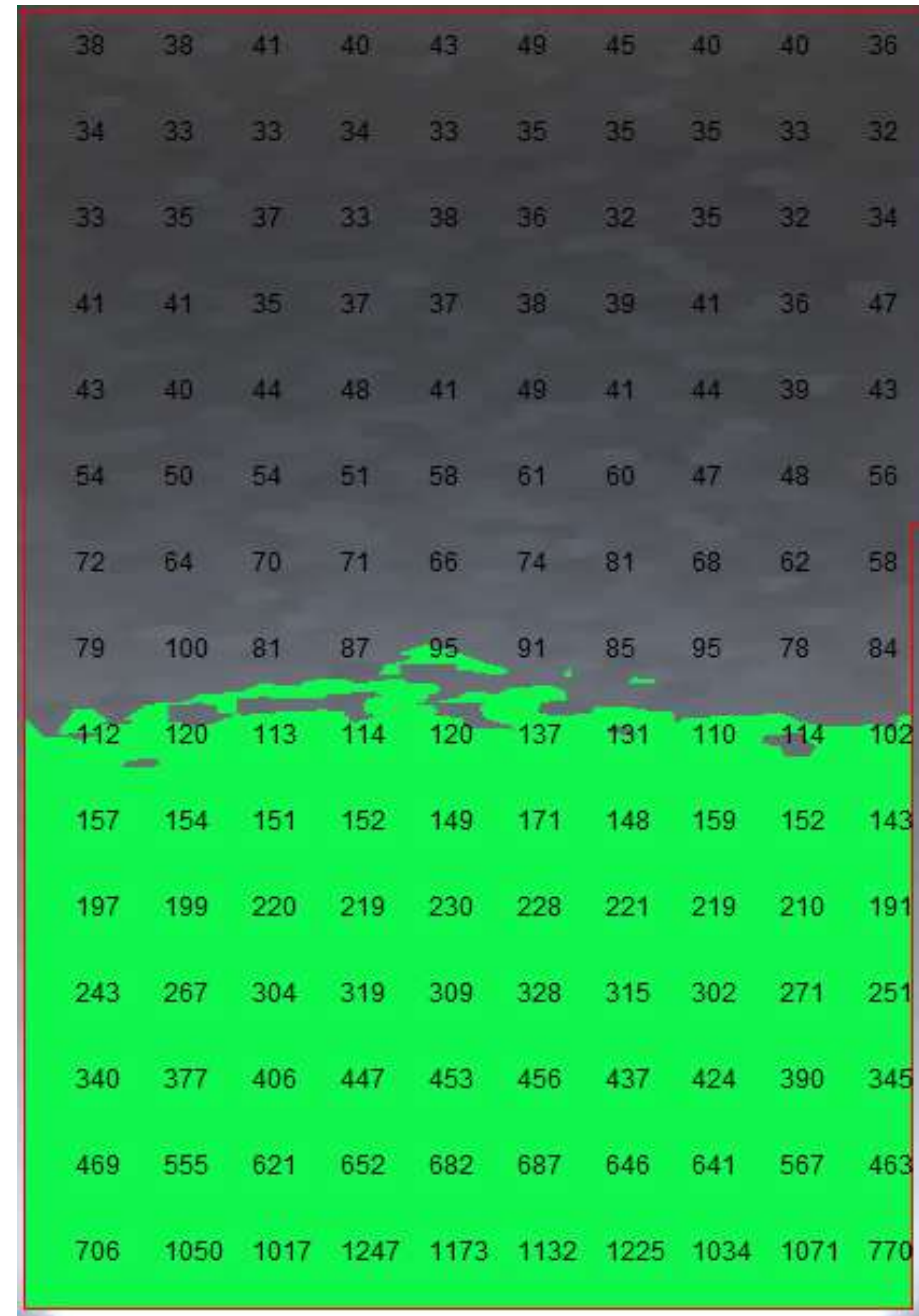
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 62.52 % ( 95.62 m²)

## Base case(Without Light shelves) - Academic class room 4 First floor

### Base case



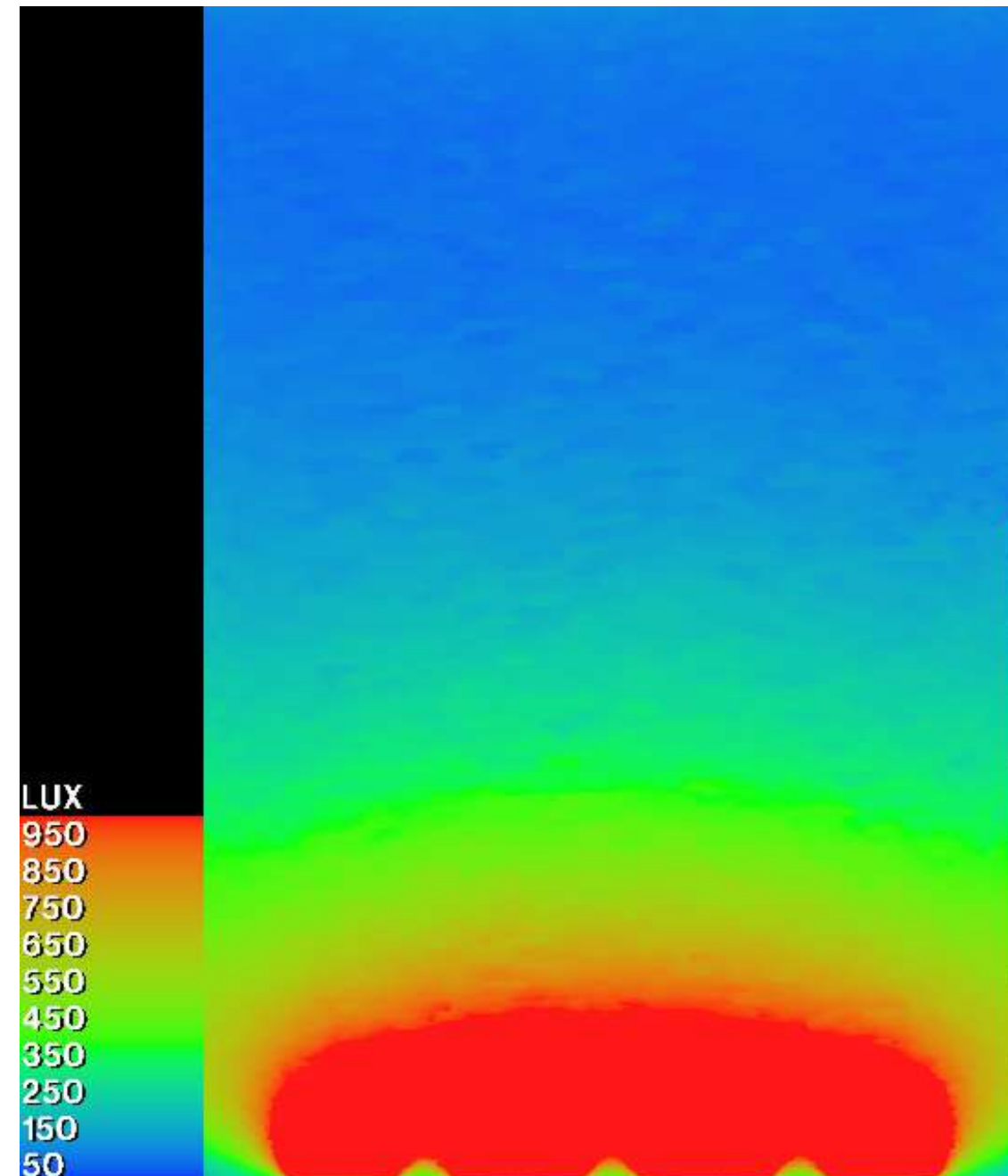
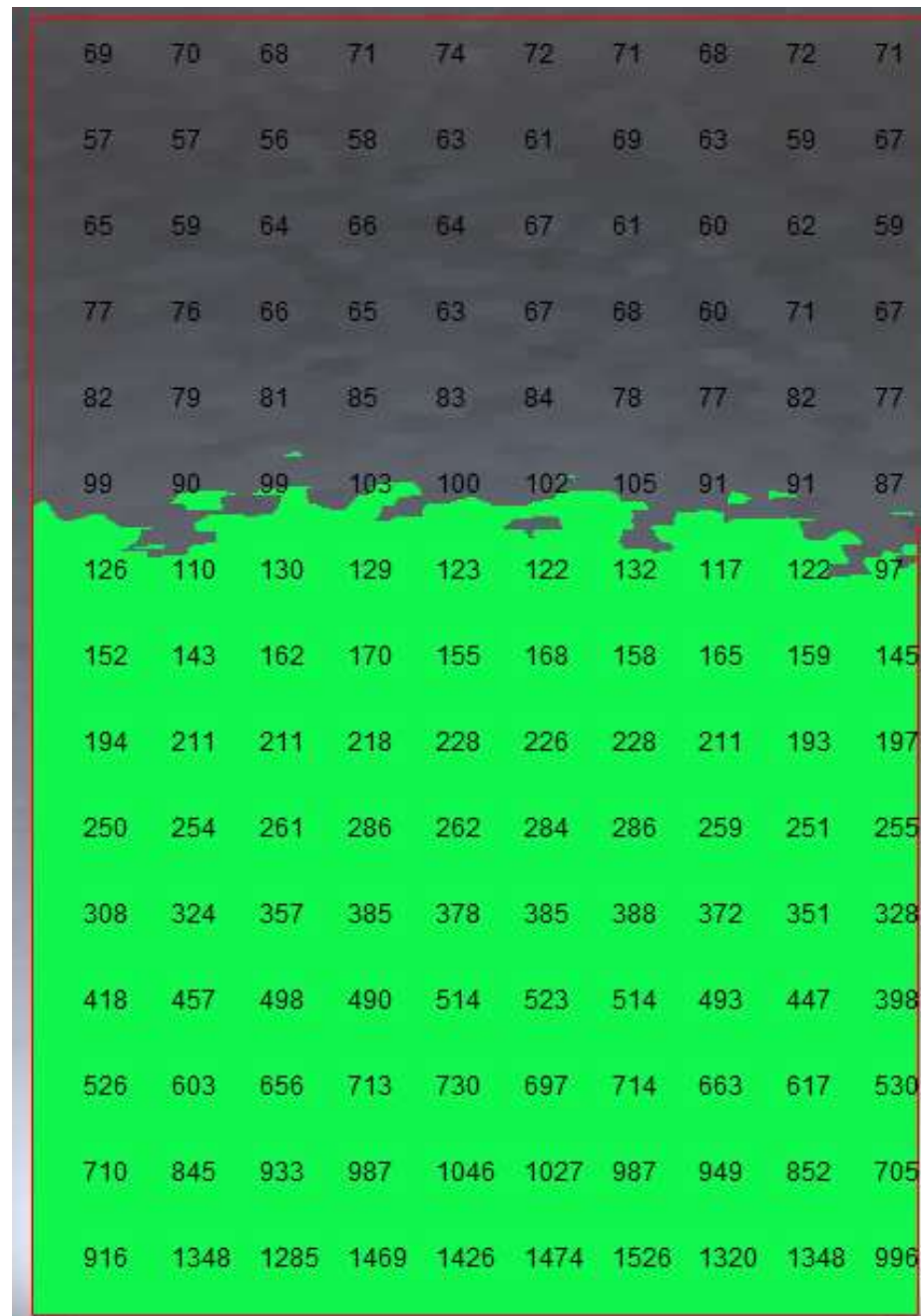
Threshold Settings

