

# Final Project Presentation

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Course: 4.464 Building Technology

Instructor: Prof. Christoph Reinhart  
Teaching Assistants: Alpha Arsano  
Yu Qian Ang

# Content

1. Introduction
2. Context
3. Daylight
4. Optimizations
5. Two C's
6. Office Concept
7. Open topics  
Q&A!

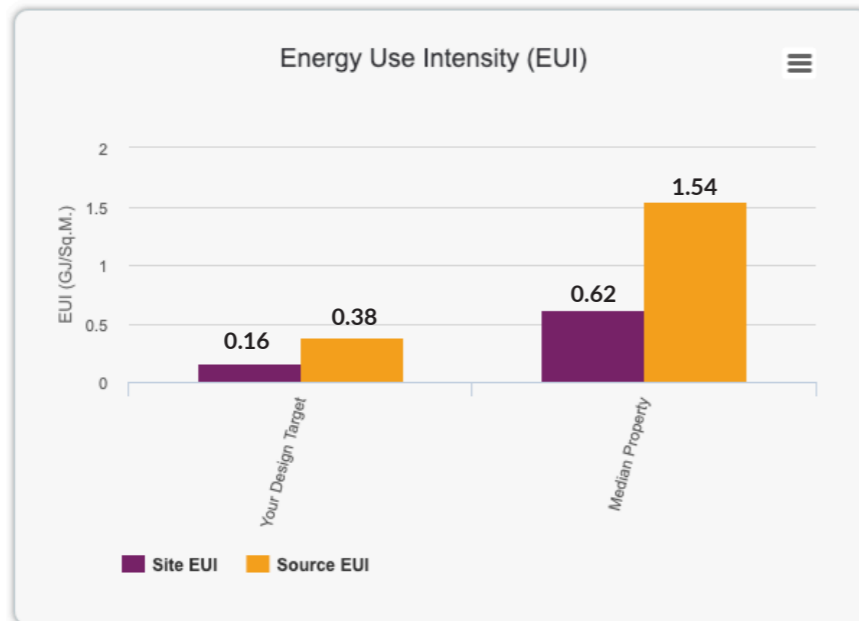
# 1. Introduction

## EUI target, design philosophy

### EUI target

Site EUI  
44.4kWh/m<sup>2</sup>

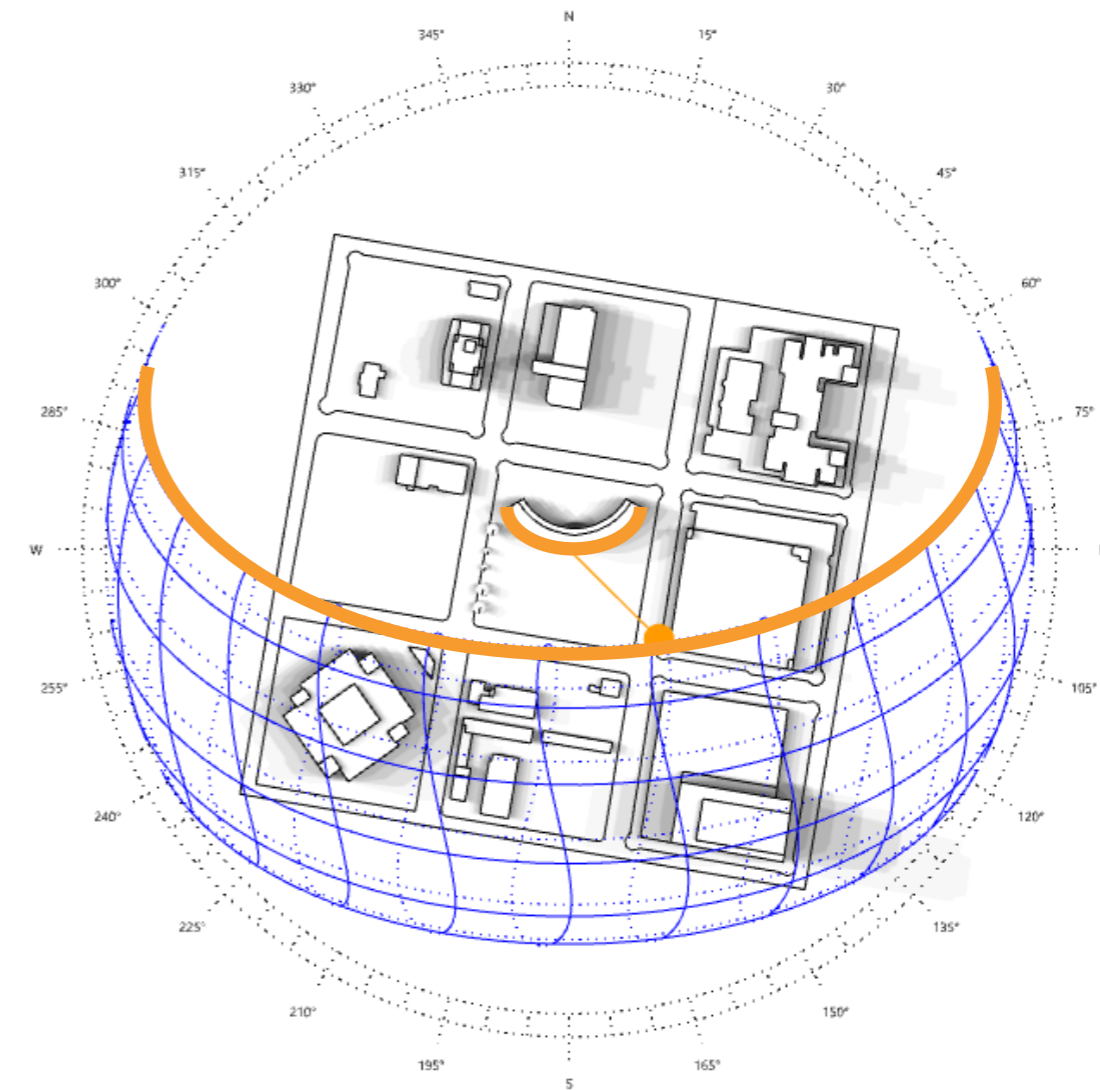
Source EUI  
105.5kWh/m<sup>2</sup>



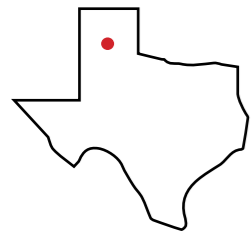
1 building  
Medium sized office in 4B climate zone

Benchmark  
Lower energy use than of comparable  
buildings in the U.S.

### Sun path



# 2. Context



State: Texas

City: Amarillo

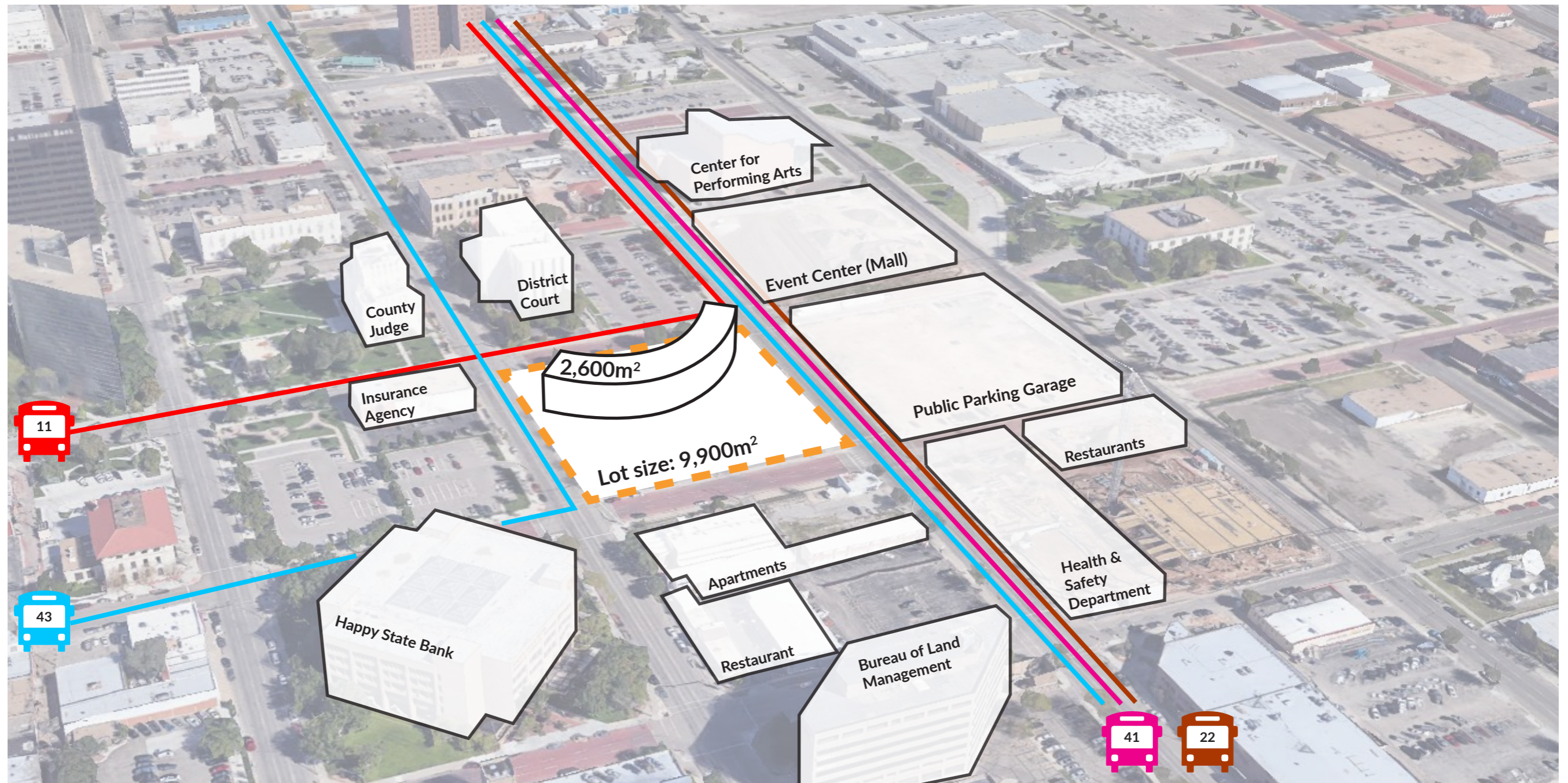
Address: SE 6th Ave, Amarillo, TX 79101

## Walkscores

**Transit Score 42**  
Some Transit  
A few nearby public transportation options.

**Walk Score 55**  
Somewhat Walkable  
Some errands can be accomplished on foot.  
15 points higher compared to Amarillo overall walkscore of 40

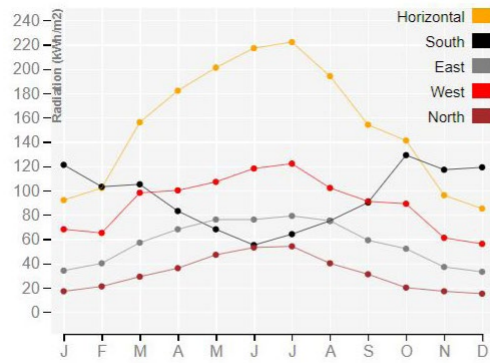
**Bike Score 43**  
Somewhat Bikeable  
Minimal bike infrastructure.



