

BT 4.464

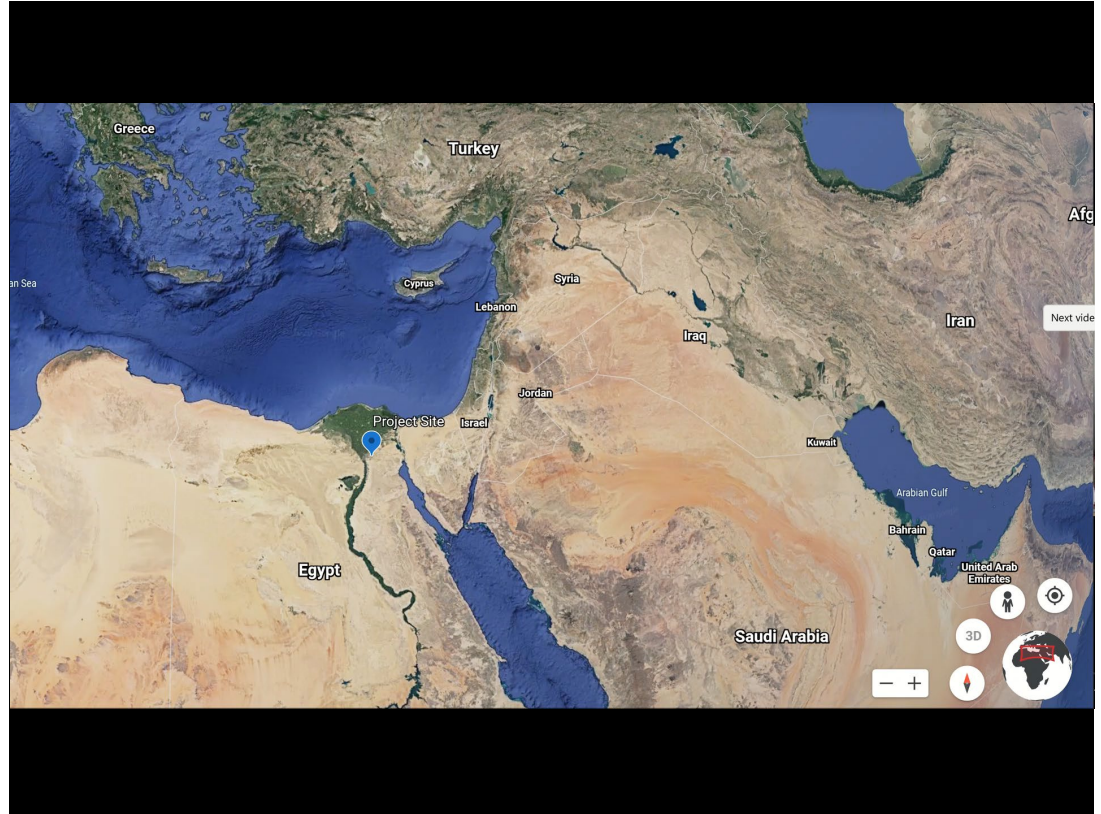
ENVIRONMENTAL TECHNOLOGIES IN BUILDINGS- Final Project

Sarah Mokhtar, Nada Tarkhan
12.16.2020



CONTEXT: NEW CAIRO

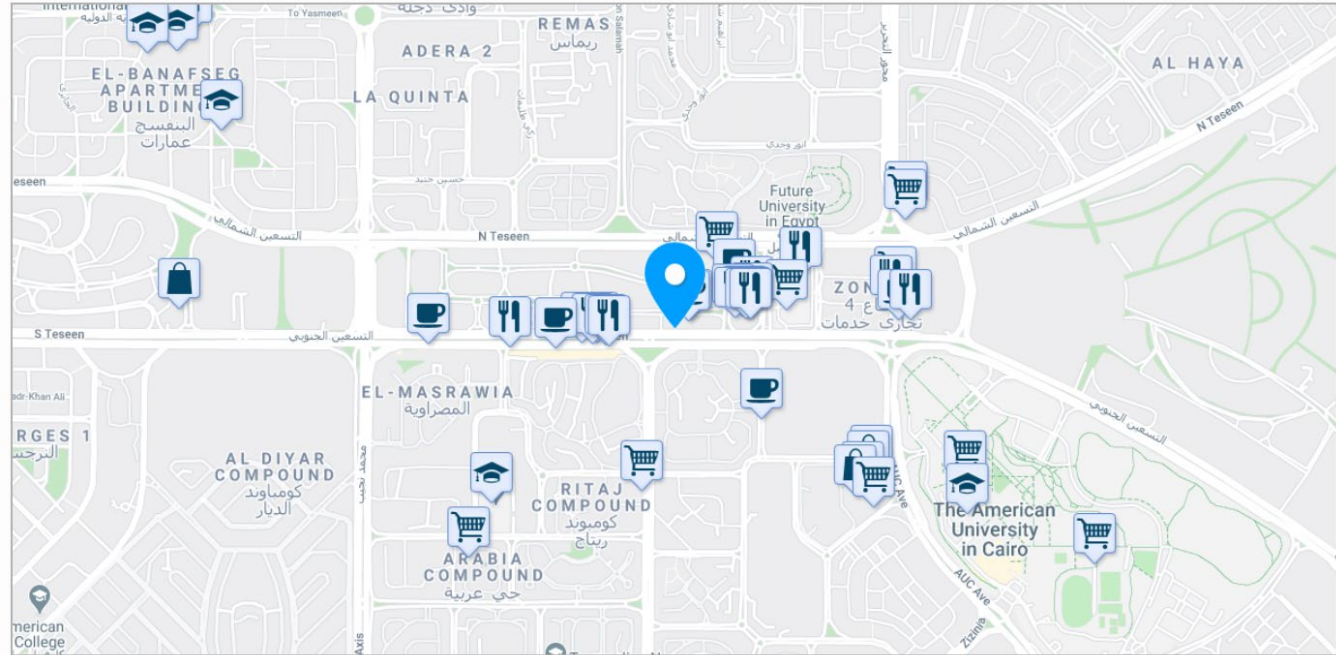
- **NEW CAIRO:** is a new satellite City connected to Cairo
- **GROWTH:** Currently represents one of Greater Cairo's most rapidly developing areas
- **DEVELOPMENTS:** Houses many campus universities and new mixed use developments as well as residential gated communities.
- **DESERT LANDSCAPE:** far from central Nile connection, more arid conditions



CONTEXT: WALKSCORE & ACCESSIBILITY

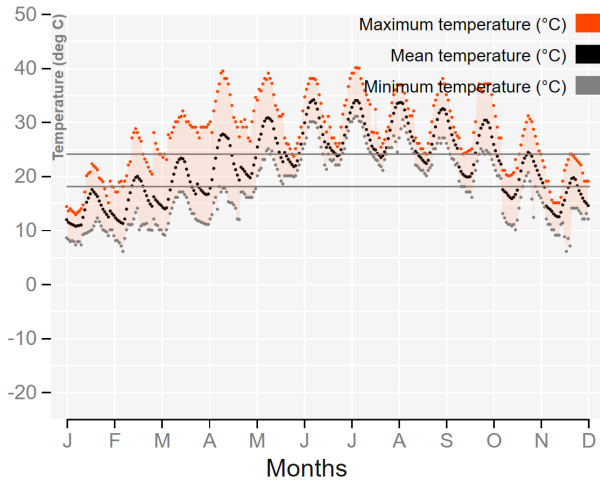
Walk Score
57

- **BUILDING PLOT:** Plot of land is connected to other office buildings
- **AMENITIES:** Has accessibility to coffee shops, small markets and restaurants
- **ACCESSIBILITY:** remains predominantly car centric due to harsh climate and large distances between services

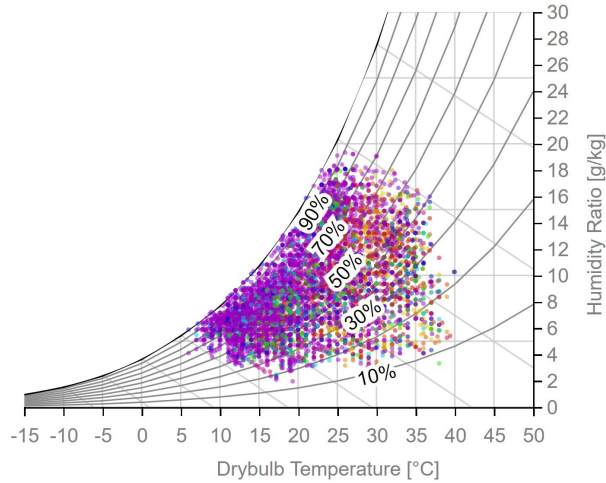


CONTEXT: CLIMATE

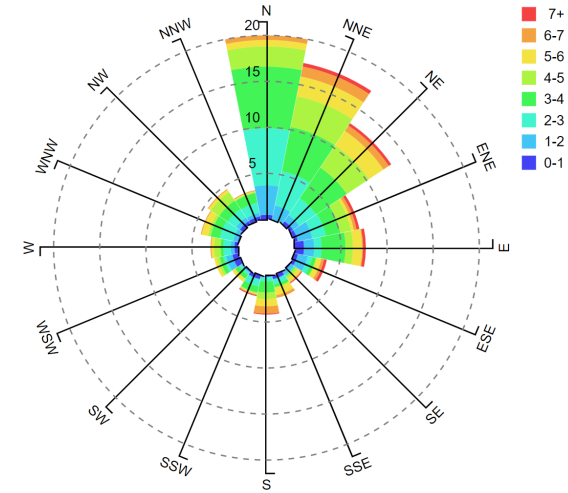
Climate Zone 2B



TEMPERATURES: High Summer temperatures (maximum 40C) and mild winters (minimum 5C)



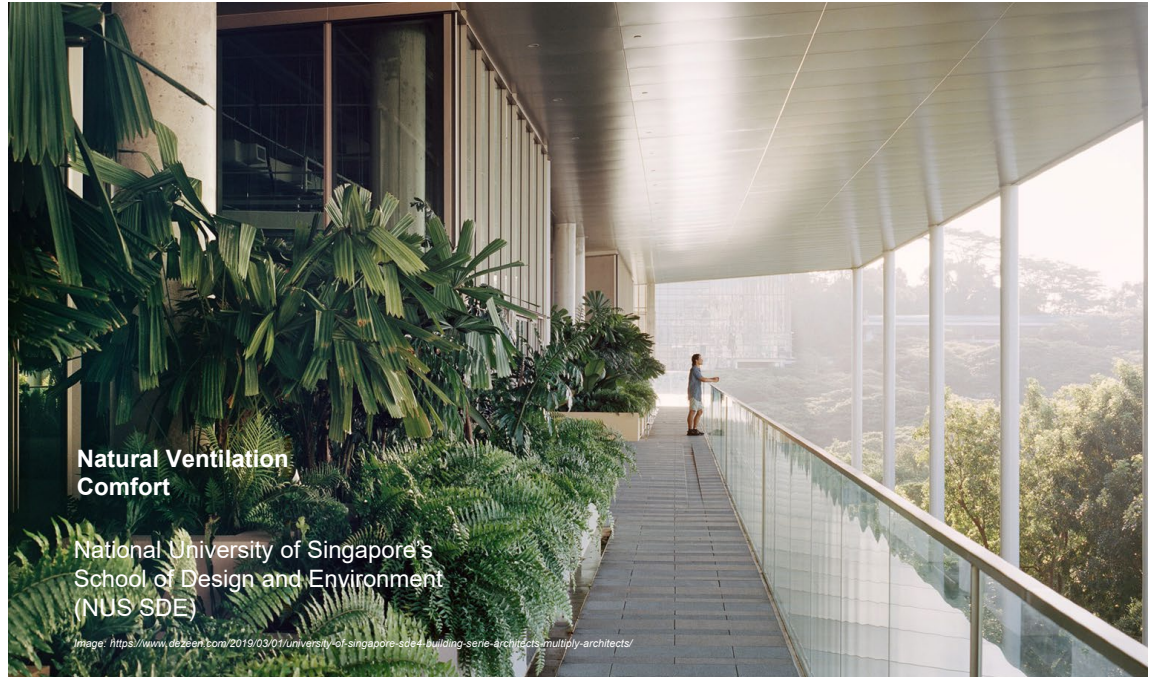
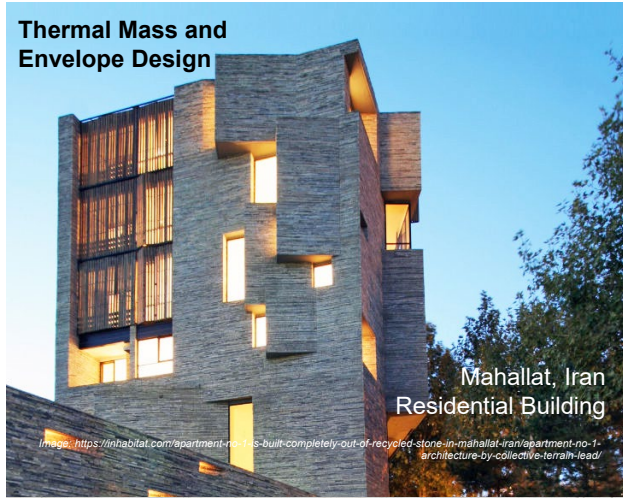
PSYCHROMETRIC CHART: Mostly dry conditions mid-day to early evening (12pm-6pm). Higher humidity hours in early mornings and late evenings



