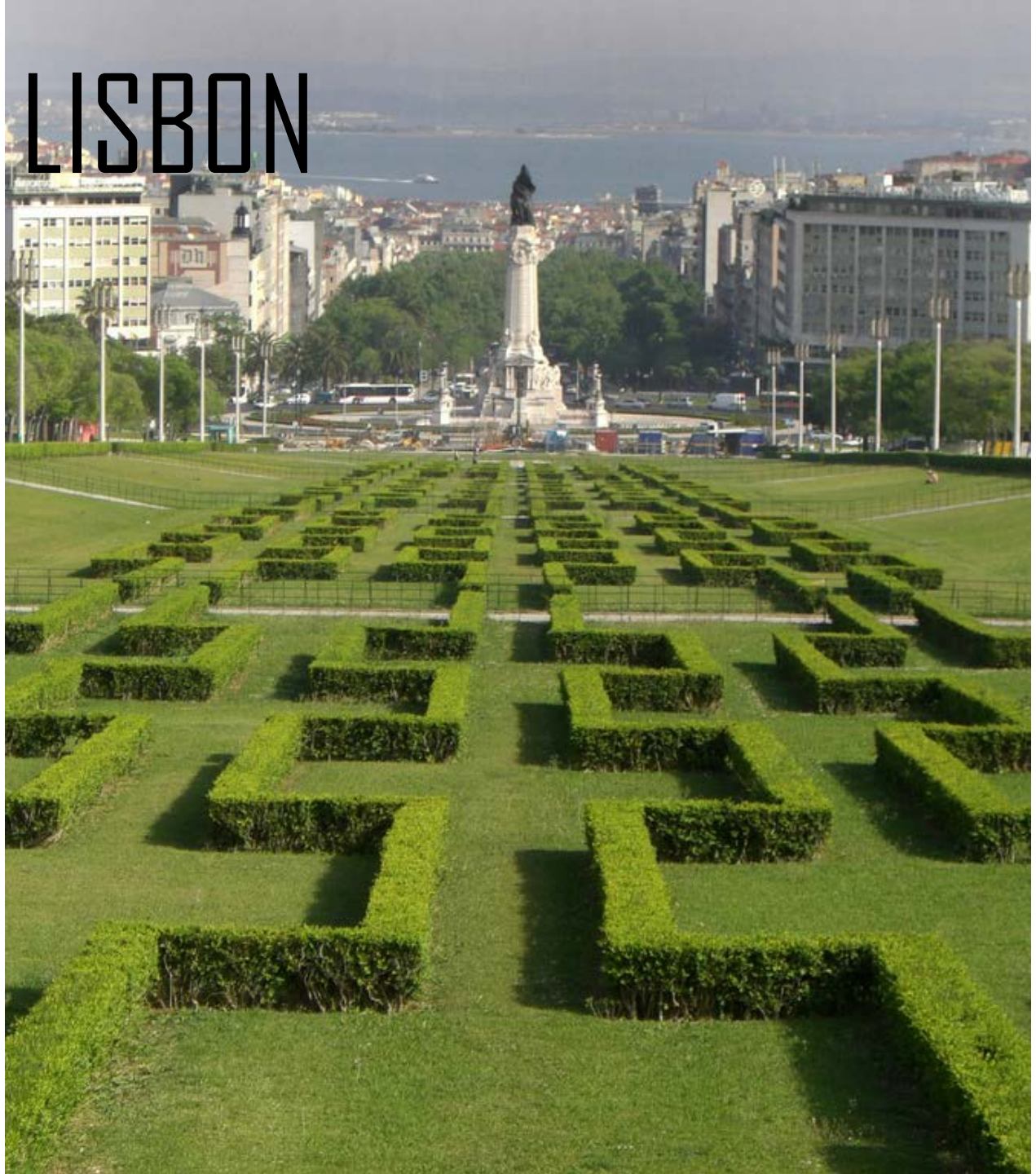
LISBON



5 . 2 . 2016

Simone Cenci Shreejay Tuladhar Sara Freitas Alpha Yacob Arsano

NEIGHBORHOOD DESIGN GOAL

harmony with immediate context

connectivity with the surrounding neighborhood

accommodating social and economic **interaction**

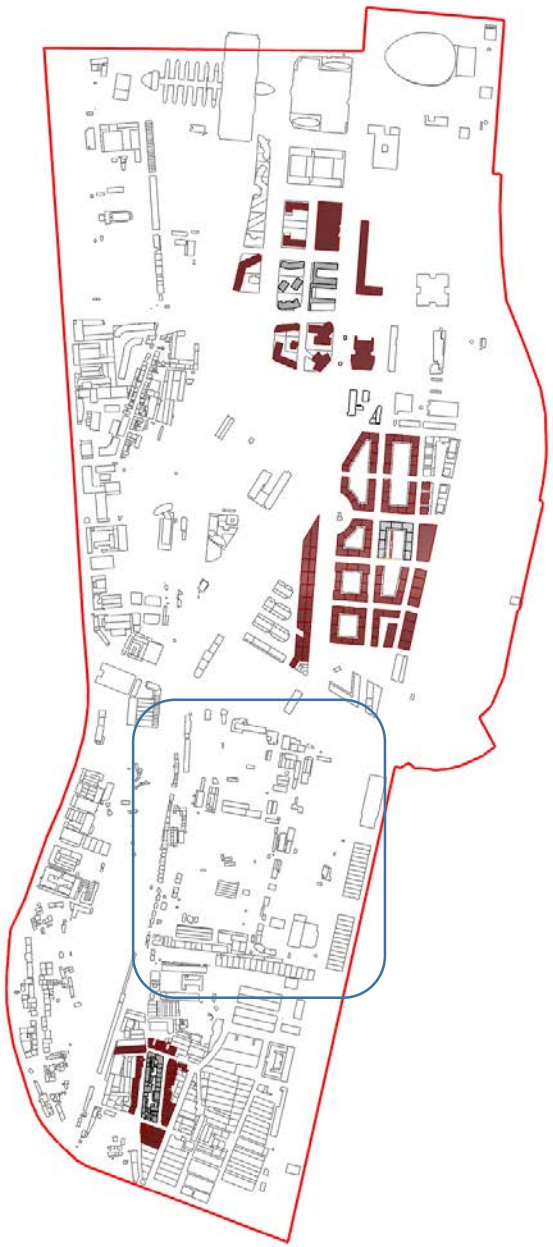
PERFORMANCE DESIGN GOAL

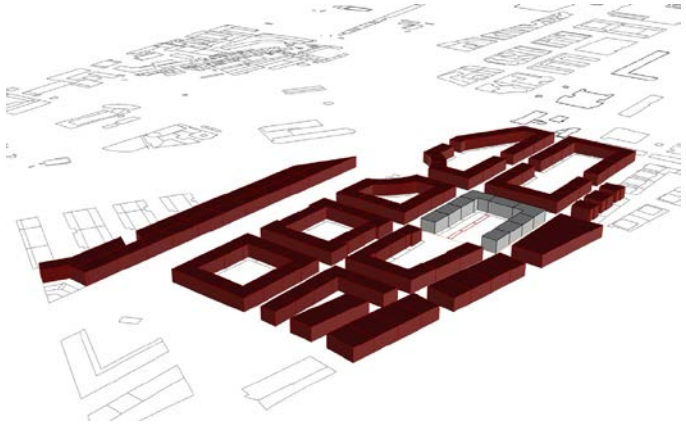
Buildings live in average 50 – 100 years