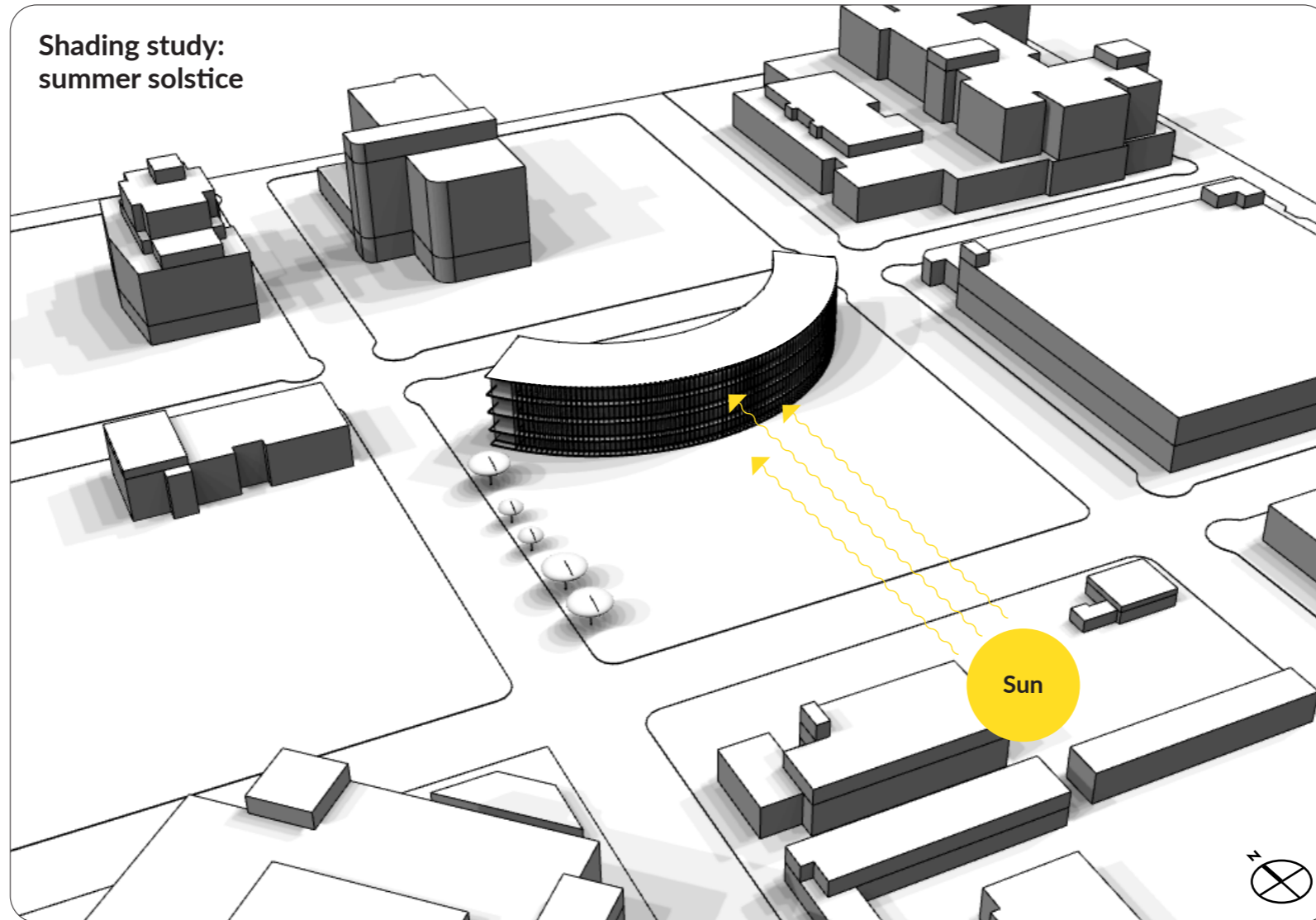
# 2. Context

## DIVA Shading Study, climaplust

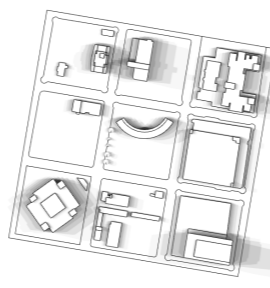
### Monthly Facade Radiation



### Shading study: summer solstice



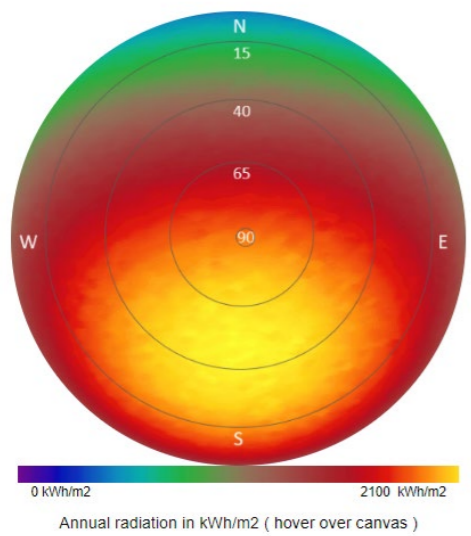
June 21st  
9:00am - 17:00pm



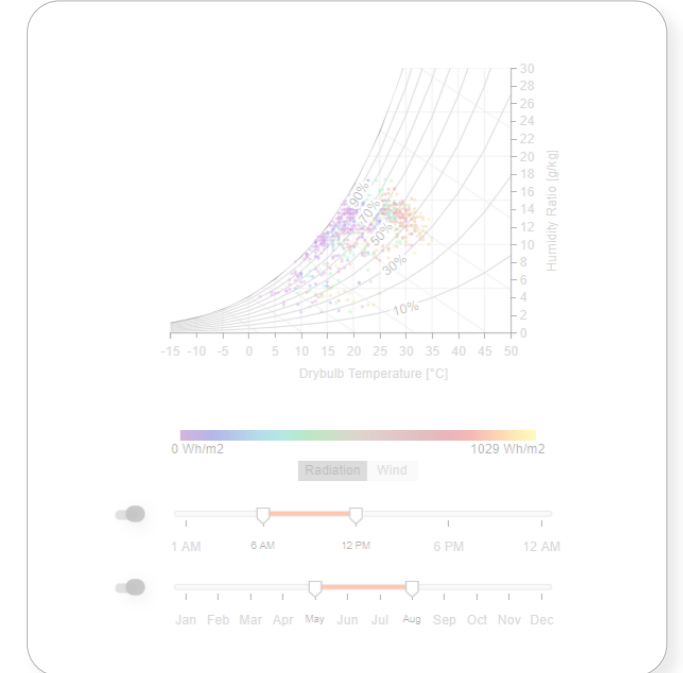
December 21st  
9:00am - 17:00pm



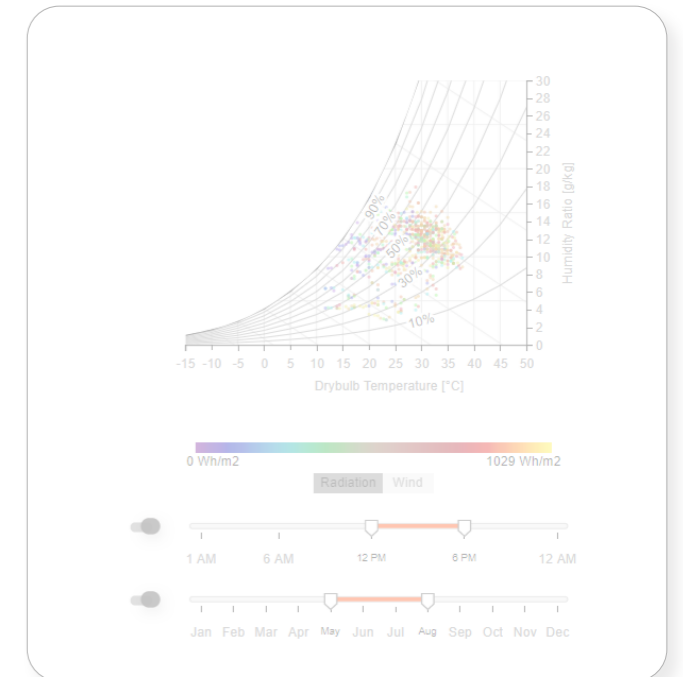
### Higher annual solar radiation



### Humid & colder summer mornings



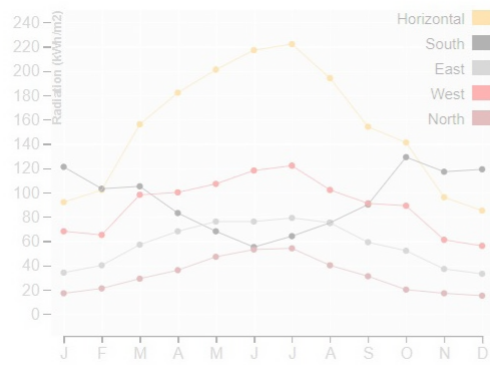
### Dry and warm summer afternoons



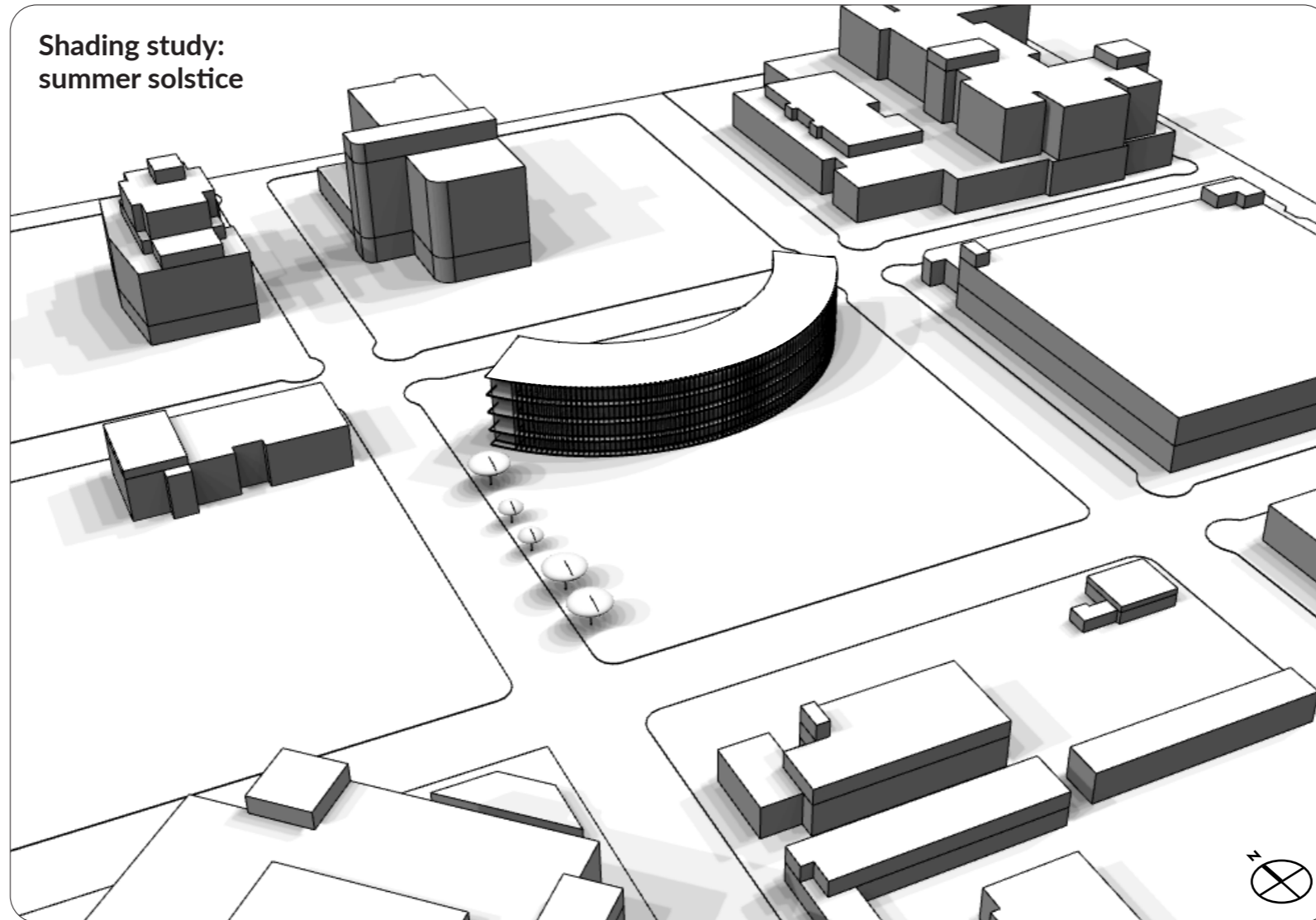
# 2. Context

## DIVA Shading Study, climaplus

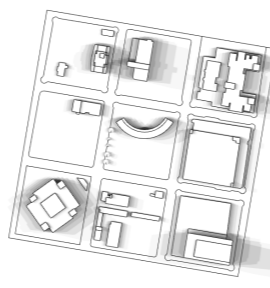
Monthly Facade Radiation



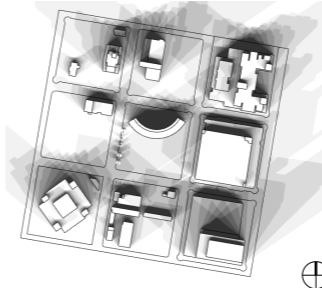
Shading study: summer solstice



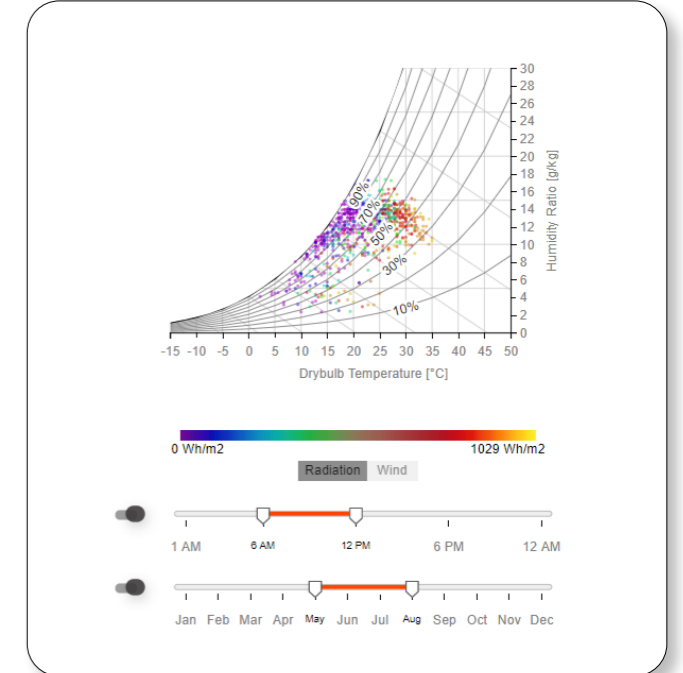
June 21st  
9:00am - 17:00pm



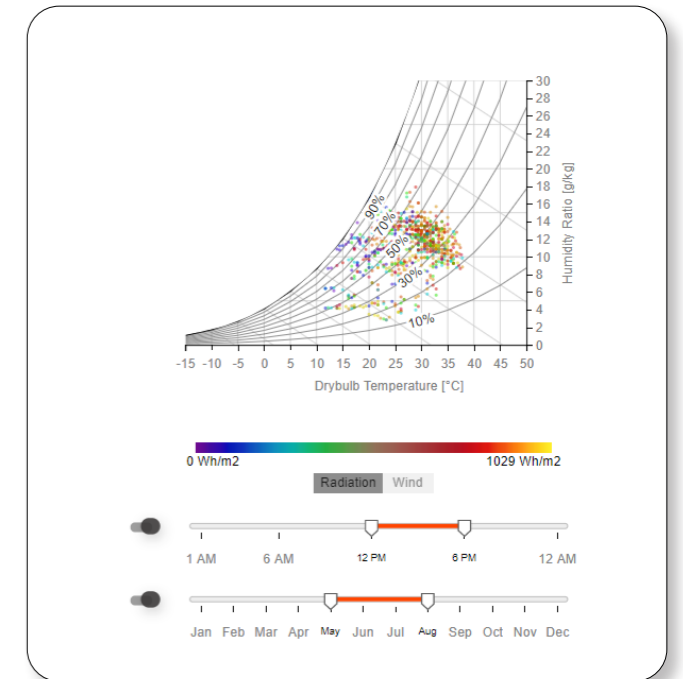
December 21st  
9:00am - 17:00pm



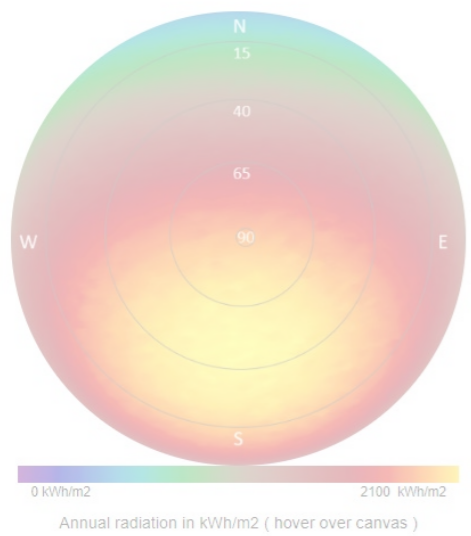
Humid & colder summer mornings



Dry and warm summer afternoons



Higher annual solar radiation





**ETH HIT e-science Lab, Zurich**

Architects:  
baumschlager eberle architekten

All photos were selected from Google search



**Ricola Marketing Building, Laufen**

Architects:  
Herzog & de Meuron

Landscape design:  
Vogt Landschaftsarchitekten



# 3. Daylight

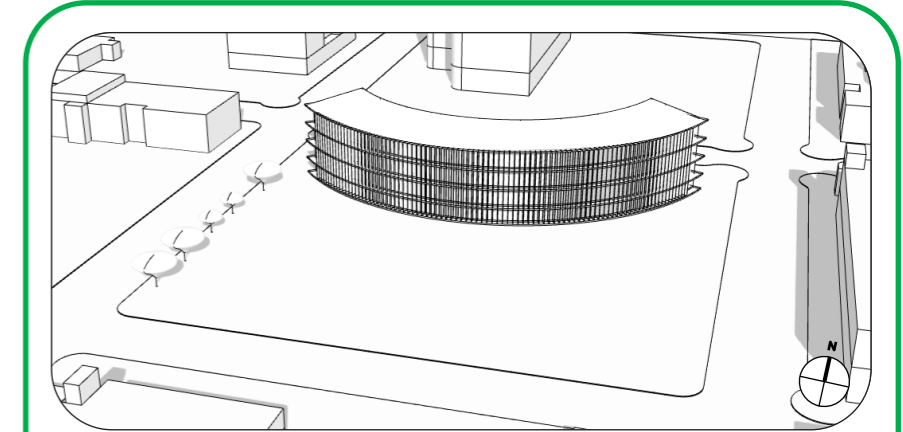
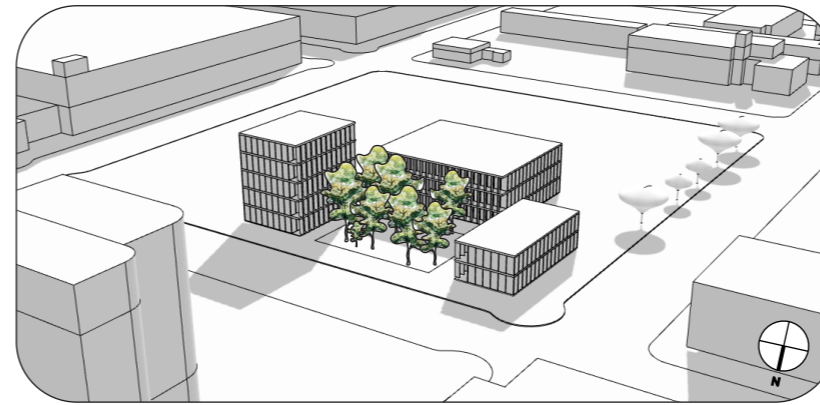
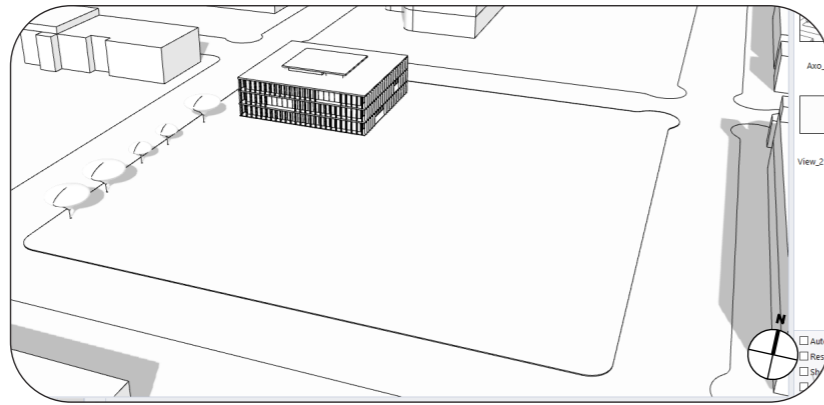
## Massing Studies