WIND: Primarily North and North-Eastern prevailing direction

PRECEDENTS

Thermal Mass and Envelope Design



NET ZERO ROAD MAP

Maximize daylight access, reduce glare

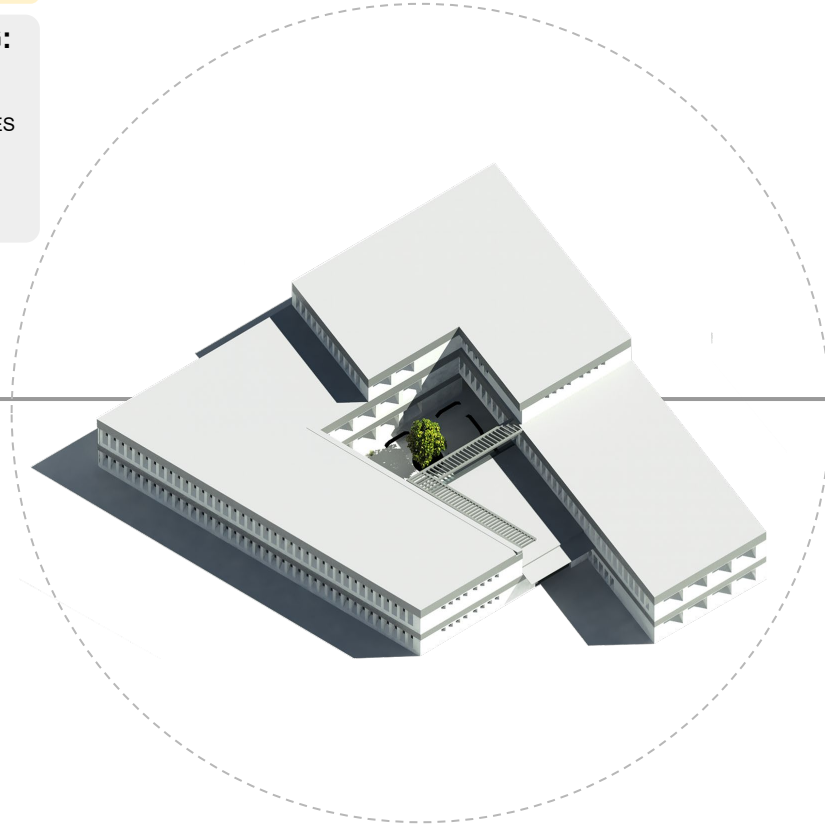
DAYLIGHTING:

- WWR
- GLAZING PROPERTIES
- SHADING & GLARE MITIGATION

Future energy profiles

FUTURE CLIMATE:

- ENERGY-USE PROFILE SHIFTS
- NATURAL VENTILATION



MASSING:

- SOLAR ORIENTATION
- SHADOW ANALYSIS
- WIND DIRECTION
- FLOOR DEPTH
- OUTDOOR COMFORT

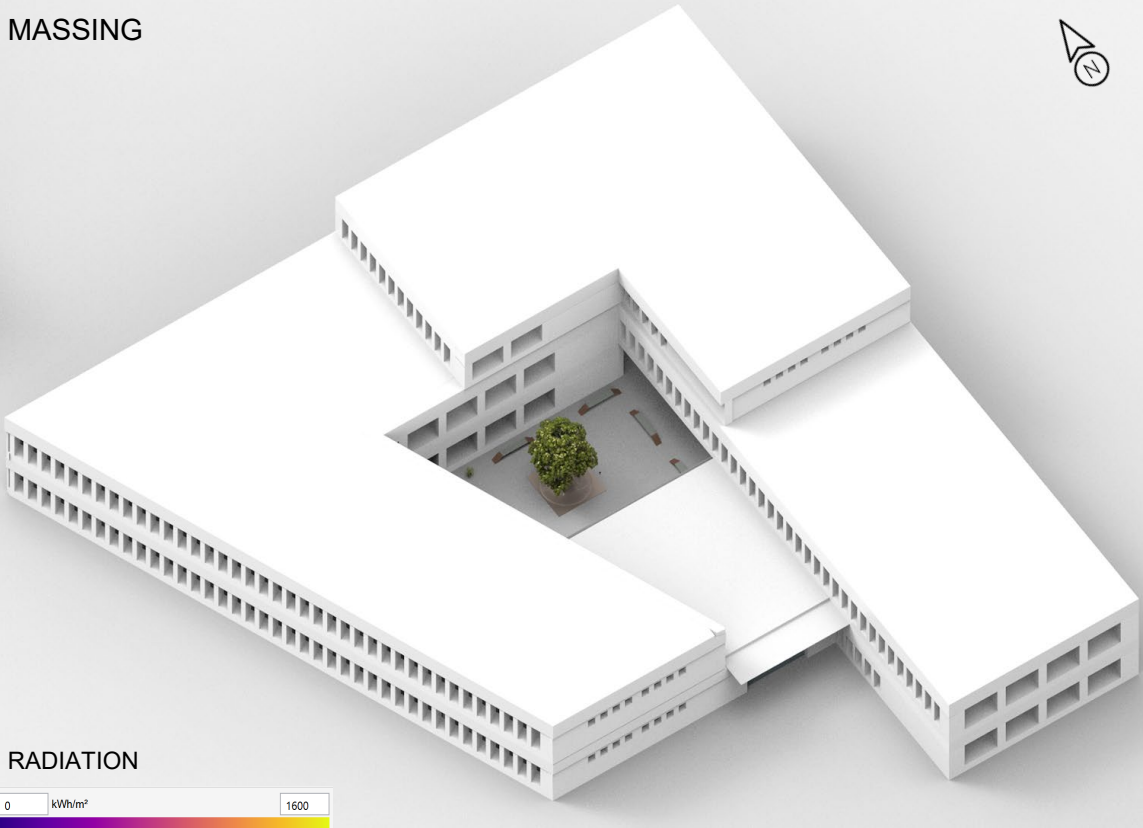
Reduce Solar gains & integrate natural ventilation

ENERGY:

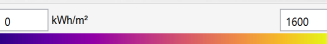
- ENVELOPE PROPERTIES
- INTERNAL LOADS
- SYSTEM PERFORMANCE
- NATURAL VENTILATION
- PV SYSTEM

80% reduction target

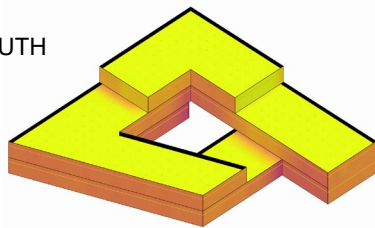
MASSING



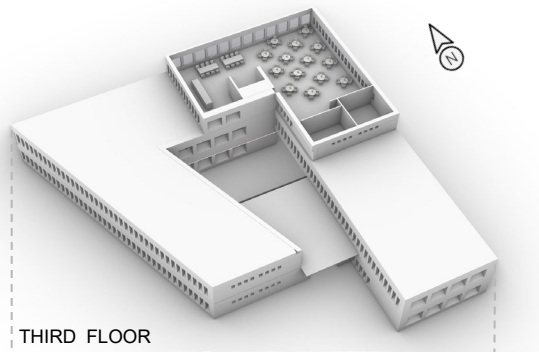
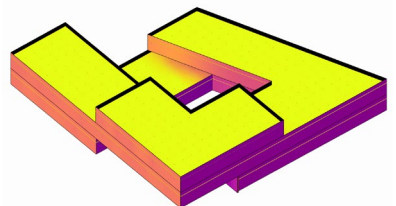
RADIATION