Natural ventilation in current time and 2080

Solar electricity production

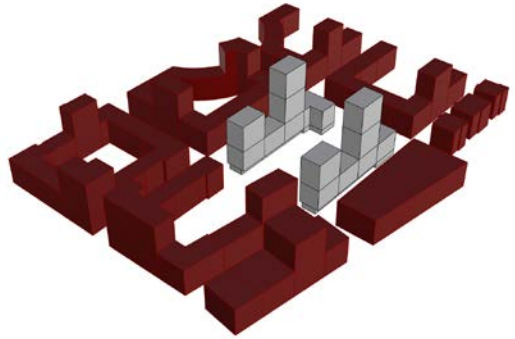
PROTOBLOCK EVOLUTION





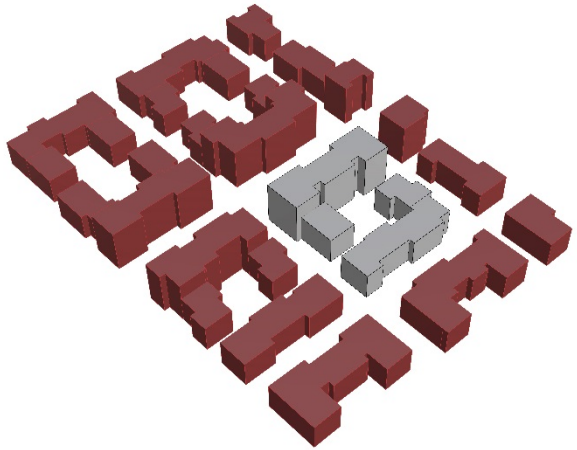
REFERENCE BLOCK

Courtyard typology
3-4 Stories.
Mainly residential.
FAR: 2



FIRST PROTOBLOCK

Courtyard typology
Mixed buildings.
FAR: 4.5



FINAL PROPOSAL

Courtyard typology
5-12 Stories.
Mixed buildings.
FAR: 3

NEIGHBORHOOD DESIGN

BUS STATIONS

MAIN AND SECONDAYR STREETS

BIKES

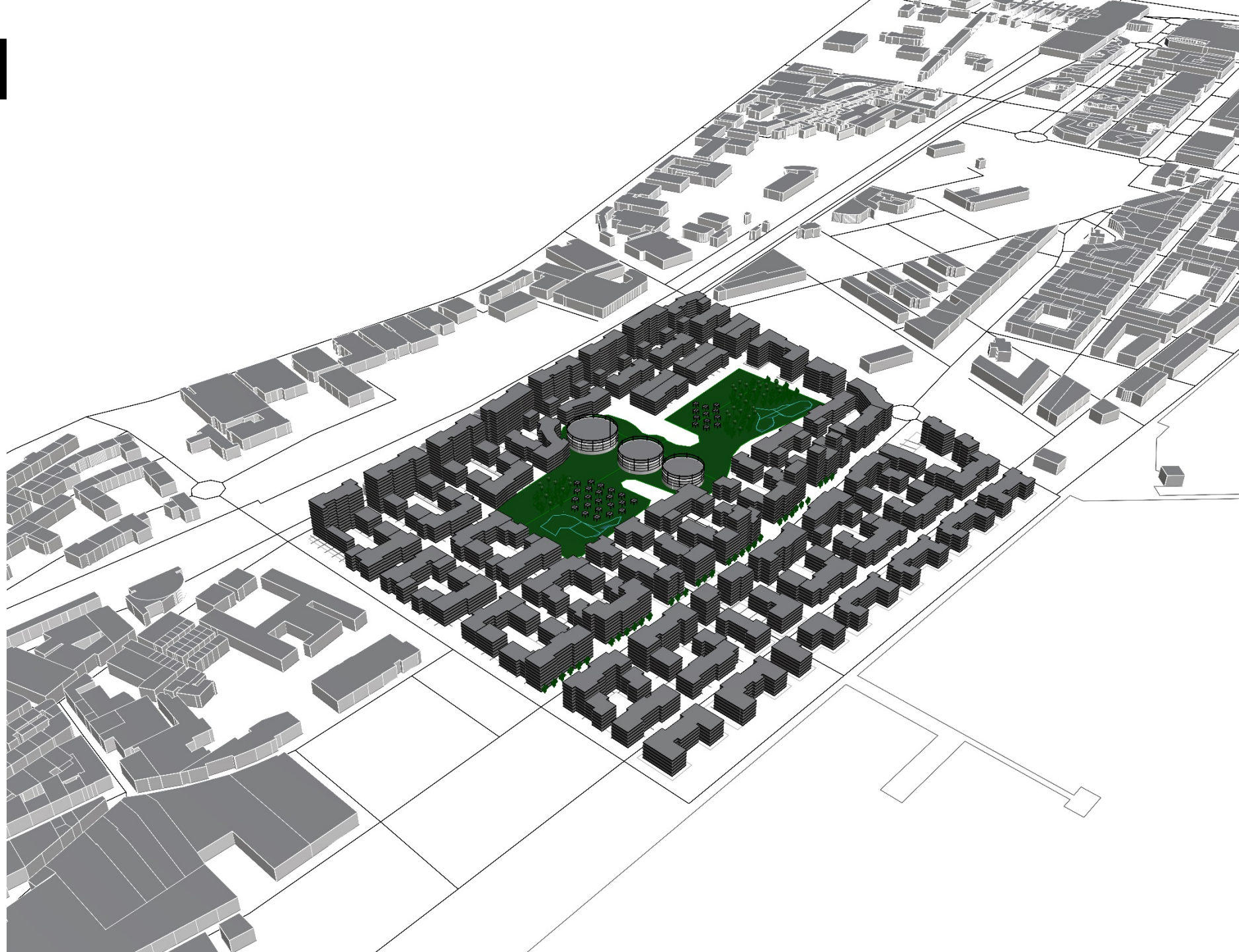
GARDEN PATH

CENTRAL PARK

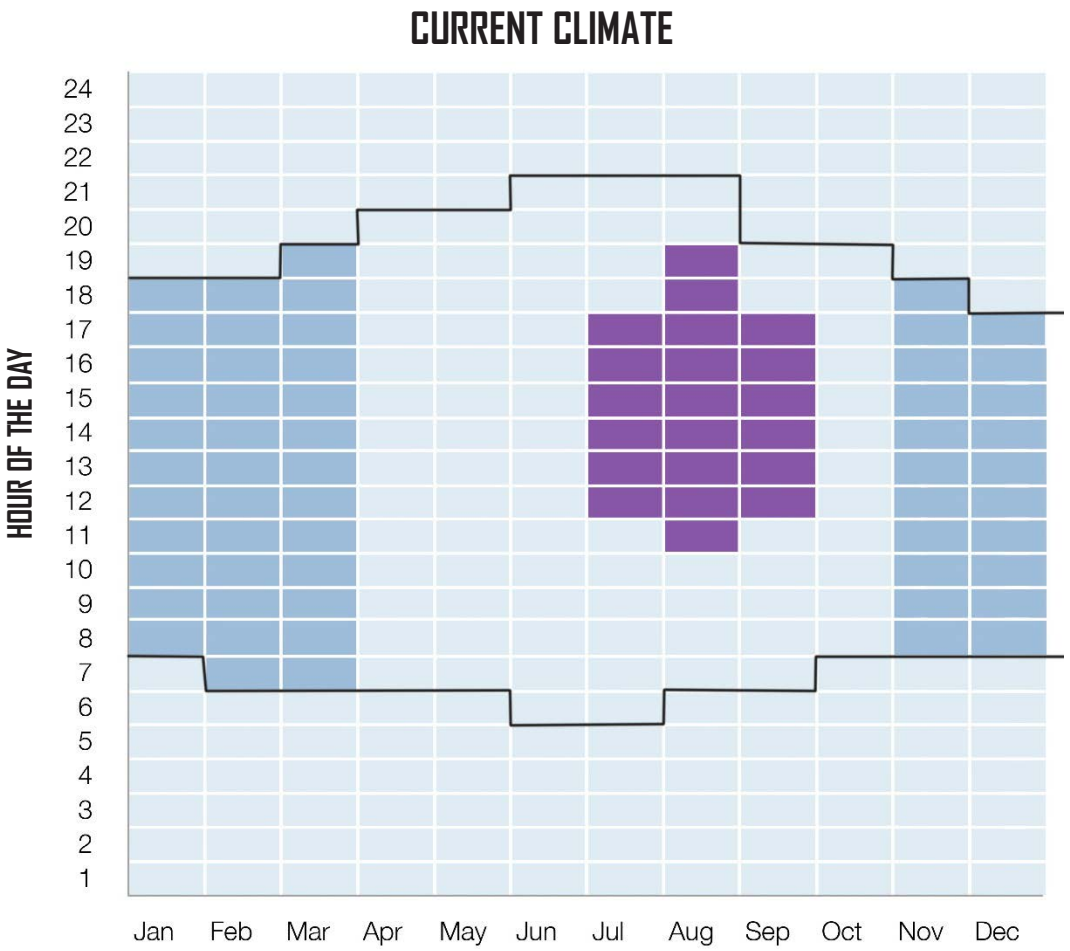
BAZAR / MARKET

WATER FRONT

RAILWAY AND HIGHWAY FACING BLOCKS