**Option 1**  
Single building

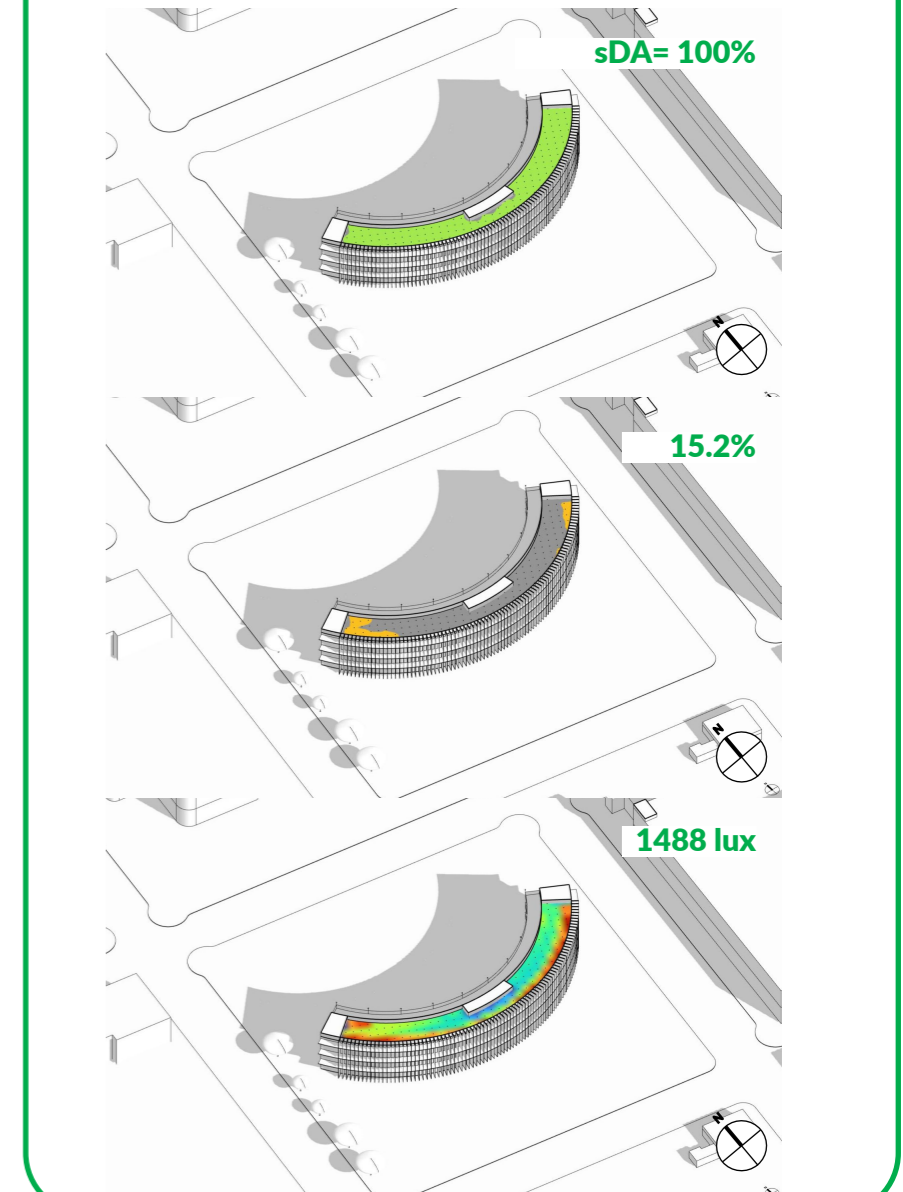
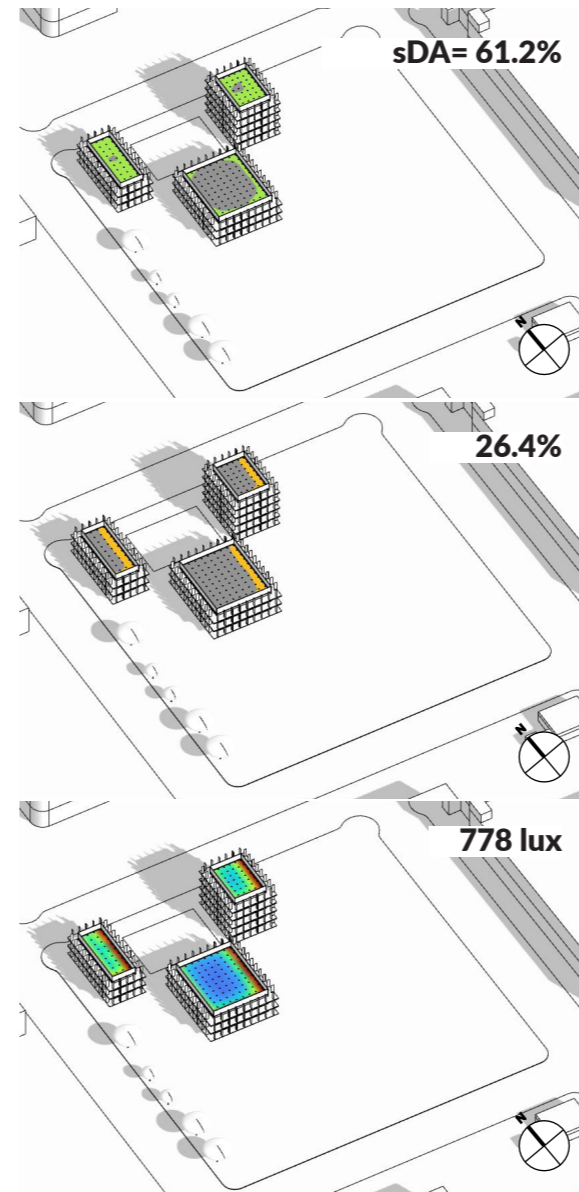
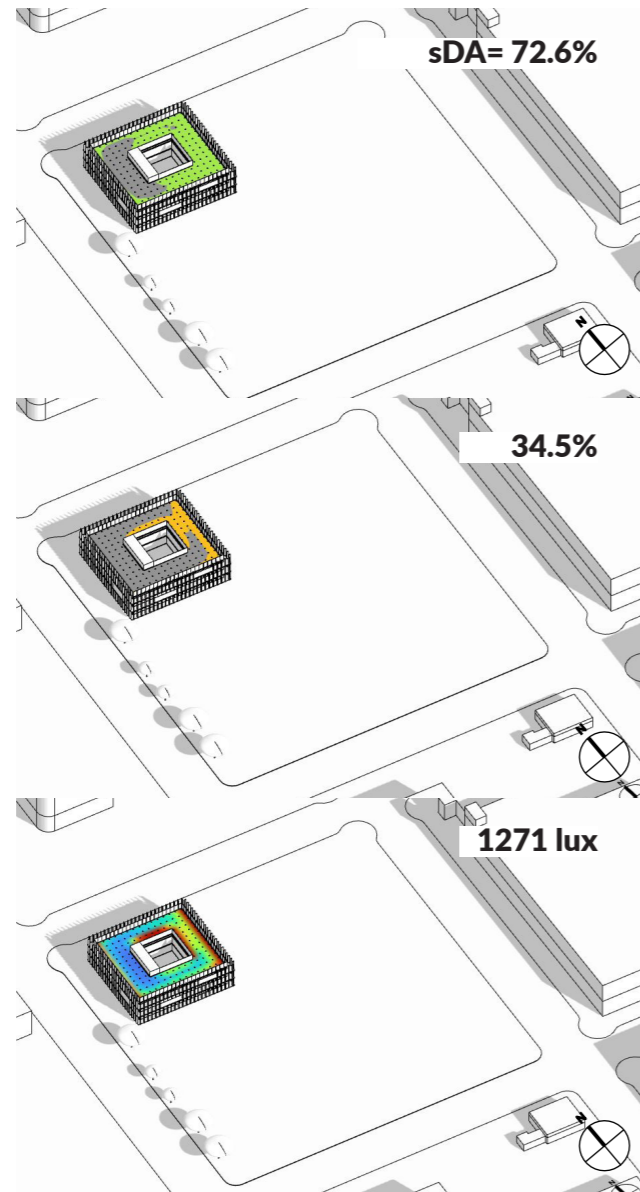
**Option 2**  
Three buildings

**Option 3**  
One curved building

Winter solstice  
Noon



Daylight autonomy  
 $sDA_{300lux}$  (50%)



Glare

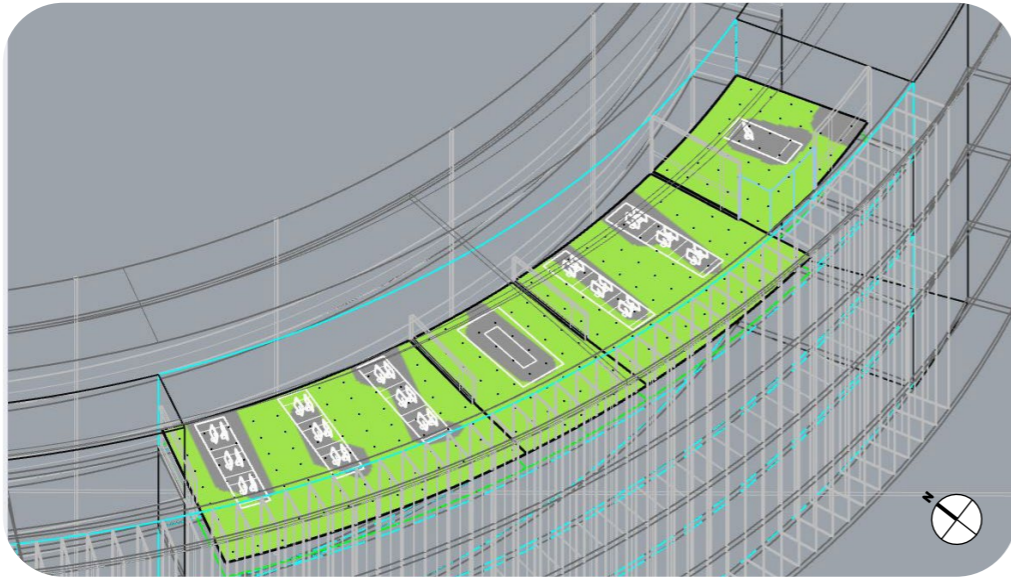
Average Lux



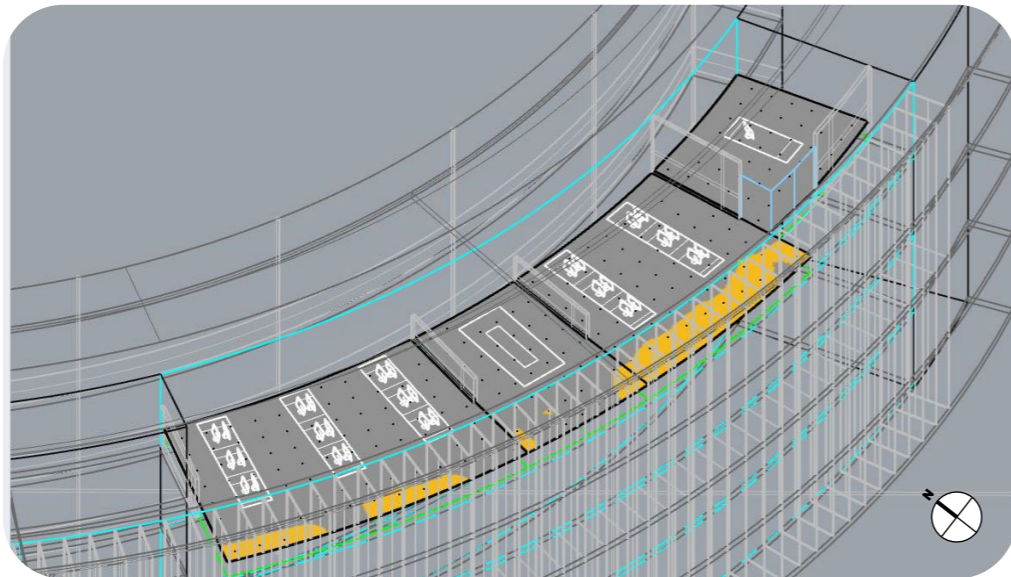
# 3. Daylight

Visual Comfort analysis & shading systems

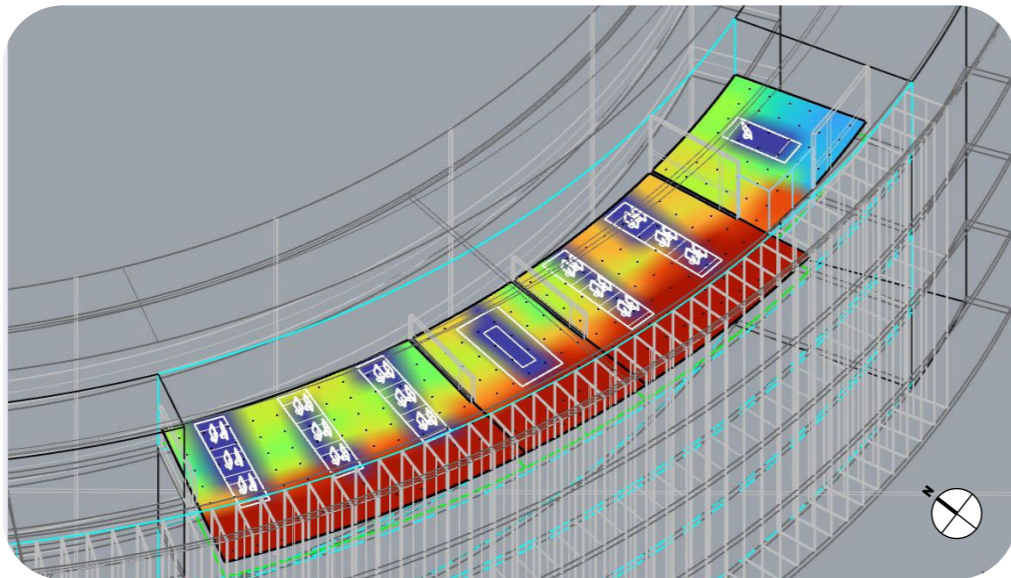
Daylight autonomy  
sDA<sub>300lux</sub> (50%)  
78.5%



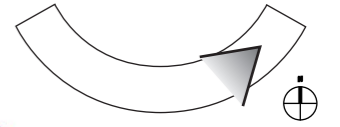
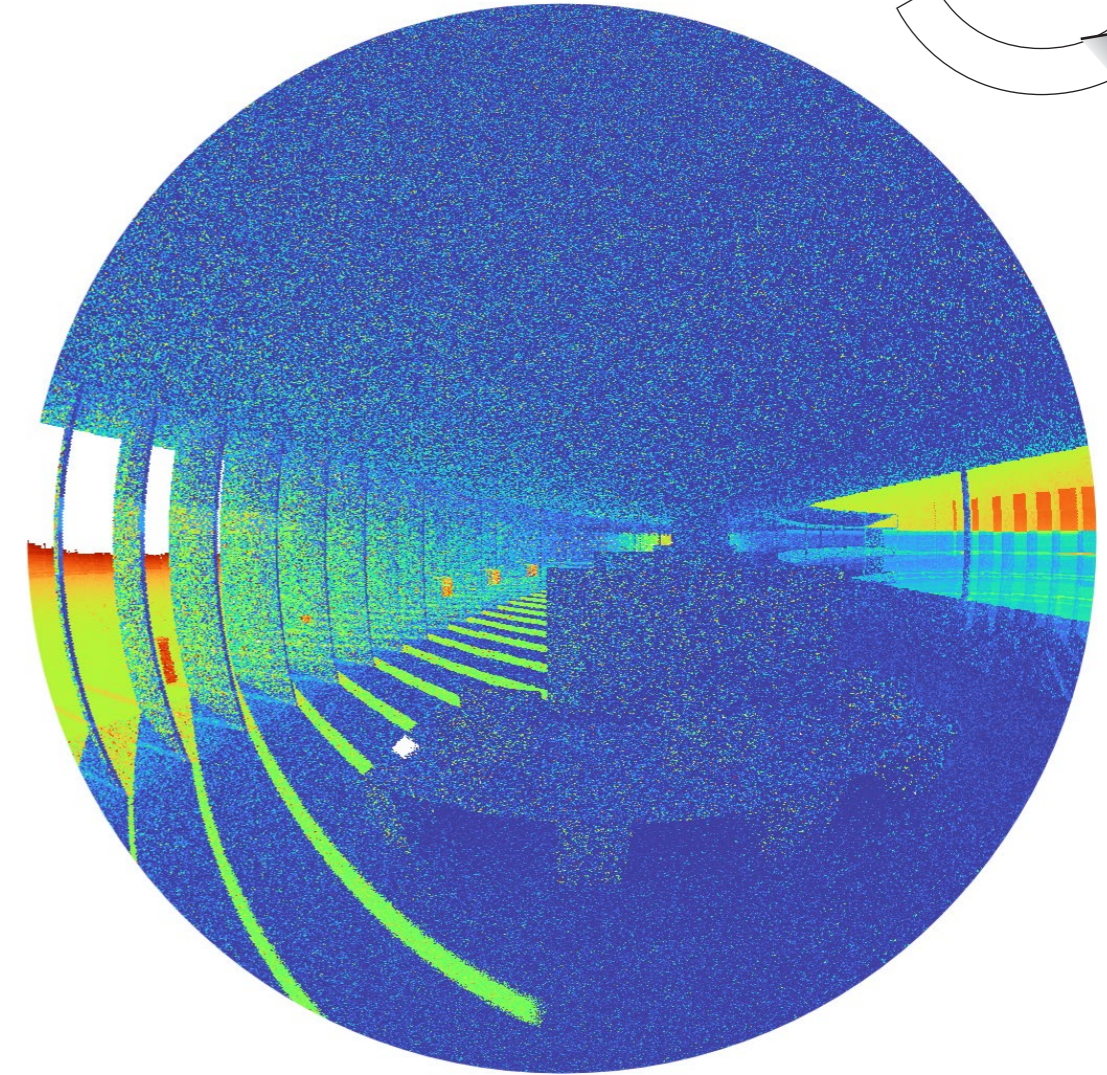
Glare  
9.9%