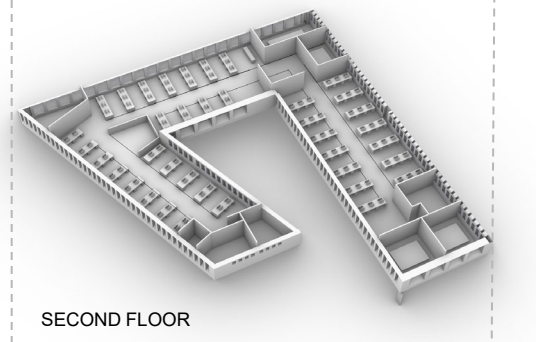
WEST & SOUTH



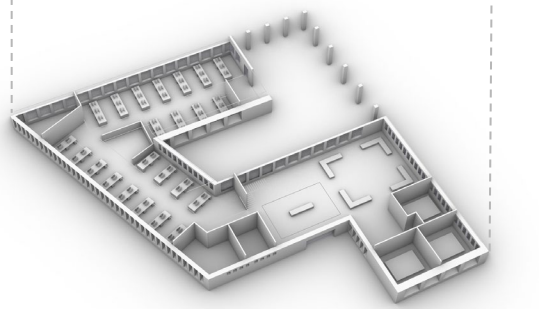
EAST & NORTH



THIRD FLOOR

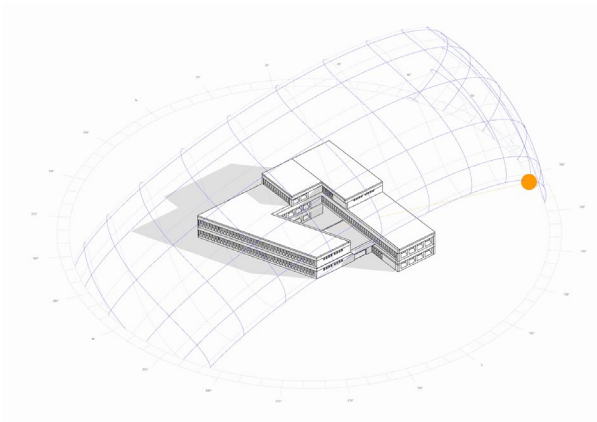


SECOND FLOOR

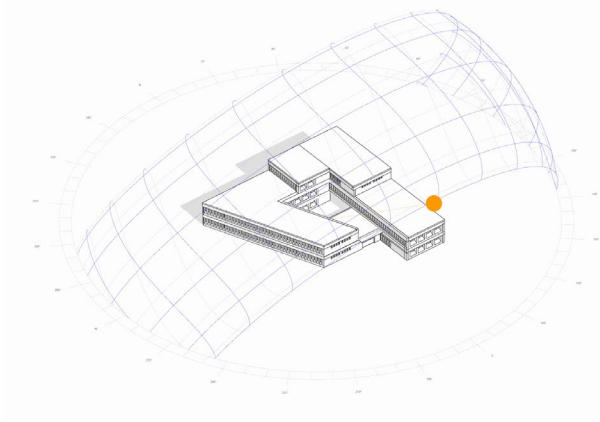


FIRST FLOOR

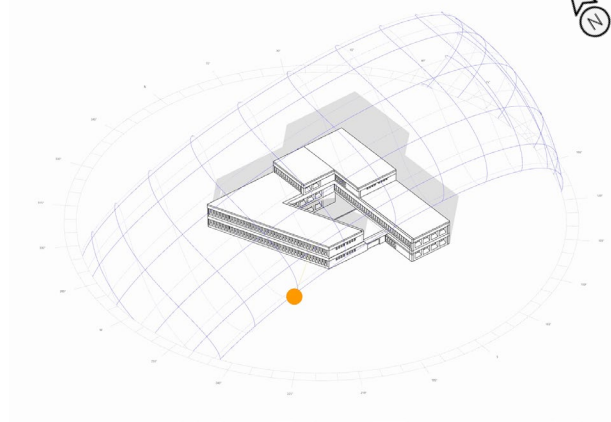
ENVIRONMENTAL: SHADOW ANALYSIS



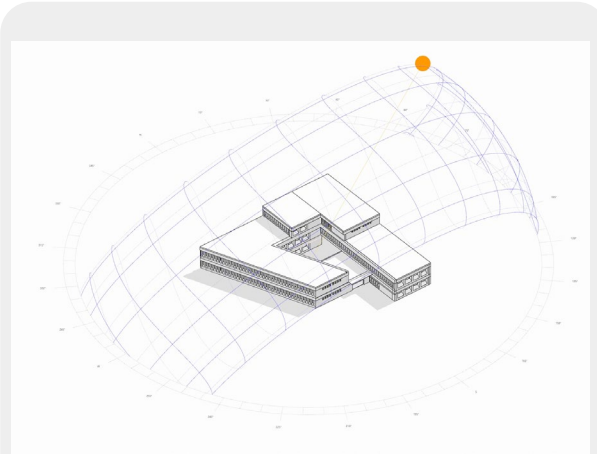
DECEMBER 21, 9AM



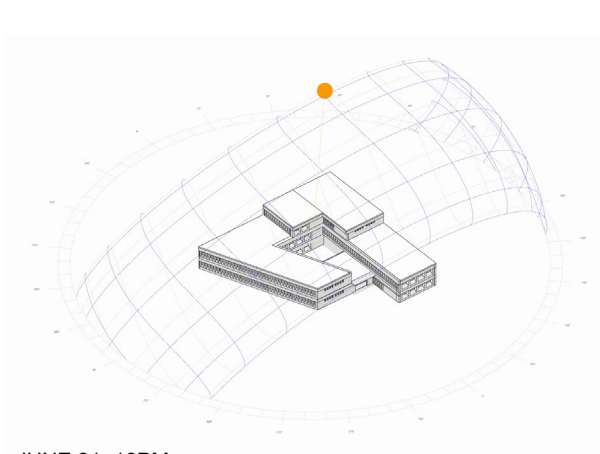
DECEMBER 21, 12PM



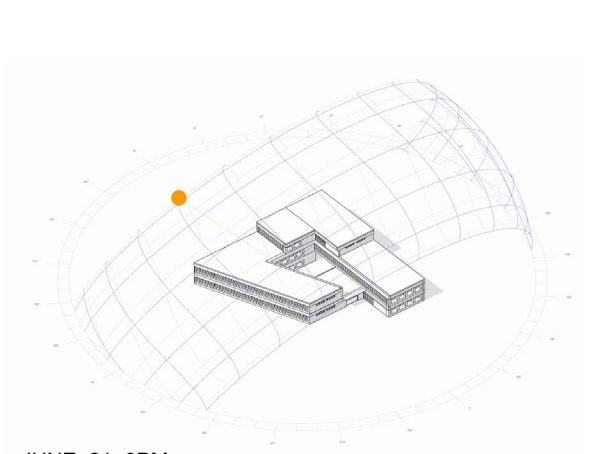
DECEMBER 21, 3PM



JUNE 21, 9AM

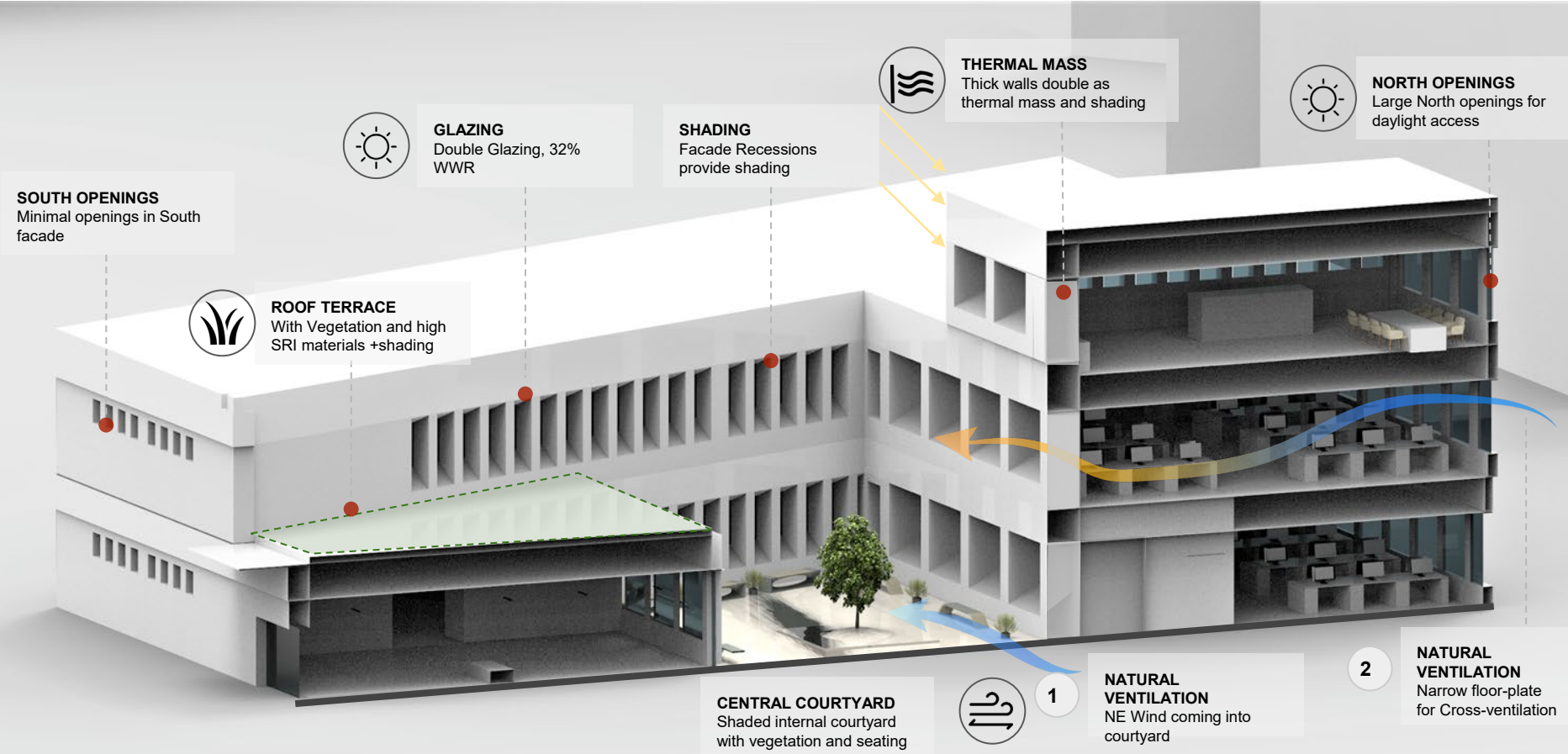


JUNE 21, 12PM



JUNE 21, 3PM

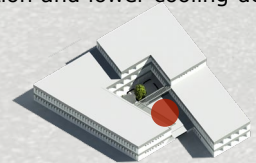
ENVIRONMENTAL: PROGRAM & STRATEGIES

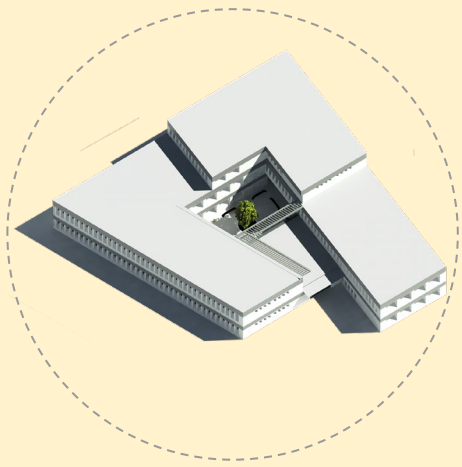




ROOF TERRACE SEATING

Light reflective materials with high SRI and vegetation to minimize heat absorption and lower cooling demand

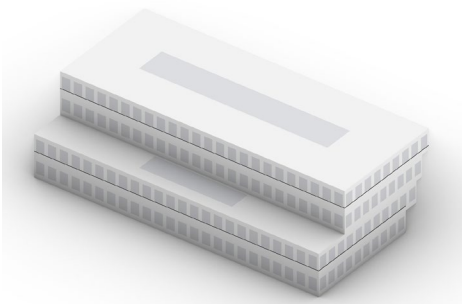
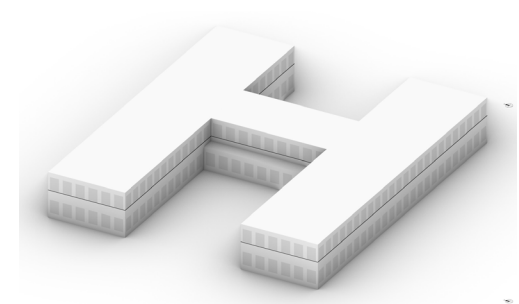
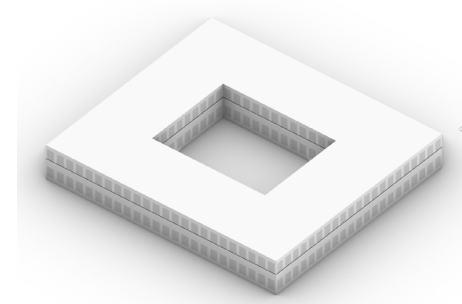
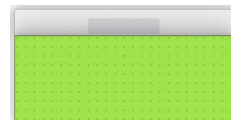
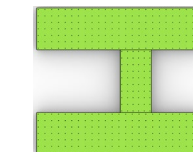
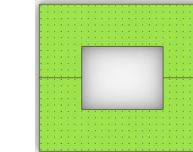
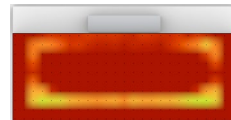
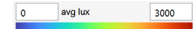
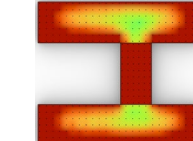
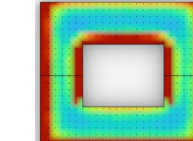
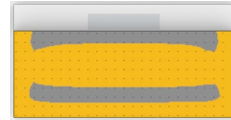
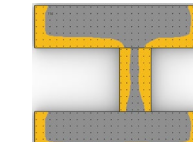
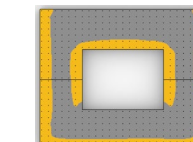




