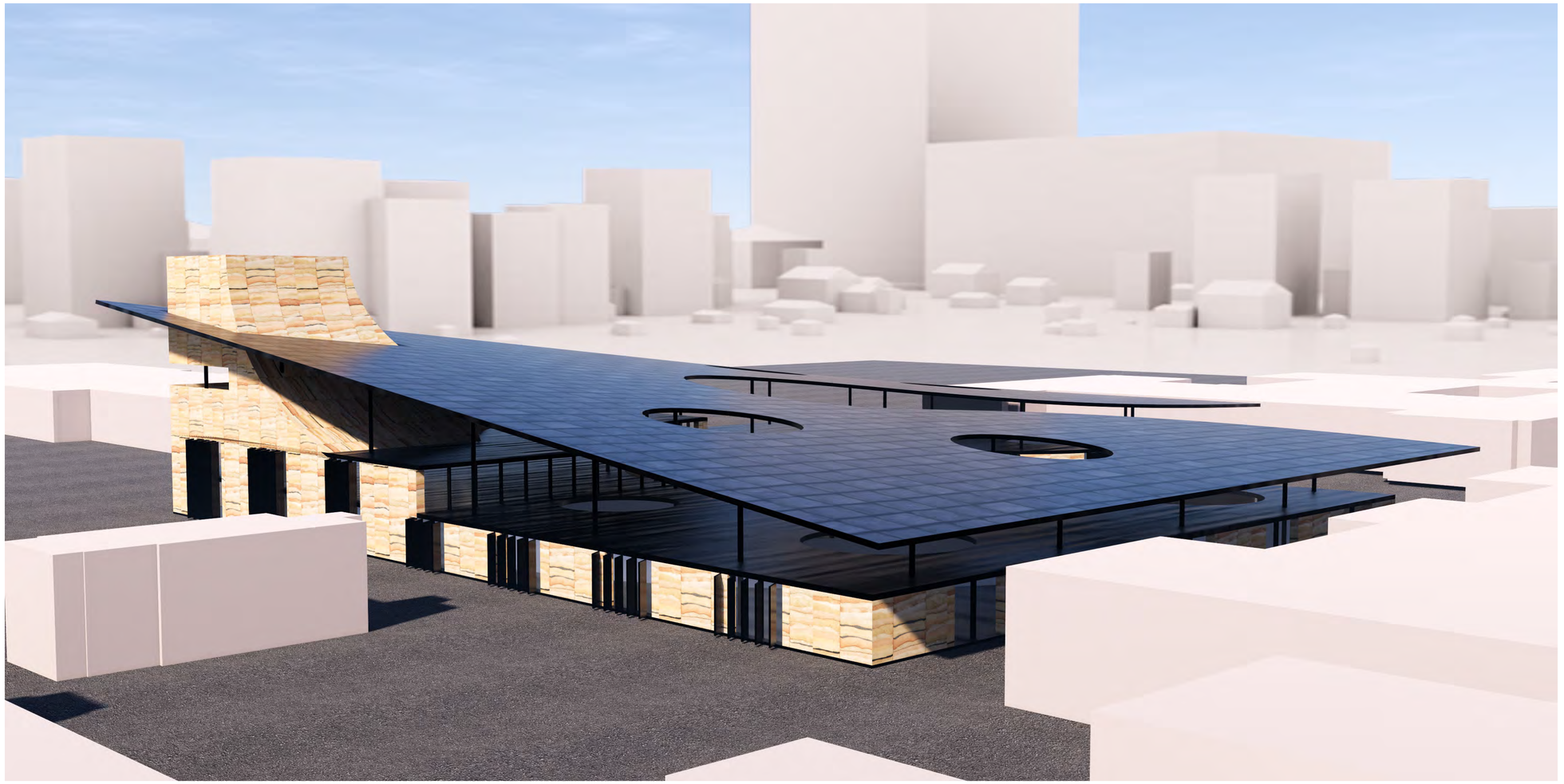
Building Technology

Tucson, Arizona

Junha and Vincent

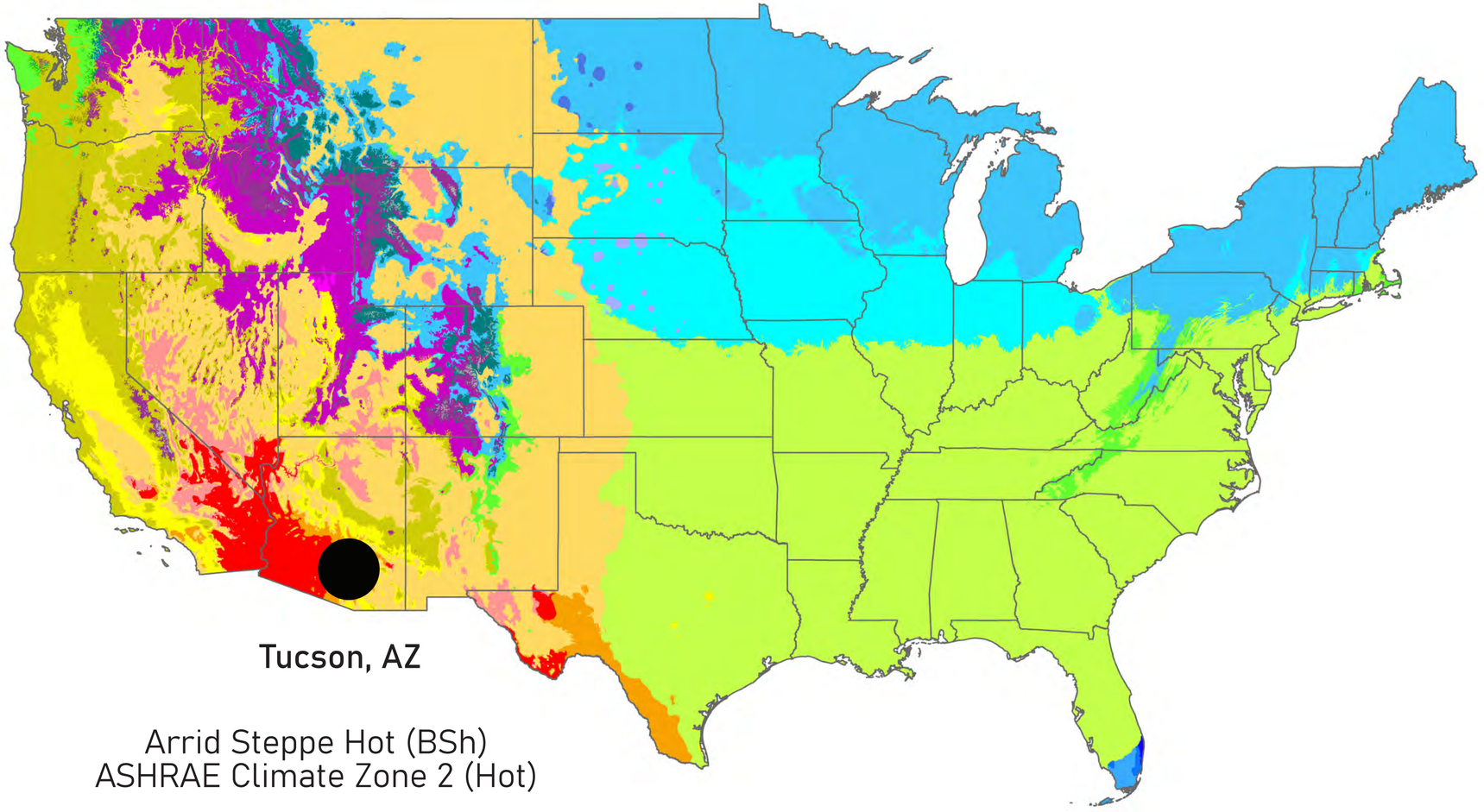
16/12/2022

Overall Design on Site



Location

Koppen Climate Map



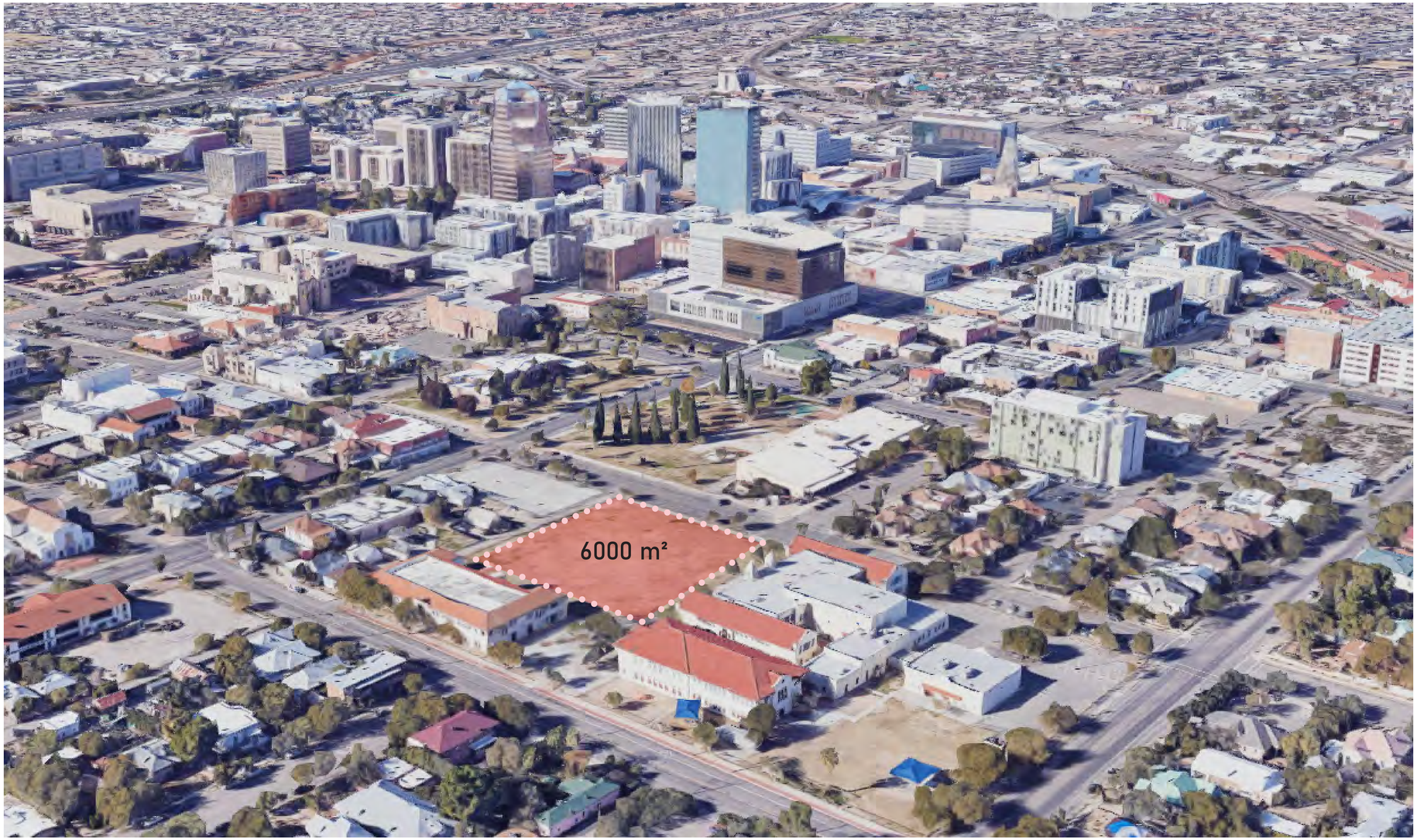
Tucson, AZ

Arrid Steppe Hot (BSh)
ASHRAE Climate Zone 2 (Hot)