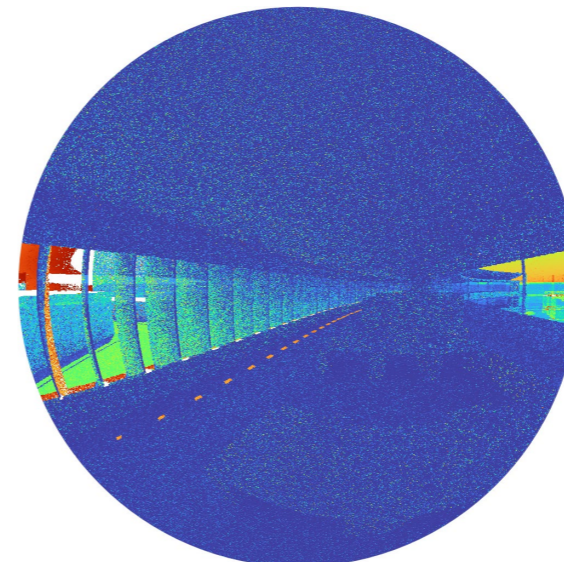
Average Lux  
at 1267



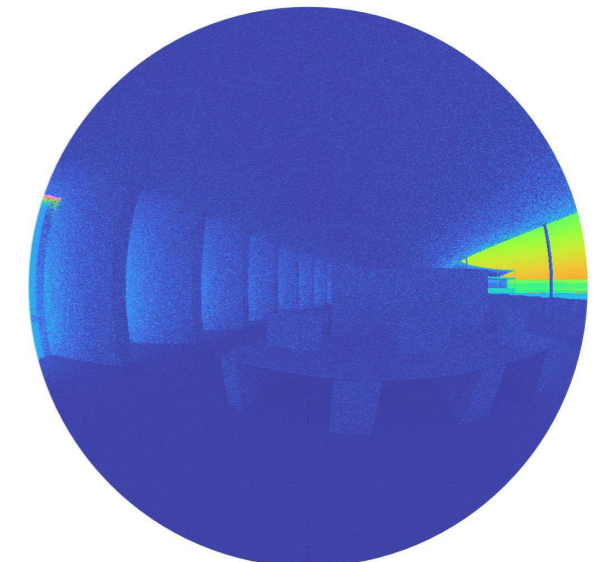
Hemispheric glare map  
December 21st at noon



WWR ca. 60% to 40%

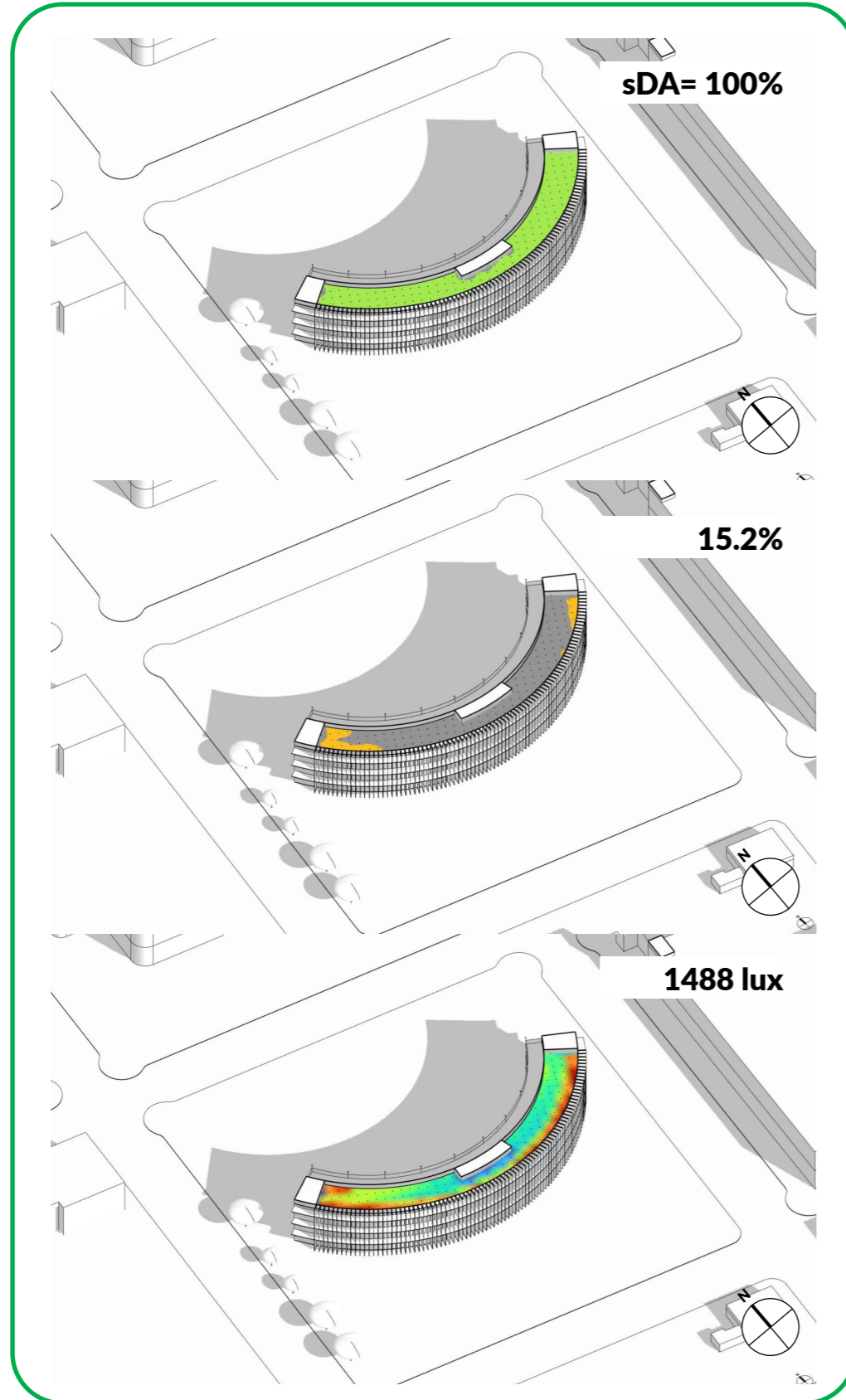


Sawtooth façade

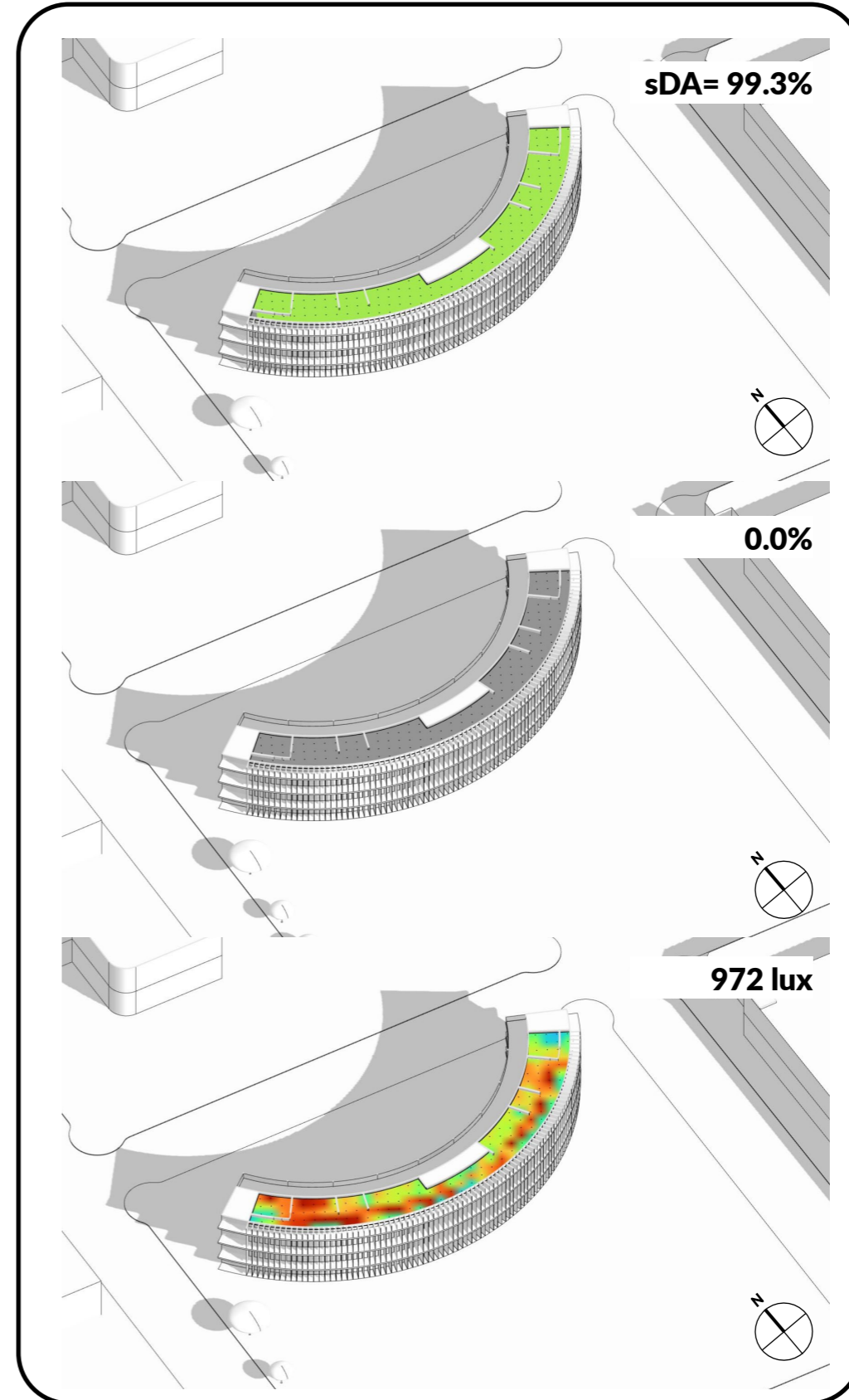


### 3. Daylight --> Updated Daylight Analysis

**Option 3**  
One curved building



**Updated daylight analysis**  
One curved building



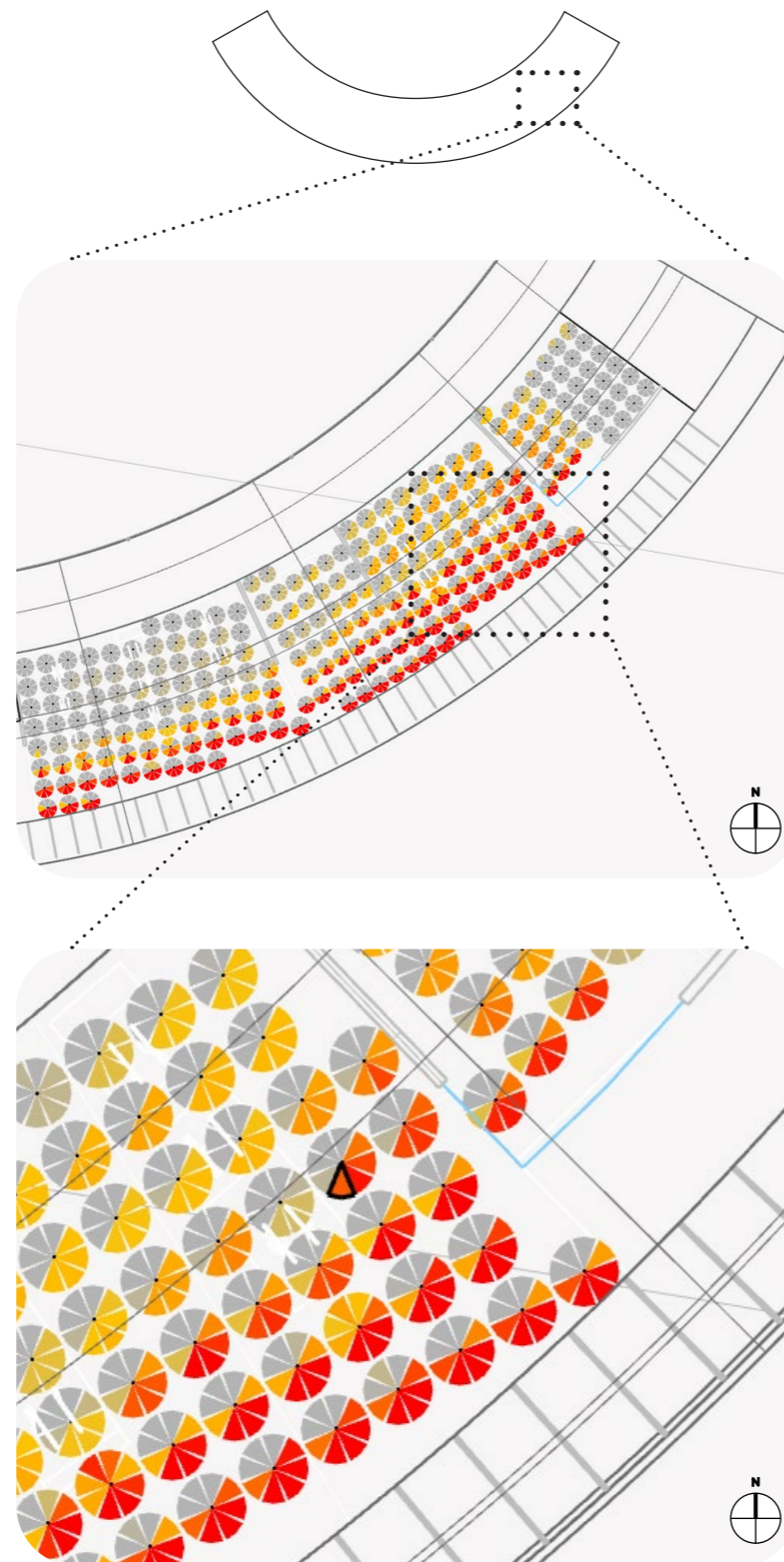
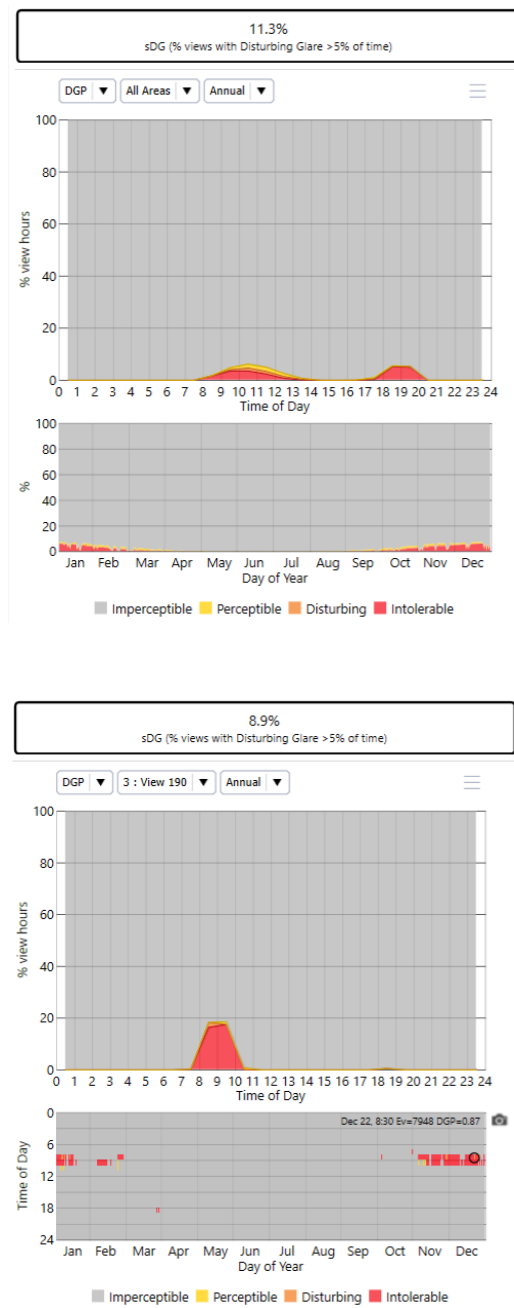
- 0.7 %