Value (Lux)  ☒ Invert

Threshold > 110.00 Lux = 45.70 % ( 69.95 m²)

## Proposed case(With Light shelves) - Academic class room 4 First floor

### Proposed case

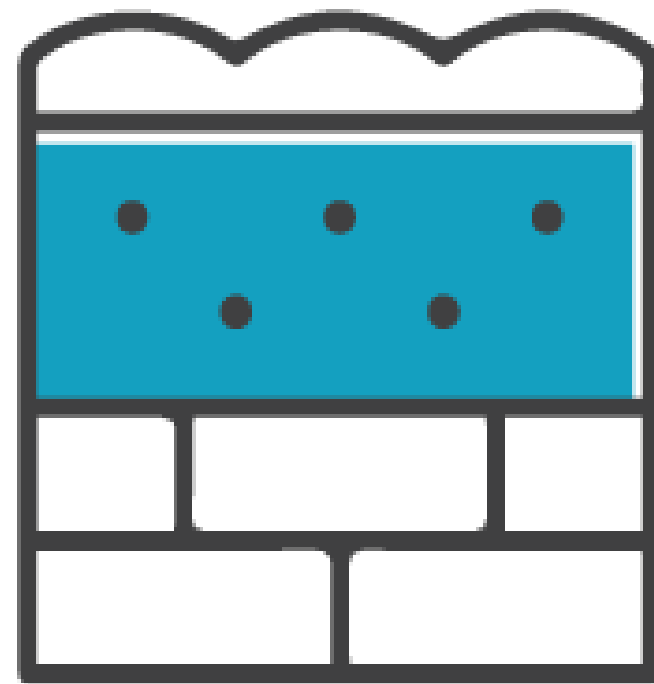


Threshold Settings

Value (Lux)  ☒ Invert

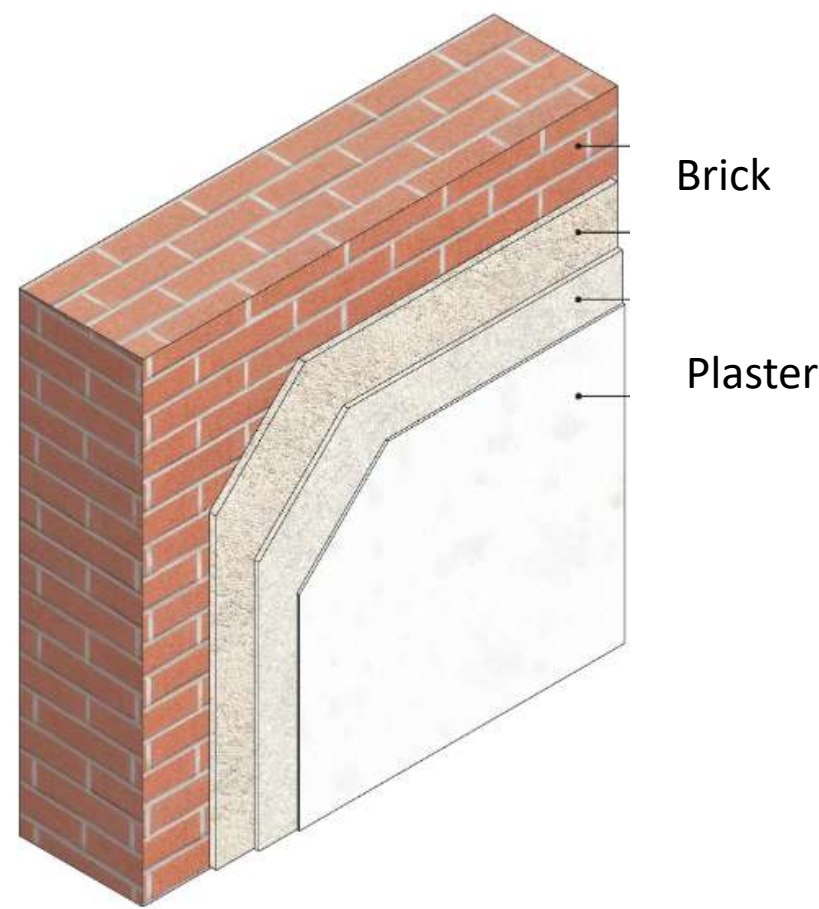
Threshold > 110.00 Lux = 60.95 % ( 93.31 m<sup>2</sup>)