Site Location

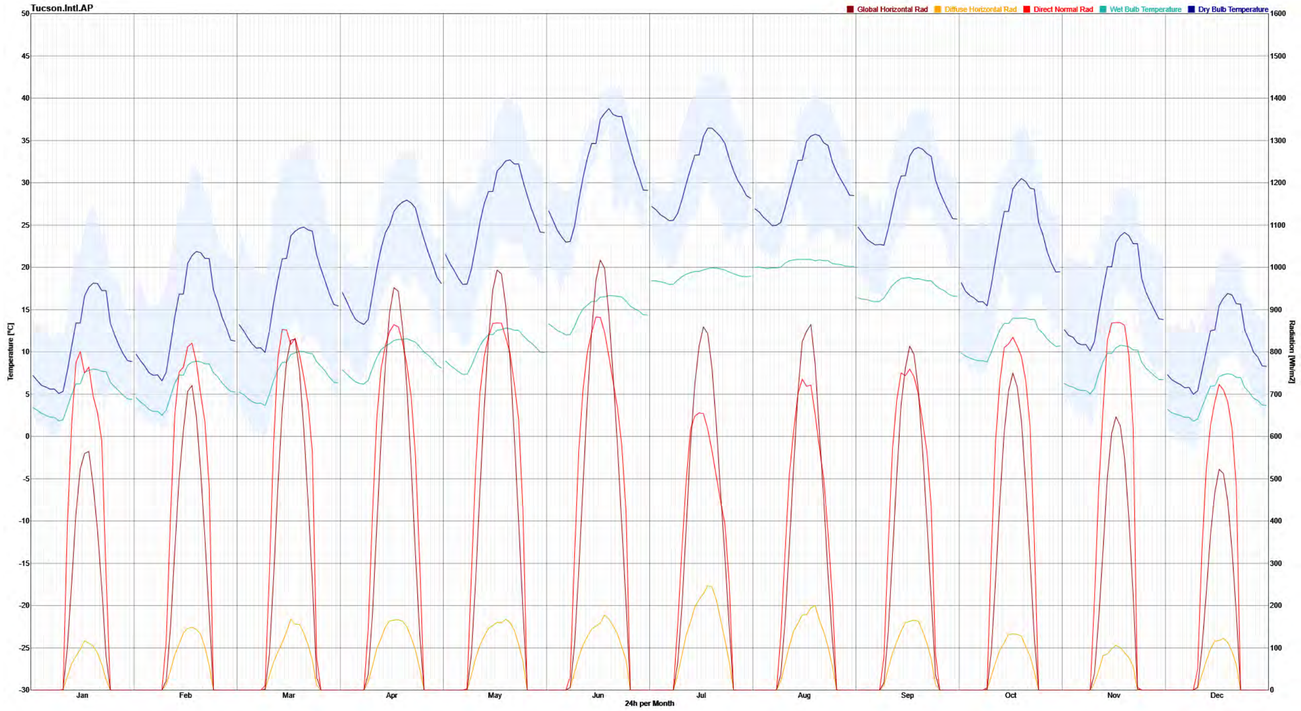
City Map

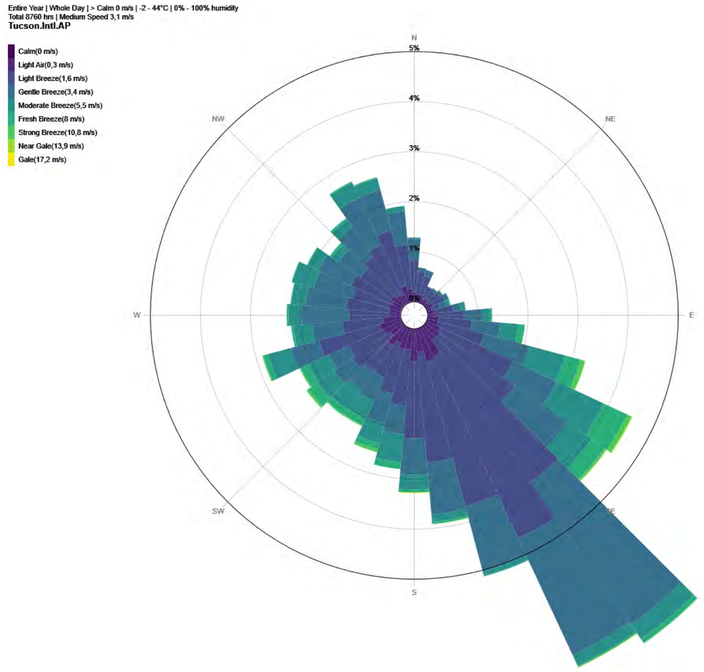
Downtown



Local Microclimate

Diaurnal Averages - Wind Rose

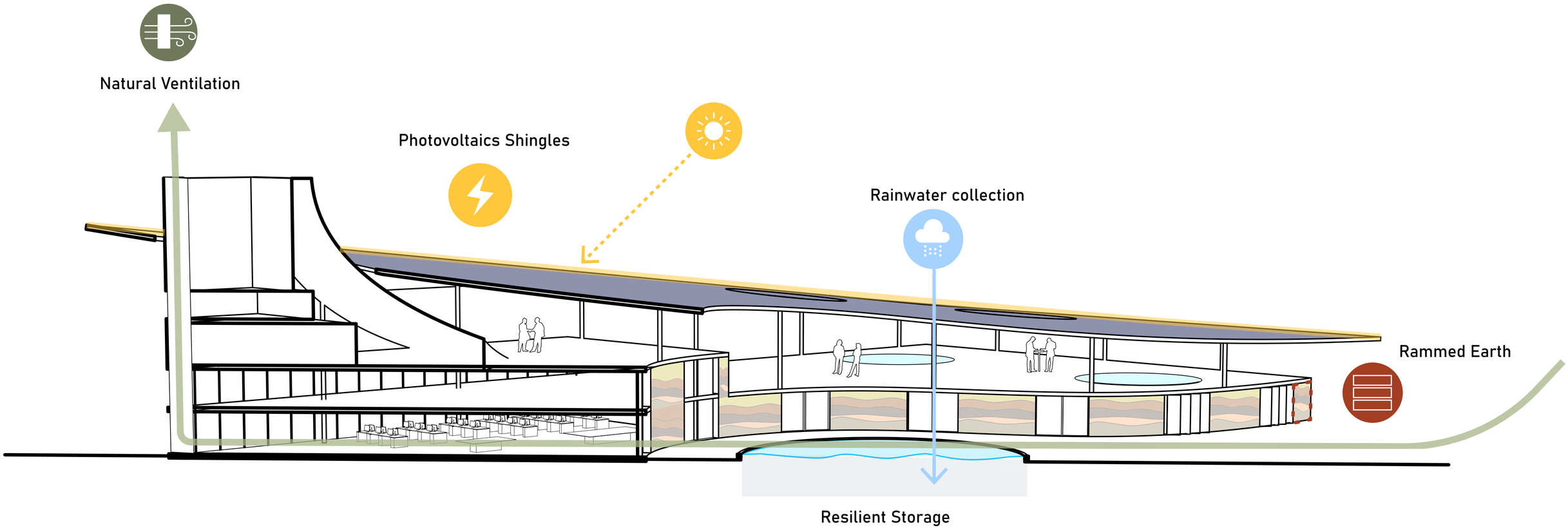




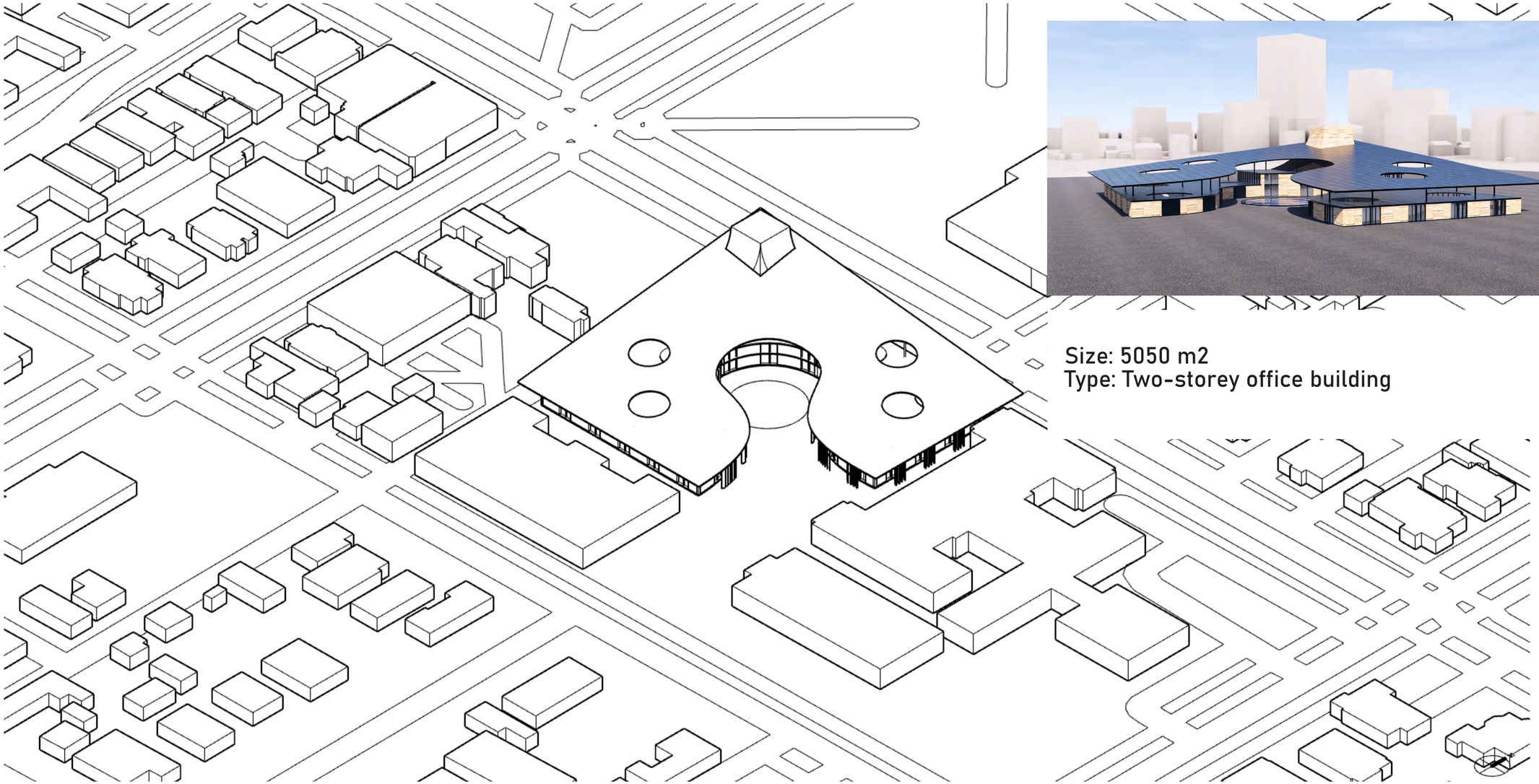
Significant Daily Temperature Swings (Delta T: 10 to 16°C)
Predominant SE Wind
Summer Monsoon
High Solar Radiation throughout the year