- 15.2 %

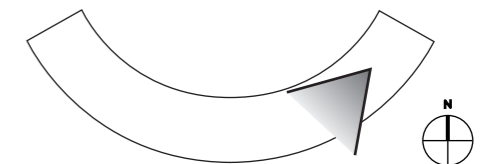
- 516 lux

# 3. Daylight

## Visual Comfort analysis & shading systems

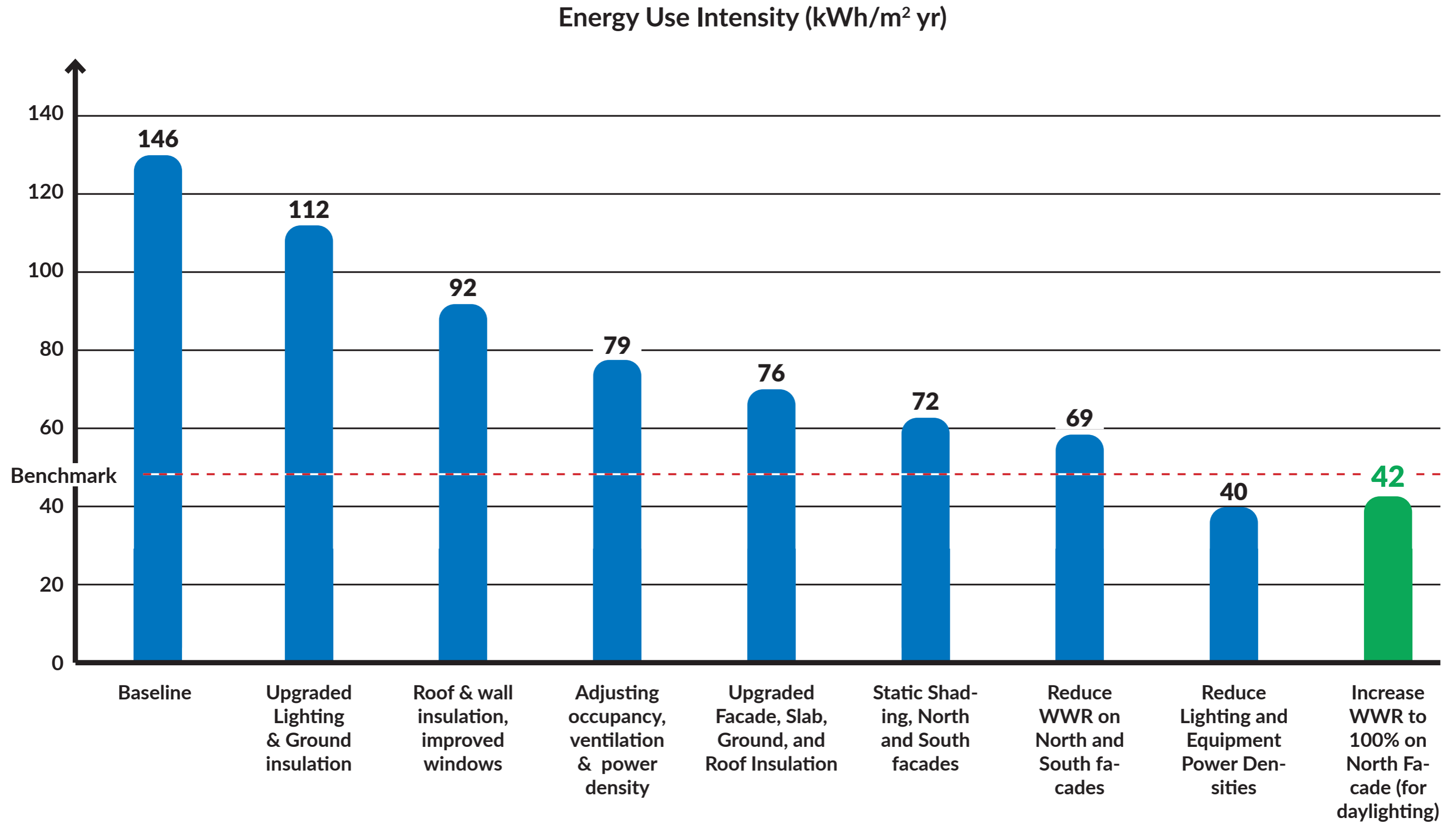


Hemispheric glare map  
December 22nd at 8:30am



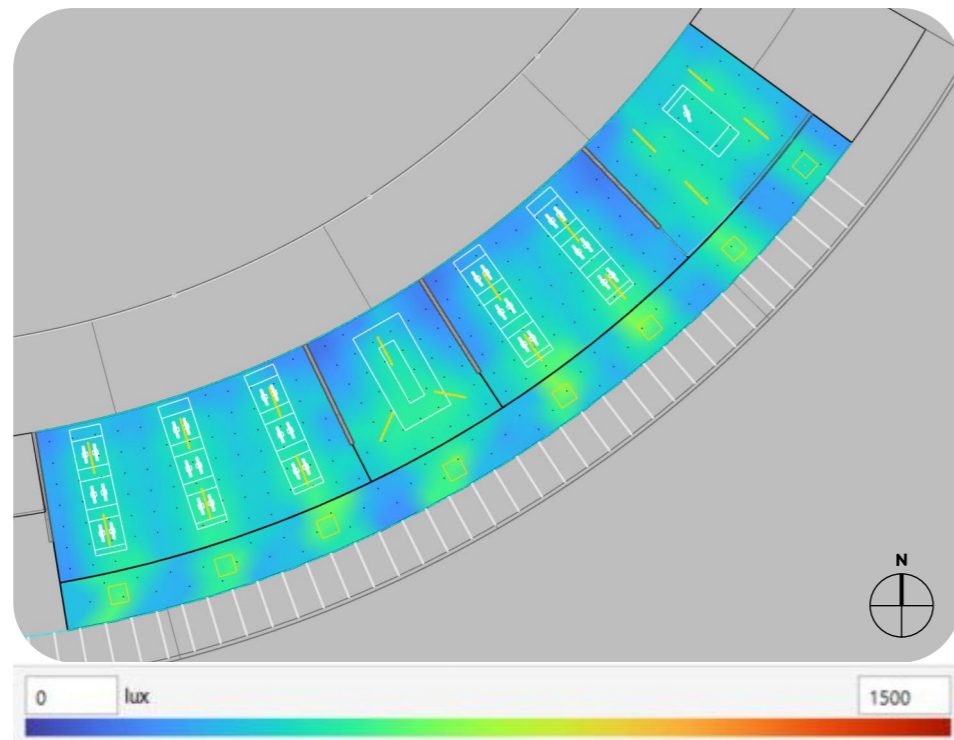
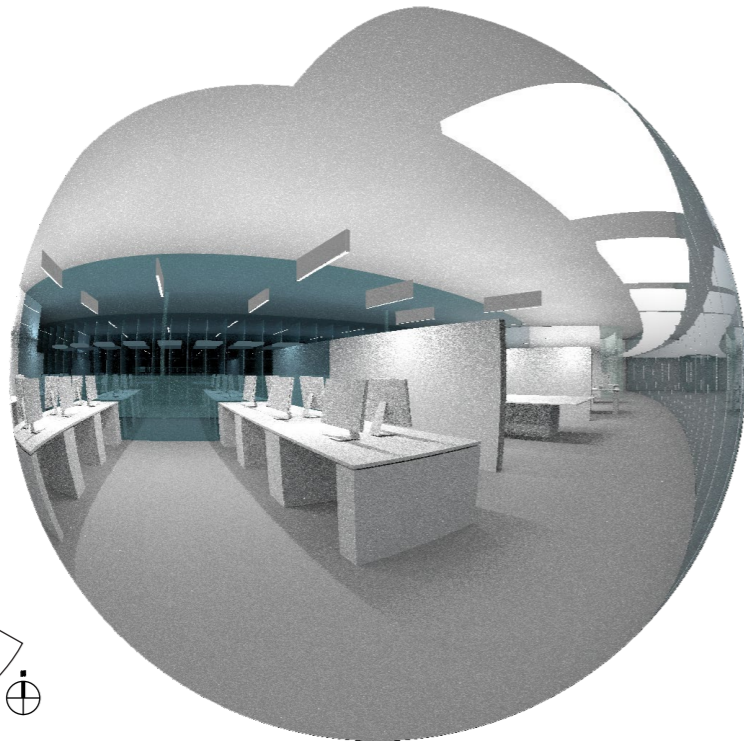
# 4. Optimizations

Building performance optimization



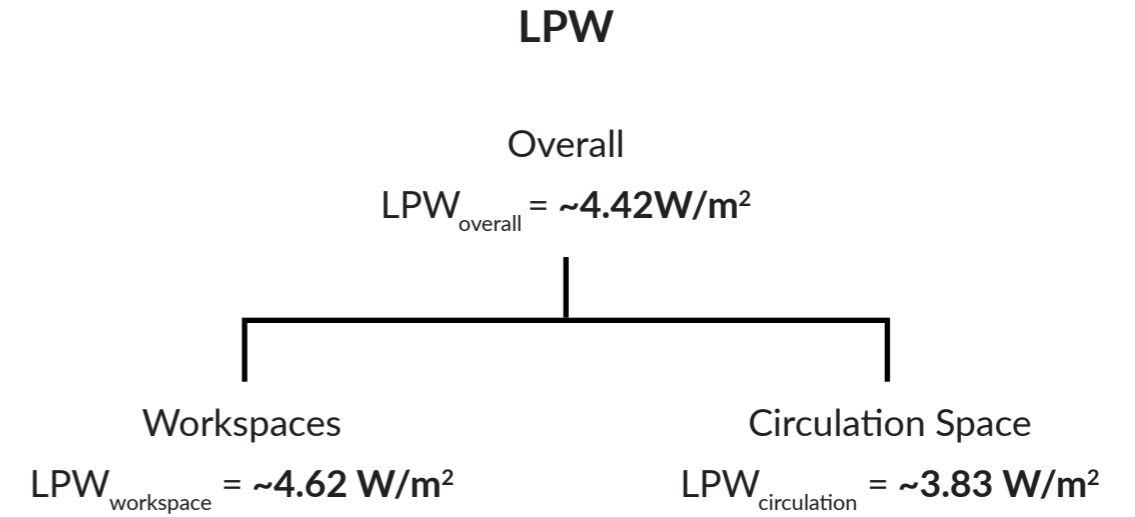
# 4. Optimizations

Electric lighting proposal with overview plan

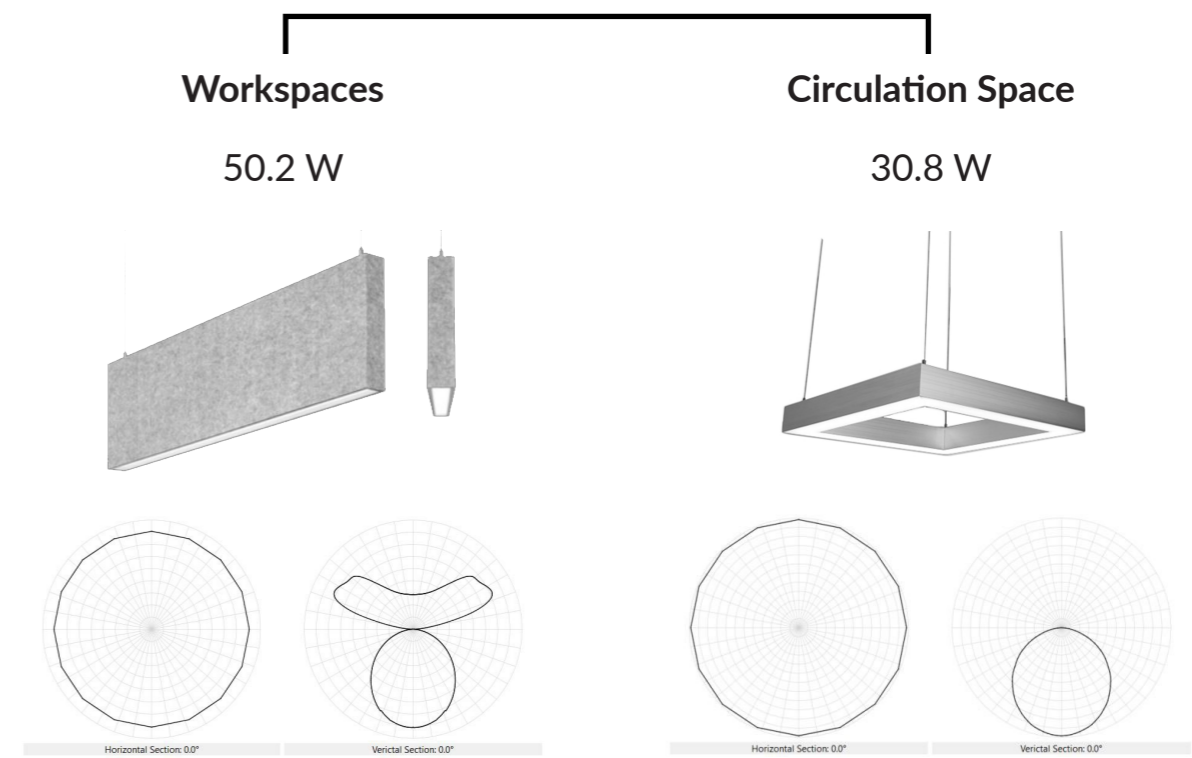


**395**  
mean lux

**396**  
median lux



## Luminaire Listing



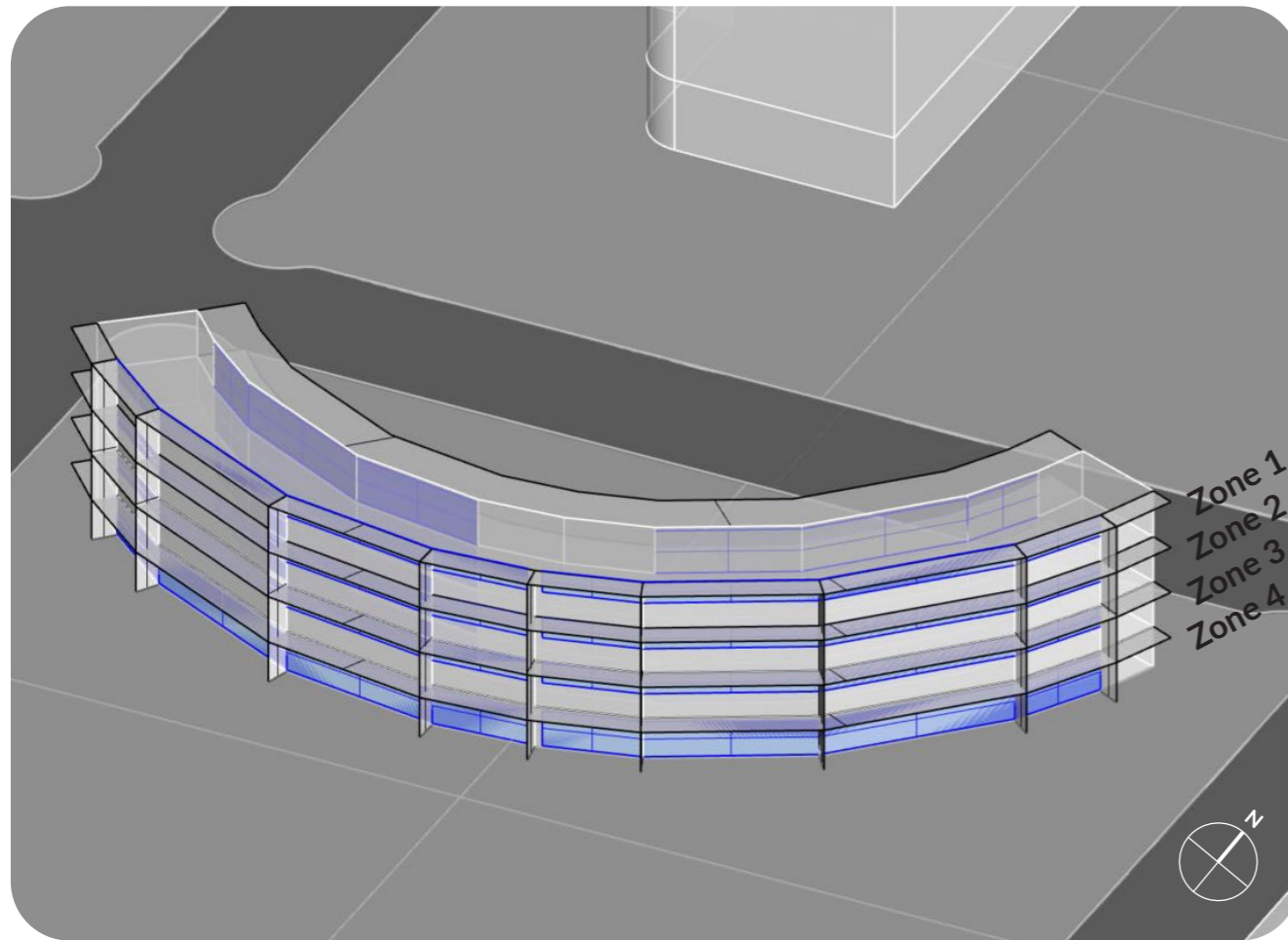
**Focal Point:**  
 Seem 1 Acoustic, Direct/Indirect LED,  
 Batwing/Regress Lens  
 5200 lm/ 4 ft. length  
 3500K