DAYLIGHTING & ELECTRIC LIGHTING

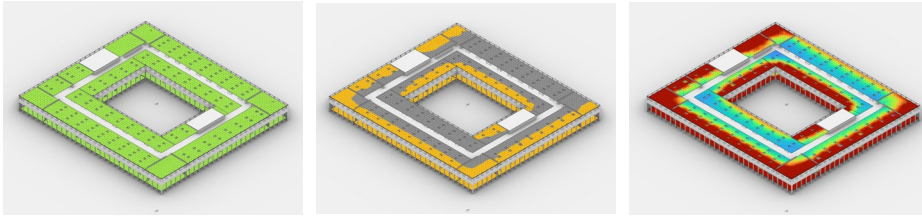
DAYLIGHTING: MASSING

Selected Geometry

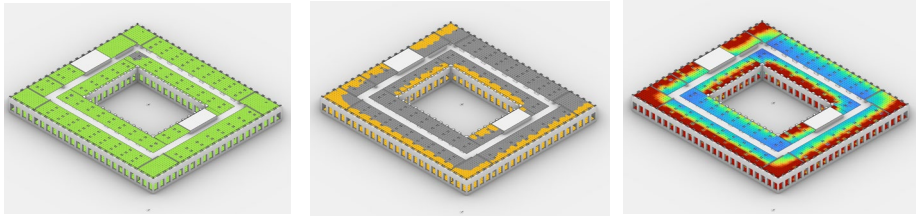
DESCRIPTION	<p>1 Compact massing with deeper floor plates and skylights. 40% glazing distributed evenly</p>	<p>2 Linear massing with H-shaped blocks with narrow floor plates. 40% glazing distributed evenly</p>	<p>3 Square Courtyard massing with narrow floor plates. 40% glazing distributed evenly.</p>
MASSING			
SDA 300/50%	 <p>100%</p>	 <p>100%</p>	 <p>100%</p>
LUX (base 3000) DISTRIBUTION	 <p>8616 avg</p> 	 <p>5154 avg</p>	 <p>2939 avg</p>
ASE 1000,250	 <p>66%</p>	 <p>41%</p>	 <p>39%</p>

DAYLIGHTING: FACADE AND SHADING

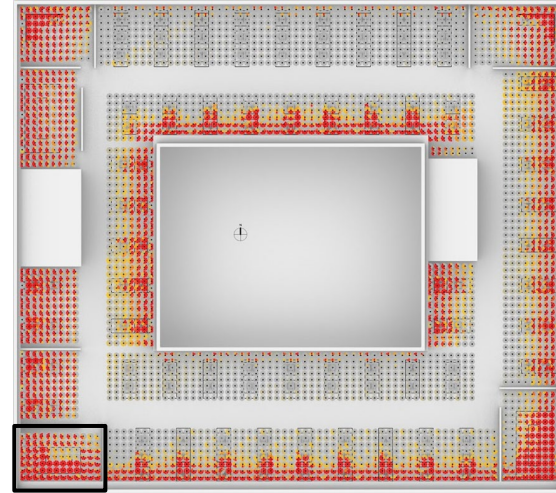
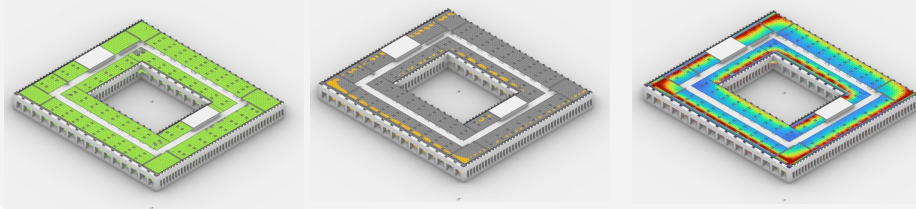
Facade A: Fully glazed facade with solid spandrel of 0.7m, 70% WWR **ASE 35%**



Facade B: Consistent 40% WWR across all facades. **ASE 25%**



Facade C: Facades varying in depth, WWRs and their distribution based on their orientation, overall 32% WWR. **ASE 8.1%**

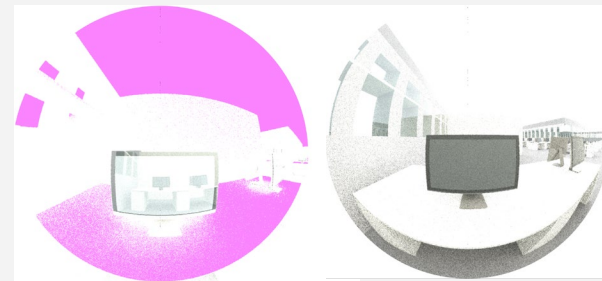


FACADE WWR:

NORTH: 43%
EAST: 20%
WEST: 20%
SOUTH: 16%

Aggregate= 32%

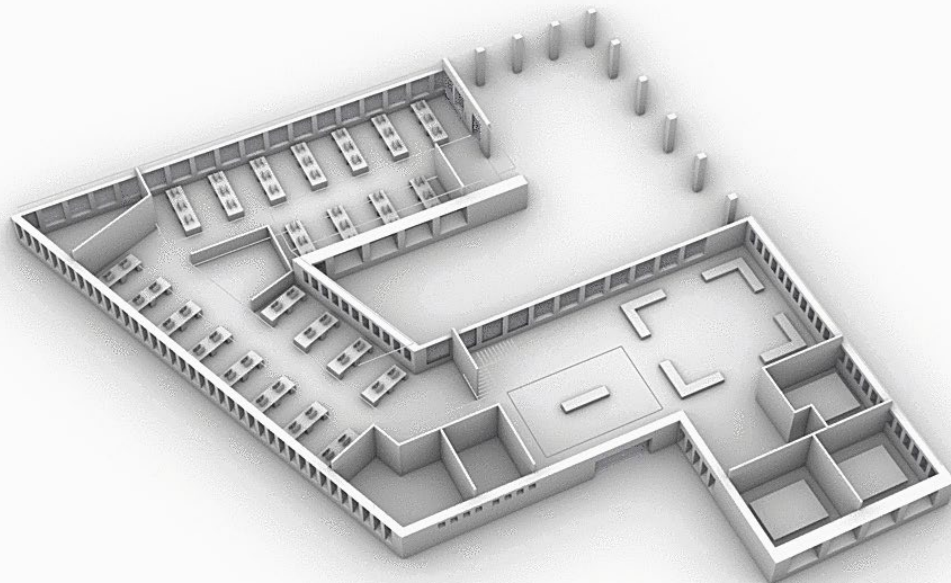
With inset depth
for shading



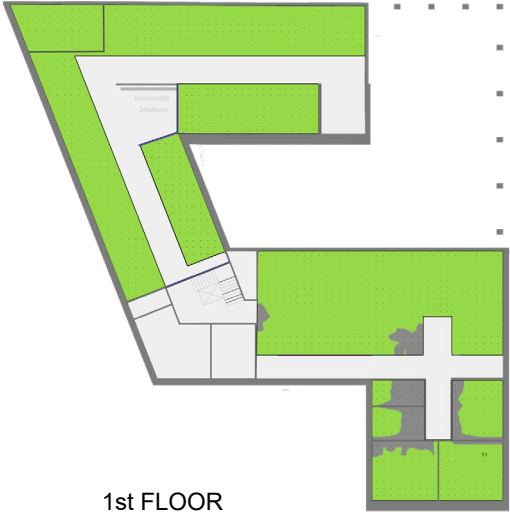
GLARE AT SW ROOM:

May 2pm Glare
Without light shelf
(left), with light shelf
(right)

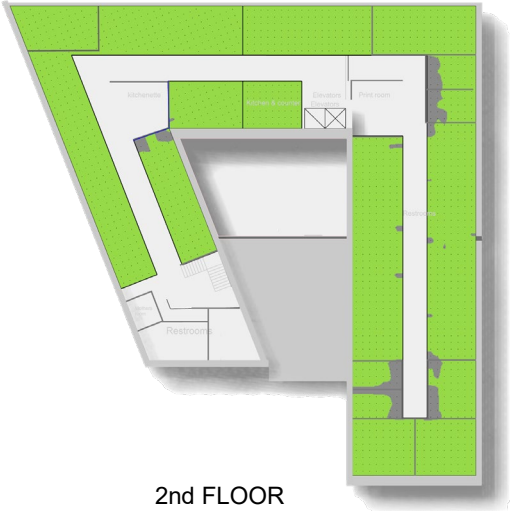
DAYLIGHTING: FINAL DESIGN



DAYLIGHTING: SDA



3* credits	94.4% sDA _{300/50%}	7.0% ASE _{1000,250}	1311 avg lux
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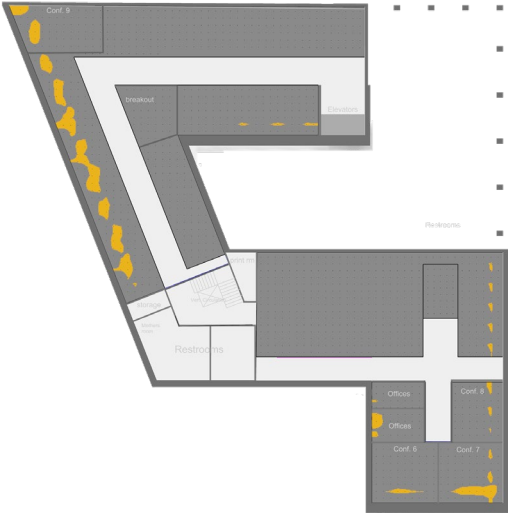


3* credits	95.6% sDA _{300/50%}	7.8% ASE _{1000,250}	1459 avg lux
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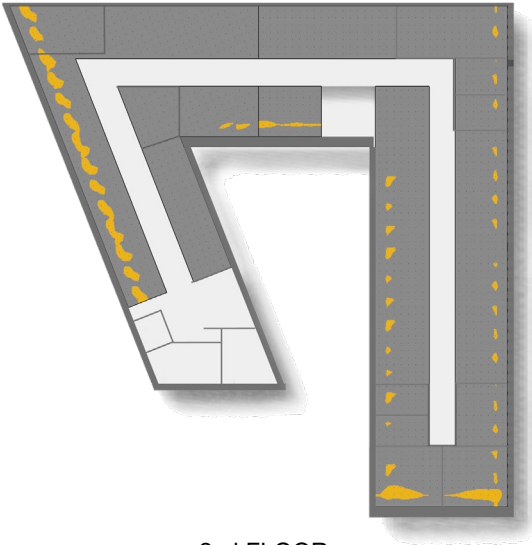
4 credits	93.2% sDA _{300/50%}	3.0% ASE _{1000,250}	1203 avg lux
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DAYLIGHTING: ASE



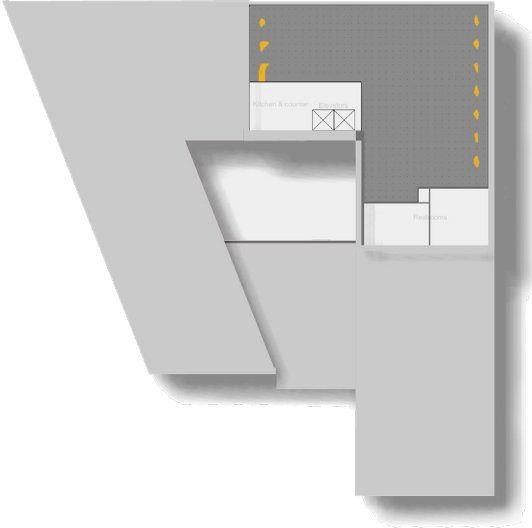
1st FLOOR

3* credits	93.5 % sDA _{300/50%}	6.7 % ASE _{1000,250}	1278 avg lux
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2nd FLOOR