Design Principles

Environmental Concepts



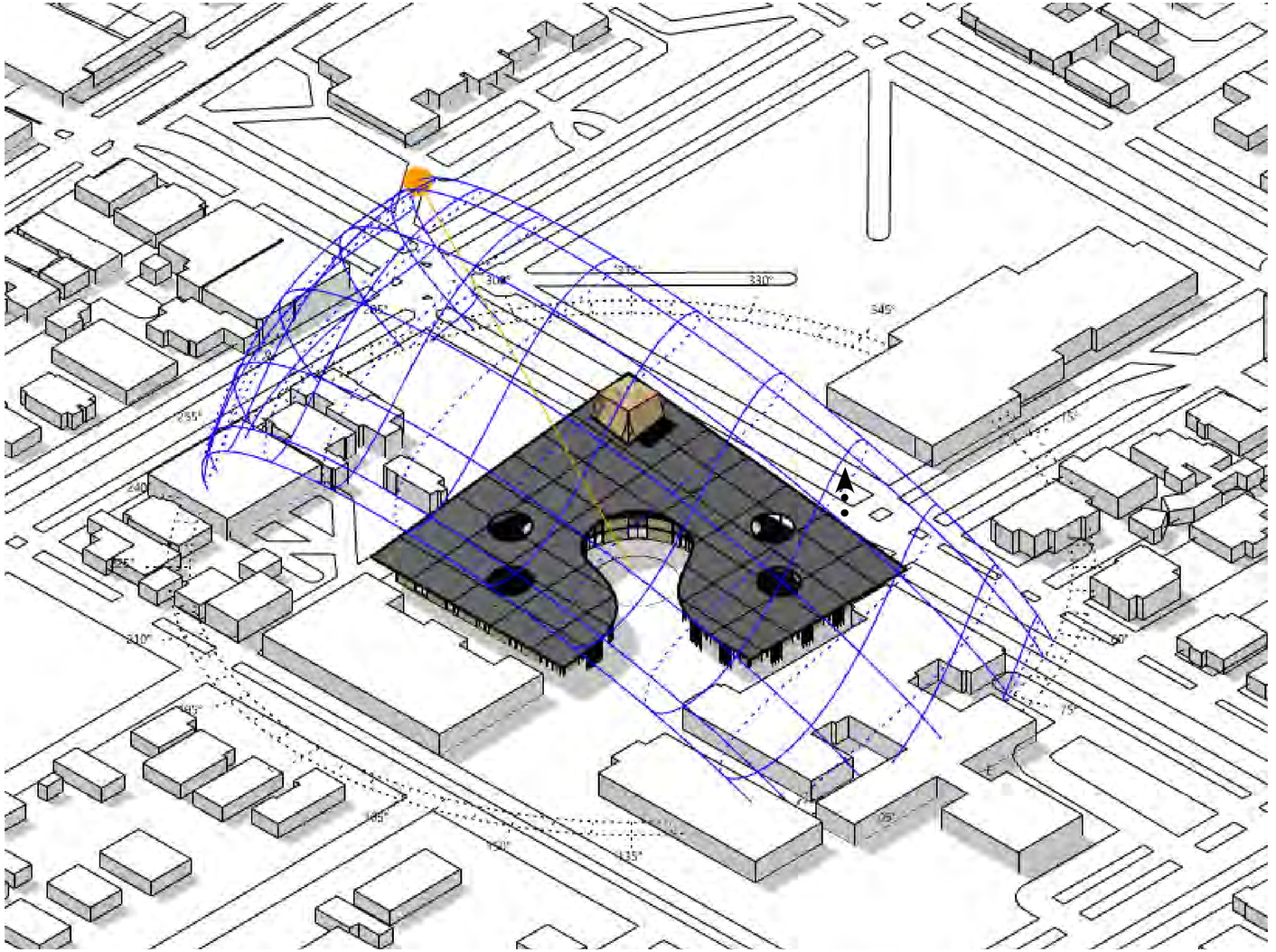
Overall Massing on Site



Size: 5050 m2
Type: Two-storey office building

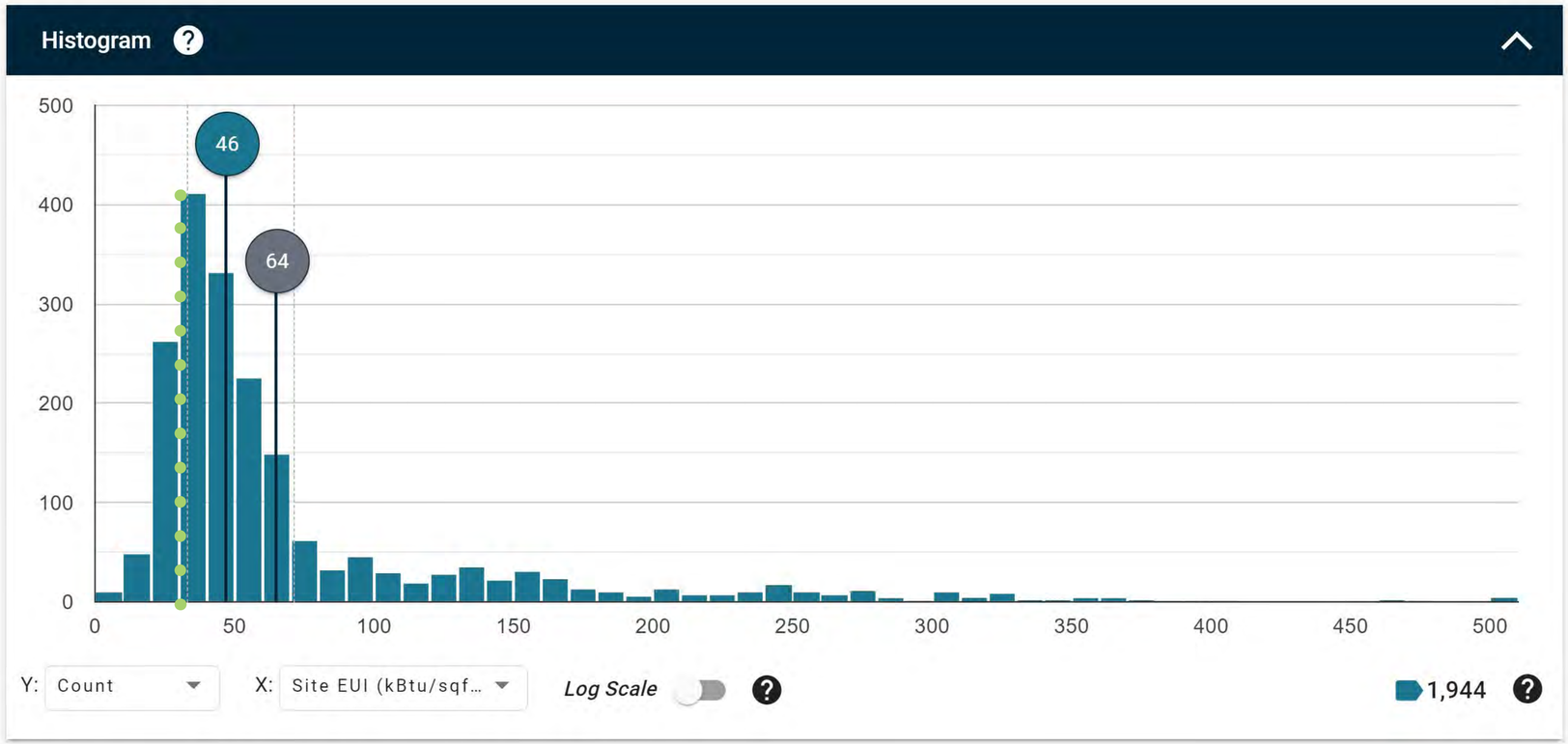
Shading Study

Massing Test - 5050 m²



Energy Target

EUI



EUI Goal

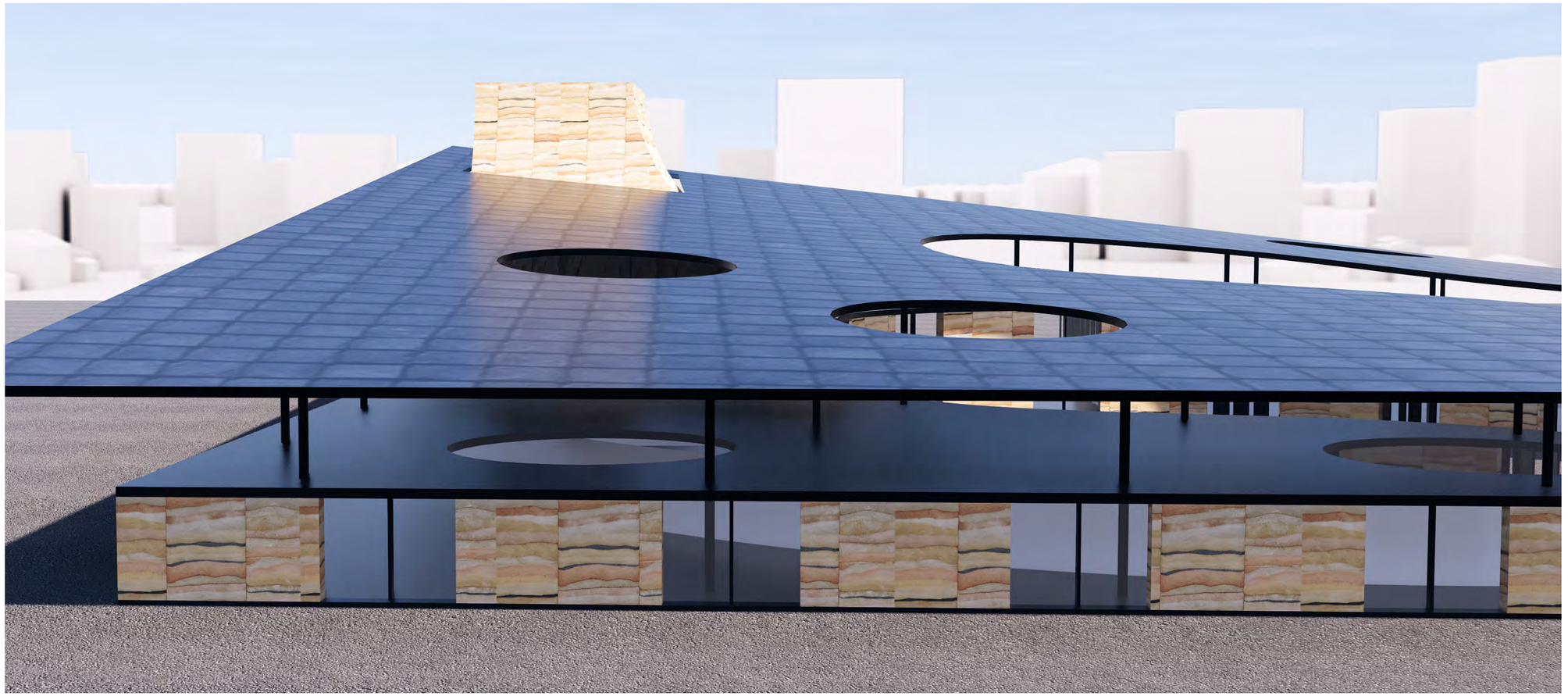
32 kBTU

100 kWh

200% Solar Energy Building

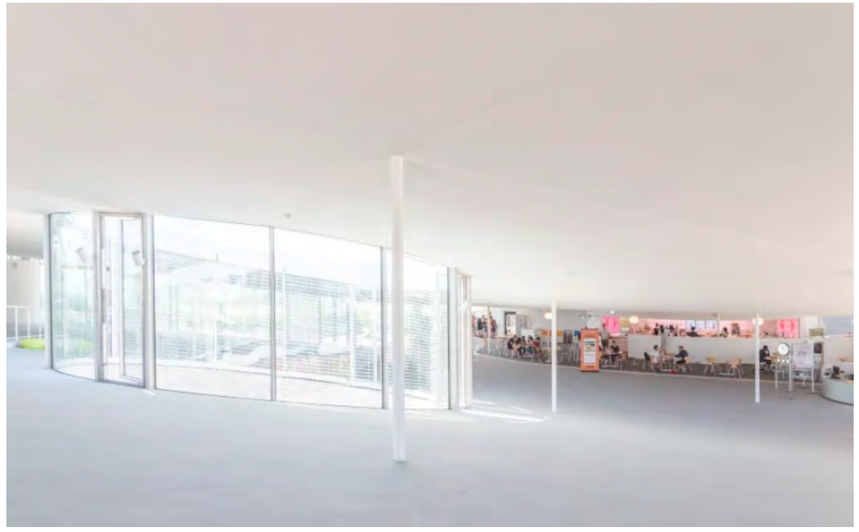
Daylight Concept

Central Curved Opening and Skylights



Daylight Precedents

Curved Opening, Light Wells, Elevation Change



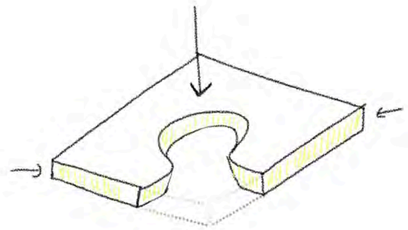
Rolex Center - SAANA - Lausanne

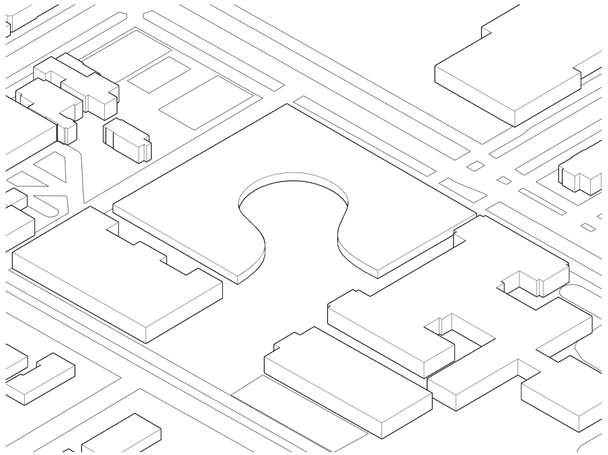
Kanagawa Institute of Technology - Ishigami