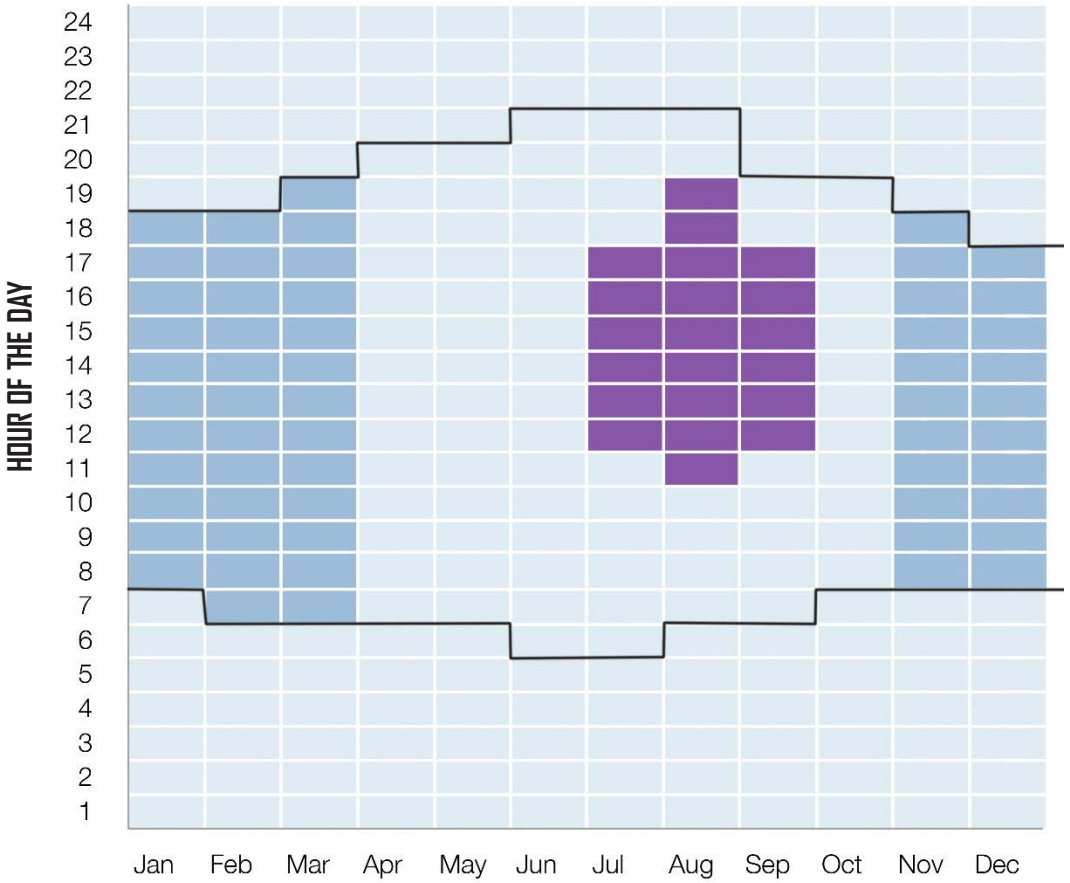
NATURAL VENTILATION



Based on Adaptive Comfort Model
92% of the year Natural Ventilation is Possible

NATURAL VENTILATION

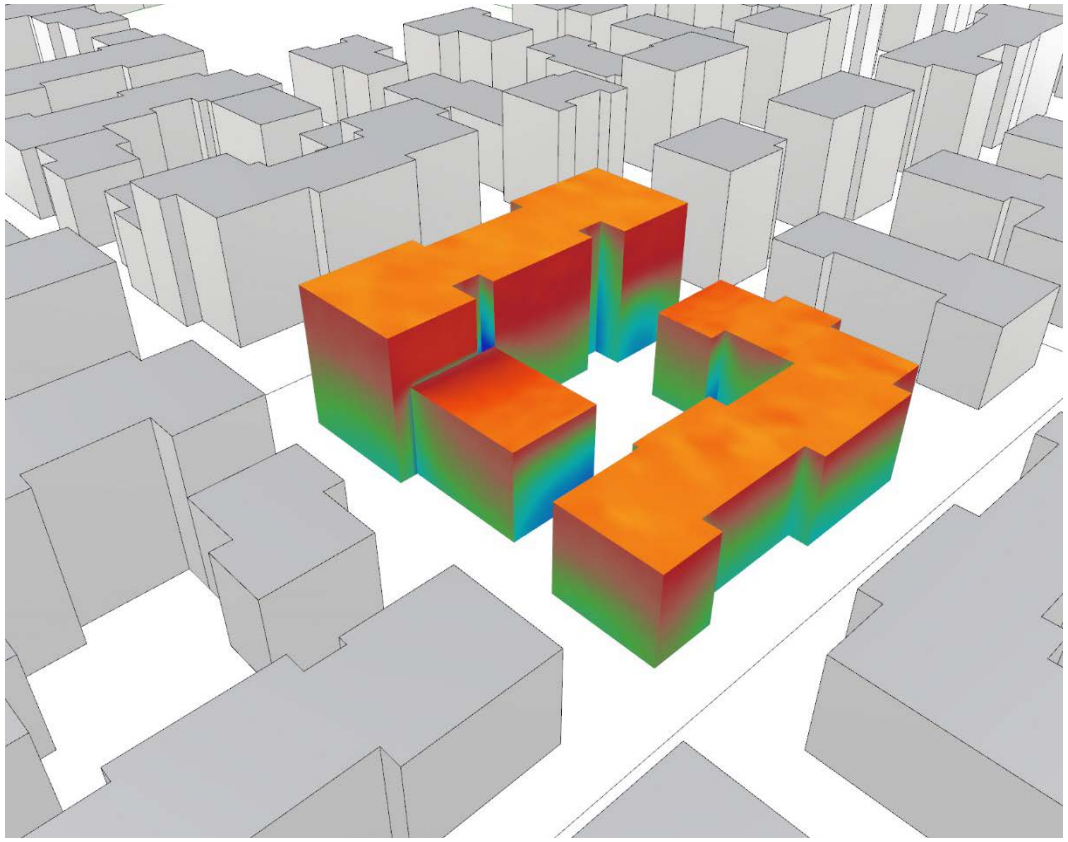
CURRENT CLIMATE



Based on Adaptive Comfort Model

92% of the year Natural Ventilation is Possible

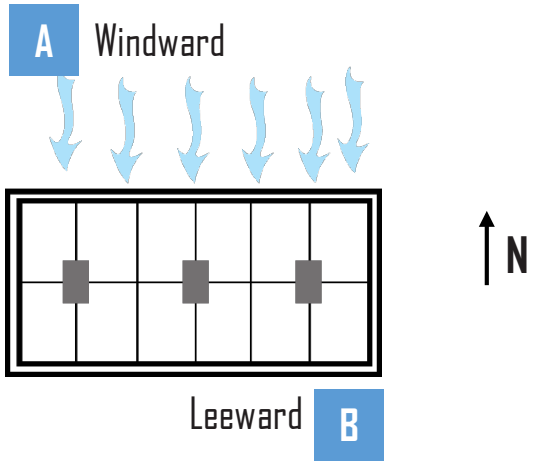
SOLAR IRRADIATION



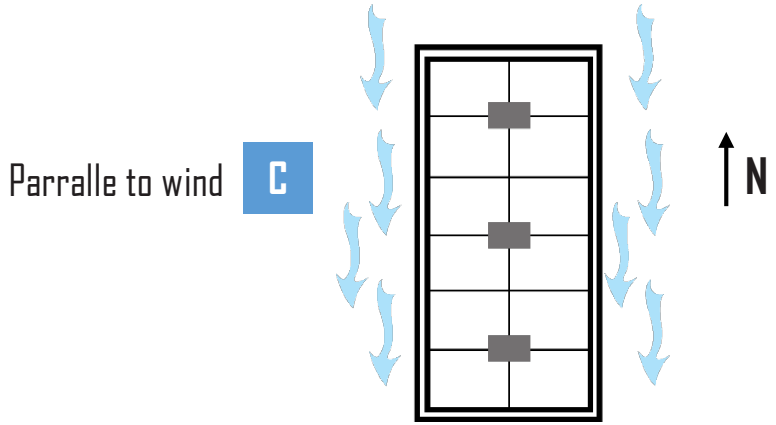
Solar Irradiation Exposure [kWh/m^2/year]

0 1800

NATURAL VENTILATION

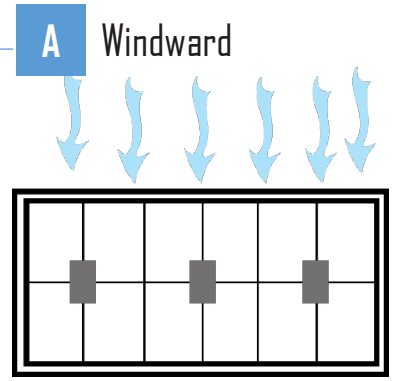


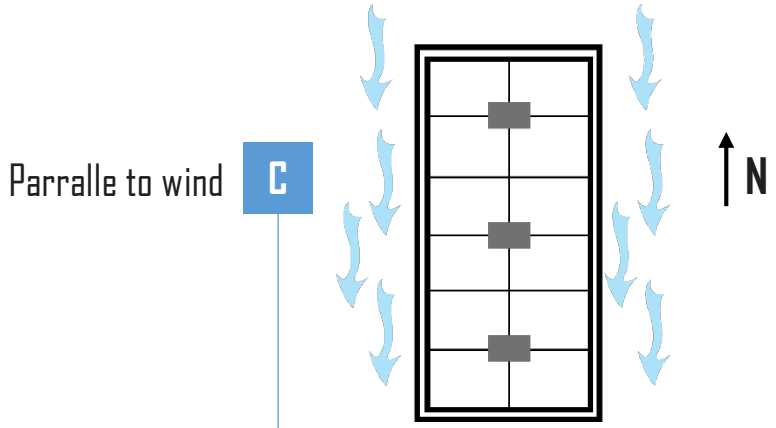
Horizontal section of **North-South** facing building