**Signify:**  
 TruGrooves Shapes,  
 Suspended Direct LED  
 1500 lm/ 2 ft. x 2 ft.  
 3500K

# 4. Optimizations

## Thermal envelope with sections

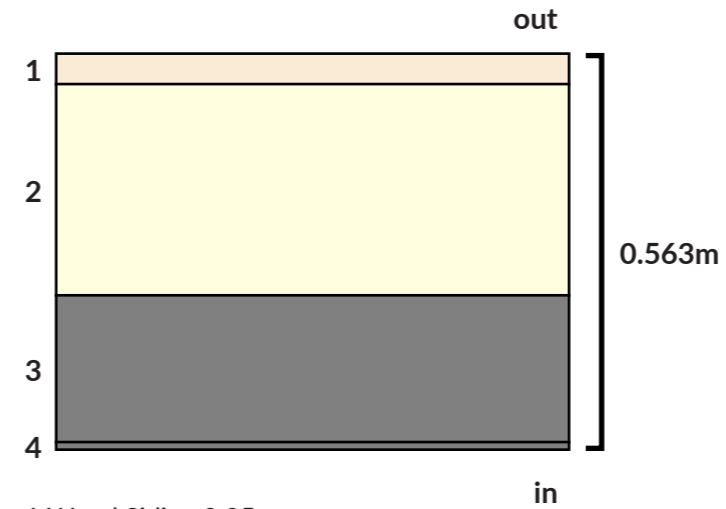
Thermal model



The fins take up a wall length of approx. 4,4m (1 fin = 0.05m x 88fins) that is taken into account the thermal model.

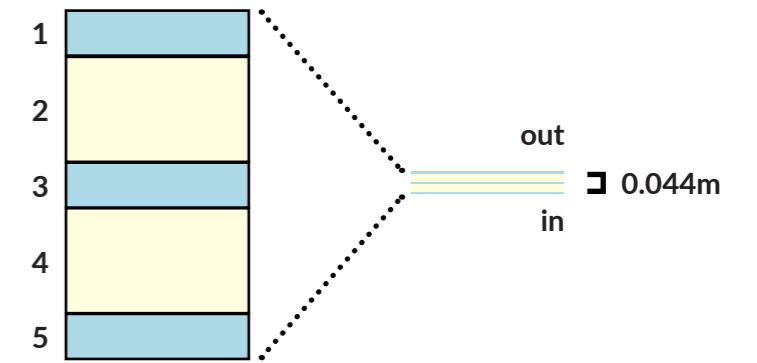
■ Window    ■ Zones

**Facade**  
U-value= 0.103 W/m<sup>2</sup>K



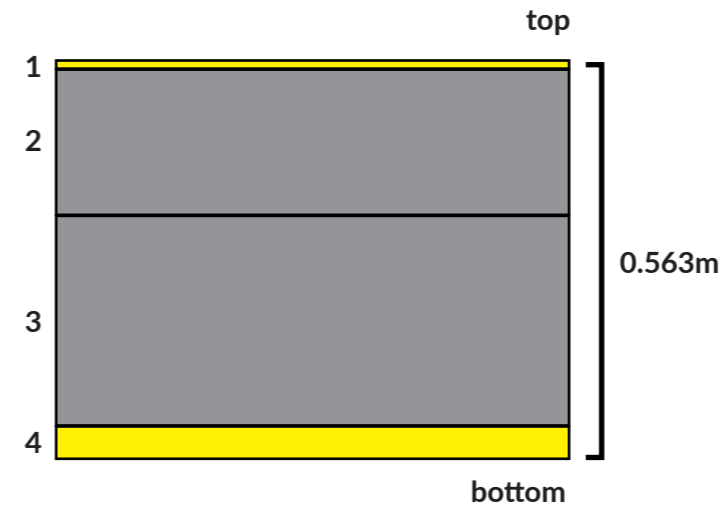
- 1 Wood Siding 0.05m
- 2 XPS Board 0.3m
- 3 General Concrete 0.2m
- 4 Medium Office-4B\_1/2IN GYPSUM 0.013m

**Window**  
U-value= 0.57 W/m<sup>2</sup>K



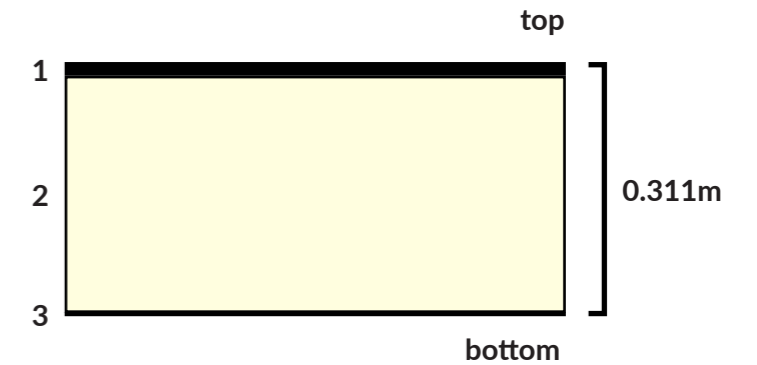
- 1 Solarban 72 on Starphire 6mm
- 2 Krypton - EN673 13mm
- 3 Solarban 72 on Starphire 6mm
- 4 Krypton - EN673 13mm
- 5 Starphire - EN673 13mm

**Floor / Ceiling**  
U-value= 0.116 W/m<sup>2</sup>K



- 1 MediumOff-4B\_CP02 CARPET PAD 0.013m
- 2 General Concrete 0.2m
- 3 MediumOff-48\_MAT-AIR-WALL 0.3m
- 4 Acoustical Tile - 0.05m

**Roof**  
U-value= 0.095 W/m<sup>2</sup>K



- 1 MediumOff-4B\_ROOF MEMBRANE 0.0095m
- 2 Insulation Expanded Polystyrene - Extruded (Smooth Skin SURface) 0.3m
- 3 MediumOff-4B\_METAL DECKING 0.0015m