Daylight Massings

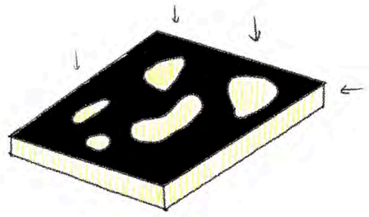
3 Concepts

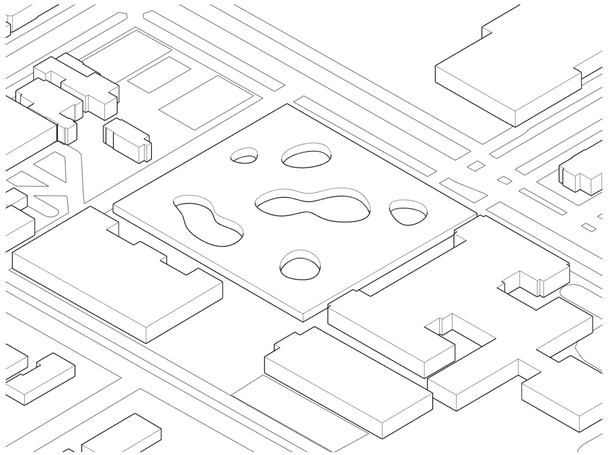
Option 01
Curved Opening



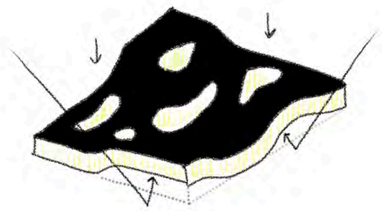


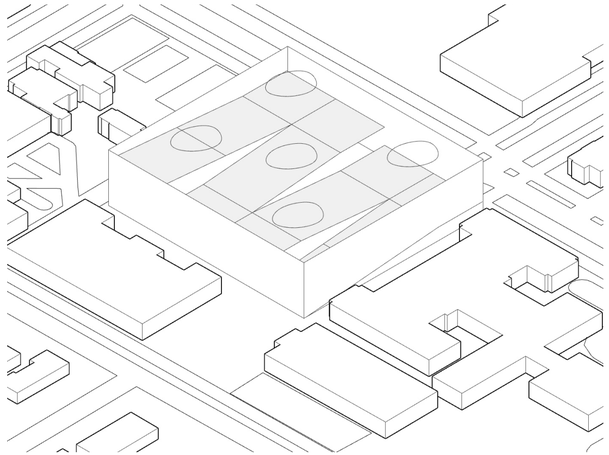
Option 02
Courtyards





Option 03
Ramp + Skylights

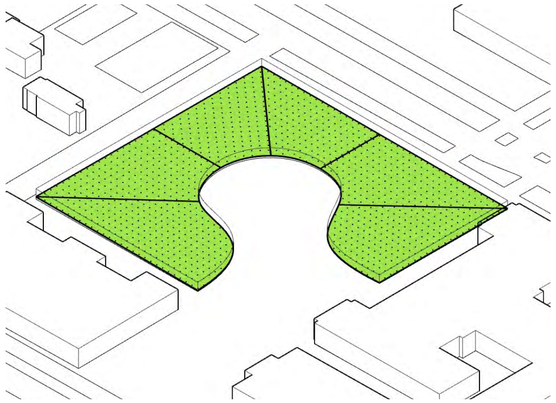




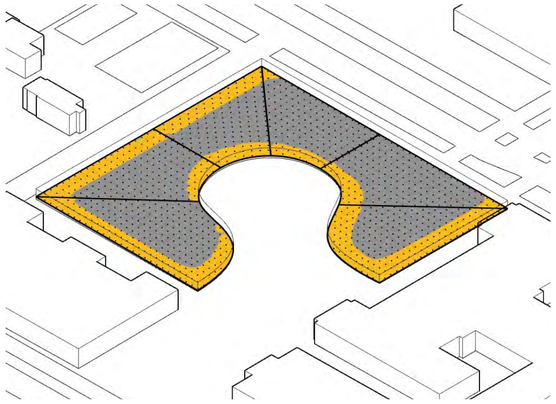
Daylight Massing Studies

Climate Studio Simulations

Option 01
Curved Opening

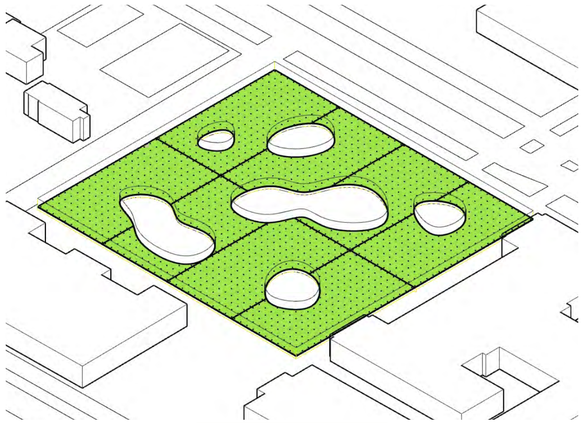


sDA = 100 %

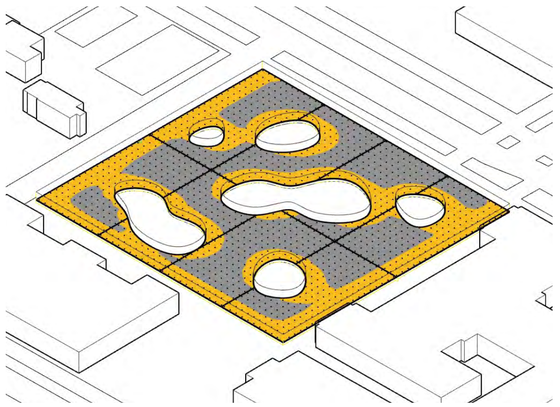


ASE = 33.1 %

Option 02
Courtyards

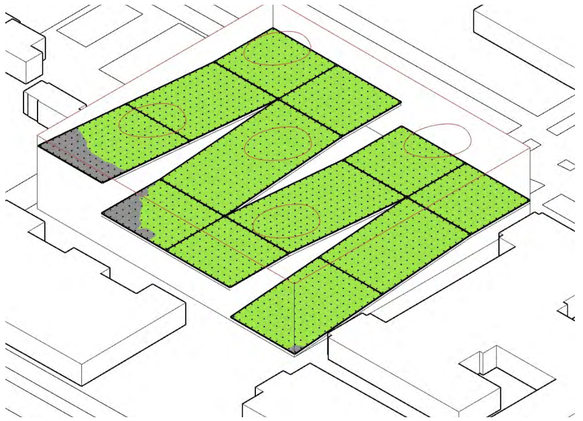


sDA = 99.9 %

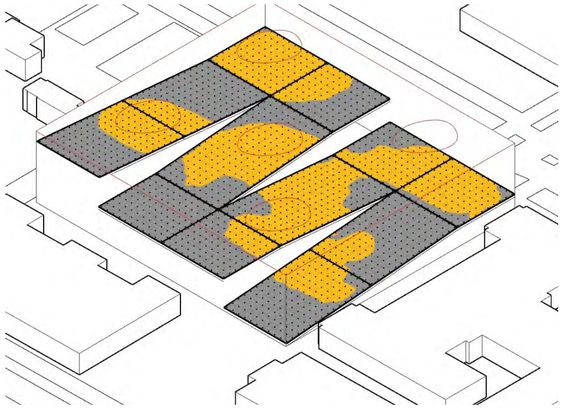


ASE = 46.6%

Option 03
Ramp + Skylights



sDA = 95.1%

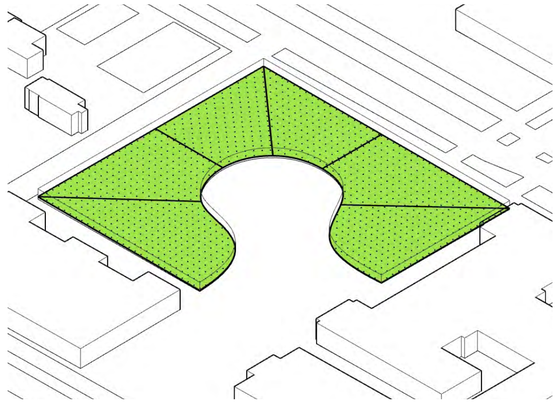


ASE = 48%

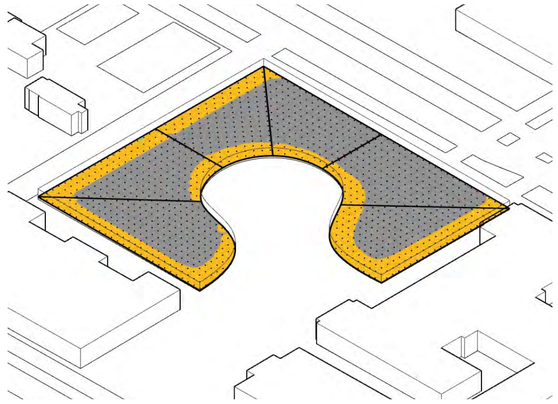
Daylight Massing Studies

Climate Studio Simulations

Option 01
Curved Opening

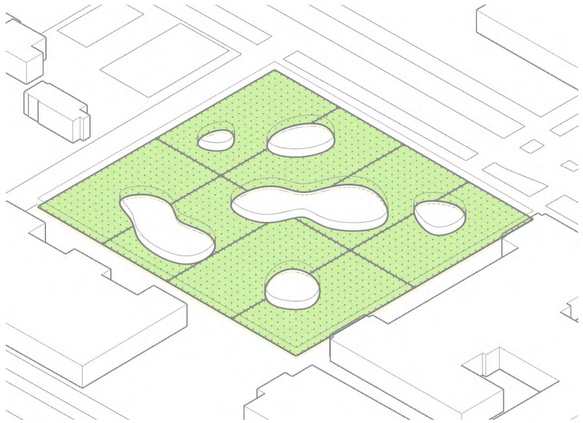


sDA = 100 %

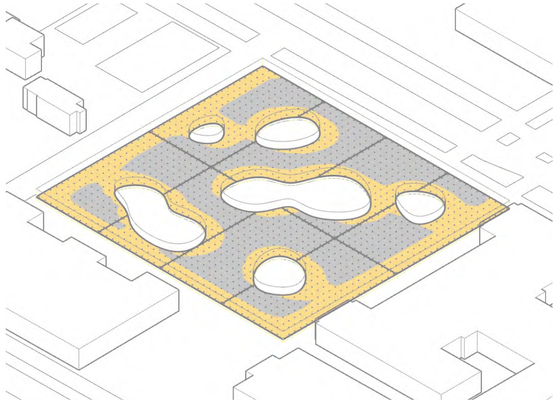


ASE = 33.1 %

Option 02
Courtyards

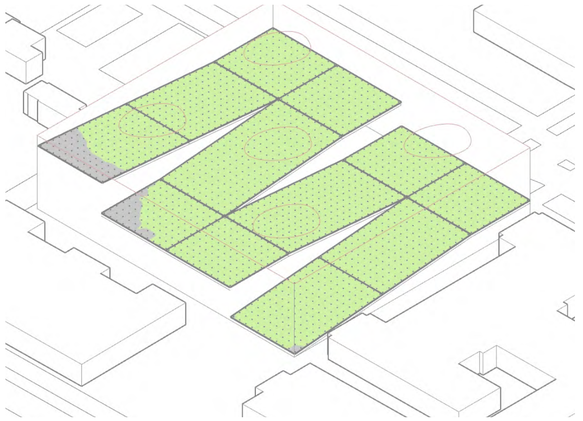


sDA = 99.9 %

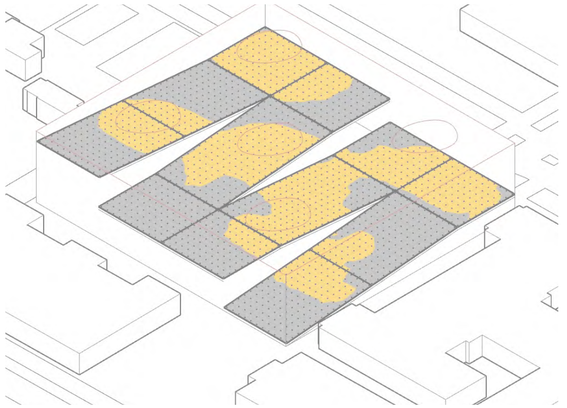


ASE = 46.6%

Option 03
Ramp + Skylights



sDA = 95.1%



ASE = 48%

Facades & Shading Systems

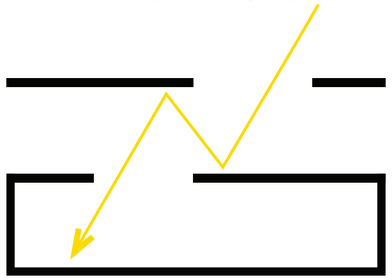
Overhang Roof, Skylights, Louvers

Iteration 01

40% WWR

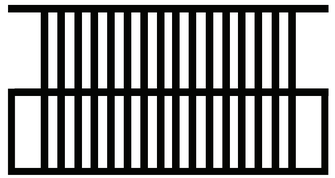
Iteration 02

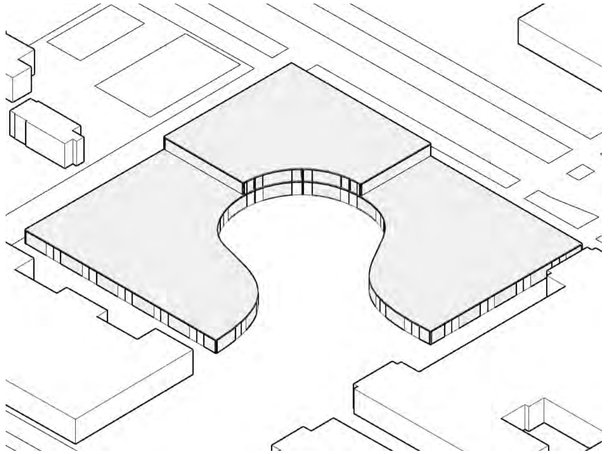
Overhang + Skylights

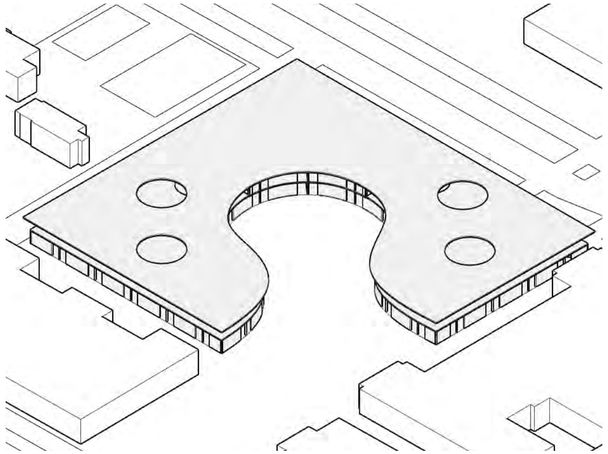


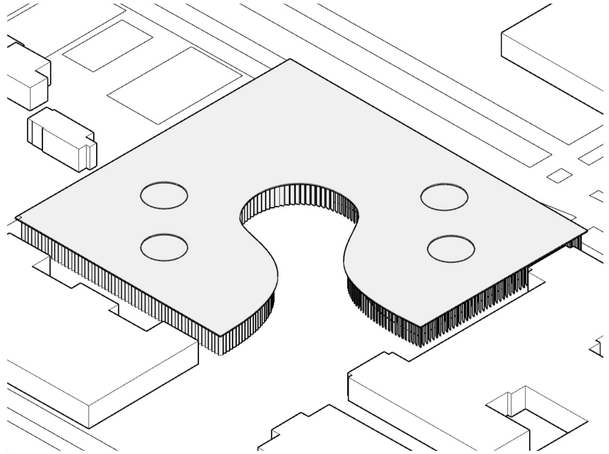
Iteration 03

Louvers





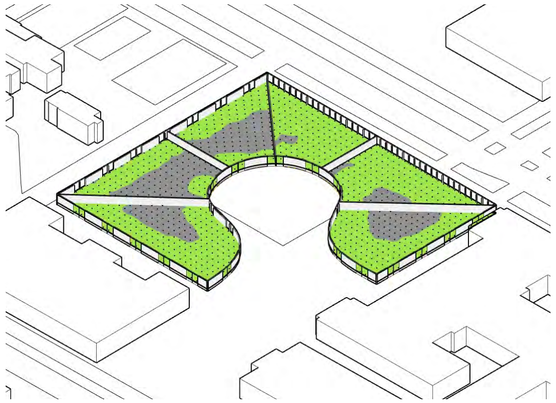




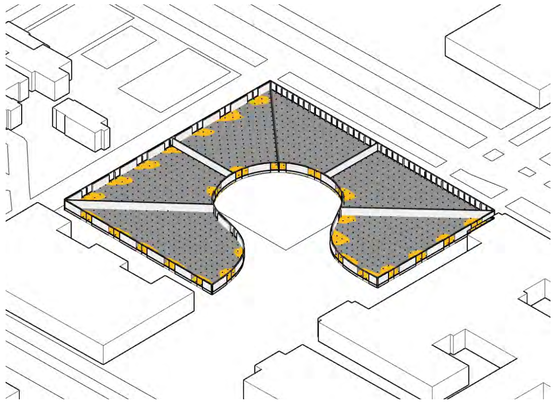
Facades & Shading Systems