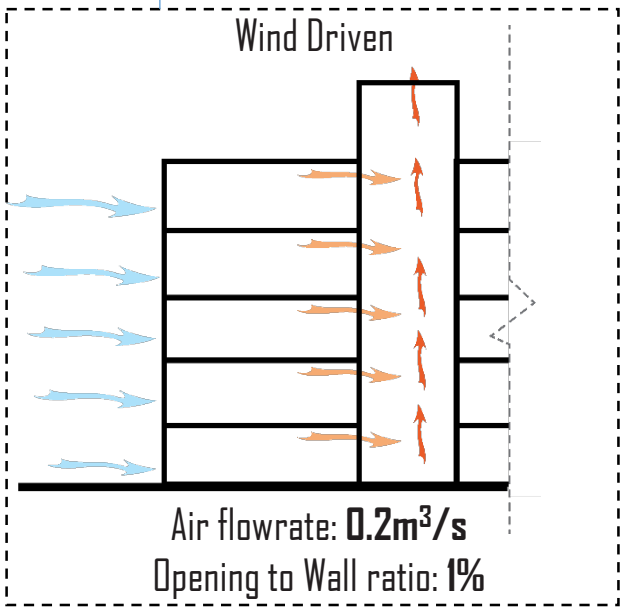


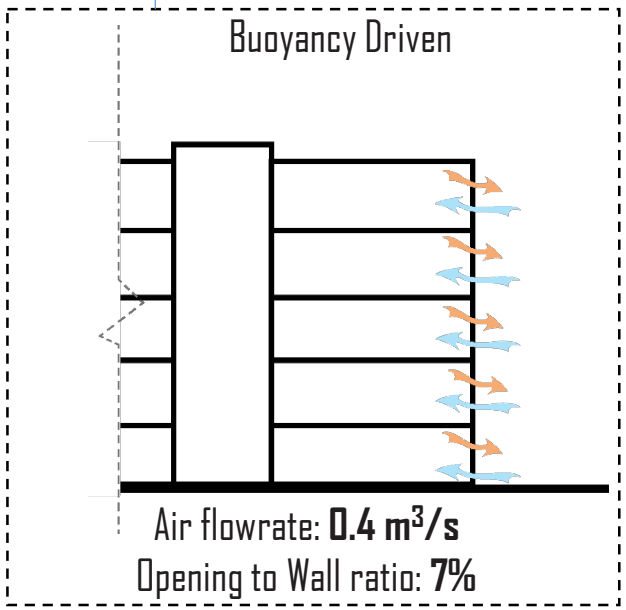
Horizontal section of **East-West** facing building

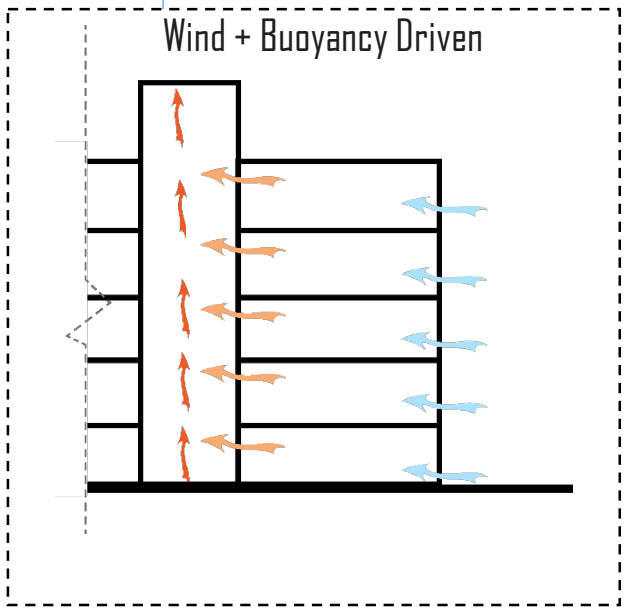
NATURAL VENTILATION







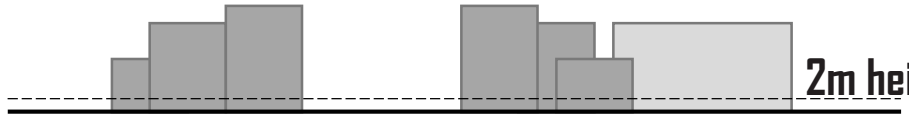




NATURAL VENTILATION

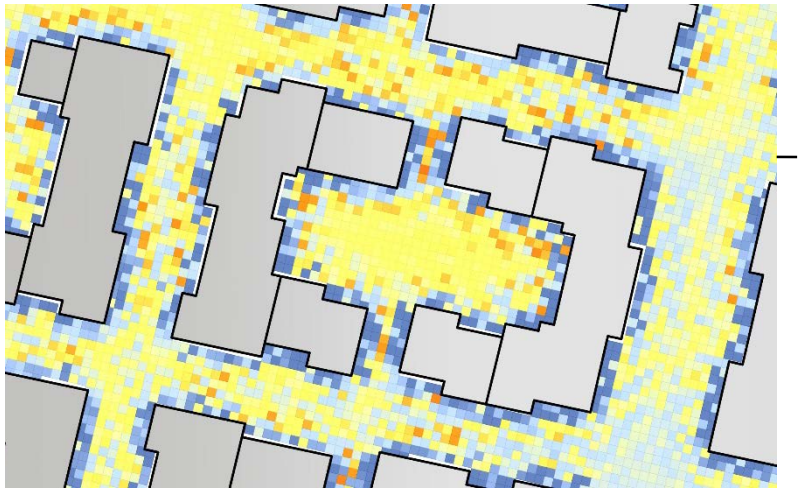
Wind Driven Natural Ventilation Potential

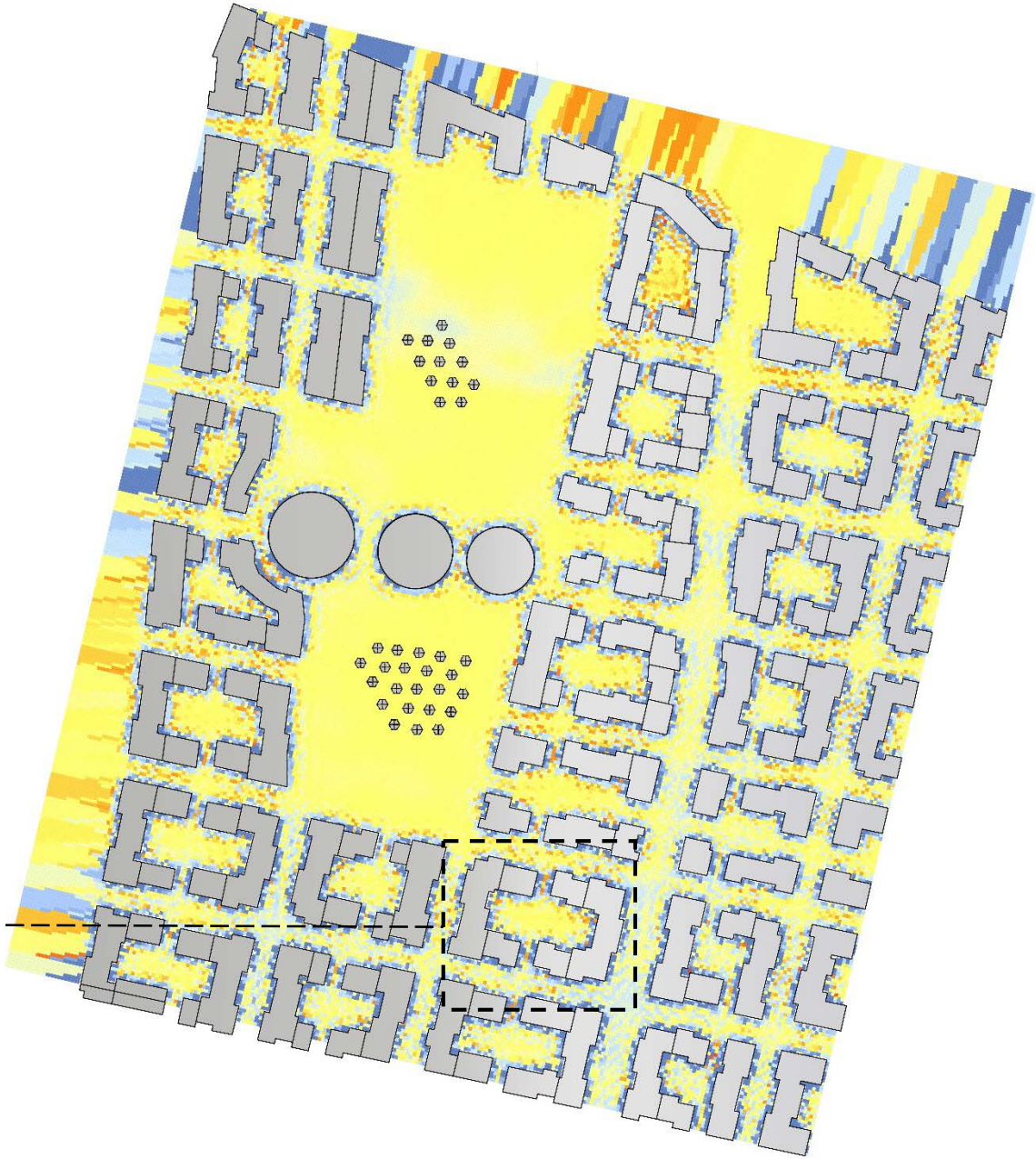
Pressure Coefficient Distribution Map



Lower CP difference between opposite sides

Lower potential for ventilation





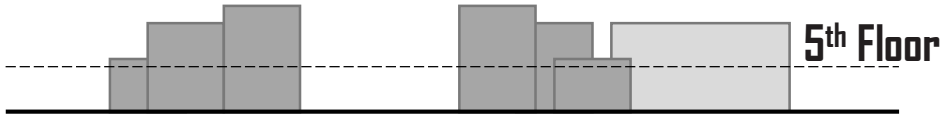
Pressure Coefficient (CP values)