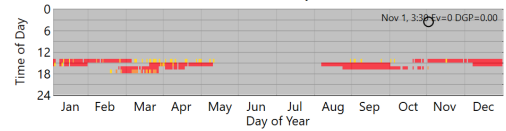
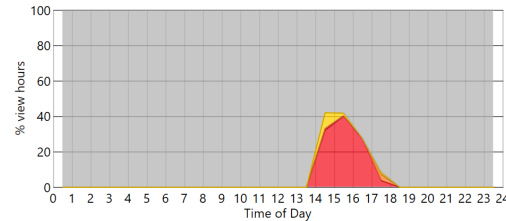
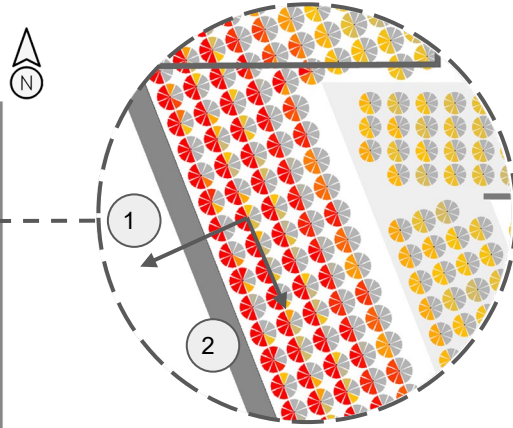
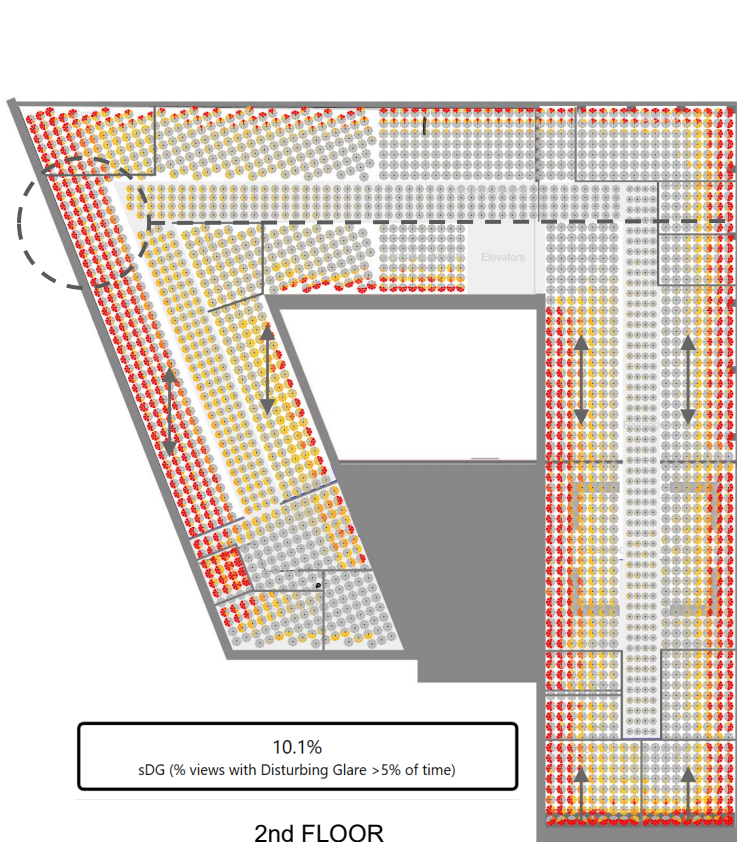
3* credits	95.6 % sDA _{300/50%}	7.8 % ASE _{1000,250}	1459 avg lux
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3rd FLOOR

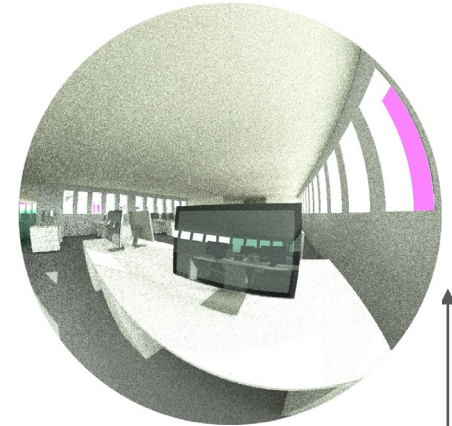
4 credits	93.2 % sDA _{300/50%}	3.0 % ASE _{1000,250}	1182 avg lux
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GLARE ASSESSMENT

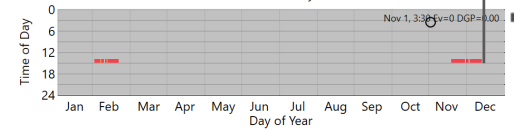
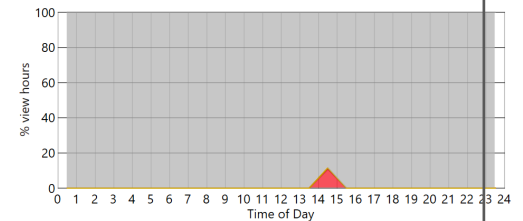


■ Imperceptible ■ Perceptible ■ Disturbing ■ Intolerable

1. WEST




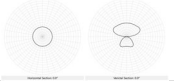

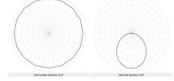

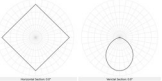
December 23, 1:30pm

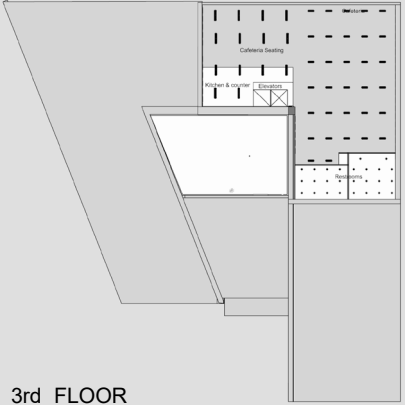
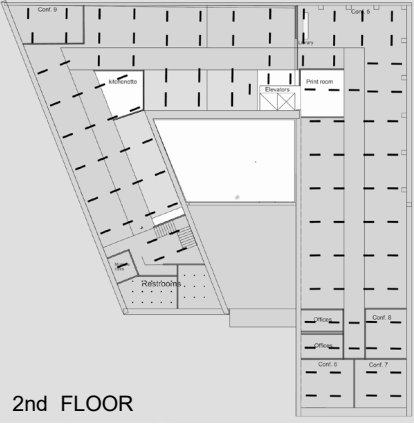
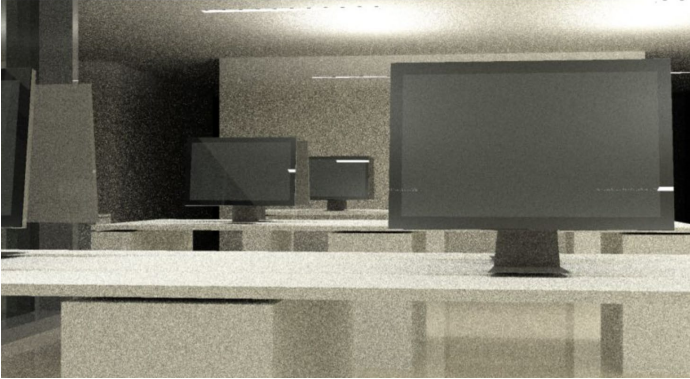


■ Imperceptible ■ Perceptible ■ Disturbing ■ Intolerable

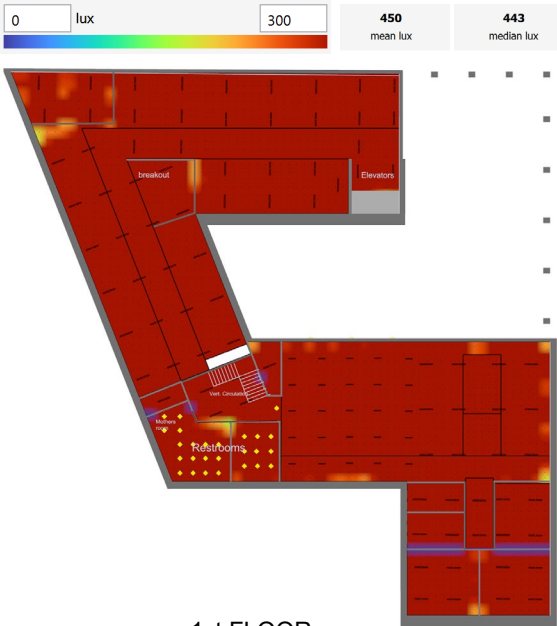
2. SCREEN DIRECTION

ELECTRIC LIGHTING: FIXTURES

Type	Perspective	Space	Luminance intensity distribution	Wattage
Verge suspended, MesoOptics Lens, 6500lm/4ft, 80 CRI, 3000K		Work Spaces, Offices, Conference rooms		56
Linear Suspended Strip Diffuse Lens 4' 24W 2450		Informal break-out areas and Cafeteria Seating		24
4" Commercial Retrofit LED 1000lm 90 27K CR4R10927U		Restrooms and circulation		11

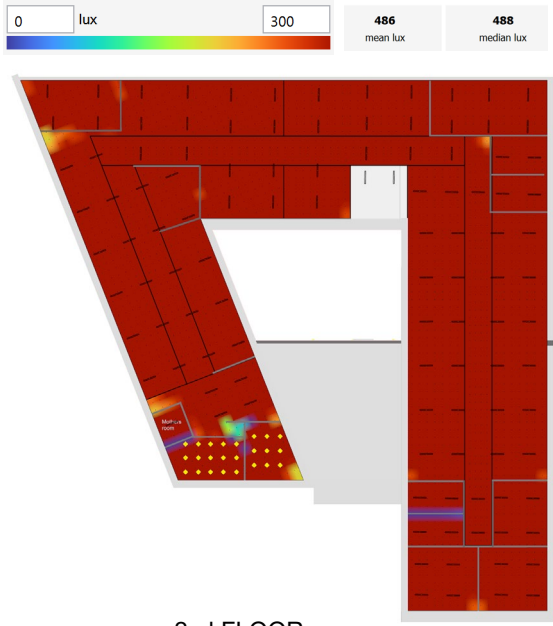


ELECTRIC LIGHTING: DISTRIBUTION



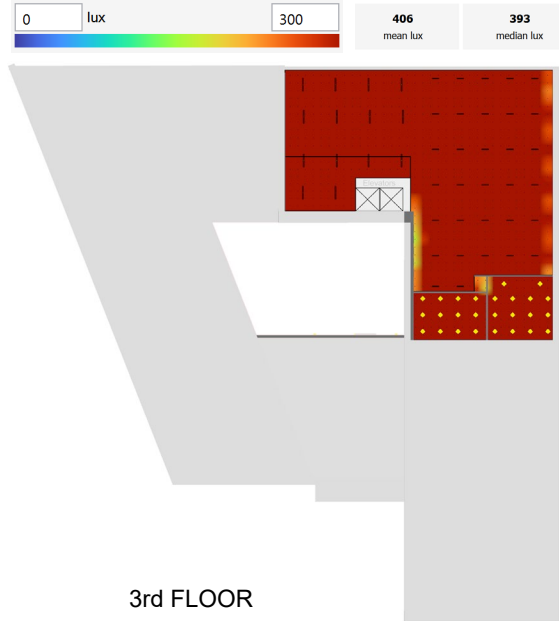
$$((26 \times 11) + (86 \times 56) + (24 \times 30)) / 1045$$