Climate Studio Simulations

Iteration 01
40% WWR

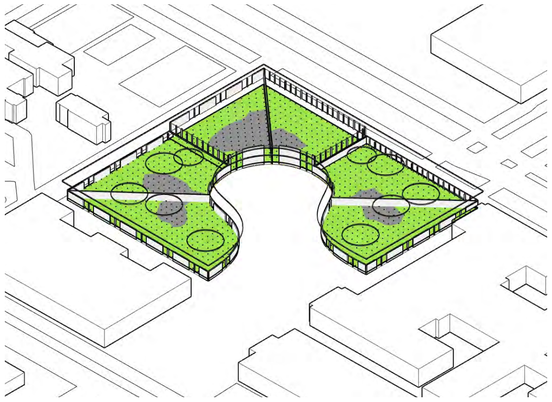


sDA = 72.1%

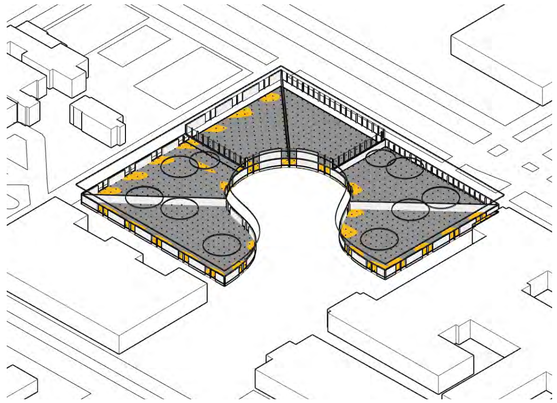


ASE = 12.3 %

Iteration 02
Overhang + Skylights

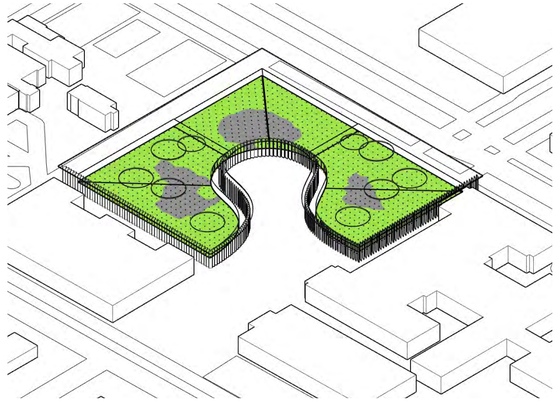


sDA = 84.0 %

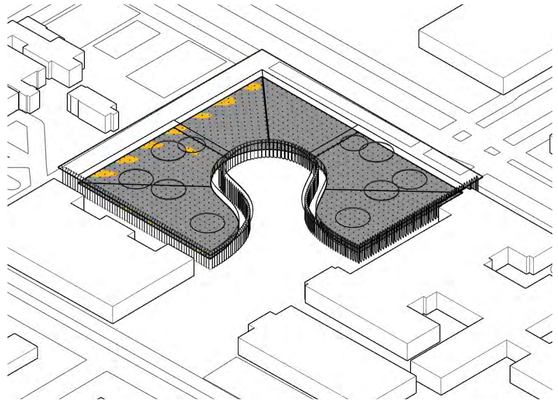


ASE = 12.0 %

Iteration 03
Louvers



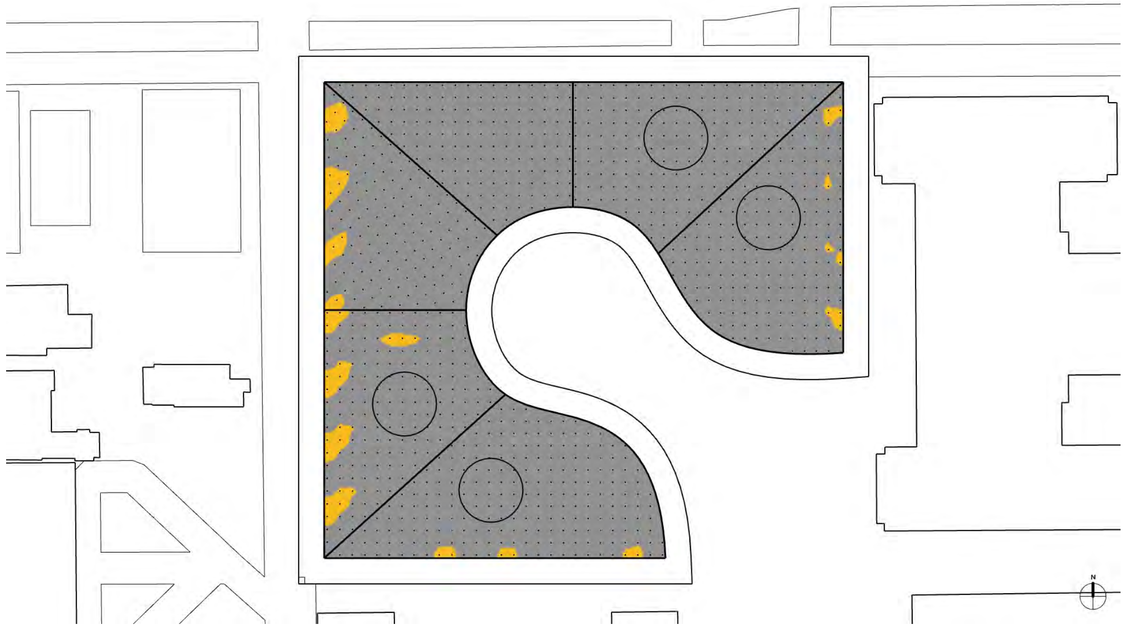
sDA = 81.6 %



ASE = 4.6 %

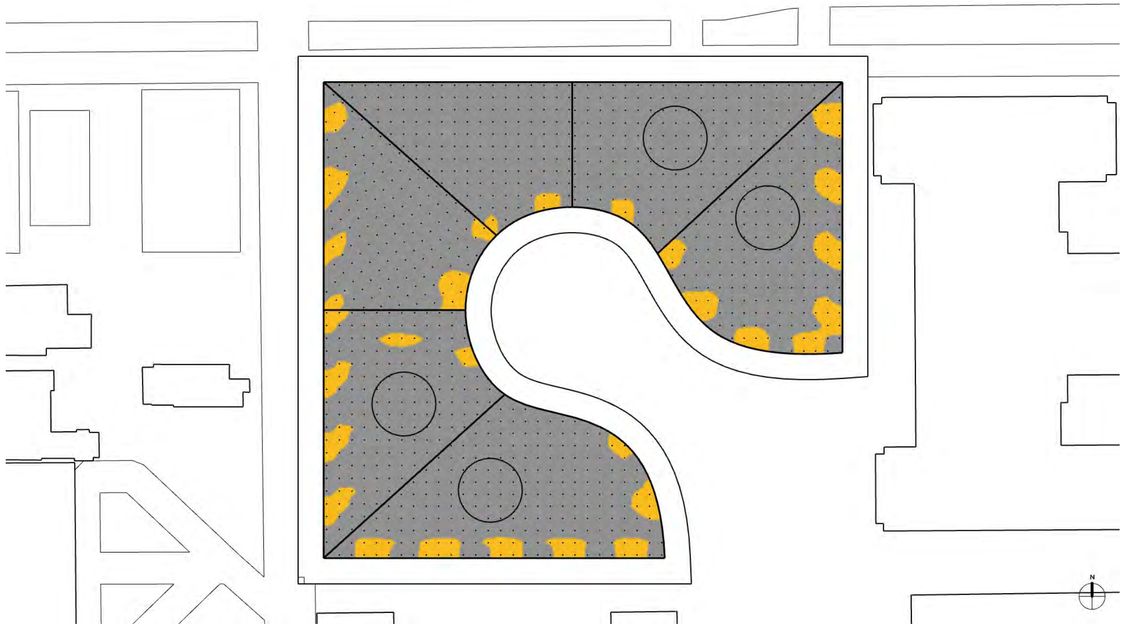
Louvers

ON/OFF



Louvers ON

ASE = 4.6 %



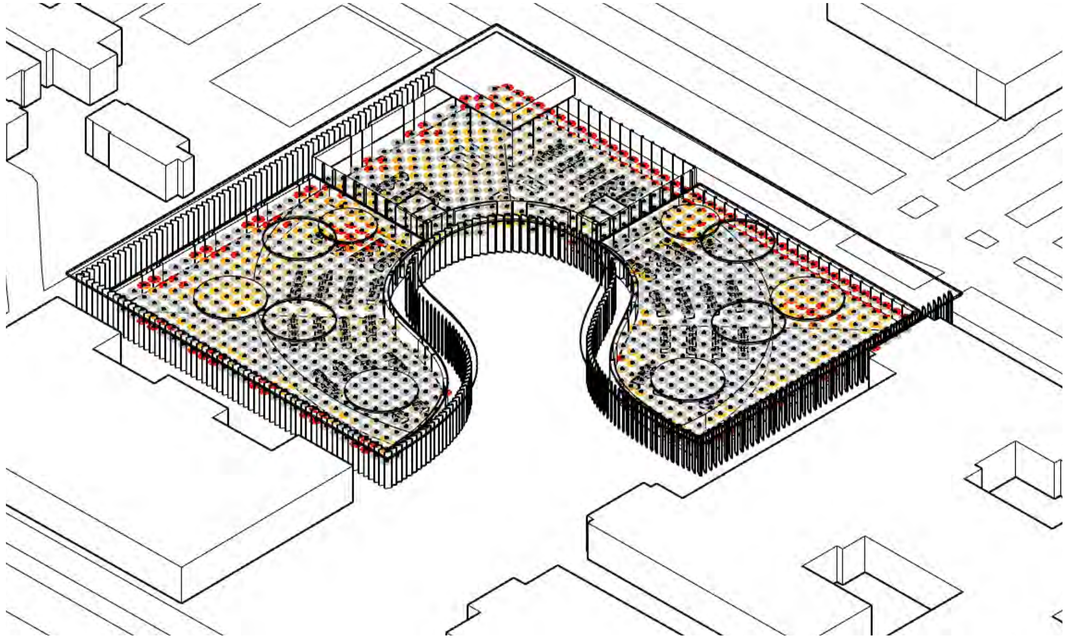
Louvers OFF

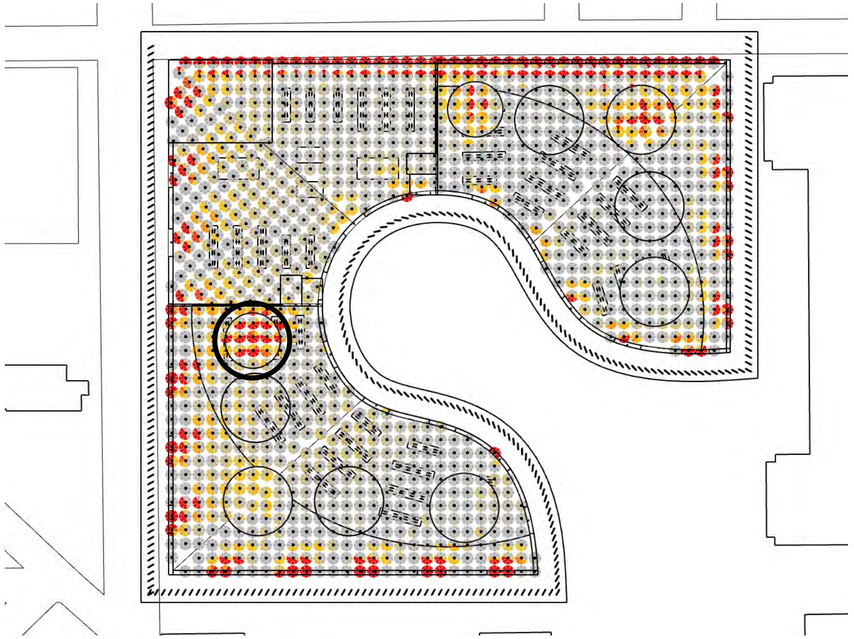
ASE = 12.0 %

Glare Analysis

Improved Massing

sDG = 7.8%



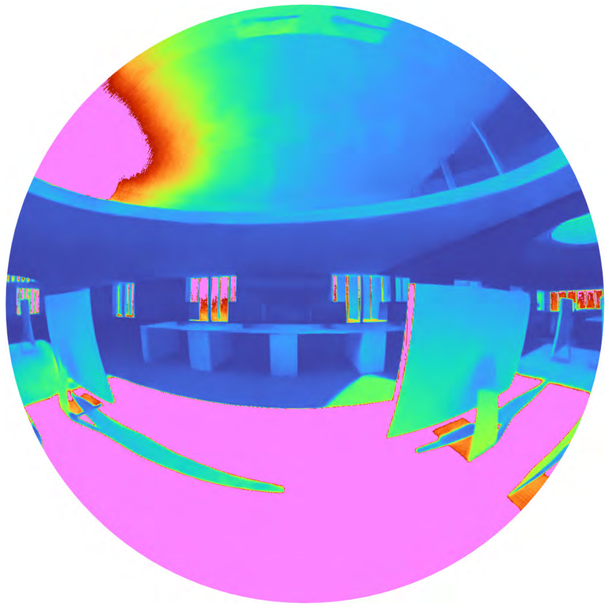


Glare Analysis

Visual Comfort Comparison

Sept 10 Midday 12:00

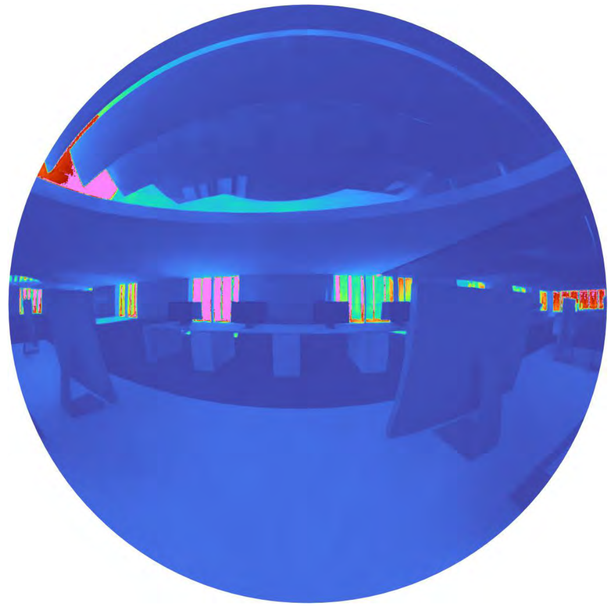
sDG = 7.4%



No shading on the skylight

Intolerable Glare

Ev = 4,566 lux, DGP = 0.74



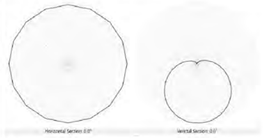
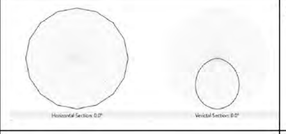
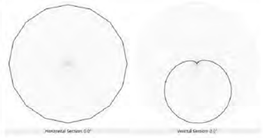
Shading on the skylight

Imperceptable Glare

Ev = 726 lux, DGP = 0.27

Electric Lighting

Layout & LPD

Type and wattage	Perspective	Luminance intensity distribution	Watt age	Location
Linear Suspended Strip Diffuse Lens 8' 103W 10240 lm			103W	Office Wings (Zone 1)
L27600 AOK Series - LED Adjustable Vaportite (L27696-90W-AOK-S5 _90W50K)			90W	Central Office 1st floor (Zone 2)
Circular Downlight 8-inch 85W 5830 lm			85W	Corridors/Circulation Areas (Zone 3)
Linear Suspended Strip Diffuse Lens 8' 103W 10240 lm			103W	Lounge (Zone 4)

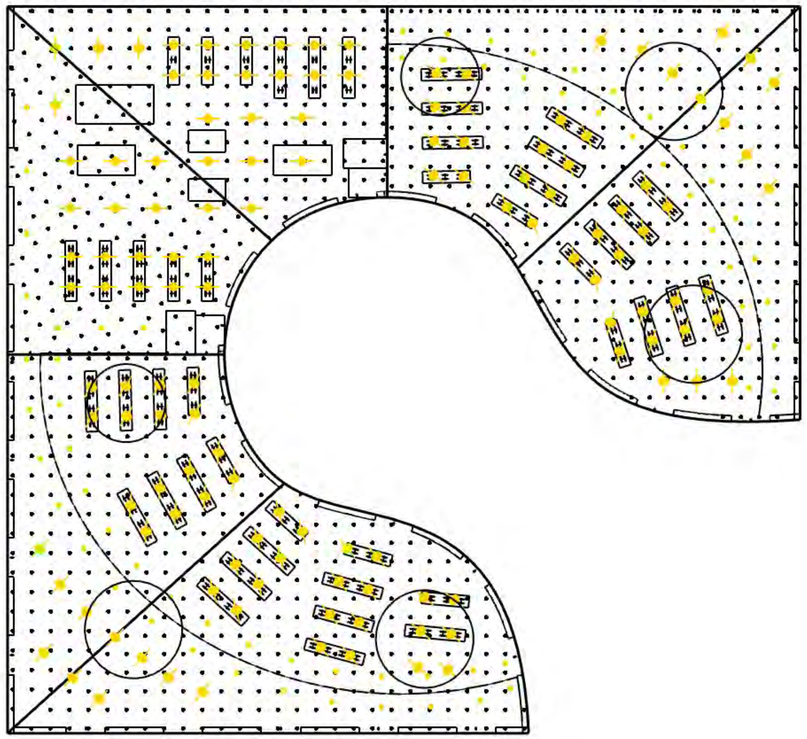
Zone 01: 74 x 103W
Zone 02: 40 x 90W
Zone 03: 64 x 85W
Zone 04: 20x 103W