-3 3

NATURAL VENTILATION

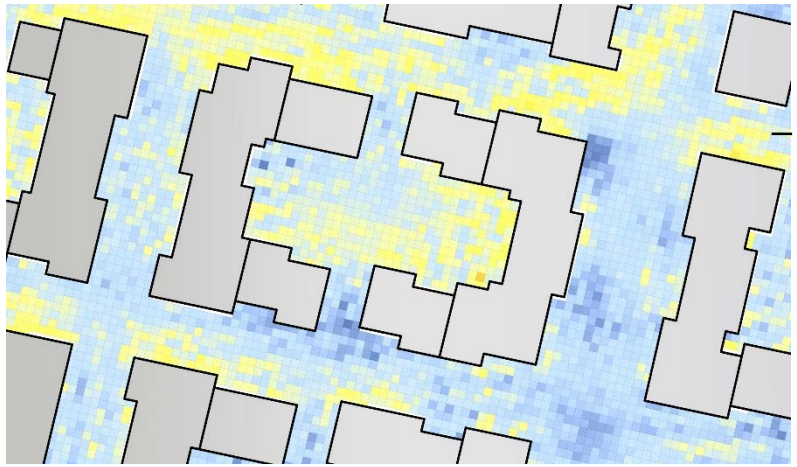
Wind Driven Natural Ventilation Potential

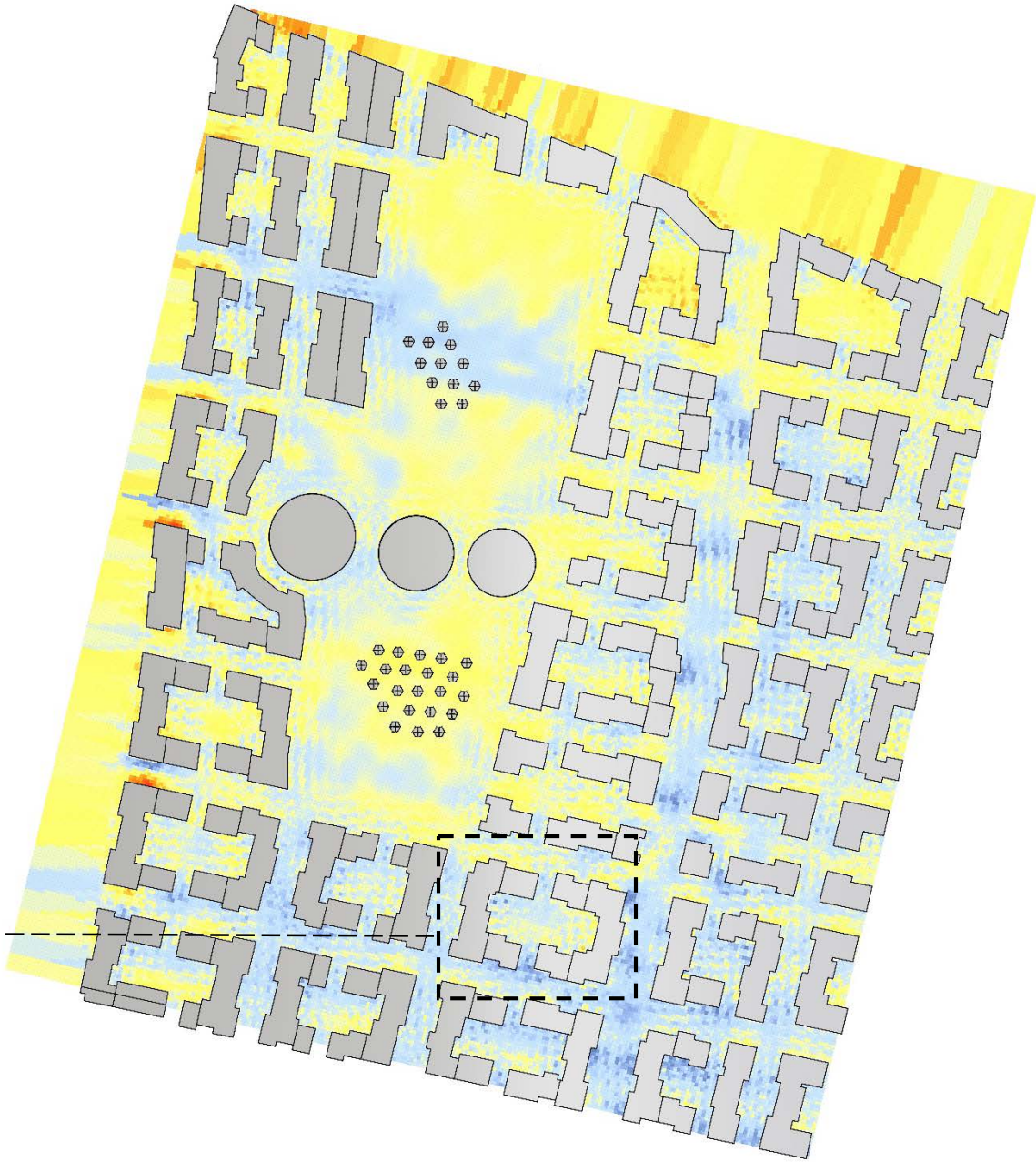
Pressure Coefficient Distribution Map



Higher CP difference between opposite sides

Higher potential for ventilation



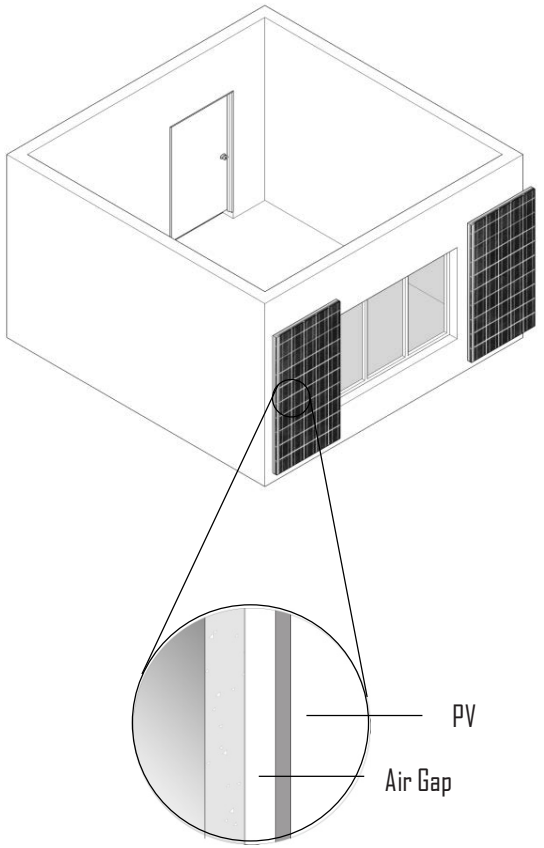


Pressure Coefficient (CP values)

-2 2

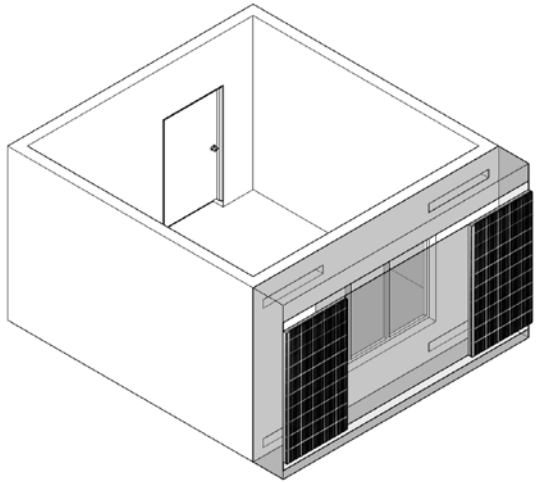
NATURAL VENTILATION + PV

Façade PV (electricity production)

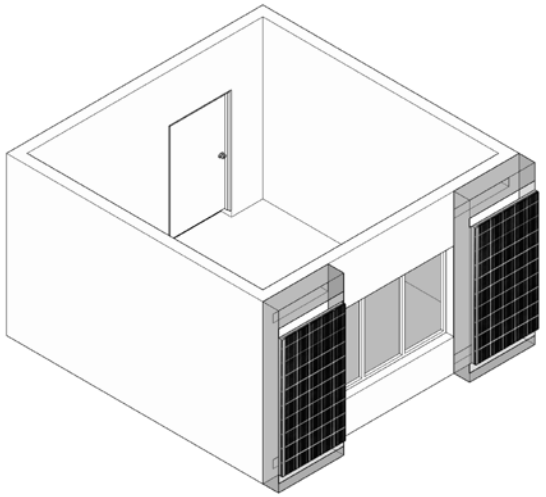


Minimum air gap between PV and facade-15 cm

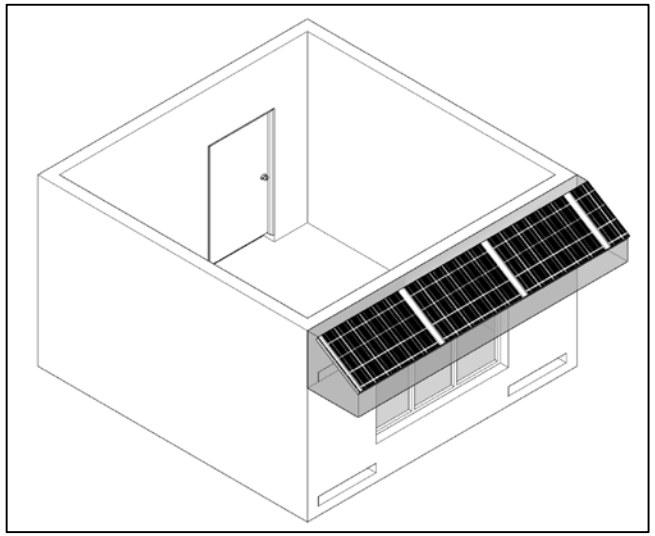
Façade PV (air preheating and electricity production)