# 4. Optimizations

## Schedules

### Occupancy

180 occupants/2,600 m<sup>2</sup> = **0.069 occ./m<sup>2</sup>**

### Lighting Controls

Lighting Power Density = **4.42 kWh/m<sup>2</sup>**

### Equipment

Schedule correlates with occupancy

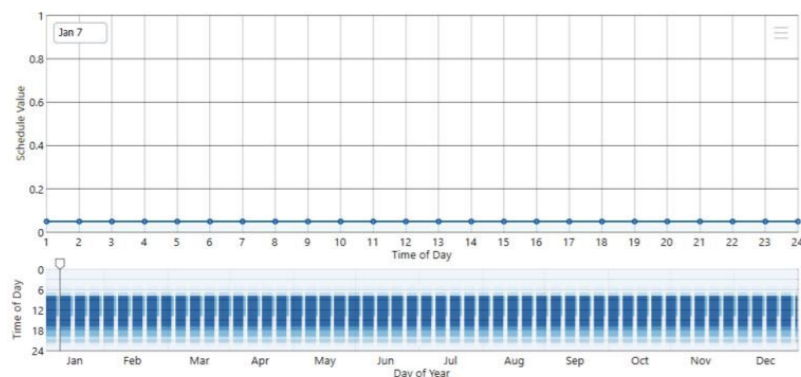
Weekdays



Saturdays



Sundays



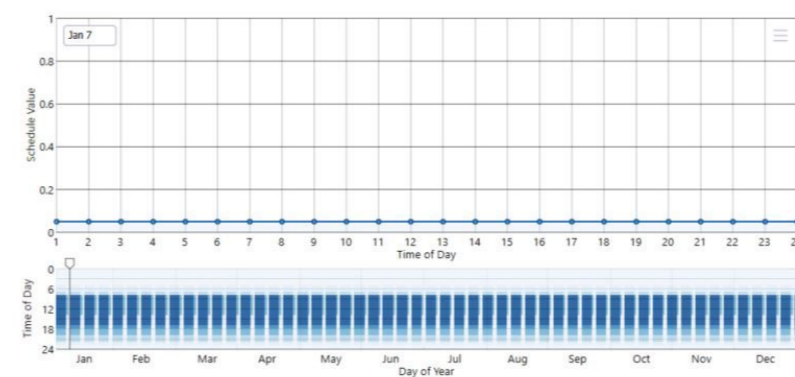
Weekdays



Saturdays



Sundays



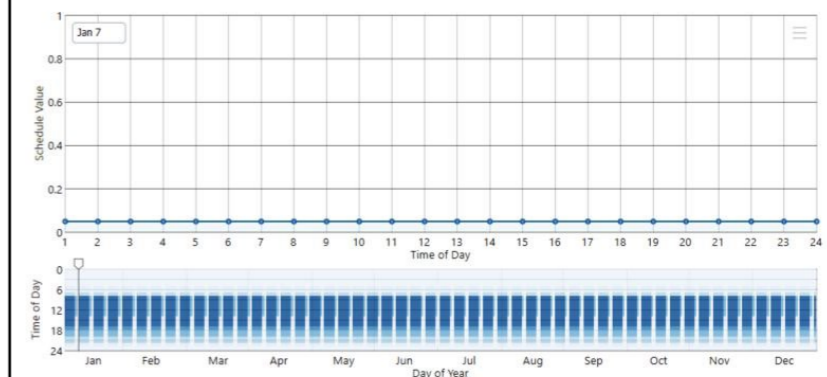
Weekdays



Saturdays



Sundays



# 4. Optimizations

## Schedules

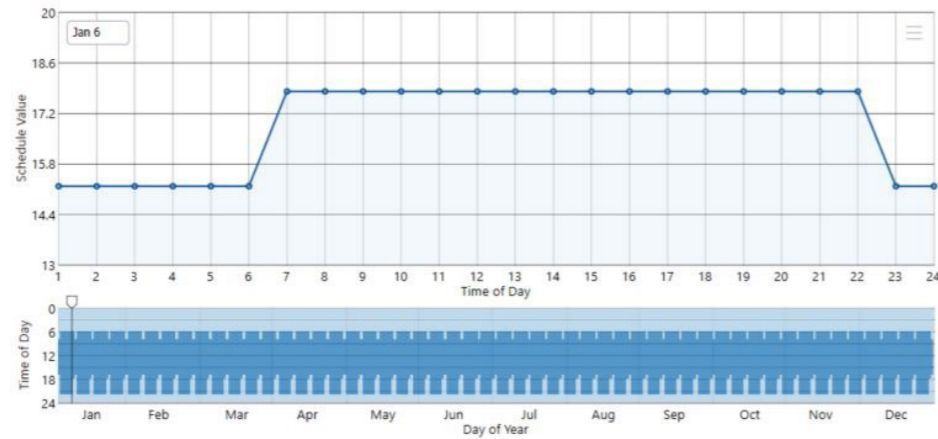
### Heating Setpoints

Unoccupied = **15.6 °C**, occupied = **18.0 °C**

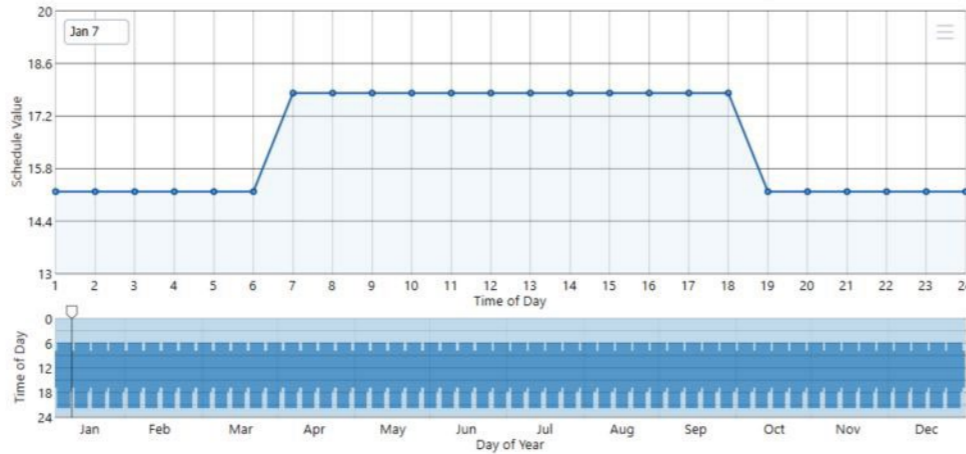
### Cooling Setpoints

Unoccupied = **30.0 °C**, occupied = **24.0 °C**

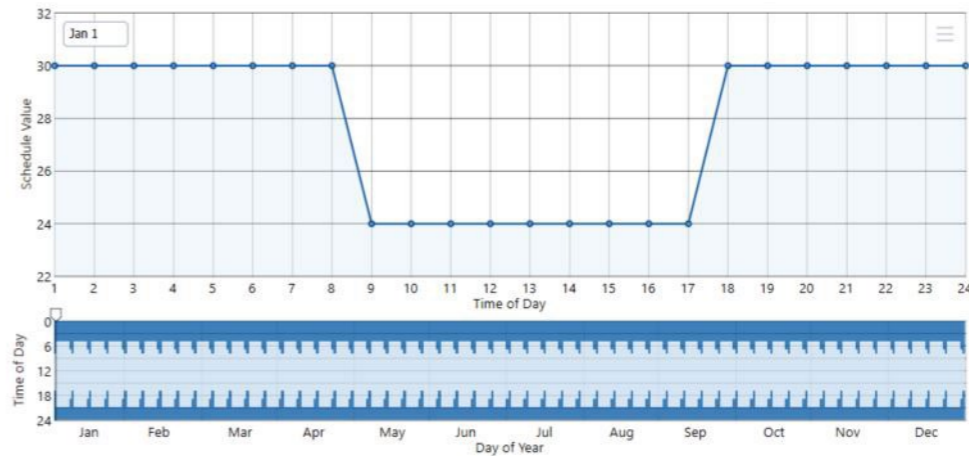
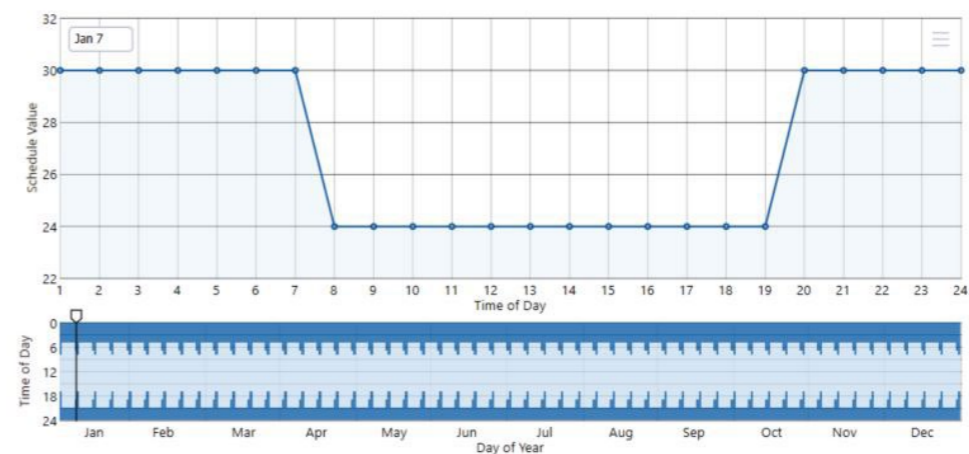
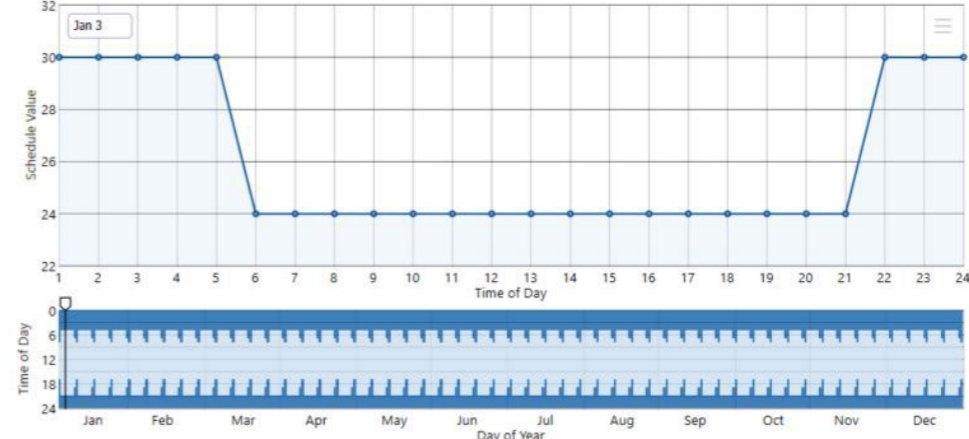
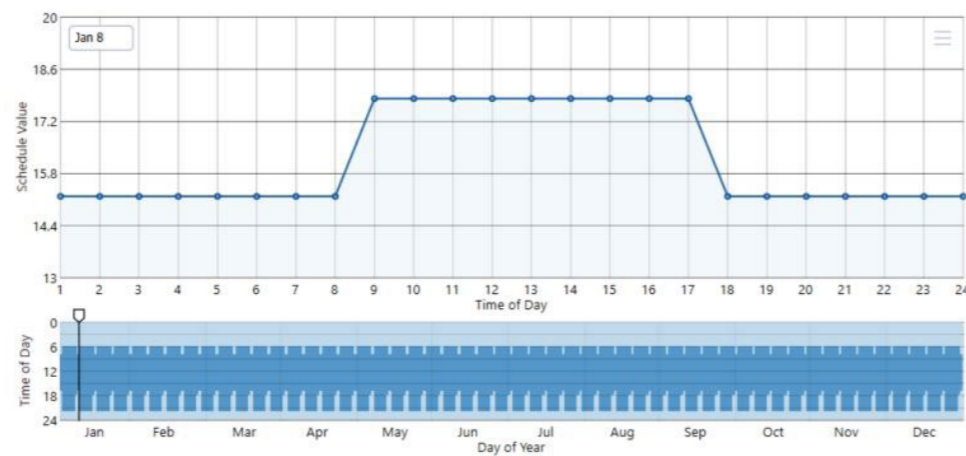
Weekdays



Saturdays



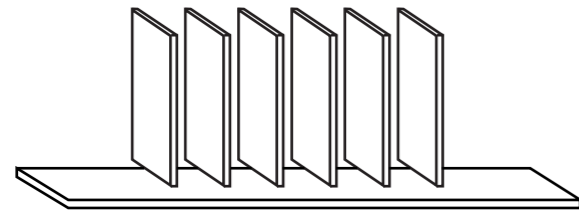
Sundays





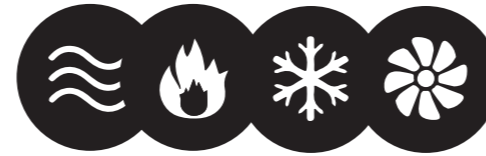
# 4. Optimizations

## Features



### Shading

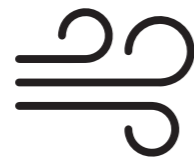
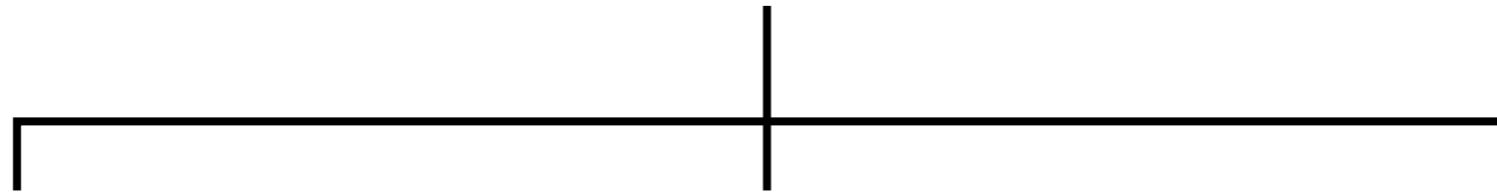
Static shading through fins in front of facade and overhang of 2.0m



### HVAC

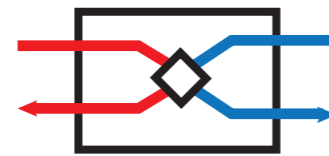


### Ventilation



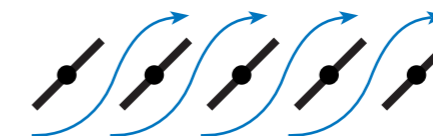
### Fresh Air

15.0 L/s/occupant



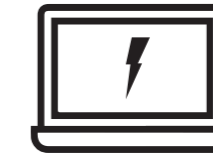
### Heat Recovery

Sensible Recovery Ratio = 0.95



### Economizer

Differential Dry Bulb Economizer



### Equipment Power Density

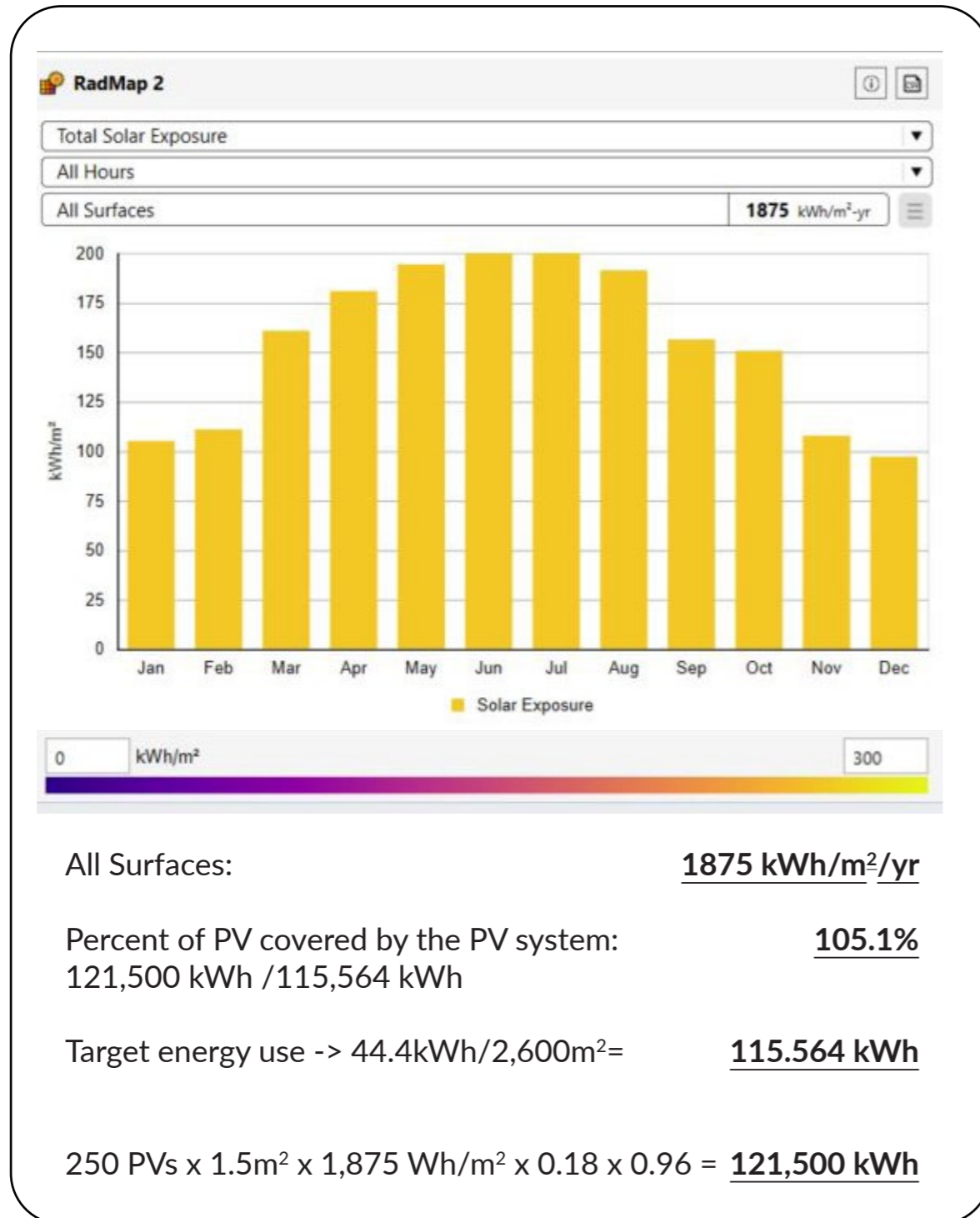
6.00 kWh/m<sup>2</sup>

170 laptops, 8 printers, 10 desktops

Open Office concept:  
Flexible workstations and hot desks

# 5. Two C's

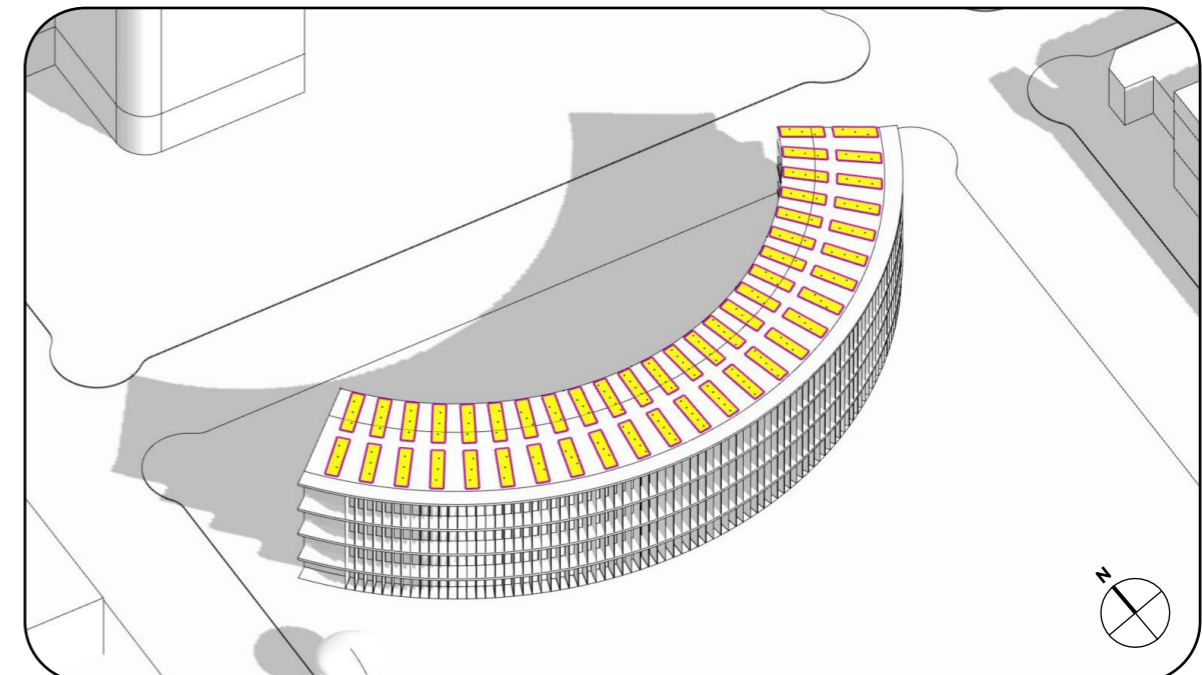
## PV system | Electricity yield calculation



## Financial Analysis

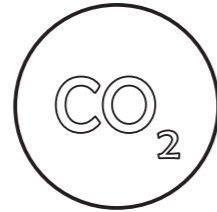
Installation costs: <i>(250 panels x 294 W<sub>p</sub>/panel x \$US 2.77/W<sub>p</sub>**)</i>	<b>\$US 203,595</b>
Federal tax break*: <i>(\$US 203,595 x 0.26)</i>	<b>\$US 52,935</b>
Total installation cost after taxes:	<b>\$US 150,660</b>
Annual revenue/savings through PV system: <i>(121,500 kWh/yr x \$US 0.22)</i>	<b>\$US 26,730</b>
Payback time: <i>(\$US 150,660 / \$US 26,730/yr)</i>	<b>5.6 years</b>

\* 26% Federal Investment Tax Credit (ITC) for Amarillo TX  
 \*\* As of December 2020

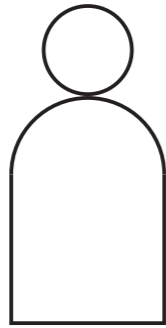


# 5. Two C's

Median Comp. Building  
(Site EUI = 172 kWh/m<sup>2</sup>/yr)



86  
kgCO<sub>2</sub>/m<sup>2</sup>/yr



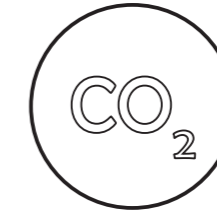
0.48  
kgCO<sub>2</sub>/m<sup>2</sup>/yr/person



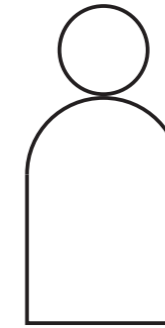
430,000 kWh/yr  
\$0.11/kWh  
\$47,300/yr

-76%

Final Design  
(Site EUI = 42 kWh/m<sup>2</sup>/yr)