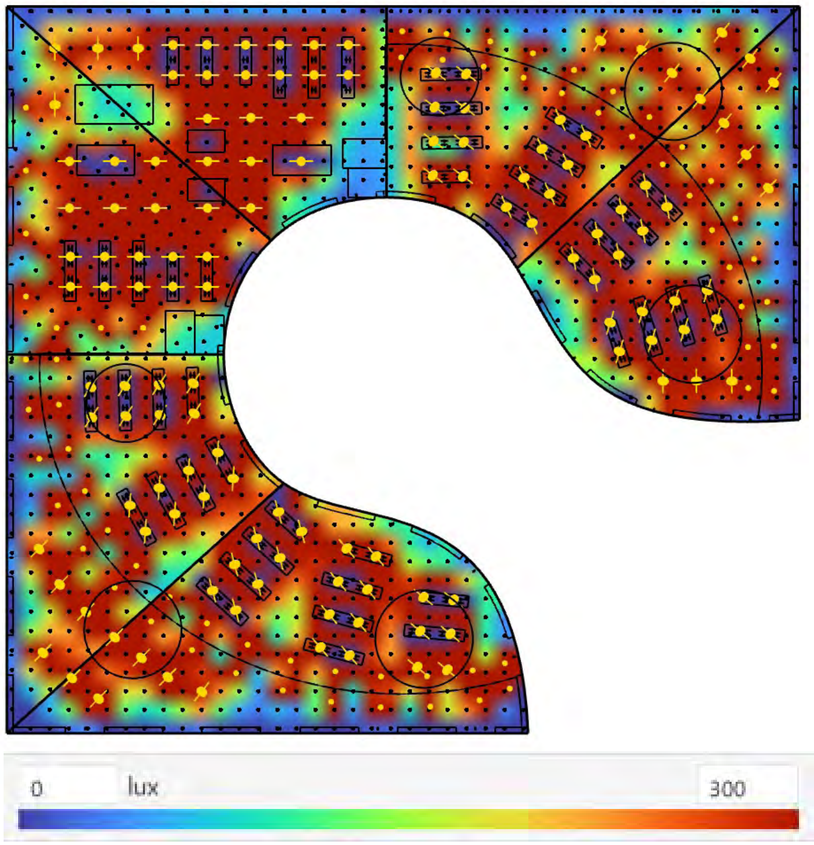
LPD for our building: (74x103 + (40x90)x2 + 64x85 + 20x103) W / 5310 m^2 = 4,2 W/ m^2

4,2 W/ m^2

Point-in-time Illuminance

Sept 10 Evening 19:00





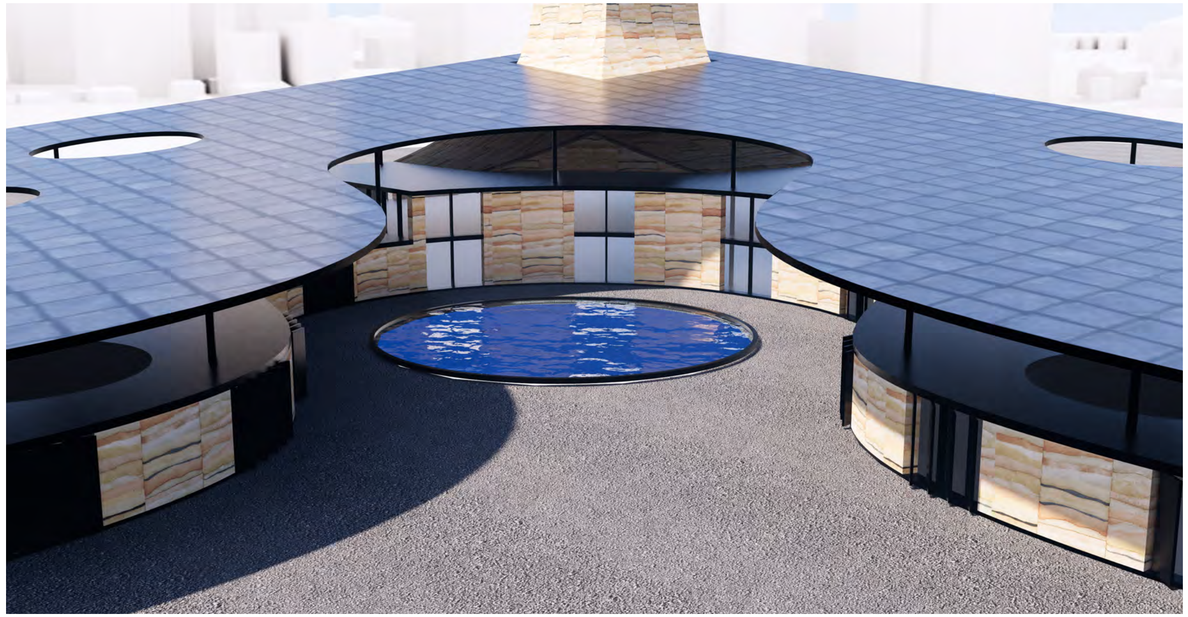
mean lux = 310

median lux = 262

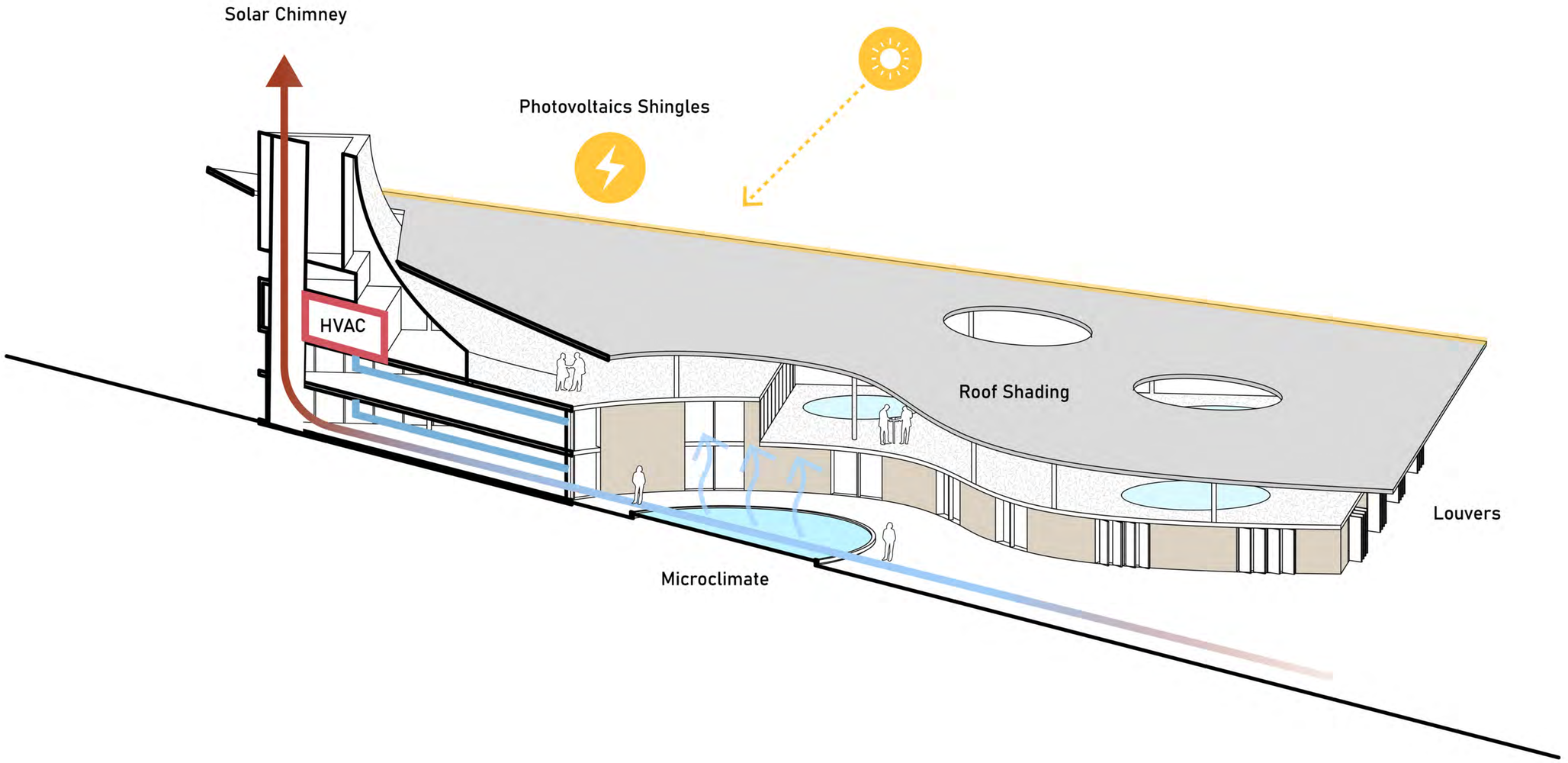
There are in total of 198 lighting specs distributed across the large floor plan, which seems a lot. While the floor plan seems well artificially lit, further optimization could look at alternative distributions and locations of the luminaires.