Causes overheating



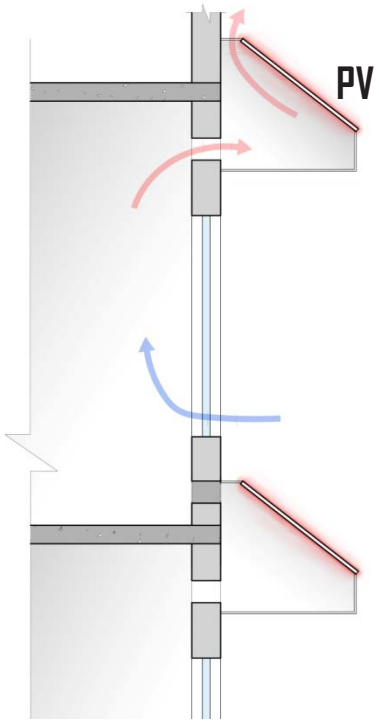
Causes overheating



Effective for NV

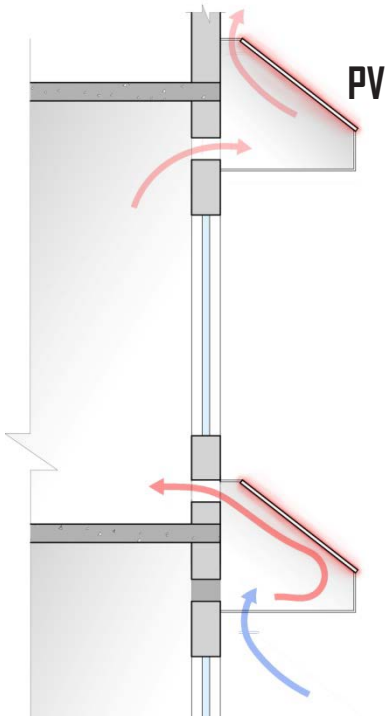
Minimum air gap between PV and facade-30 cm

NATURAL VENTILATION + PV METRIC



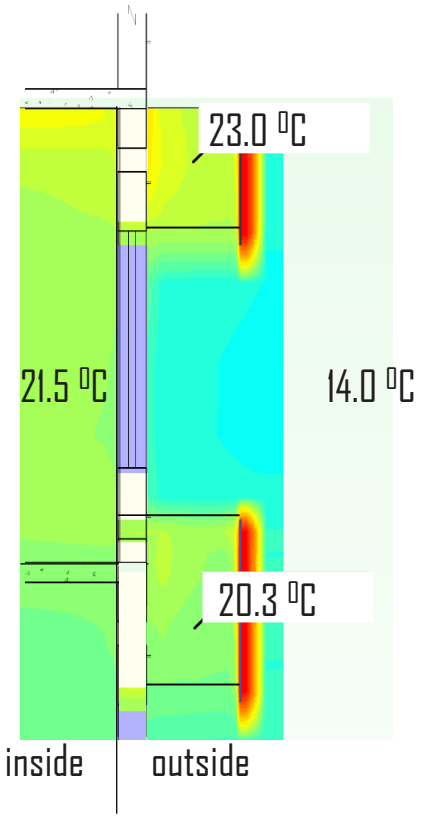
Warm Season

Direct outdoor air for NV



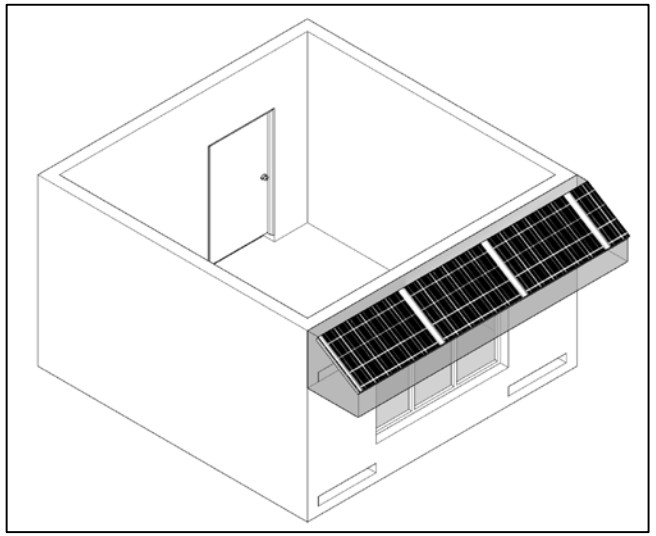
Cold Season

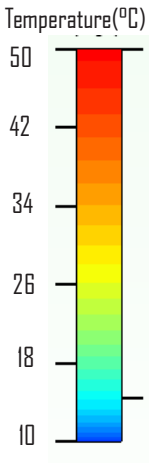
Preheated outdoor air for NV



Façade PV
(air preheating and electricity production)

South and East Facade





PV

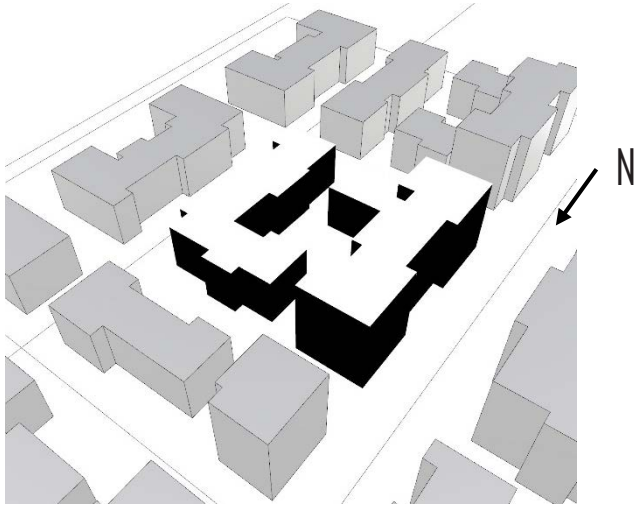
Roof Top PV (electricity production)

178 kWh/m^2/year

75% of horizontal rooftop

Crystalline Silicon PV (c-Si)

15% efficiency
0.45% loss per ^{0}C



Irradiation < 1000 kWh/m^2/year

Façade PV (air preheating and electricity production)

130 kWh/m^2/year

1/3rd of South and East Facades

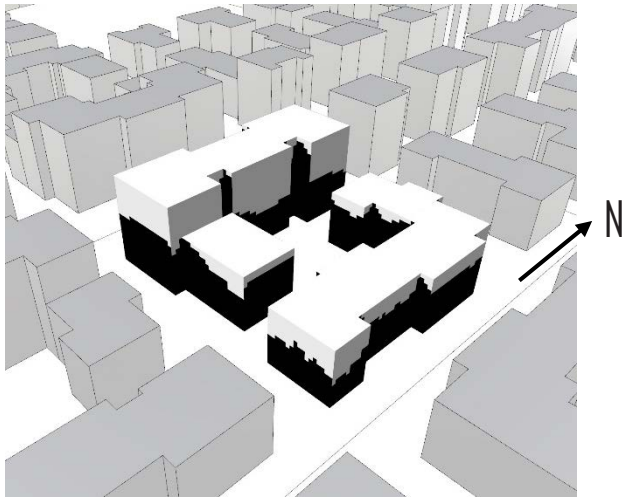
Façade PV (electricity production)

70 kWh/m^2/year

South and East Facades

Amorphous Silicon PV (a-Si)

8% efficiency
0.21% loss per ^{0}C

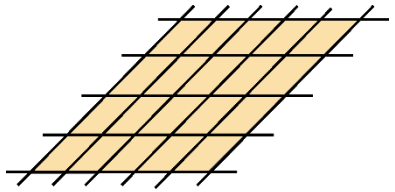


Irradiation < 1000 kWh/m^2/year

NATURAL VENTILATION + PV METRIC

SCORE CARD

PV Score



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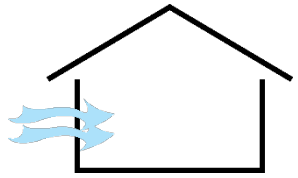
%

PV PRODUCTION/ EUI

NV Score



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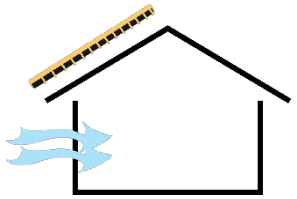
%

NATURALLY VENTILATED HRS/ COMFORT HRS

PV+NV Score



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%

AVERAGE (NV SCORE, PV SCORE)

PV Score = $\frac{\text{PV Electricity Production}}{\text{Total EUI}}$

NV Score = $\frac{\text{Naturally Ventilated Hours}}{\text{Comfortable Hours}}$

**Naturally Ventilated Hours are considered for times which are within adaptive comfort model.

Current: **outdoor temperature is between 18 and 26.5^{0}C.**

2080: **outdoor temperature is between 19 and 27.5^{0}C.**

REGULATIONS: Natural Ventilation and PV

Prescriptive

FOR NATURALLY VENTILATED BUILDINGS

Indoor temperature range 18°C - 27°C.