## MATERIAL AND LIFE-CYCLE ANALYSIS

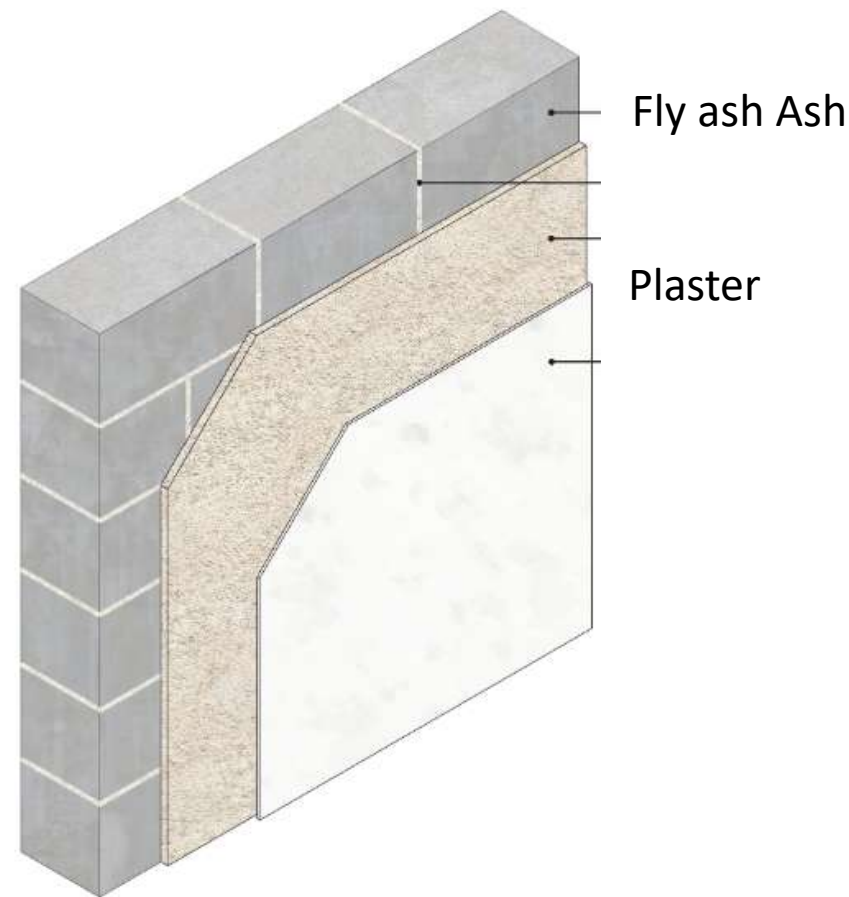


## MATERIAL ANALYSIS

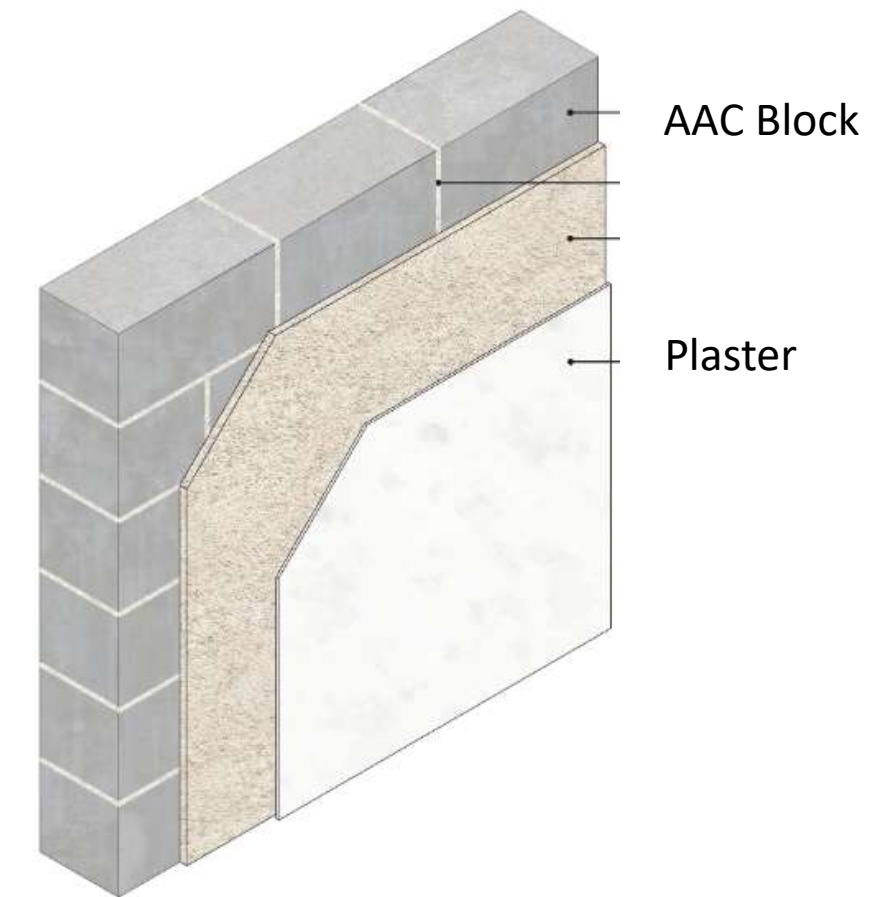
- Material Analysis is done using IESVE Simulation Tool
- Three wall assembly has been taken for the comparative analysis
- The result is compared using U-values from the result generated.