Inside Renders

Exterior Renders

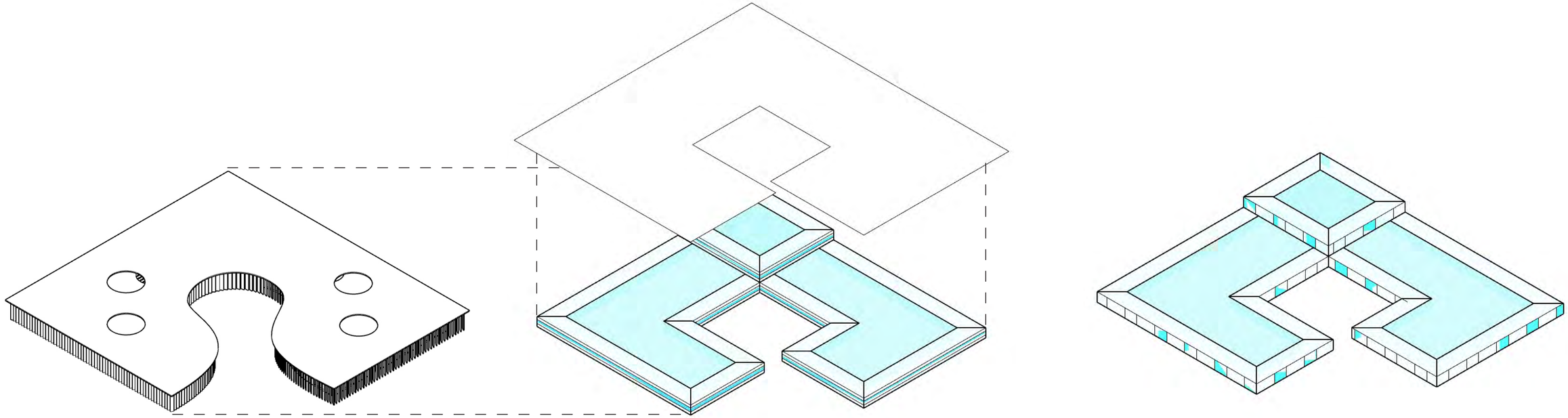


Energy Concept



Thermal Study

Zones - Baseline Design



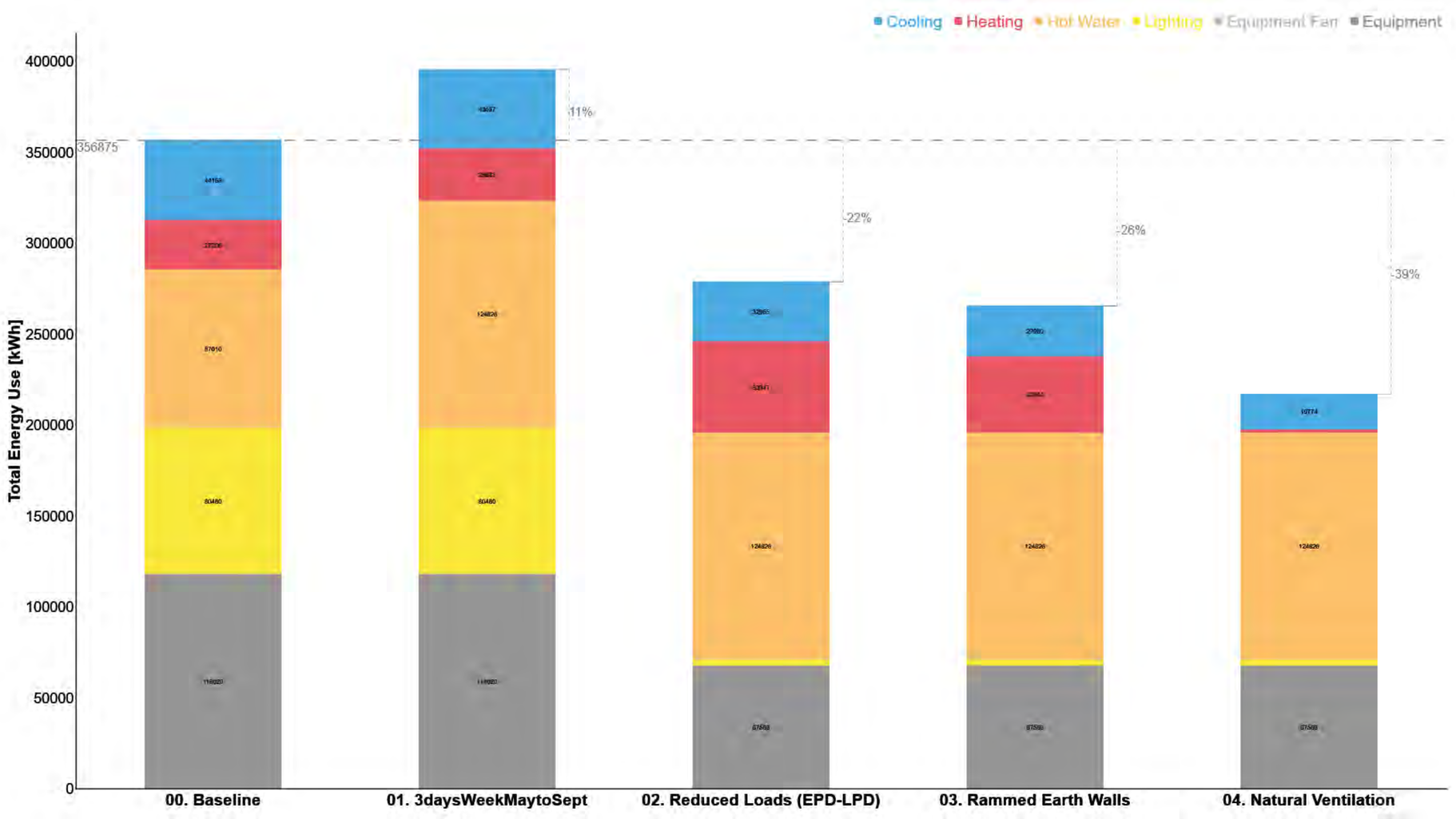
Goal

Site EUI = 154

Site EUI = 100

KWh/m^2

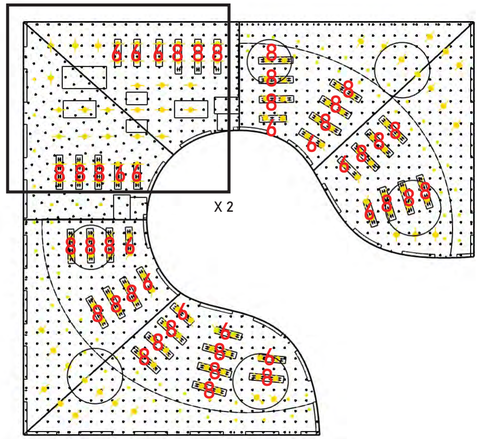
Key Iterations



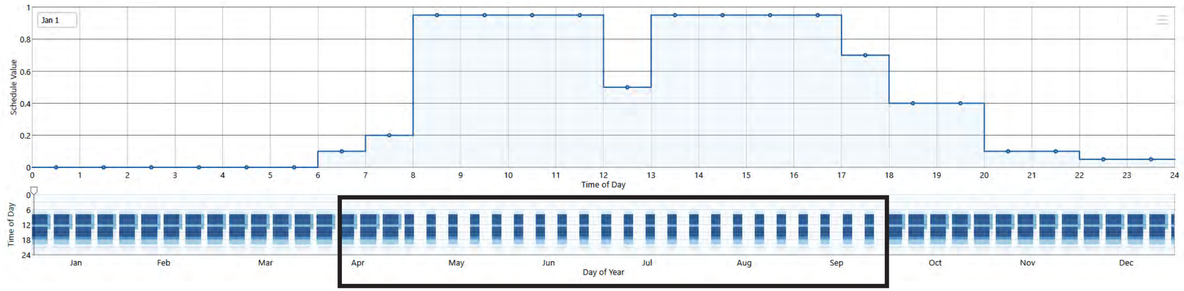
154 KWh/m^2 | 171 KWh/m^2 | 121 KWh/m^2 | 115 KWh/m^2 | 94 KWh/m^2

1. Occupancy

Upgrade Description



410 people / 5310 m^2 = 0.07721281 P/m^2



3days week for 5 months

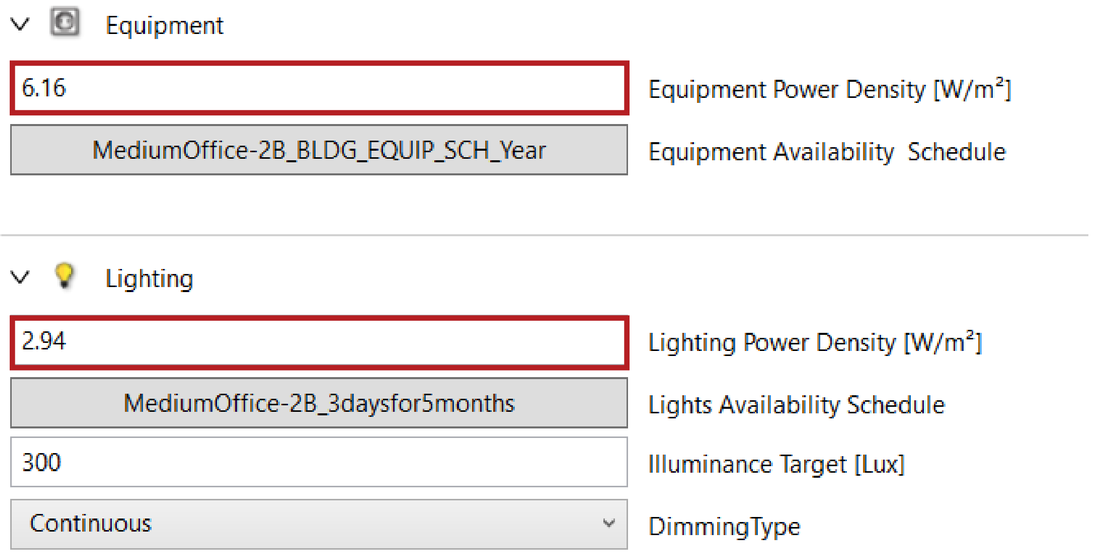
Upgrade Performance

Site EUI = 171

KWh/m^2

2. Reduced Loads

Upgrade Description



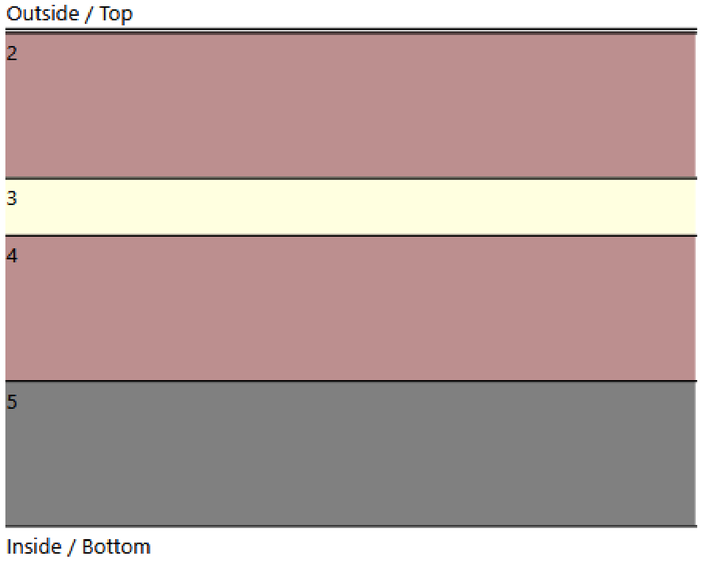
Upgrade Performance

Site EUI = 121

KWh/m²

3.Rammed Earth

Upgrade Description



MediumOffice-2B_RammedEarth

U-Value[W/(m²·K)] = 0.329
R-Value[m²K/W] = 2.866
Thermal Capacitance[kJ/K/m²] = 1300.59
Embodied Energy[MJ/m²] = 64
Embodied Carbon[kgCO2/m²] = 22.935

Layers: (Outside - Inside)

1 - MediumOffice-2B_WOOD SIDING 0.01 [m]
2 - Rammed Earth 0.25 [m]
3 - Cork 0.1 [m]
4 - Rammed Earth 0.25 [m]
5 - defaultMat 0.25 [m]