21  
kgCO<sub>2</sub>/m<sup>2</sup>/yr



0.12  
kgCO<sub>2</sub>/m<sup>2</sup>/yr/person



105,000 kWh/yr  
\$0.11/kWh  
\$11,550/yr

-75%

\$35,750/yr savings  
on electrical costs

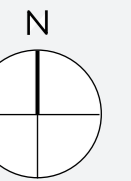
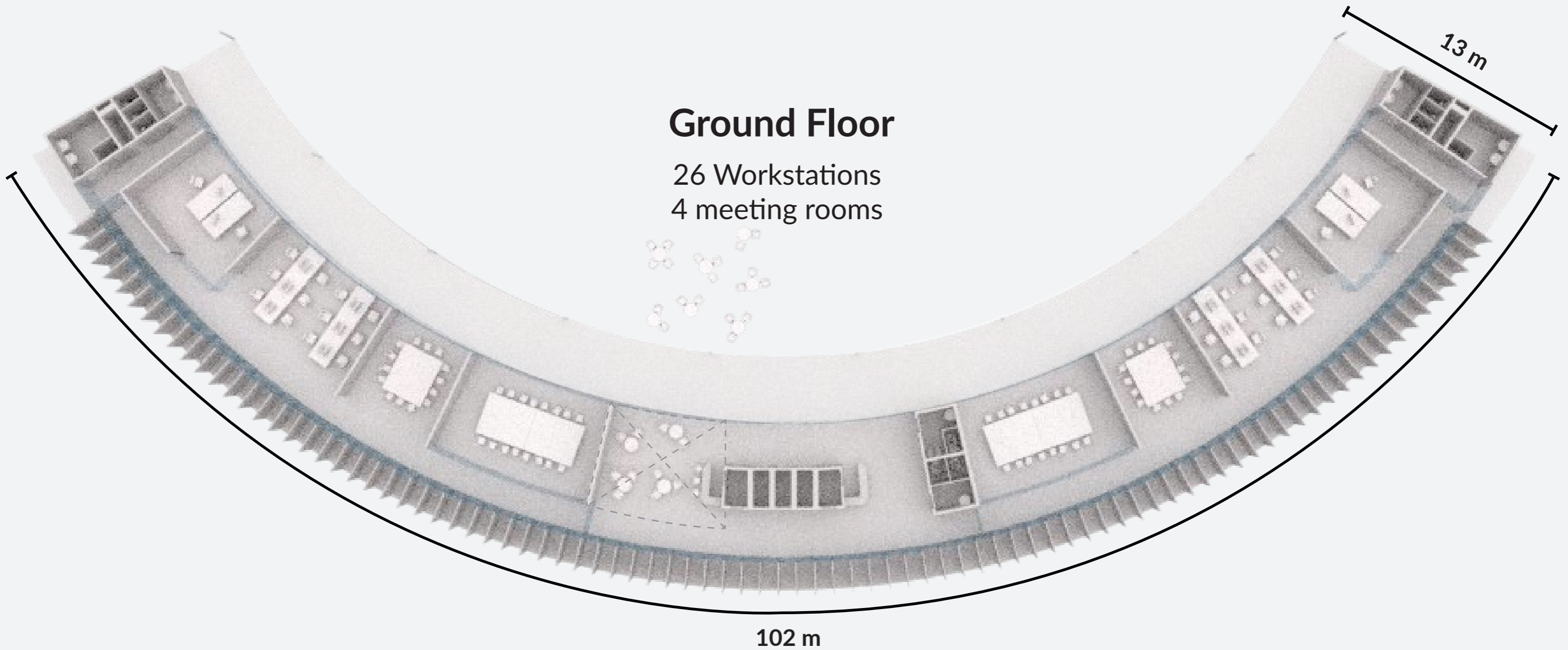


Portico  
Second floor



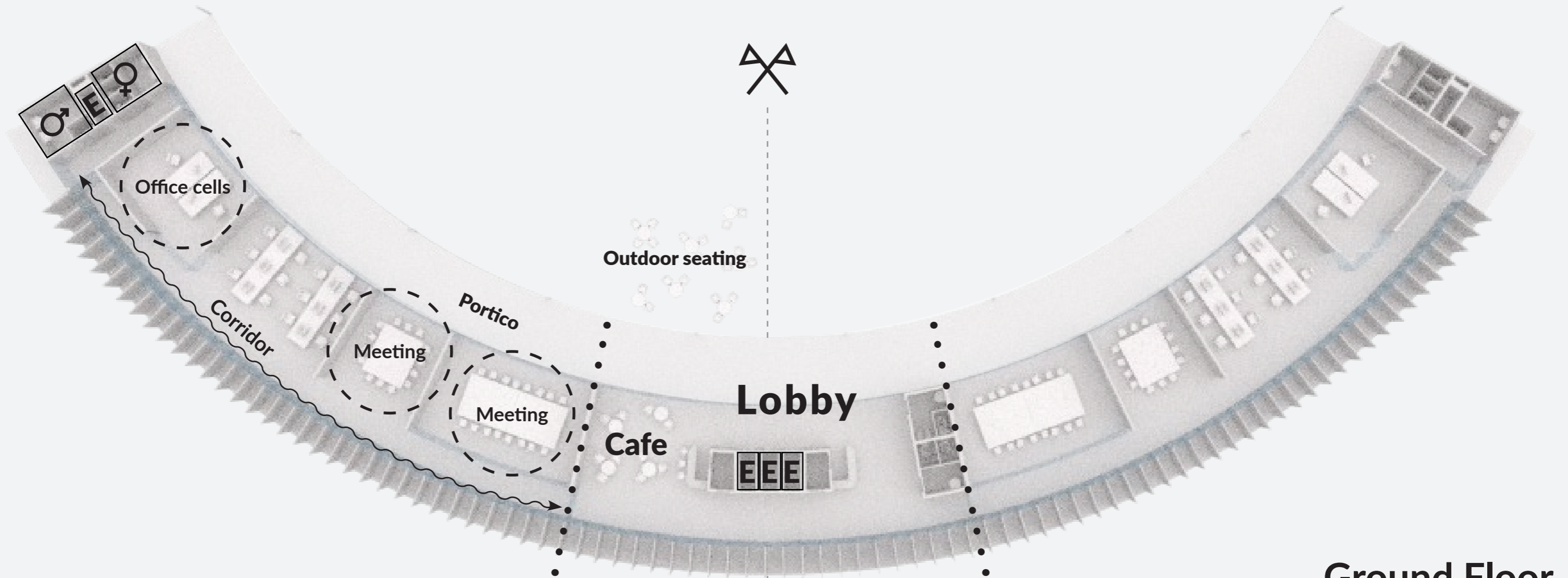
# 6. Office Concept

Sample floor plans



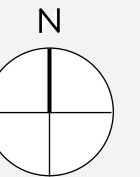
# 6. Office Concept

Sample floor plans



## Ground Floor

26 Workstations  
4 meeting rooms



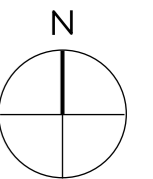
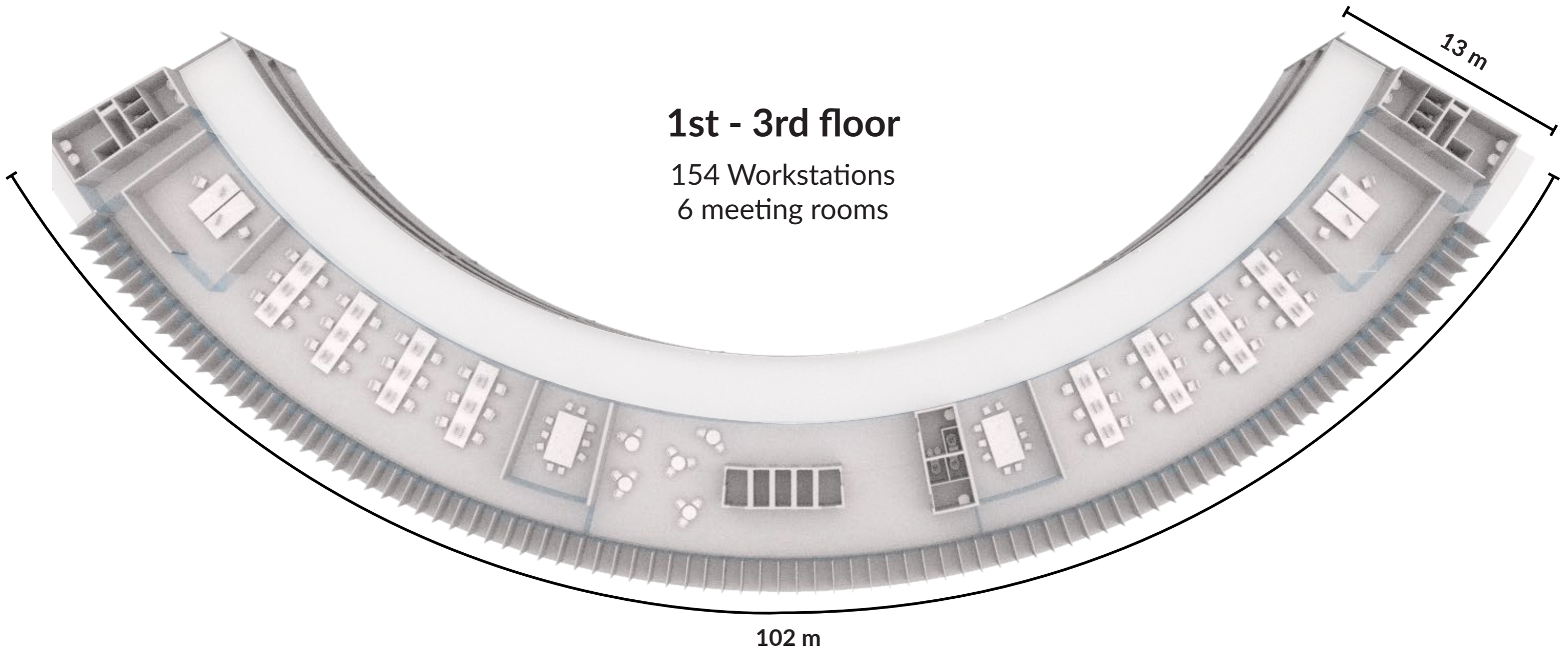


Work spaces  
Second Floor



# 6. Office Concept

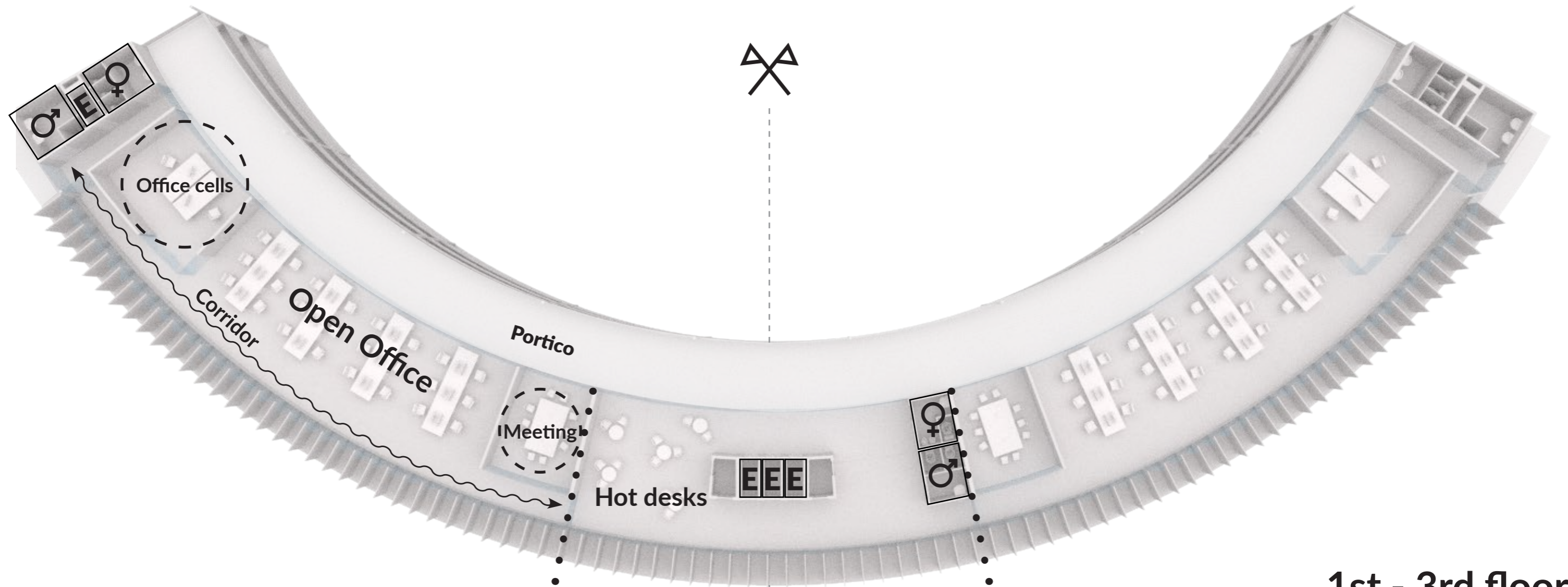
Sample floor plans





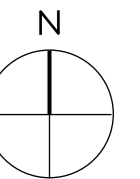
# 6. Office Concept

Sample floor plans



**1st - 3rd floor**

154 Workstations  
6 meeting rooms

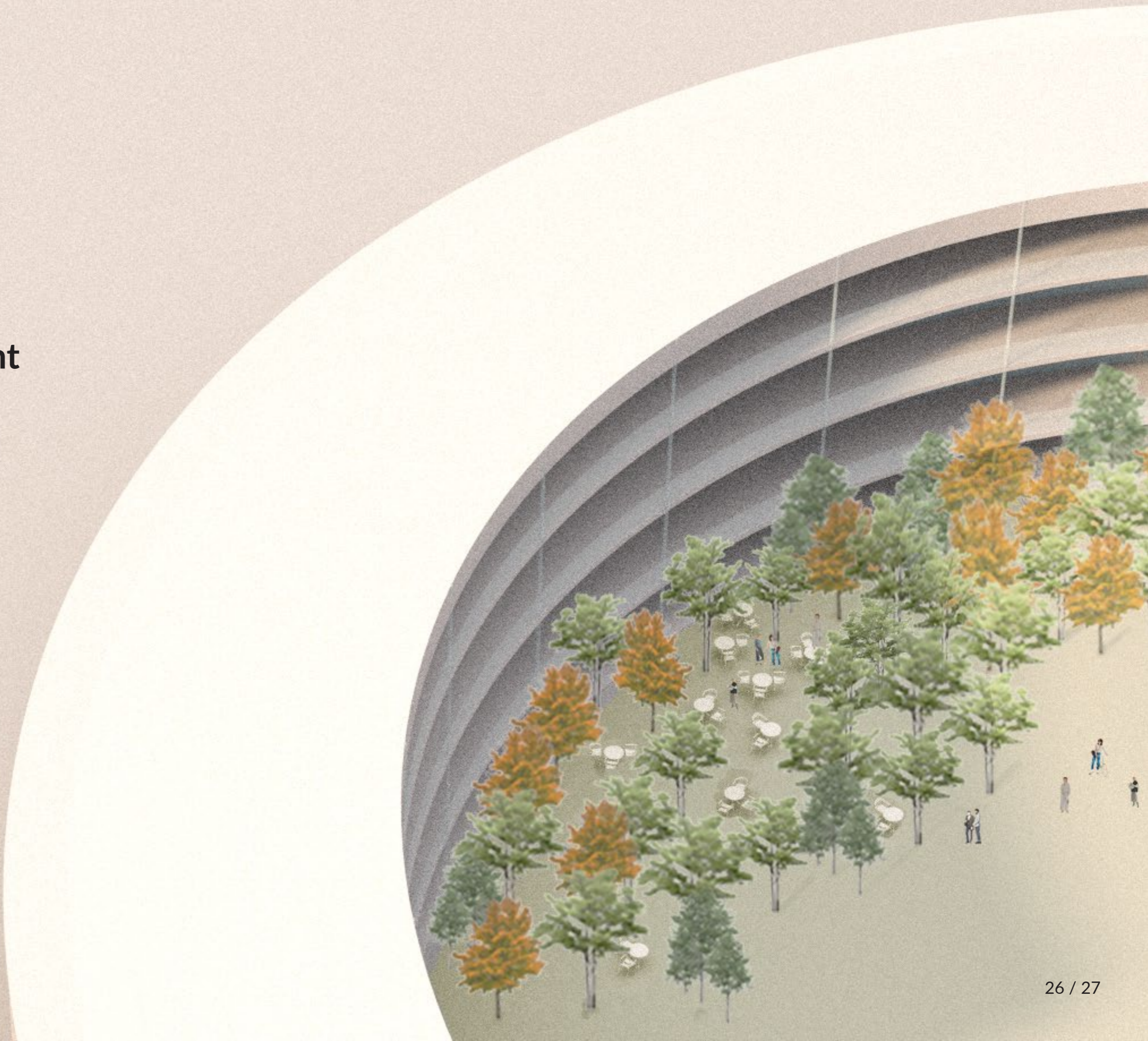


## 7. Open Topics

Natural ventilation

Fin design

Courtyard development



An architectural rendering of a modern building with a facade of vertical wooden slats. The building is long and rectangular, with a flat roof. In the background, there are other large, blocky buildings. The sky is a mix of blue and orange, suggesting a sunset or sunrise. In the foreground, there are several trees with green and orange leaves, and a few small figures of people walking on a paved area.

Thank you.

We welcome any questions!