LPD= 5.5 w/m²



$$((24 \times 11) + (109 \times 56)) / 1117$$

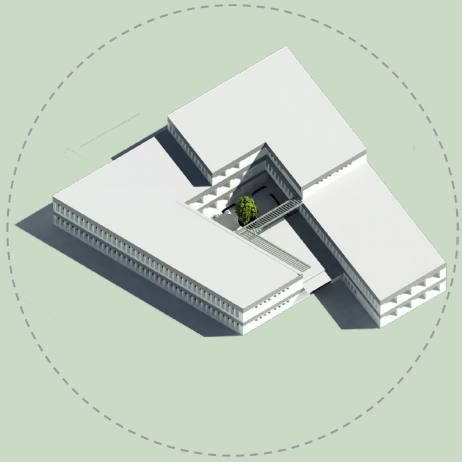
LPD= 5.7 w/m²



$$((26 \times 11) + (15 \times 56) + (32 \times 24)) / 430$$

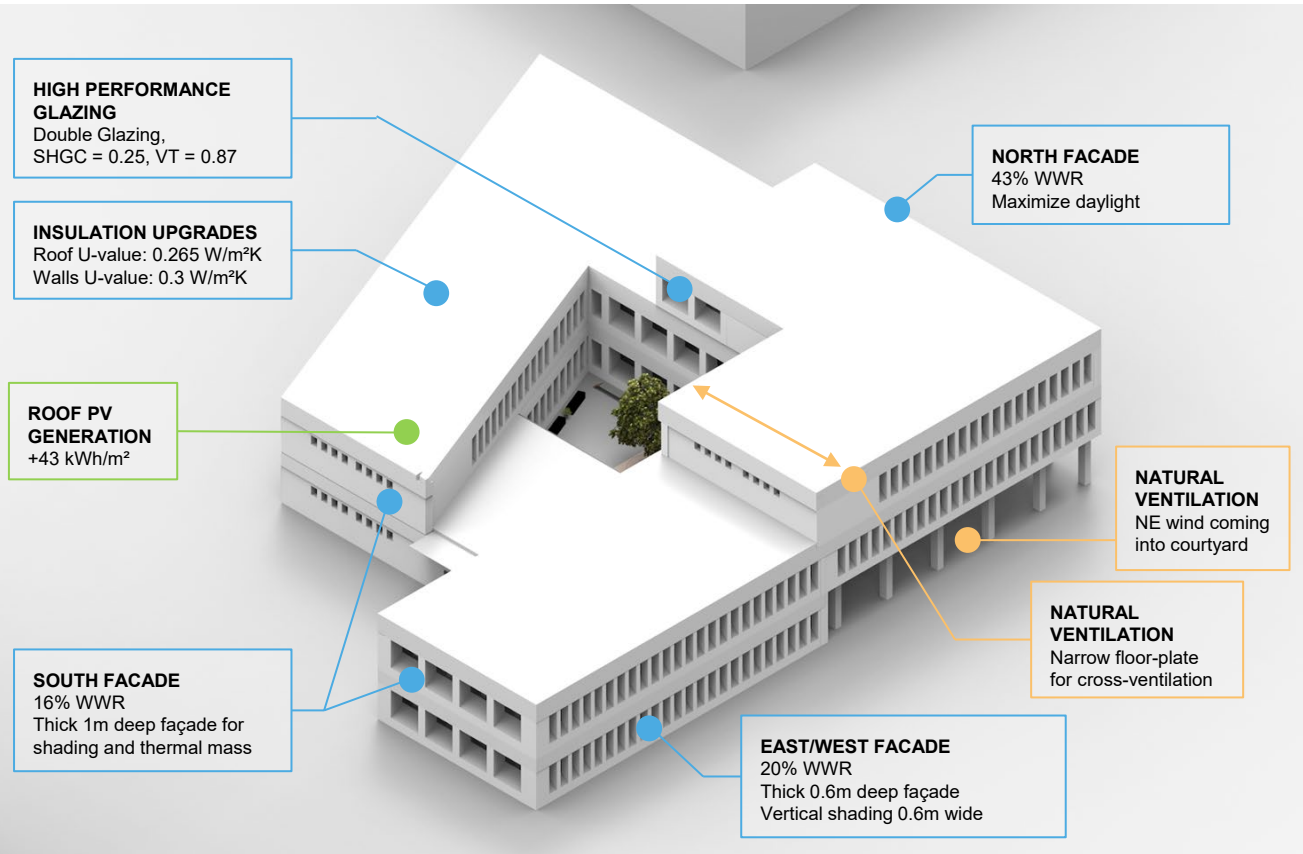
LPD= 4.4 w/m²

Building Area weighted LPD= 5.2w/m²



ENERGY AND COMFORT

ENERGY STRATEGIES



Architectural

1 Lighting and Envelope Upgrades

Continuous dimming controls, 300lux target, 5.2 W/m² LPD
Glazing ratios and shading orientation-dependent
Envelope insulation upgrades: Roof (U-value: 0.265 W/m²K) and Walls (U-value: 0.3 W/m²K), Glazing

2 Internal Loads

Occupancy load (0.072 pp/m²) and schedule
Equipment load (8.38 W/m²) and schedule
Separate schedules and loads for kitchen and cafeteria

3 HVAC Upgrades

Cooling system COP to 4.41
Heat recovery
Economizer

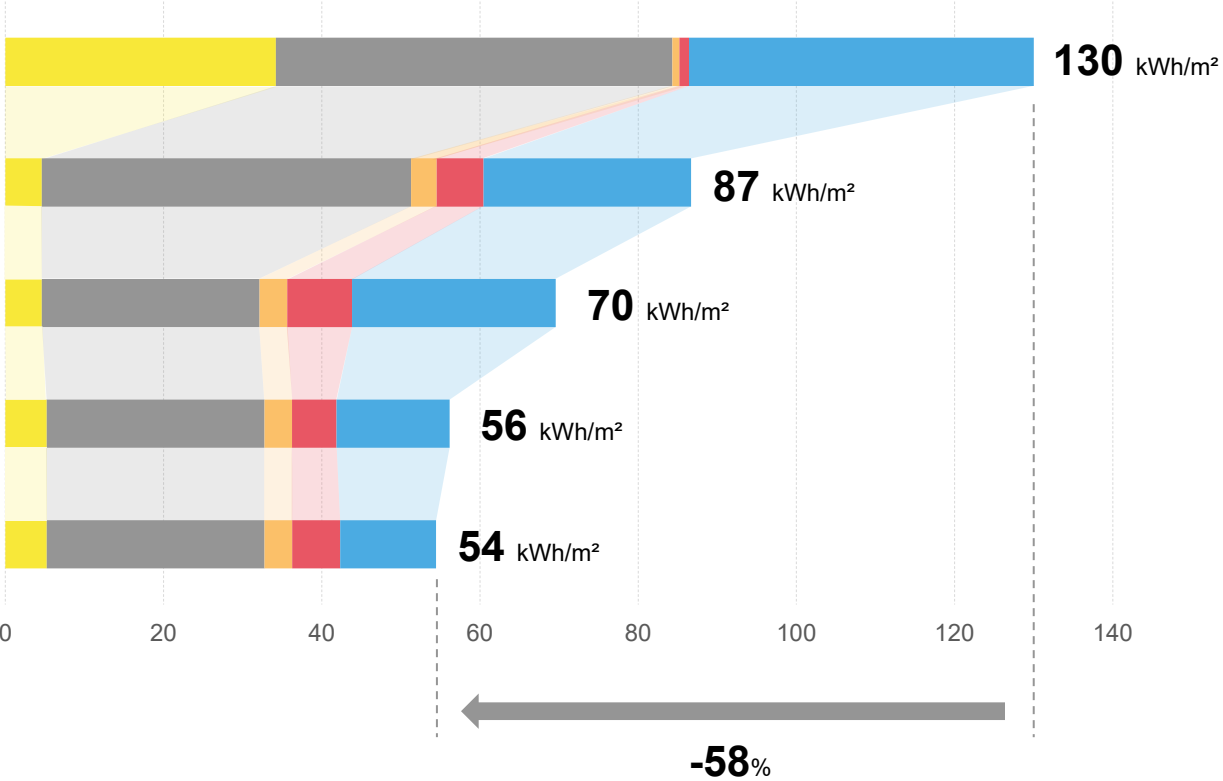
Architectural

4 Natural Ventilation

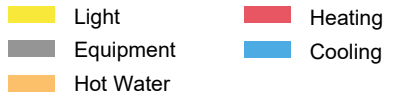
Narrow floor-plate for cross-ventilation
Building porosity

5 Energy Production

ENERGY



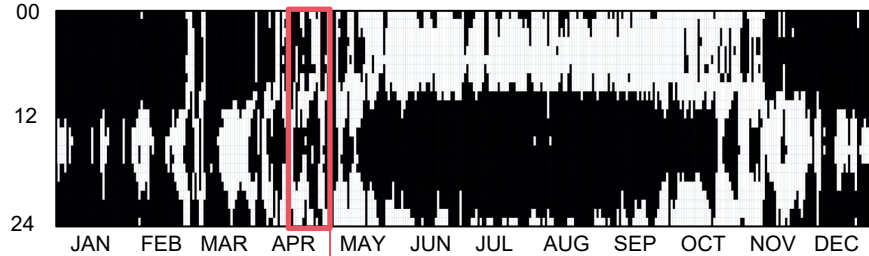
- 0 Baseline**
- 1 Lighting and Envelope Upgrades**
 Continuous dimming controls, 300lux target, 5.2 W/m2 LPD
 Glazing ratios and shading orientation-dependent
 Envelope insulation upgrades: Roof (U-value: 0.265 W/m2K) and Walls (U-value: 0.3 W/m2K), Glazing
- 2 Internal Loads**
 Occupancy load (0.072 pp/m²) and schedule
 Equipment load (8.38 W/m²) and schedule
 Separate schedules and loads for kitchen and cafeteria
- 3 HVAC Upgrades**
 Cooling system COP to 4.41
 Heat recovery
 Economizer
- 4 Natural Ventilation**



-58%

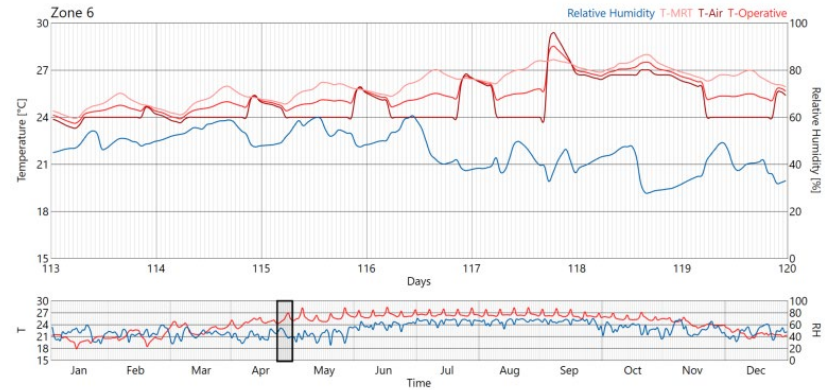
NATURAL VENTILATION – TEMPERATURE PROFILES

Natural Ventilation Schedule
($18C < T < 26C$)