Tucson Mountain Retreat by DUST

Tucson Vernacular Adobe Construction

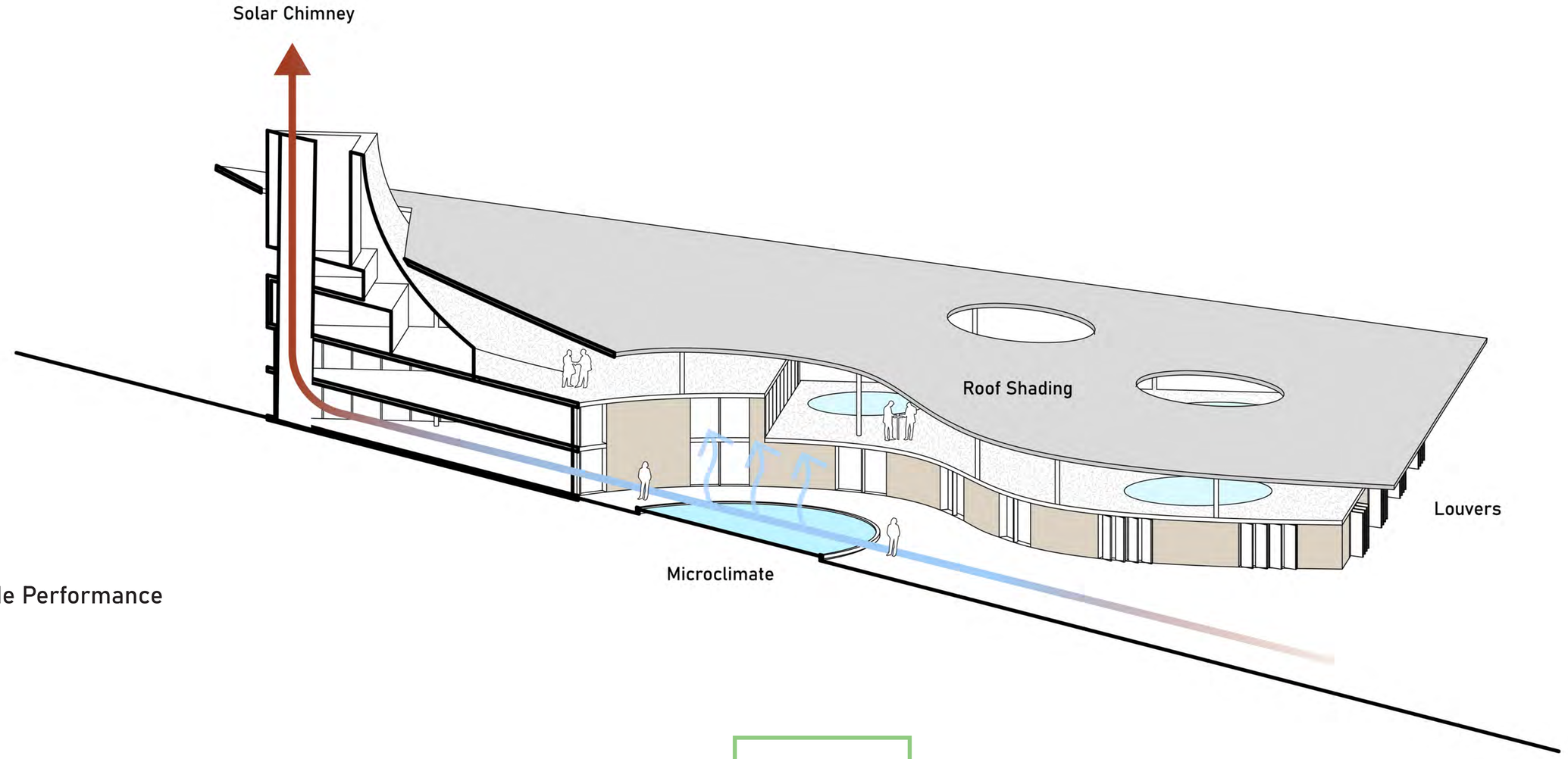
Upgrade Performance

Site EUI = 115

KWh/m²

4.Natural Ventilation

Upgrade Description



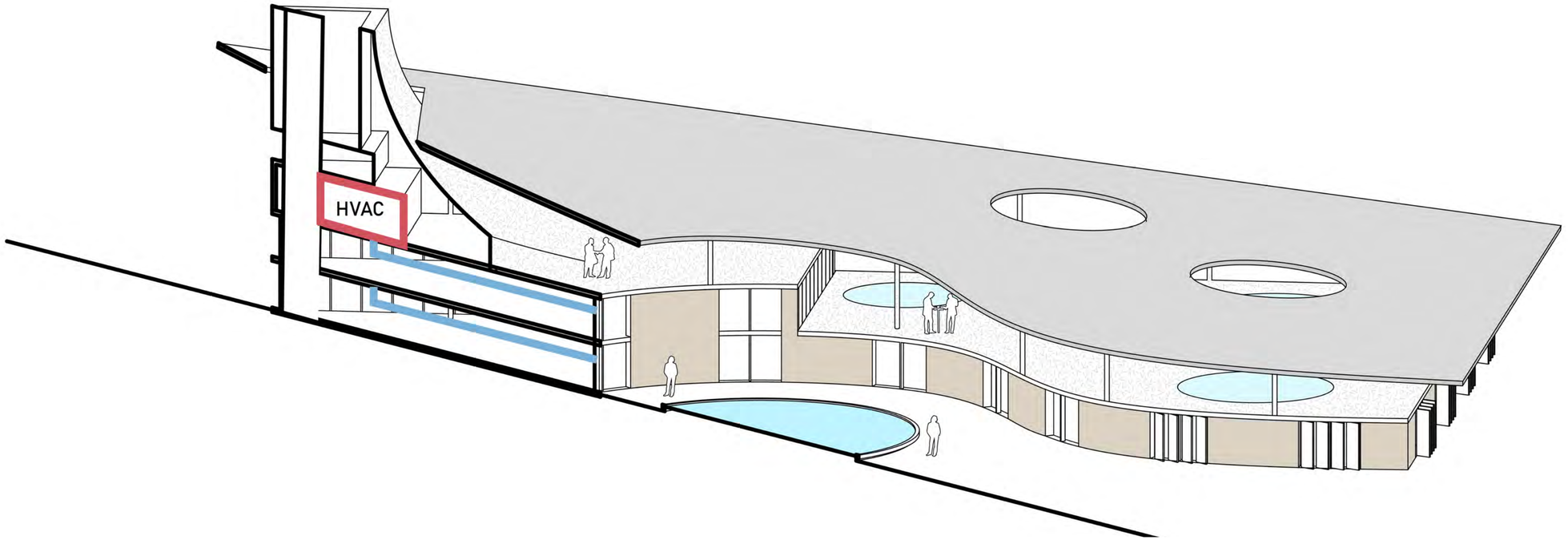
Upgrade Performance

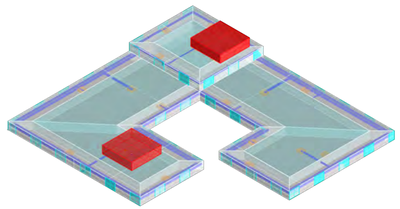
Site EUI = 94

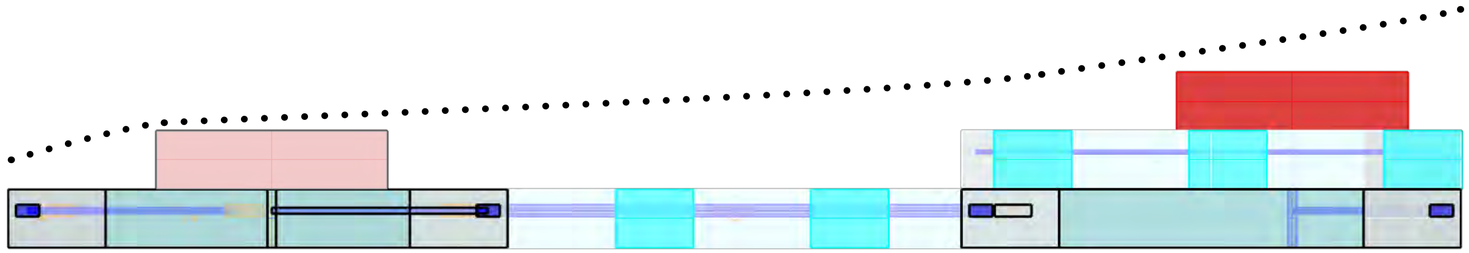
KWh/m^2

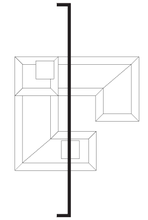
HVAC Design

VRF Overall Layout



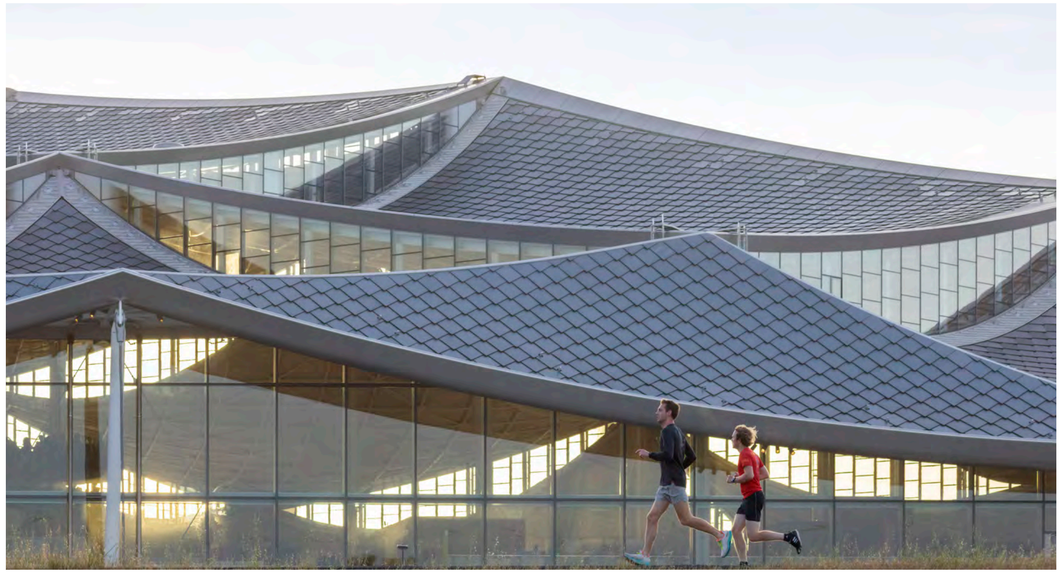




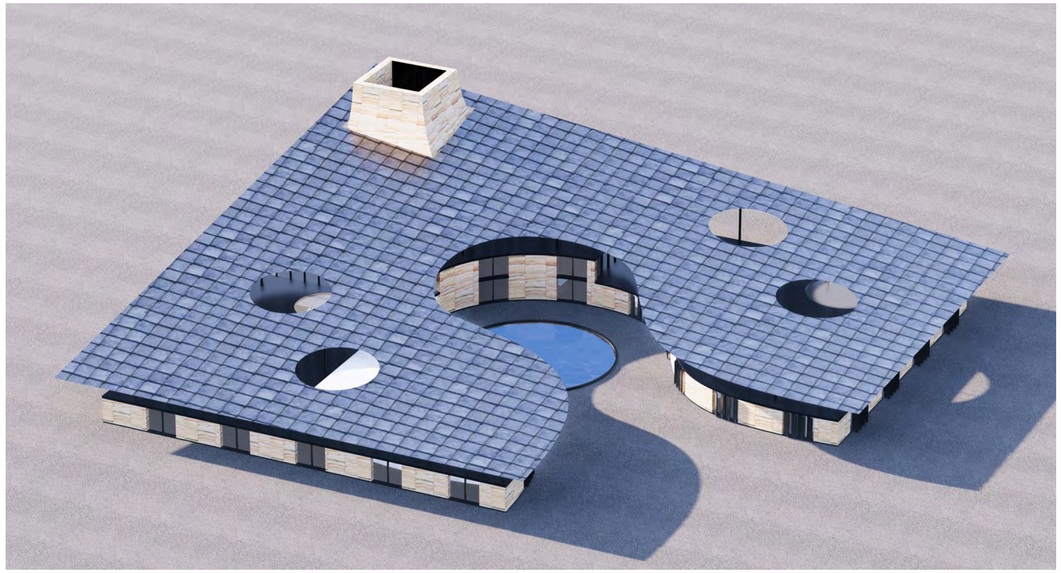


PV Design

Akuo Shingles

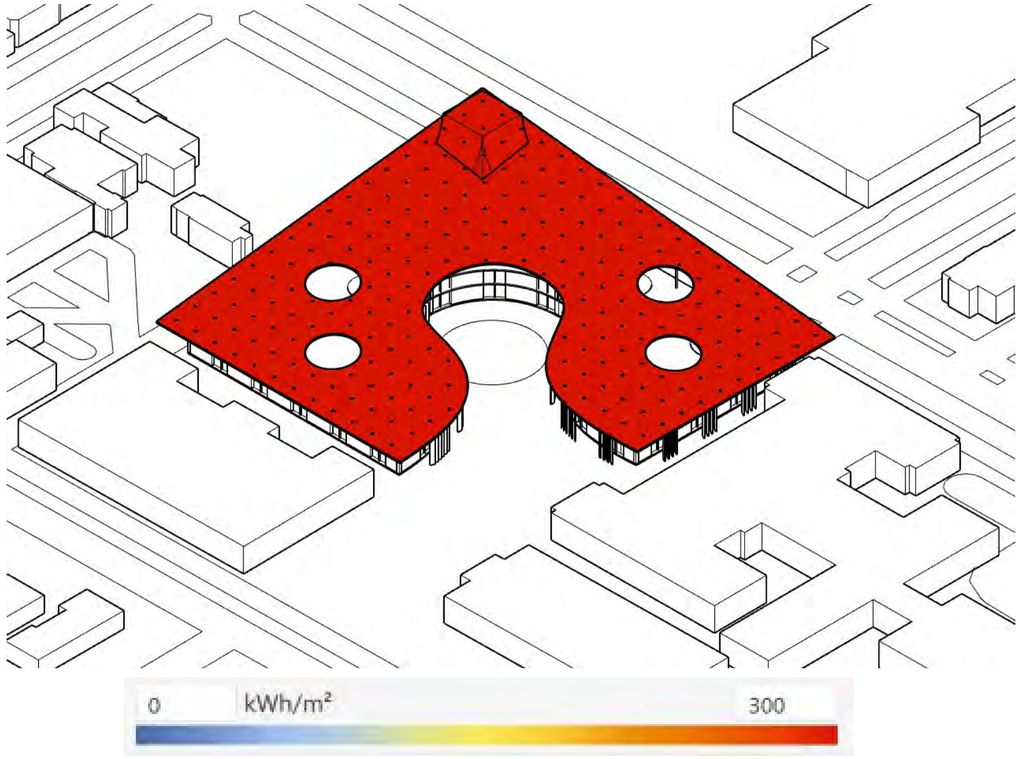


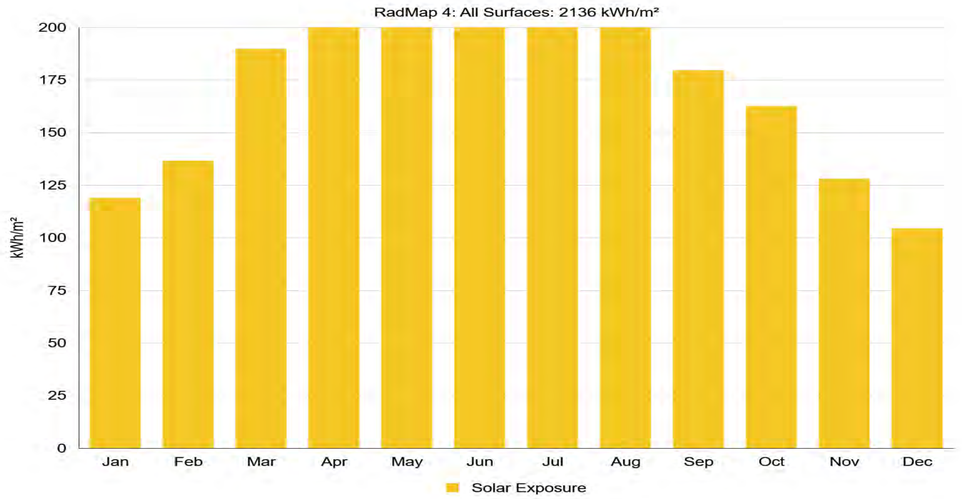
Google Mountain View HQ by BIG



Final Radiation

Yearly Results

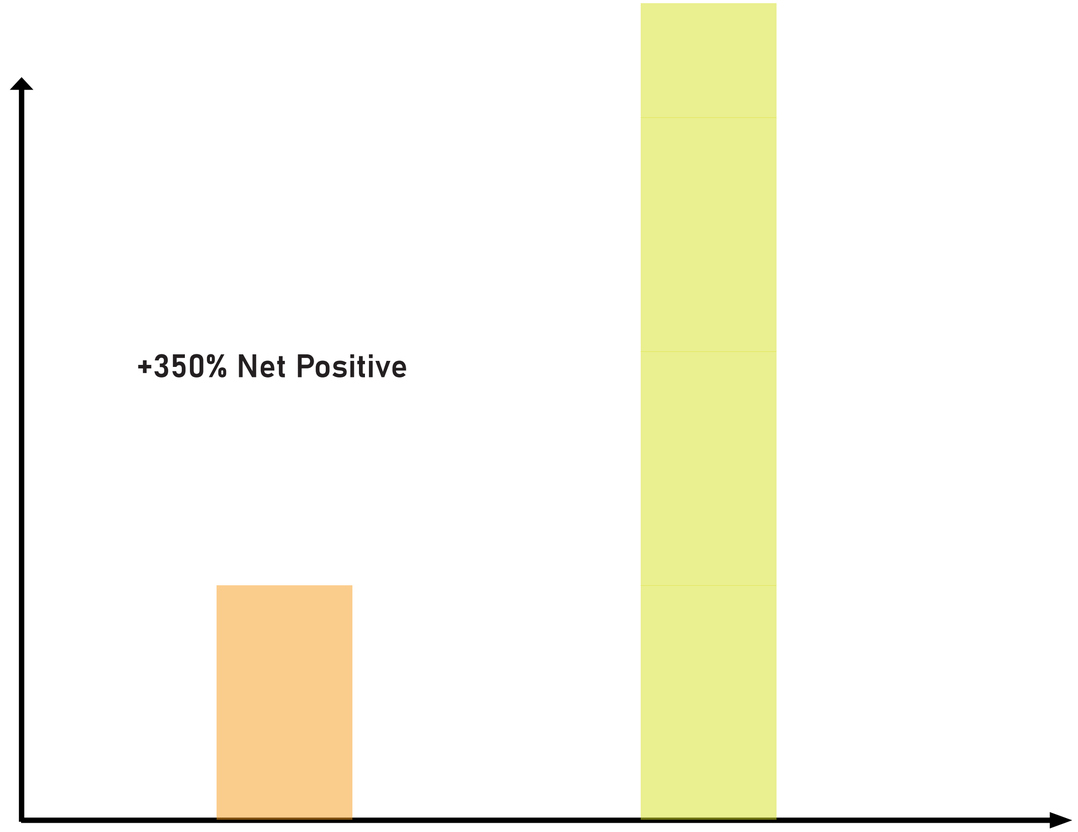




2136 KWh/m² x 5300 m² x 0.86 x 0.17 = **1 655 100 KWh per year**

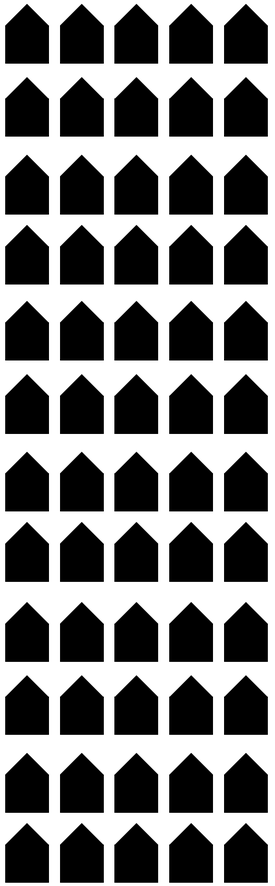
Conclusion

Net Positive Building - EUI



474 700 KWh
Building EUI

1 655 100 KWh
Solar Production



60 Tucson
Households