Minimum opening to wall ratio:

North and West facade is 1%.

South and East facade is 5%.

Overheated hours should not exceed 20% of the year or 1750 hrs.

FOR ALL BUILDINGS

No PV panels on **first and second** floors.

Crystalline Silicon PV **(c-Si)** used for **preheating** ventilation air

Maximum coverage 30% of façade

Minimum air gap 30cm from façade..

Crystalline Silicon PV **(c-Si)** used **only for electricity**

Minimum air gap 15cm from façade.

REGULATIONS: Natural Ventilation and PV

Performative

FOR NATURALLY VENTILATED BUILDINGS

Minimum opening to wall ratio:

North and West facade can be lower than **1%** if:
Airflow rate is 0.2 m^3/s
Air speed is lower than 0.8 m/s

South and East facade can be lower than **5%** if:
Airflow rate is 0.4 m^3/s
Air speed is lower than 0.8 m/s

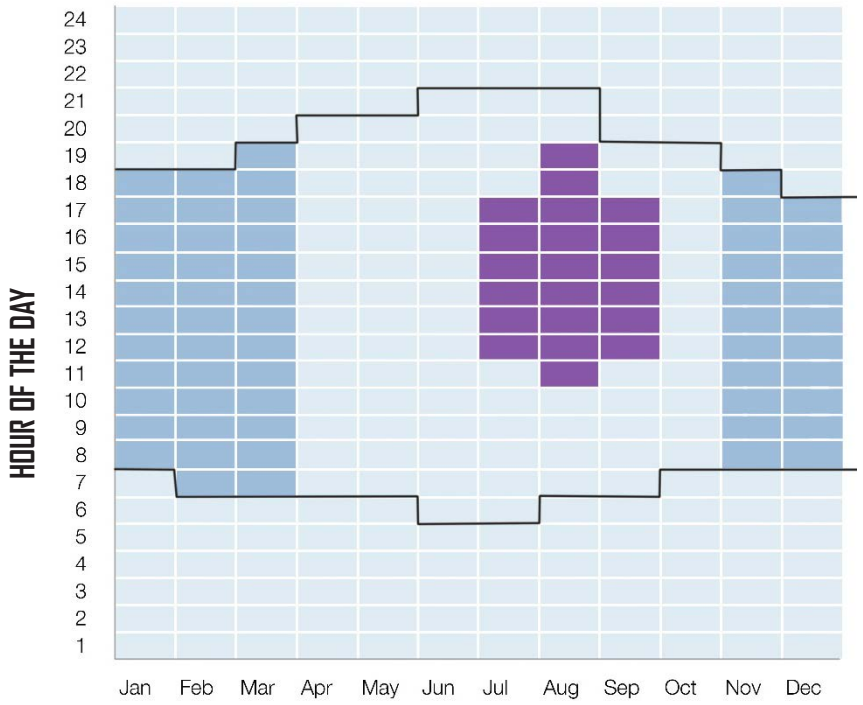
FOR ALL BUILDINGS

Amorphous Silicon (a-Si) PV panels can be installed on the **first and second** floors if annual solar radiation is above **1000 kWh/m2/year**.

ENERGY USE INTENSITY

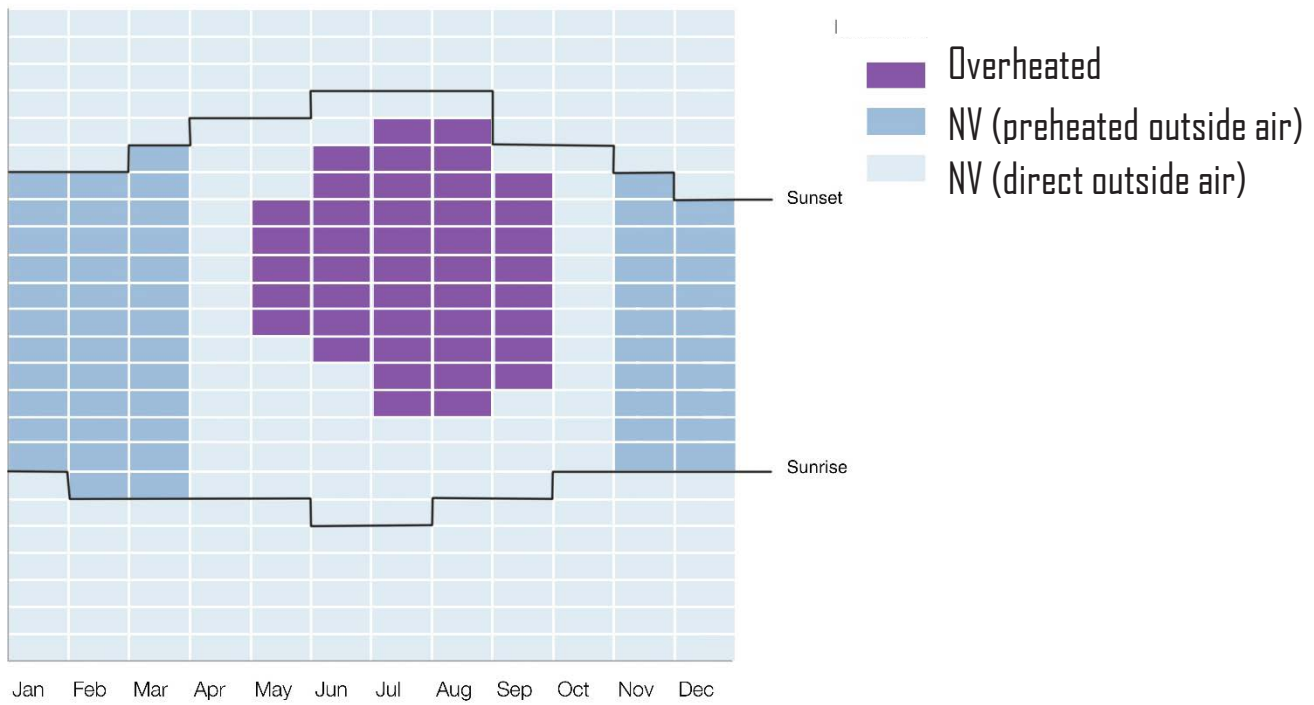
NATURAL VENTILATION SCHEDULE BASED ON OUTDOOR TEMPRATURE

CURRENT TIME



92% of the year Natural Ventilation is Possible

2080



84% of the year Natural Ventilation is Possible

ENERGY USE INTENSITY

New schedule based on design for natural ventilation and solar energy use

Heating load reduced by using pre-heated air with building integrated PV panels

Cooling load reduced by using natural ventilation majority of the time.

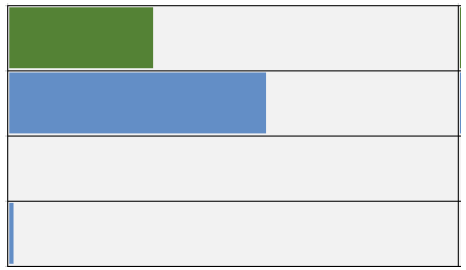
Comfortable hours are improved.

ENERGY USE INTENSITY

CURRENT

2080

BASE CASE



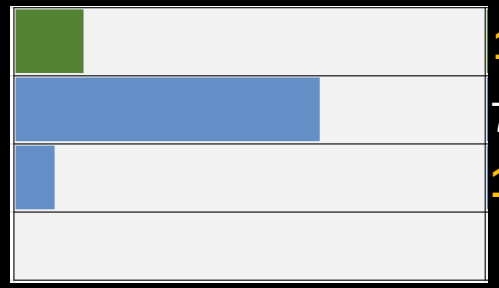
2,800 hrs

69 kWh/m²

0 kWh/m²

1 kWh/m²

PROPOSED USE PROFILE



1,270 hrs

78 kWh/m²

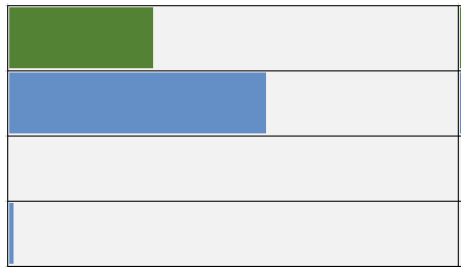
10 kWh/m²

0 kWh/m²

ENERGY USE INTENSITY

CURRENT

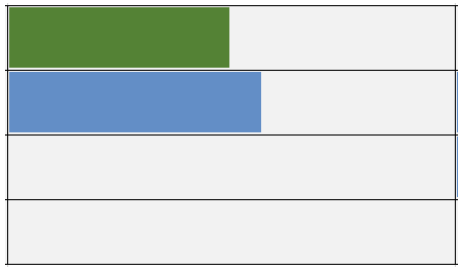
BASE CASE



OVER HEATED HOURS	2,800 hrs
TOTAL EUI	69 kWh/m²
COOLING LOAD	0 kWh/m²
HEATING LOAD	1 kWh/m²