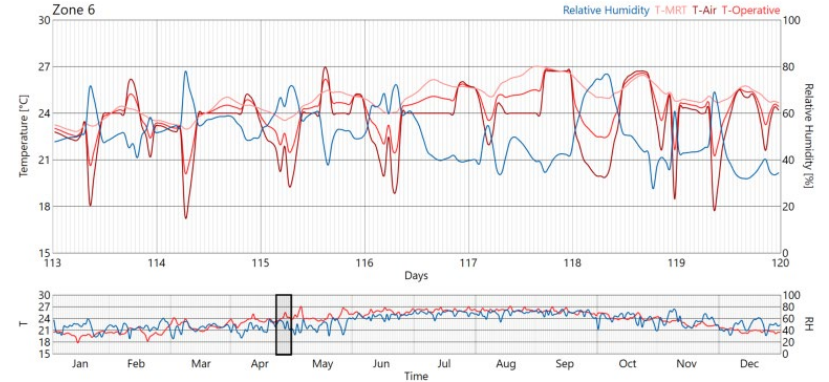


Temperature Profiles
April

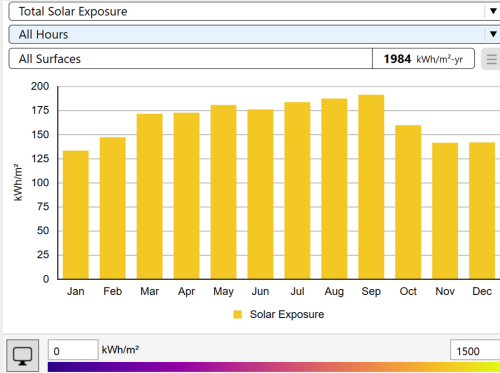
without Natural Ventilation



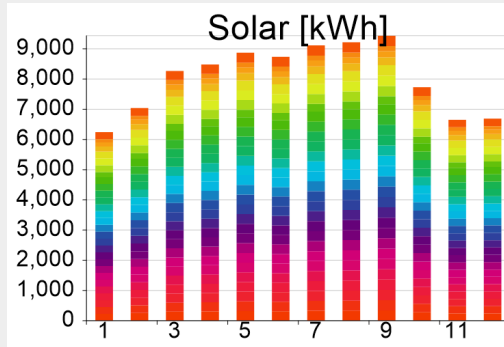
with Natural Ventilation



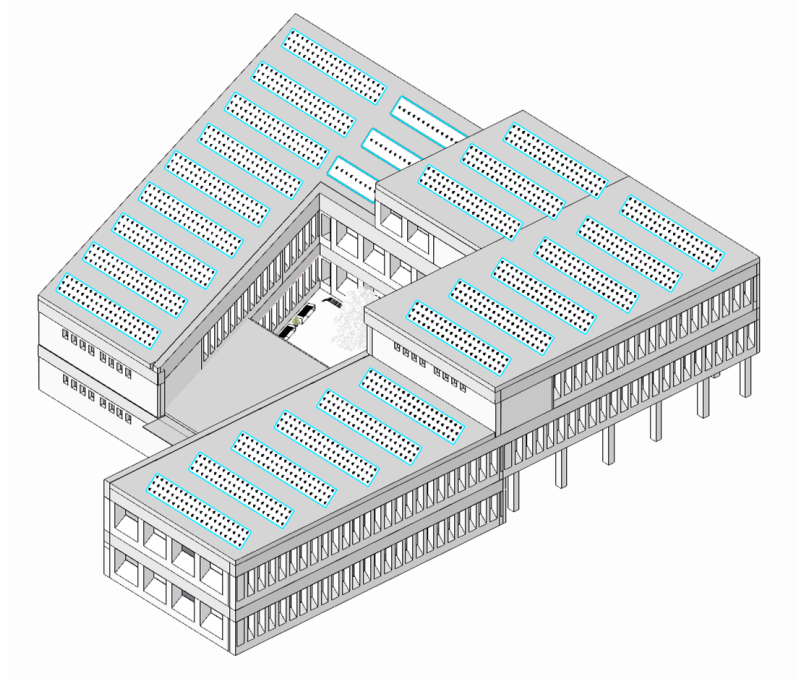
ENERGY PRODUCTION



Annual Radiation



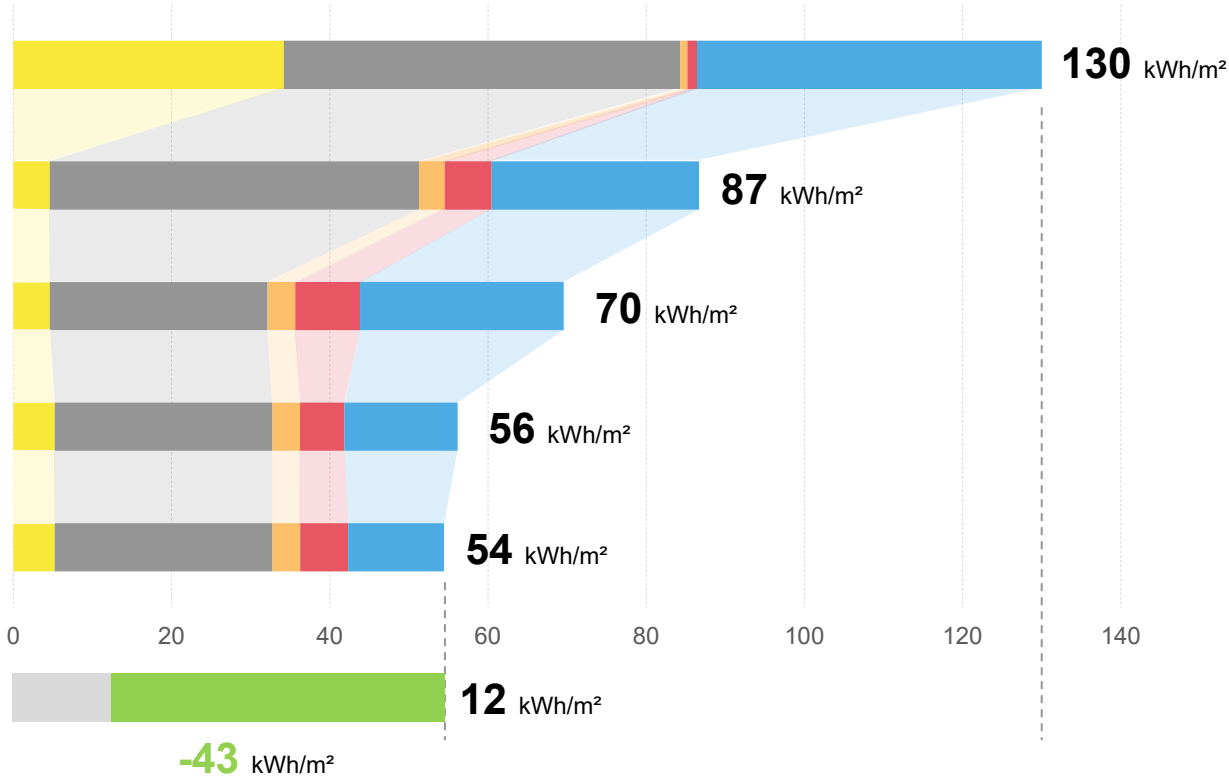
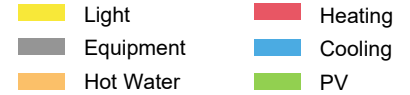
Monthly PV yield



PV OUTPUT: $240 \times 1.5\text{m}^2 \times 1984 \times 0.18 \times 0.96 = \mathbf{123,420 \text{ kWh}}$

ENERGY-USE COVERAGE: $(123,420 \text{ kWh}/153,954 \text{ kWh}) \times 100 = \mathbf{80\%}$ of annual demand covered

ENERGY

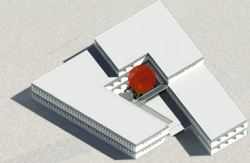


- 0 Baseline**
- 1 Lighting and Envelope Upgrades**
 Continuous dimming controls, 300lux target, 5.2 W/m² LPD
 Glazing ratios and shading orientation-dependent
 Envelope insulation upgrades: Roof (U-value: 0.265 W/m²K) and Walls (U-value: 0.3 W/m²K), Glazing
- 2 Internal Loads**
 Occupancy load (0.072 pp/m²) and schedule
 Equipment load (8.38 W/m²) and schedule
 Separate schedules and loads for kitchen and cafeteria
- 3 HVAC Upgrades**
 Cooling system COP to 4.41
 Heat recovery
 Economizer
- 4 Natural Ventilation**
- 5 Energy Production**

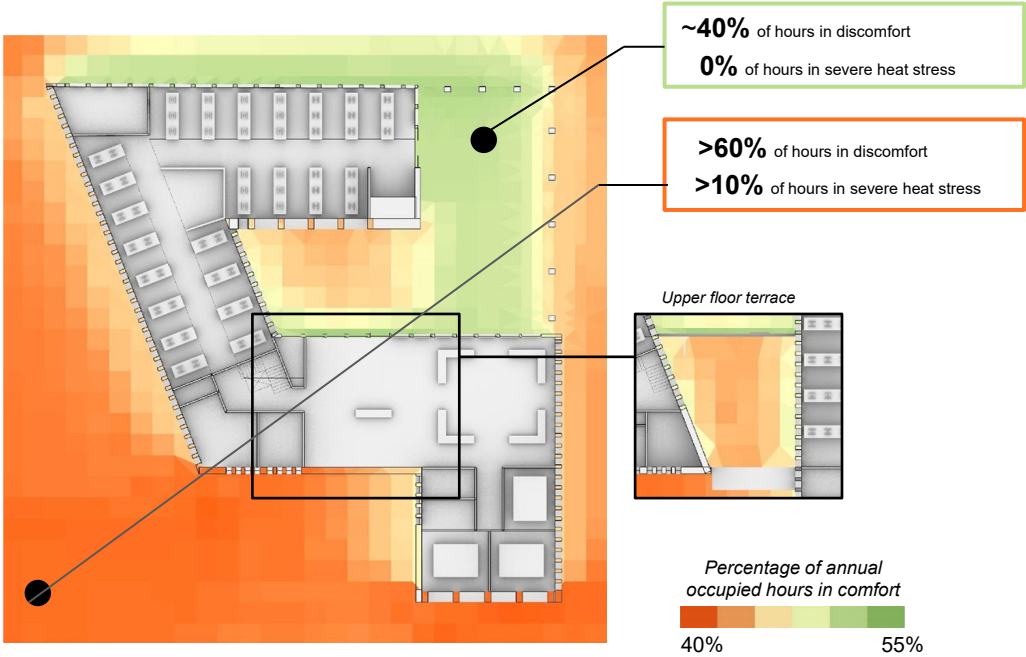
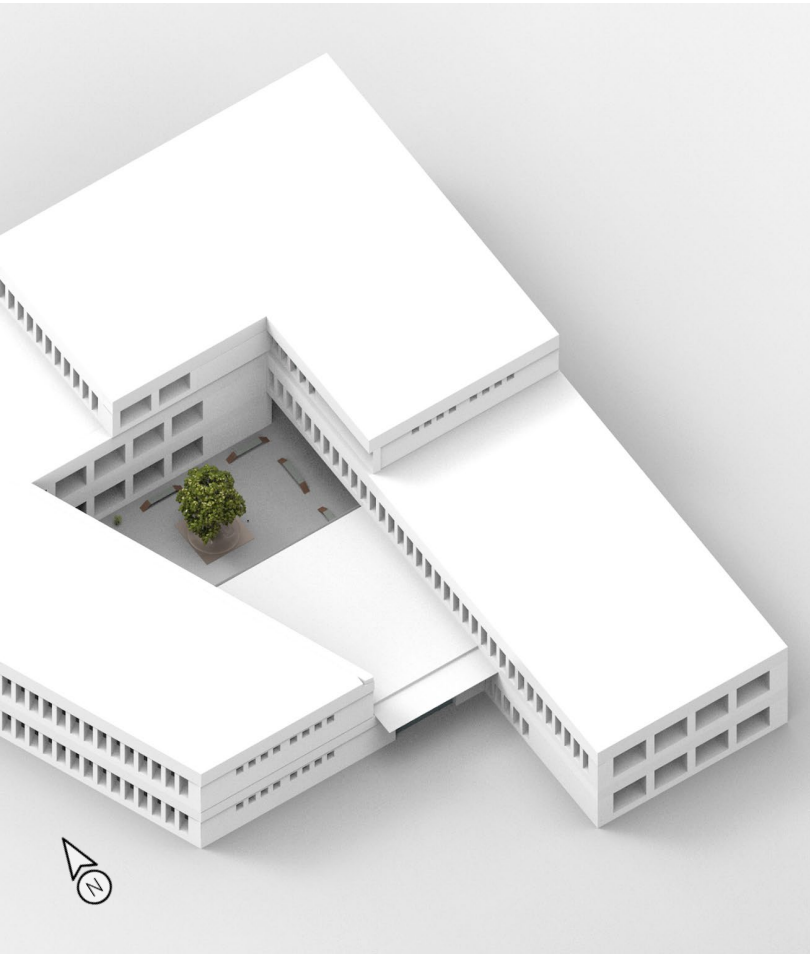


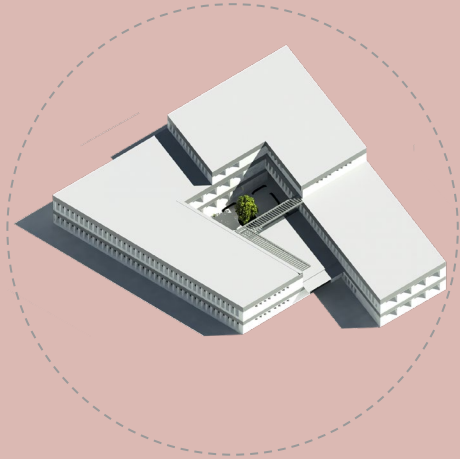
CENTRAL COURTYARD

Central shaded gathering space providing seating options oriented towards prevailing NE wind.