**Project Base case : Brick**  
**Wall U value – 3.28 W/m<sup>2</sup>k**

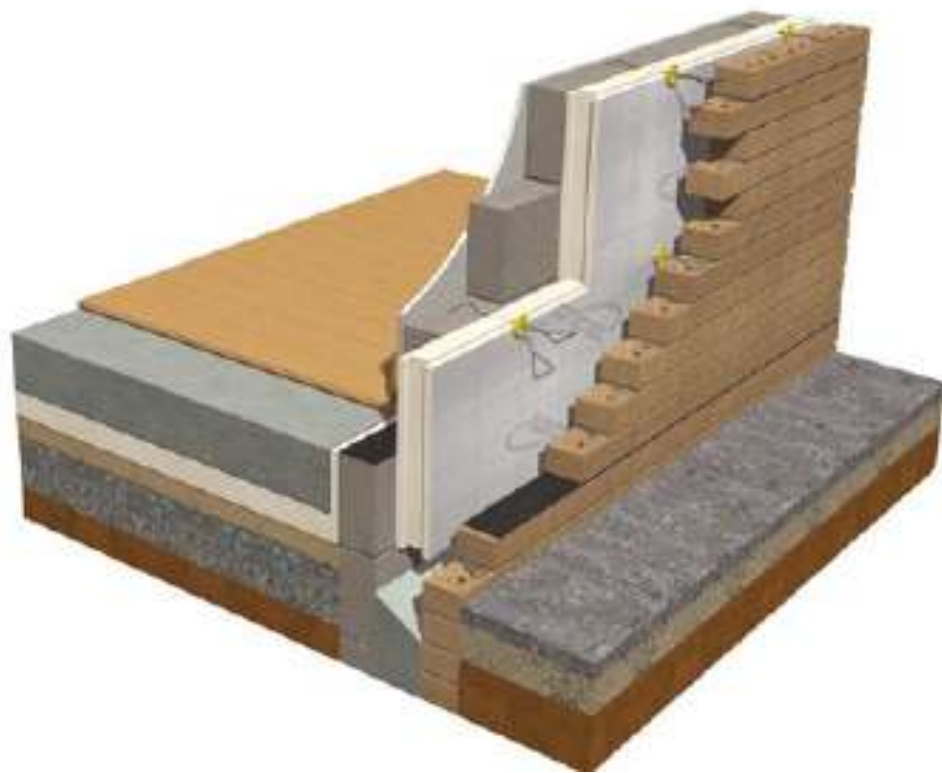


**Proposed case 1 :Fly ash**  
**Wall U value – 2.32 W/m<sup>2</sup>k**

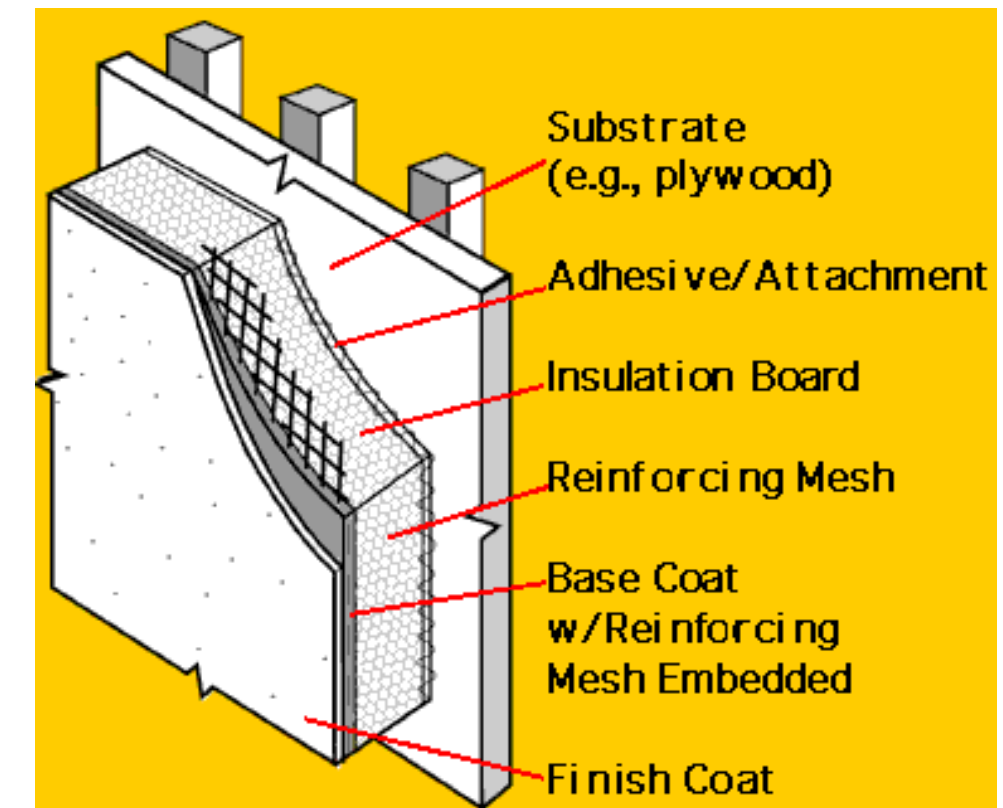


**Proposed case 2: AAC Block**  
**Wall U value – 0.98 W/m<sup>2</sup>k**

## MATERIAL ANALYSIS



**Proposed case 3 : Cavity wall**  
**Wall U value – 1.35 W/m<sup>2</sup>K**



**Proposed case 4 :EIFS**  
**Wall U value – 0.25 W/m<sup>2</sup>K**

## LIFE-CYCLE ANALYSIS

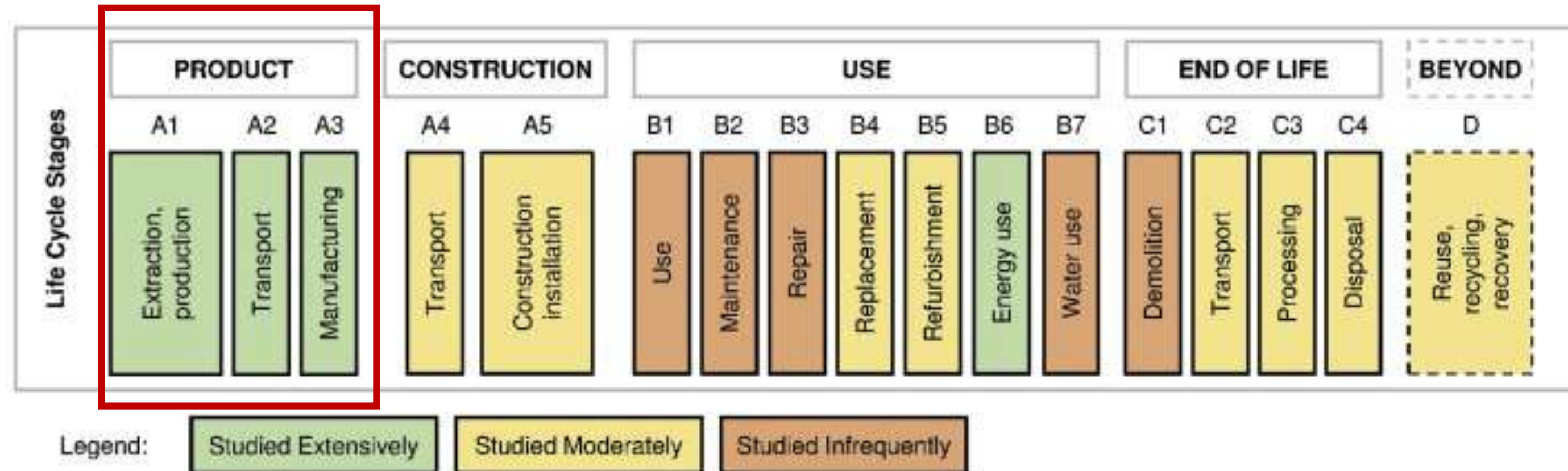
Address: Shiv Nadar University, Chennai

Author: Earthonomic Engineers Pvt Ltd, Chennai

### The life cycle assessment scope and service life

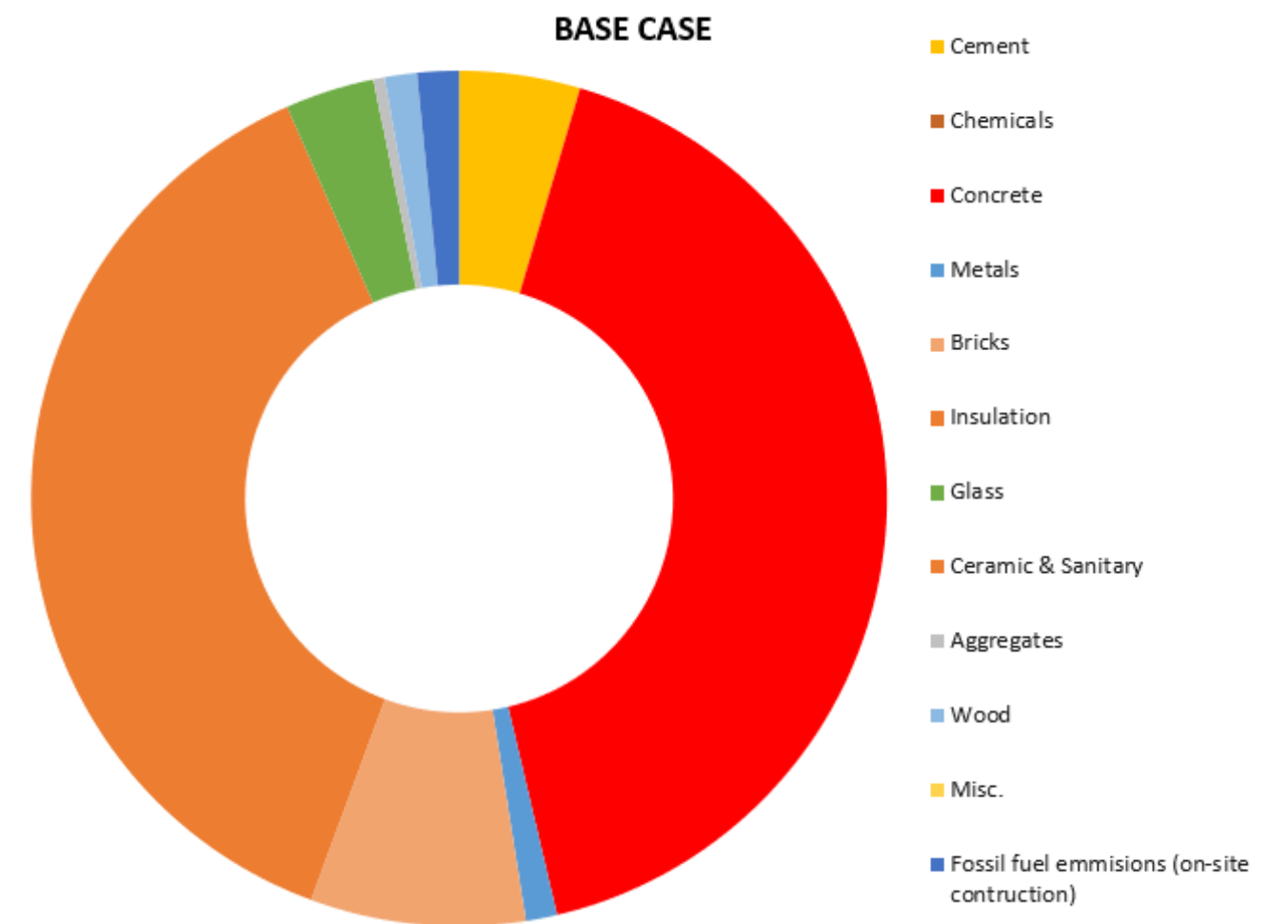
The material scope in was the same in both baseline and proposed design. The LCA analysis included following building elements

In the assessment following life cycle stages according to EN 15804 (2012) were included:



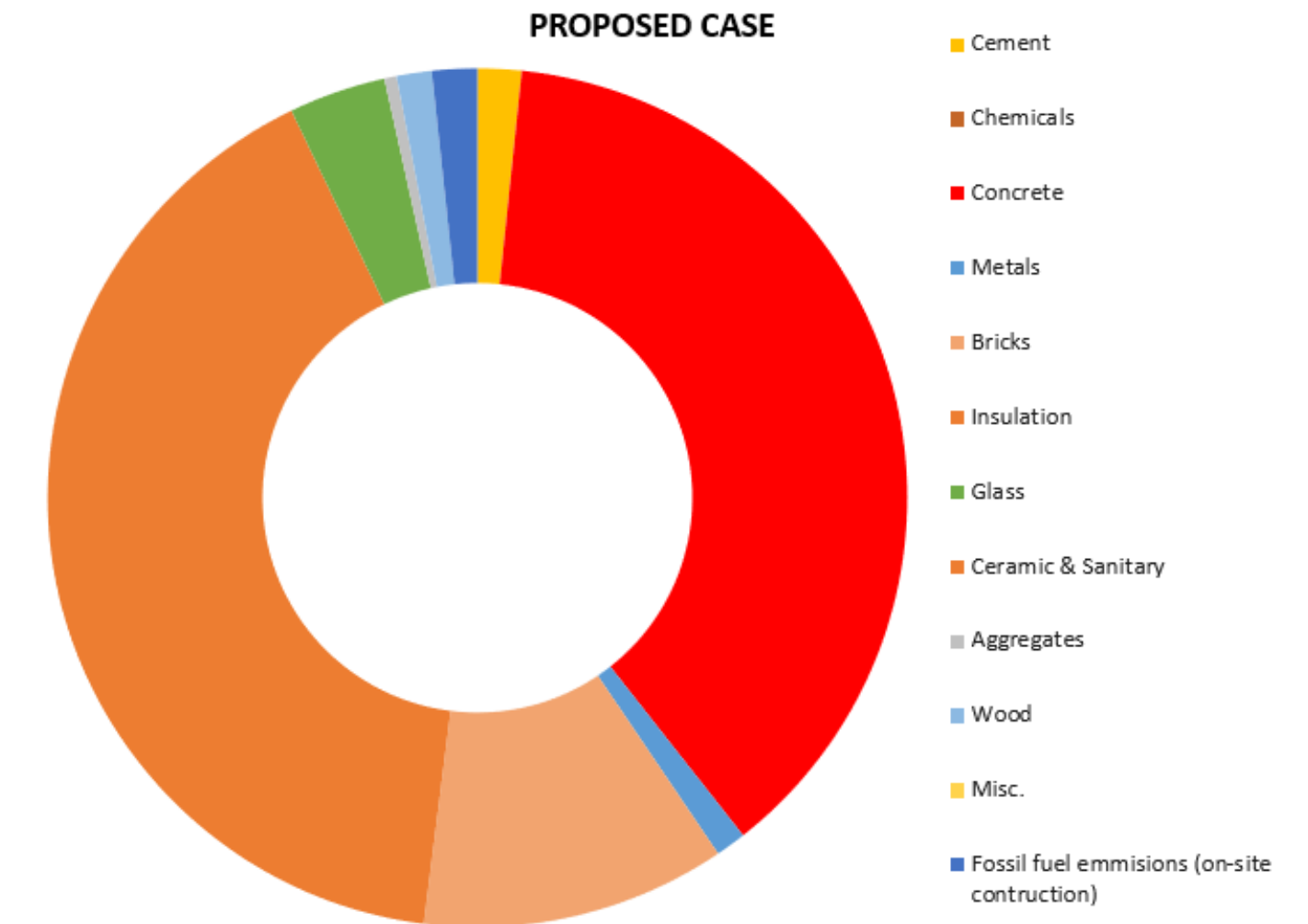
## LIFE-CYCLE ANALYSIS- Academic Building(Base case)

| Materials                                   | Carbon Emission Value | Units |
|---------------------------------------------|-----------------------|-------|
| Cement                                      | 13.68                 | tCO2  |
| Chemicals                                   | 0.00                  | tCO2  |
| Concrete                                    | 125.05                | tCO2  |
| Metals                                      | 3.54                  | tCO2  |
| Bricks                                      | 24.35                 | tCO2  |
| Insulation                                  | 113.17                | tCO2  |
| Glass                                       | 10.09                 | tCO2  |
| Ceramic & Sanitary                          | 0.00                  | tCO2  |
| Aggregates                                  | 1.28                  | tCO2  |
| Wood                                        | 3.65                  | tCO2  |
| Misc.                                       | 0.00                  | tCO2  |
| Fossil fuel emmisions (on-site contruction) | 4.70                  | tCO2  |
| TOTAL EMBODIED CARBON in tons of CO2        | 299.51                |       |
| TOTAL EMBODIED CARBON in kgs of CO2         | 299507.98             |       |
| kgCO2 / sqm.                                | 20.69                 |       |
| TCO2 / sqm.                                 | 0.02                  |       |



## LIFE-CYCLE ANALYSIS- Academic Building (Designed case)

| Materials                                   | Carbon Emission Value | Units |
|---------------------------------------------|-----------------------|-------|
| Cement                                      | 4.56                  | tCO2  |
| Chemicals                                   | 0.00                  | tCO2  |
| Concrete                                    | 104.50                | tCO2  |
| Metals                                      | 3.17                  | tCO2  |
| Bricks                                      | 31.71                 | tCO2  |
| Insulation                                  | 113.17                | tCO2  |
| Glass                                       | 10.09                 | tCO2  |
| Ceramic & Sanitary                          | 0.00                  | tCO2  |
| Aggregates                                  | 1.28                  | tCO2  |
| Wood                                        | 3.65                  | tCO2  |
| Misc.                                       | 0.00                  | tCO2  |
| Fossil fuel emmisions (on-site contruction) | 4.70                  | tCO2  |
| TOTAL EMBODIED CARBON in tons of CO2        | 276.83                |       |
| TOTAL EMBODIED CARBON in kgs of CO2         | 276827.66             |       |
| kgCO2 / sqm.                                | 19.12                 |       |
| TCO2 / sqm.                                 | 0.02                  |       |



## LIFE-CYCLE ANALYSIS- Academic Building (Basecase vs Proposed)

| BASELINE CARBON EMISSION (embodied + operational)                 |                    |                        | PROPOSED CASE CARBON EMISSION (embodied + operational)            |                    |                        |
|-------------------------------------------------------------------|--------------------|------------------------|-------------------------------------------------------------------|--------------------|------------------------|
| End use                                                           | Energy consumption | Units                  | End use                                                           | Energy consumption | Units                  |
| Embodied Carbon for 0 year                                        | 299,507.98         | KgCO <sub>2</sub>      | Embodied Carbon for 0 year                                        | 276827.66          | KgCO <sub>2</sub>      |
| Over all Baseline Consumption                                     | 834,000            | kWh                    | Over all Baseline Consumption                                     | 754,000            | kWh                    |
| Emission factor                                                   | 0.82               | KgCO <sub>2</sub> /kWh | Emission factor                                                   | 0.82               | KgCO <sub>2</sub> /kWh |
| Embodied & Operational Carbon emissions accumulated after 1 year  | 983,387            | KgCO <sub>2</sub>      | Embodied & Operational Carbon emissions accumulated after 1 year  | 895,107            | KgCO <sub>2</sub>      |
| Embodied & Operational Carbon emissions accumulated after 5 year  | 3,718,907          | KgCO <sub>2</sub>      | Embodied & Operational Carbon emissions accumulated after 5 year  | 3,370,027          | KgCO <sub>2</sub>      |
| Embodied & Operational Carbon emissions accumulated after 10 year | 7,138,307          | KgCO <sub>2</sub>      | Embodied & Operational Carbon emissions accumulated after 10 year | 6,461,427          | KgCO <sub>2</sub>      |

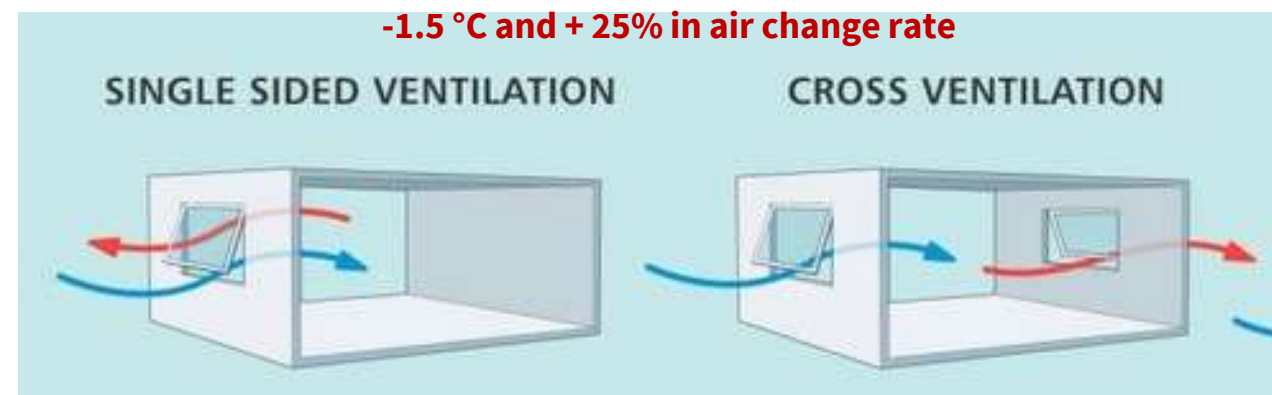
The Proposed case's accumulated carbon emission is predicted to be 9.48% lesser than Baseline emission due to selection of efficient Building Envelope and associated ,HVAC savings.

## Ventilation Analysis

### STUDY:

Simulation performed for Non-Airconditioned spaces considering 50% operable area to determine annual air flow and peak room temperature

### INFERENCE:



There is reduction in indoor temperature by 3.63 °C due to EIFS Material, wind flow and cross ventilation combined with SRI paint on facades and trees for shading the façade and cooling the wind.

## SUMMARY

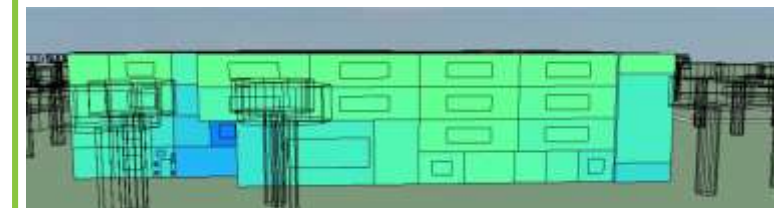
## Solar Analysis

### STUDY:

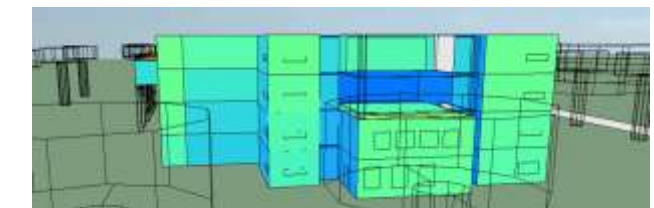
The impact of solar radiation on different facades through simulation and design recommendations

### INFERENCE:

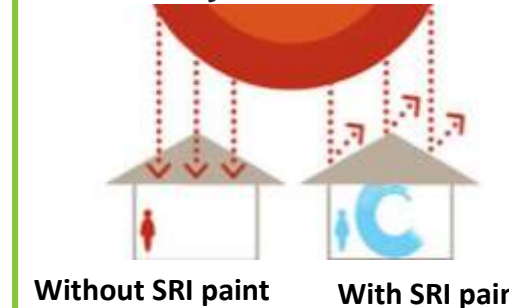
#### Academic Building



South Façade-463 kwh/sqm to 1023 kwh/sqm



West Façade-463 kwh/sqm to 1023 kwh/sqm



Implementing High SRI paint on Roof, Southern and Western façade shall reduce ingress into the Building.

## Daylight Analysis

### STUDY:

The impact of Light Shelves, Window wall ratio (WWR) and glass Visual light transmittance (VLT) on daylight for Academic building through daylight simulation.

### INFERENCE:



- Daylighting is enhanced by use of light shelves.
- Lower VLT of 23 % is recommended in Air-conditioned spaces.
- Non-Air-conditioned spaces should use clear glass of VLT 80%.

# SUMMARY

## LCA

**STUDY:**  
Comparative study of Embodied & operational carbon emission for Base case and proposed building through life cycle stages according to EN 15804 (2012)

**INFERENCE:**

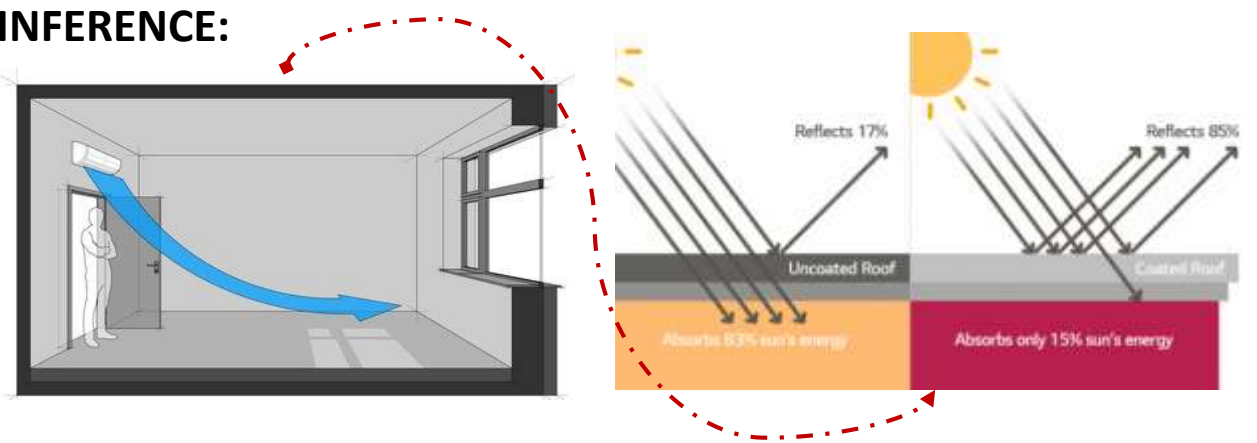
|                                                                            |           |       |
|----------------------------------------------------------------------------|-----------|-------|
| Baseline Embodied & Operational Carbon emissions accumulated after 10 year | 7,138,307 | KgCO2 |
| Proposed Embodied & Operational Carbon emissions accumulated after 10 year | 6,461,427 | KgCO2 |

The Proposed case’s accumulated carbon emission is predicted to be 9.48% lesser than Baseline emission due to selection of efficient Building Envelope and associated ,HVAC savings.