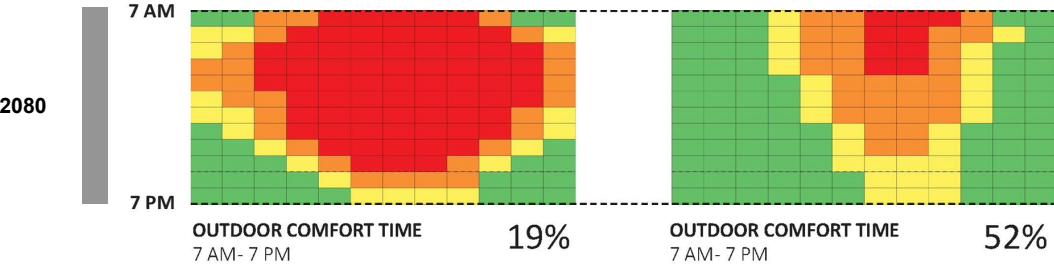
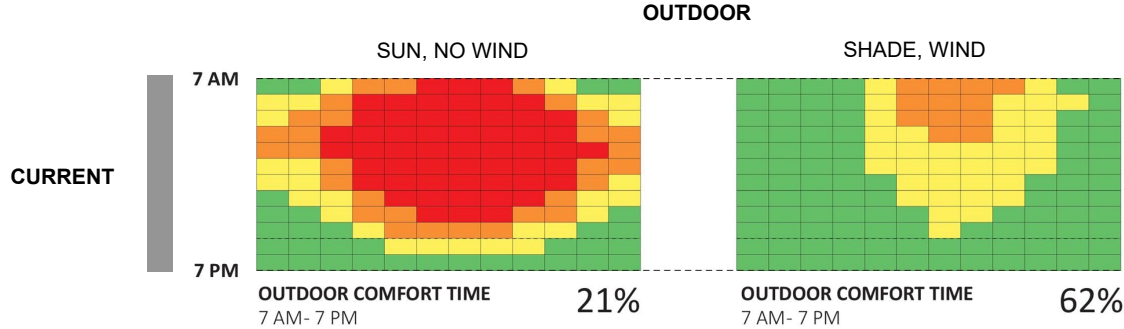
COURTYARD THERMAL COMFORT





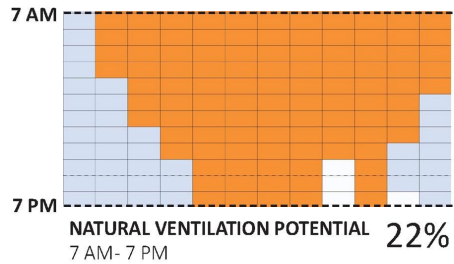
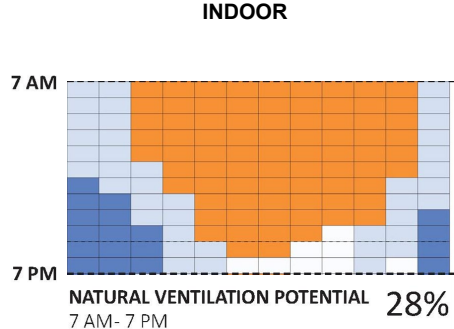
FUTURE CLIMATE

FUTURE CLIMATE SCENARIOS | CLIMATE



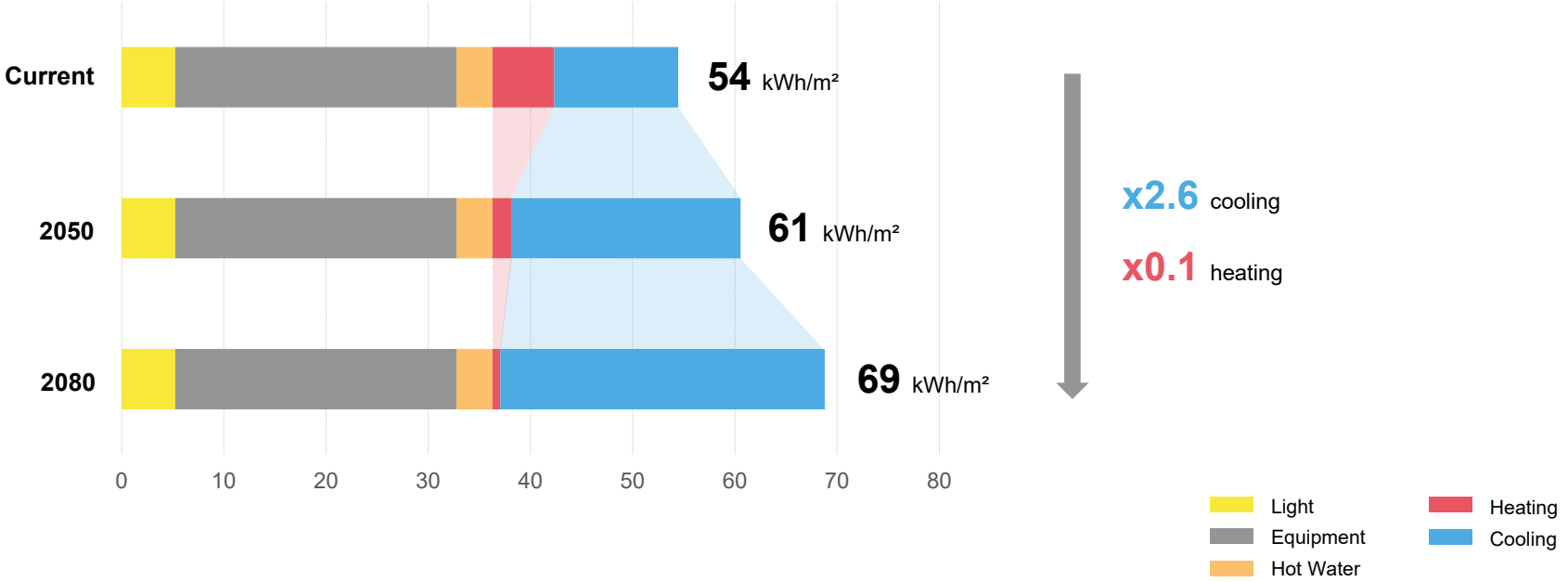
UTCI Temperature

- Serious Heat Risks > 38°C
- Moderate Overheating 32°C < UTCI < 38°C
- Slight Overheating 26°C < UTCI < 32°C
- Comfort 9°C < UTCI < 26°C



- Potential for Natural Ventilation
- Temperature > 30.5°C
- Temperature < 18.5°C
- Humidity > 80%

FUTURE CLIMATE SCENARIOS



CONCLUDING THOUGHTS

RESILIENCE AND ADAPTATION

Architecture

- **Envelope Improvements:** Roof Insulation
- **Solar Chimney:** exploring additional ventilation schemes

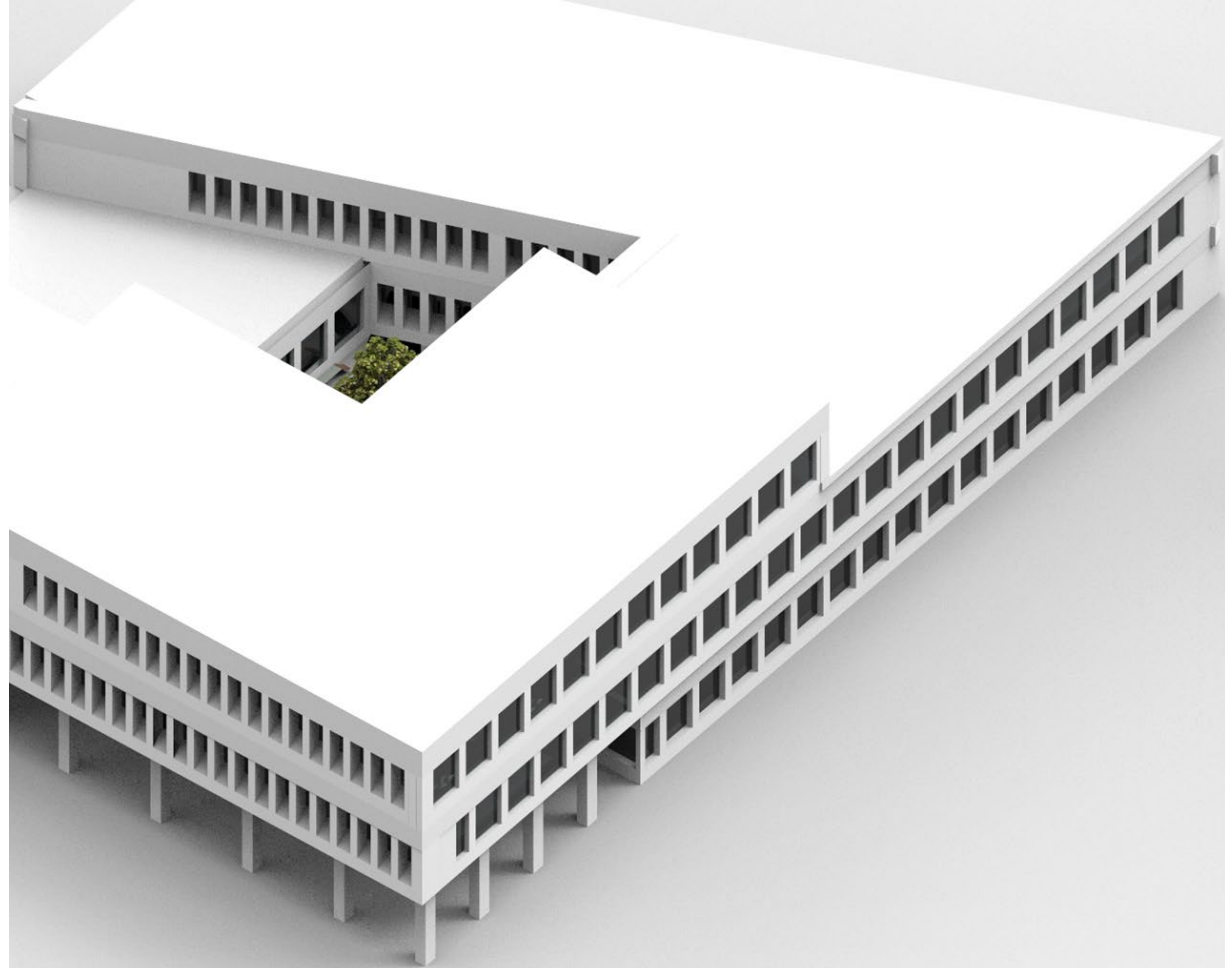
Systems

- **PV Generation:** 22% panel efficiency covers 98% of annual energy demand
- **MEP Systems:** Additional efficiency gains through technology advancements

Urban

- **District Cooling:** Potential for building clusters





THANK YOU