## HVAC Analysis

**STUDY:**  
HVAC analysis is performed to give accurate HVAC sizing (Tonnage ) for the proposed Building.

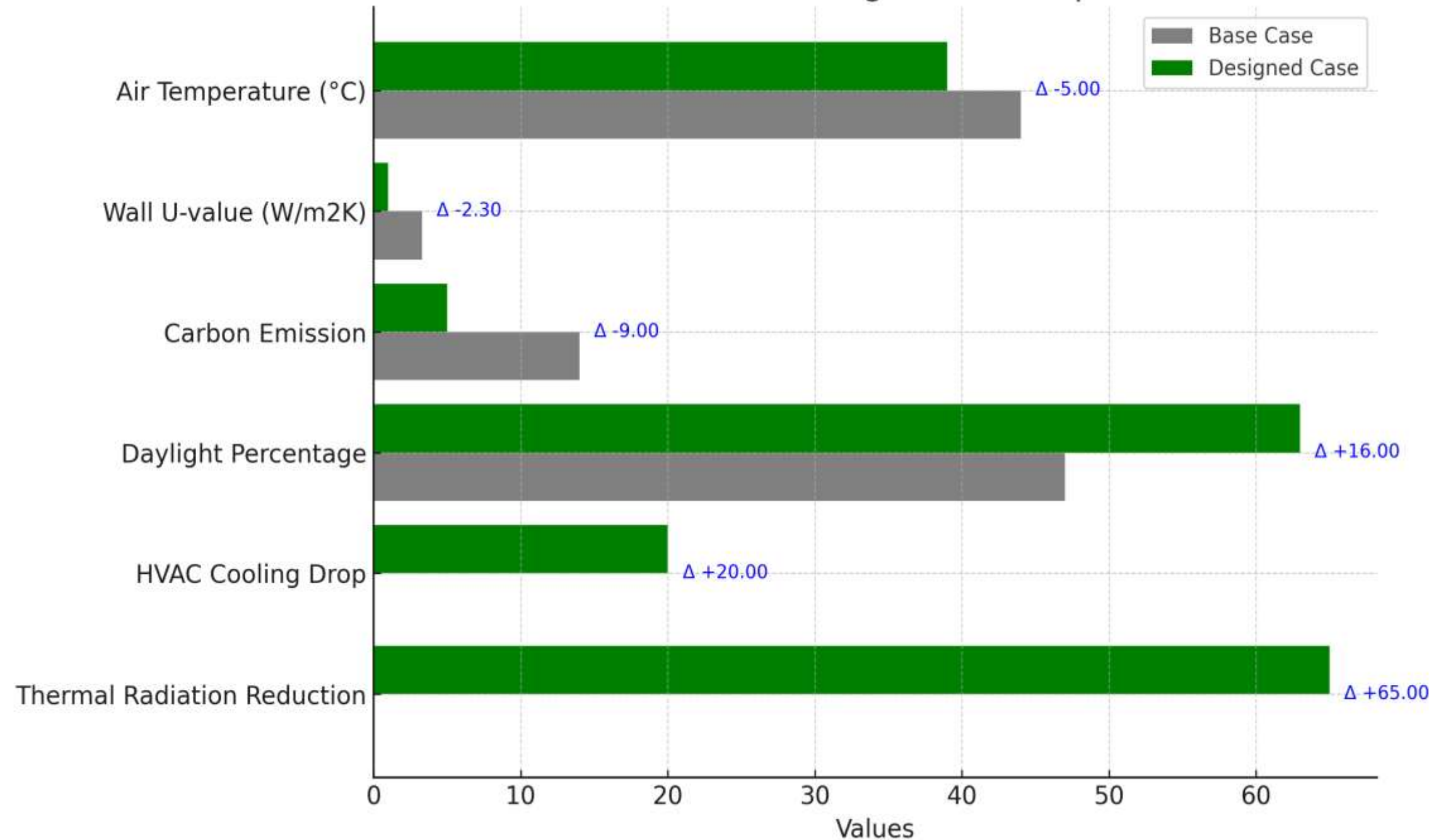
**INFERENCE:**



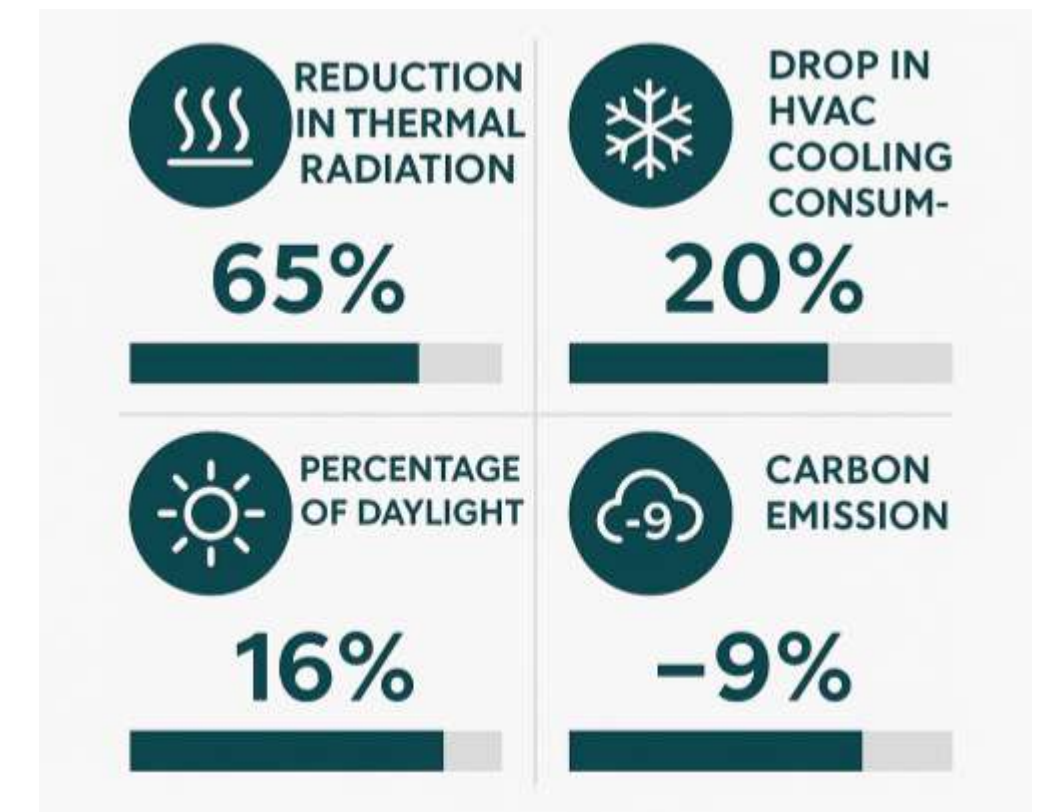
Proposed EIFS system achieves 24.02% drop in cooling load and 20.29% drop in Energy consumption for Academic Building compared to Box model.

## Advantages of the proposed design case

Horizontal Bar Chart: Base vs. Designed with Improvement Annotations



- The proposed design case achieved a 65% reduction in thermal radiation, significantly reducing solar heat gain and thereby improving indoor thermal comfort.
- The indoor air temperature was lowered by 5°C, contributing to improved occupant comfort and reduced cooling loads.
- There is a 20% decrease in HVAC energy consumption in the designed case, reflecting enhanced thermal performance and reduced cooling demand due to passive strategies.
- The designed building allows 16% more daylight, improving indoor lighting quality and reducing dependency on artificial lighting.
- A 9% reduction in carbon emissions was achieved, demonstrating the design's contribution to sustainability and lower environmental impact.
- The wall U-value was significantly reduced by 2.3 W/m<sup>2</sup>K, indicating better insulation and thermal resistance in the proposed design case.



# MEP SYSTEM – OPERATING COST COMPARISON

## Savings in HVAC Power Consumption :

| S. No | Description                                           | Base Case      | Proposed Case  |
|-------|-------------------------------------------------------|----------------|----------------|
| 1     | Total Cooling Capacity (TR)                           | 333.60         | 277.87         |
| 2     | Cooling Capacity after applying 75 % diversity        | 250.20         | 208.40         |
| 3     | Average Power Consumption (ikw / TR)                  | 0.80           | 0.53           |
| 4     | Operating Hours per Day                               | 8              | 8              |
| 5     | No of Days per year                                   | 250            | 250            |
| 6     | Annual Power Consumption (kWh)                        | 3,97,955       | 2,20,581       |
| 7     | Annual Energy Cost (Energy Cost Assumed as ₹ 8 / kWh) | ₹ 31,83,636 /- | ₹ 17,64,644 /- |
|       | Saving in Annual Power Consumption Cost               | ₹ 14,18,992 /- |                |

## Savings in Fresh Air Power Consumption :

| S. No | Description                                                                                                                            | Base Case             | Proposed Case        |
|-------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------|
| 1     | Fresh Air Cooling Capacity (TR)                                                                                                        | 125.91                | 116.90               |
| 2     | Cooling Capacity after applying 75 % diversity                                                                                         | 94.43                 | 87.68                |
| 3     | Average Power Consumption (ikw / TR)                                                                                                   | 0.80                  | 0.53                 |
| 4     | Operating Hours per Day                                                                                                                | 8                     | 8                    |
| 5     | No of Days per year                                                                                                                    | 250                   | 250                  |
| 6     | Annual Power Consumption (kWh)                                                                                                         | 1,50,198              | 92,799               |
| 7     | Annual Power Consumption due to the fresh air regulation through the CO2 Sensors for all air conditioning rooms. (Applied 30% savings) | -                     | 64,959               |
| 8     | <b>Annual Energy Cost (Energy Cost Assumed as ₹ 8 / kWh)</b>                                                                           | <b>₹ 12,01,583 /-</b> | <b>₹ 5,19,674 /-</b> |
|       | <b>Saving in Annual Power Consumption Cost</b>                                                                                         | <b>₹ 6,81,909 /-</b>  |                      |

## Savings in Lighting Power Consumption :

| S. No | Description                                           | Base Case      | Proposed Case |
|-------|-------------------------------------------------------|----------------|---------------|
| 1     | Built-up Area (Sq.m)                                  | 9,492          | 9,492         |
| 2     | Lighting Power Distribution (Watts / Sqm)             | 10.7           | 5             |
| 3     | Total Power Consumption (kW)                          | 101.56         | 47.46         |
| 4     | Operating Hours per Day                               | 8              | 8             |
| 5     | No of Days per year                                   | 250            | 250           |
| 6     | Annual Power Consumption (kWh)                        | 2,03,129       | 94,920        |
| 7     | Annual Energy Cost (Energy Cost Assumed as ₹ 8 / kWh) | ₹ 16,25,030 /- | ₹ 7,59,360 /- |
|       | Saving in Annual Power Consumption Cost               | ₹ 8,65,670 /-  |               |
|       | Saving in Annual Power Consumption Cost (%)           | 53 %           |               |

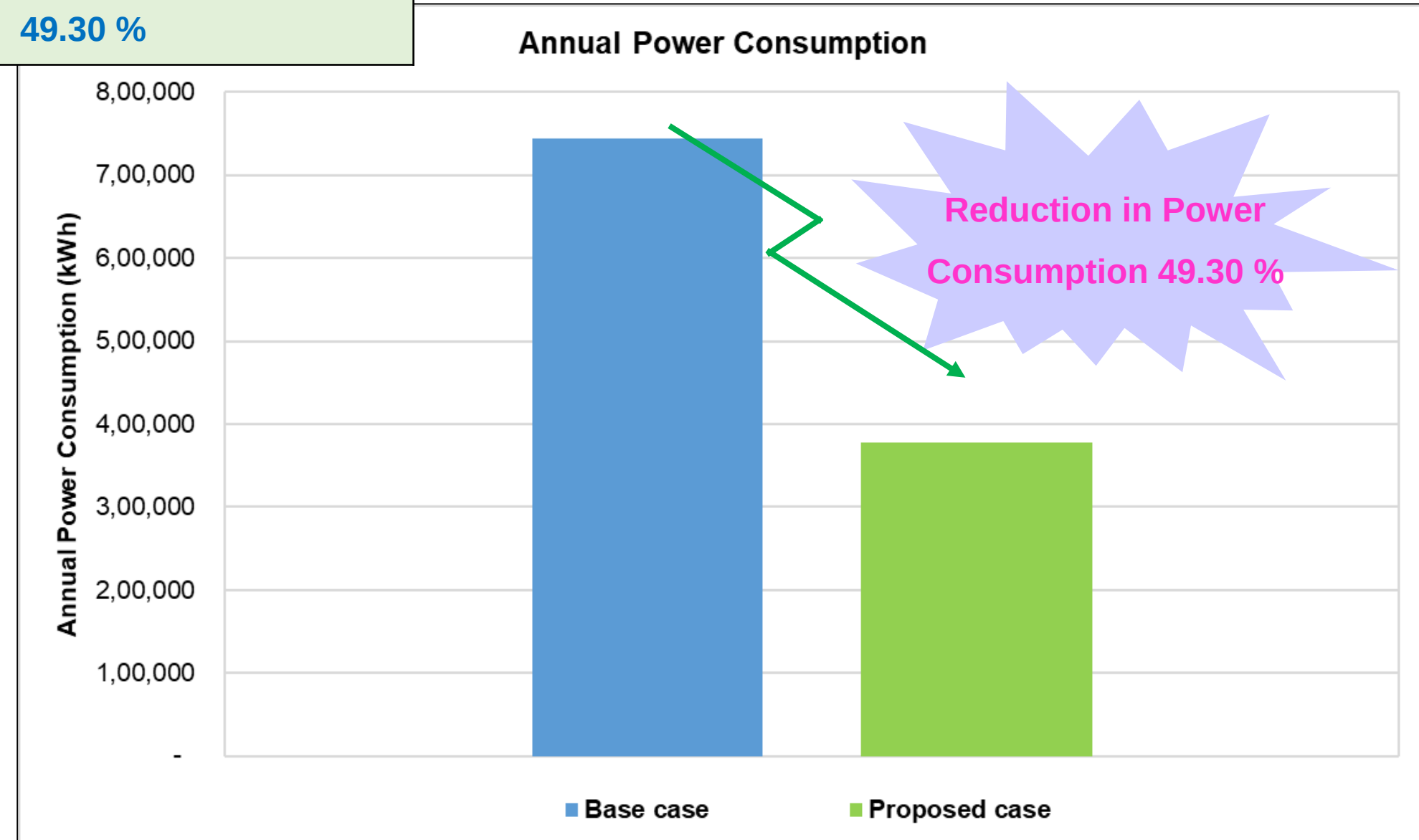
## Savings in Water Supply :

| S. No    | Description                                                                                                                           | Base Case            | Proposed Case<br>(20% Efficient<br>Fixtures) |
|----------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------------------------------|
| <b>A</b> | <b>Savings on Water Demand</b>                                                                                                        |                      |                                              |
| 1        | Domestic Water Demand per Day (KLD)                                                                                                   | 28.6                 | 22.8                                         |
| 2        | Flush Water Demand per Day (KLD)                                                                                                      | 20.7                 | 16.56                                        |
| 3        | Total Water Demand per Day (KLD)                                                                                                      | 49.3                 | 39.44                                        |
| 4        | Savings in Water Demand per Day (KLD)                                                                                                 | 9.86                 |                                              |
|          | <b>Annual Savings in Water Demand (KL)</b>                                                                                            | <b>2470</b>          |                                              |
|          | <b>Annual Cost Savings on Water (Assuming ₹ 1,000 /- per 12,000 Litres Tanker)</b>                                                    | <b>₹ 2,05,417 /-</b> |                                              |
| <b>B</b> | <b>Savings on Sewage treatment</b>                                                                                                    |                      |                                              |
| 1        | Sewage Generation per day in KLD at 85%                                                                                               | 41.91                | 33.52                                        |
| 2        | Savings in Water Demand per Day (KLD)                                                                                                 | 8.38                 |                                              |
|          | <b>Annual Savings in Treatment (KL)</b>                                                                                               | <b>2095</b>          |                                              |
|          | <b>Annual Treatment Cost savings INR</b>                                                                                              | <b>₹ 6,28,575 /-</b> |                                              |
| <b>C</b> | <b>Domestic, Flush and Water Treatment plant pump power Saving</b>                                                                    |                      |                                              |
| 1        | Pump Power Consumption (kW)                                                                                                           | 1.85                 | 1.29                                         |
| 2        | Annual Power Consumption kWh<br>(Domestic Water Pump & Flush Water = 4 hours x 250 days)<br>(Filter feeder Pump = 8 hours x 250 days) | 2,400                | 1,660                                        |
|          | <b>Annual Energy Cost (Energy Cost Assumed as ₹ 8 / kWh)</b>                                                                          | <b>₹ 19,200 /-</b>   | <b>₹ 13,280 /-</b>                           |
|          | <b>Saving in Annual Power Consumption Cost</b>                                                                                        | <b>₹ 5,920 /-</b>    |                                              |

# MEP SYSTEM – ANNUAL POWER CONSUMPTION

## MEP System – Annual Power Consumption

| S. No | Description                                 | Base Case       | Proposed Case   |
|-------|---------------------------------------------|-----------------|-----------------|
| 1     | HVAC Annual Power Consumption (kWh)         | 3,97,955        | 2,20,581        |
| 2     | Fresh Air Annual Power Consumption (kWh)    | 1,50,198        | 64,959          |
| 3     | Electrical Annual Power Consumption (kWh)   | 2,03,129        | 94,920          |
| 4     | PHE Annual Power Consumption Pump(kWh)      | 2,400           | 1,660           |
|       | <b>Total Annual Power Consumption (kWh)</b> | <b>7,53,681</b> | <b>3,82,120</b> |
|       | <b>Reduction in power consumption</b>       | <b>49.30 %</b>  |                 |



# MEP SYSTEM – RETURN OF INVESTMENT (ROI) ANALYSIS

## Return of Investment (ROI) Analysis

| S. No | Description                                                      | Amount           |
|-------|------------------------------------------------------------------|------------------|
| 1     | Increase in Capital Investment<br>(Civil and MEP System)         | ₹ 2,07,29,258 /- |
| 2     | Savings in Operating Cost                                        |                  |
| A     | Savings in HVAC System                                           | ₹ 14,18,992 /-   |
| B     | Savings in Fresh Air Load (With CO <sub>2</sub> Sensors Control) | ₹ 6,81,909 /-    |
| C     | Savings in Lighting Power Consumption                            | ₹ 8,65,670 /-    |
| D     | Savings in Water Consumption                                     | ₹ 8,33,992 /-    |
| E     | Savings in Water Power Consumption                               | ₹ 5,920 /-       |
|       | Total Savings in Operating Cost                                  | ₹ 38,06,483 /-   |
|       | Return of Investment (in Years)                                  | 5.45 Years       |

**Note :** There are onsite and offsite renewable energy are available in our project. Hence, the operation cost savings will be more and ROI will further reduce and more attractive.

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**THANK YOU**