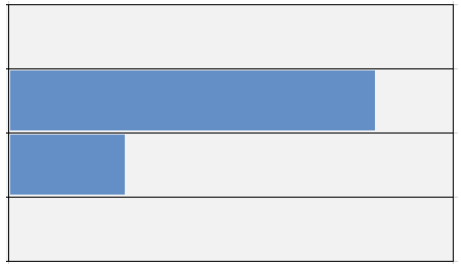
2080

SCENARIO 1 (no cooling system)



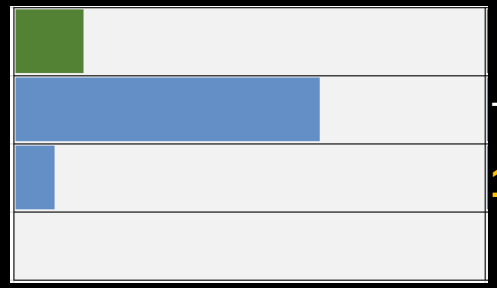
OVER HEATED HOURS	**4,300 hrs**
TOTAL EUI	68 kWh/m²
COOLING LOAD	0 kWh/m²
HEATING LOAD	0 kWh/m²

SCENARIO 2 (cooling system)



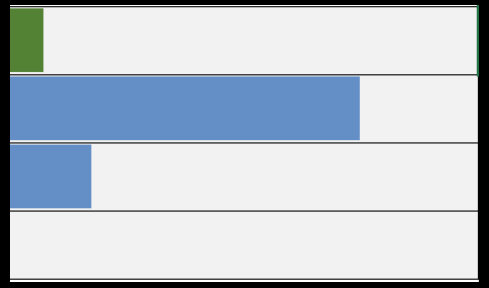
OVER HEATED HOURS	0 hrs
TOTAL EUI	99 kWh/m²
COOLING LOAD	**31 kWh/m²**
HEATING LOAD	0 kWh/m²

PROPOSED USE PROFILE



OVER HEATED HOURS	1,270 hrs
TOTAL EUI	78 kWh/m²
COOLING LOAD	**10 kWh/m²**
HEATING LOAD	0 kWh/m²

SCENARIO 3 (hybrid natural ventilation and cooling system)

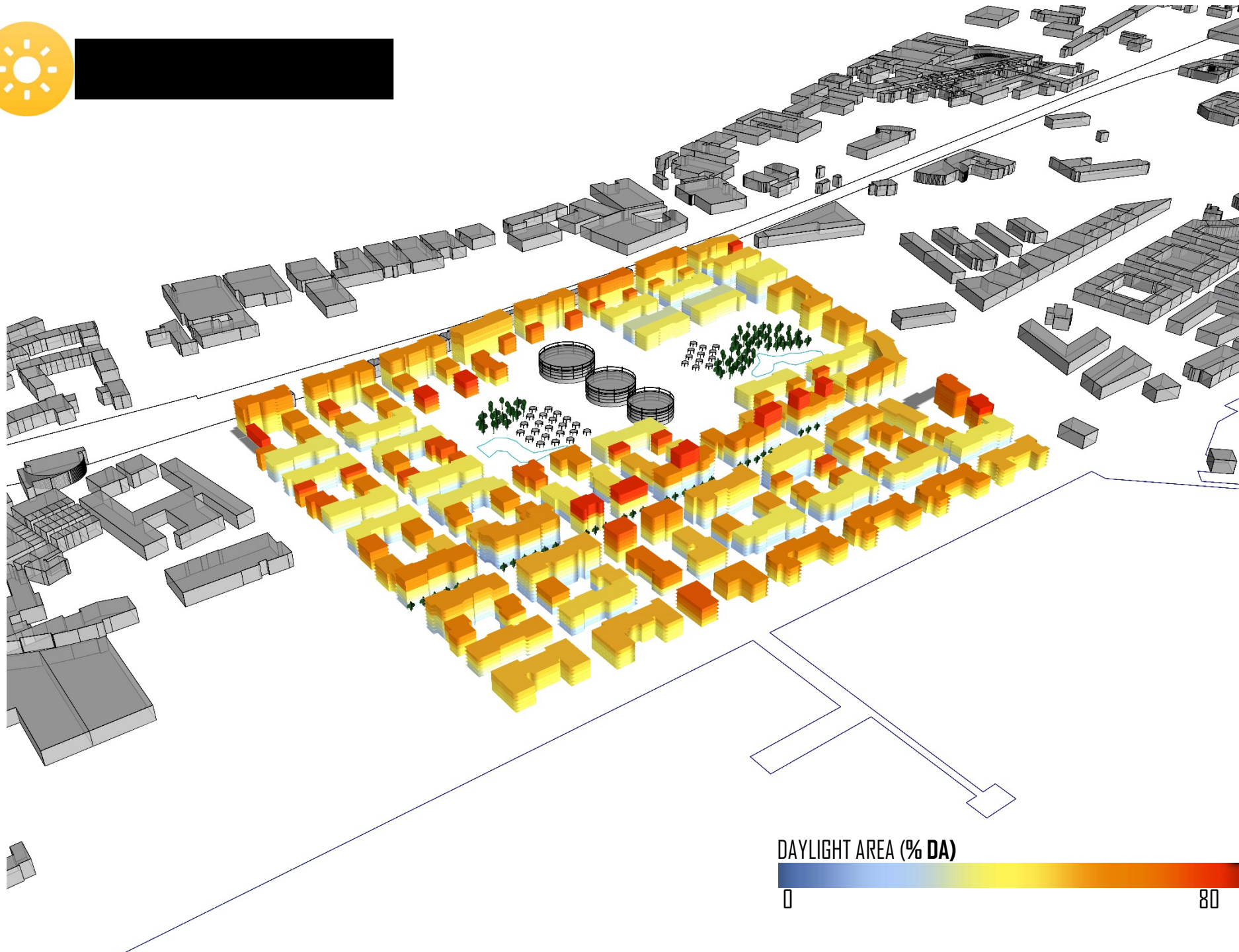


OVER HEATED HOURS	650 hrs
TOTAL EUI	90 kWh/m²
COOLING LOAD	**21 kWh/m²**
HEATING LOAD	0 kWh/m²

URBAN DAYLIGHT

sDA- 36%
(200 lux)

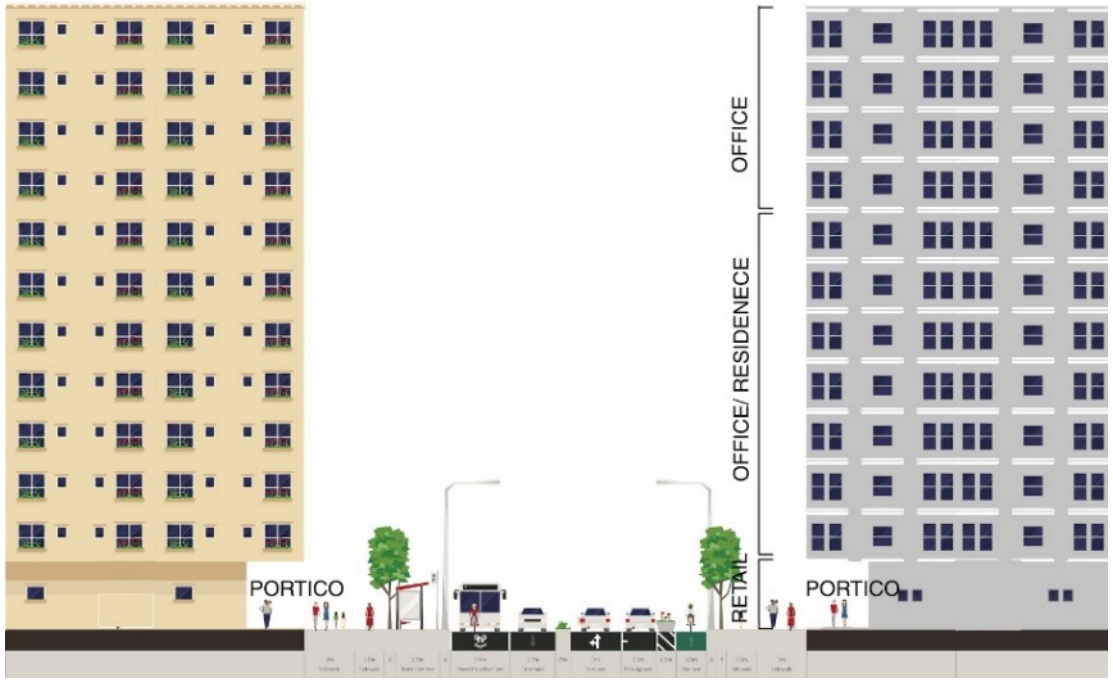
Functional Distribution:
Upper levels are prioritized for office spaces.



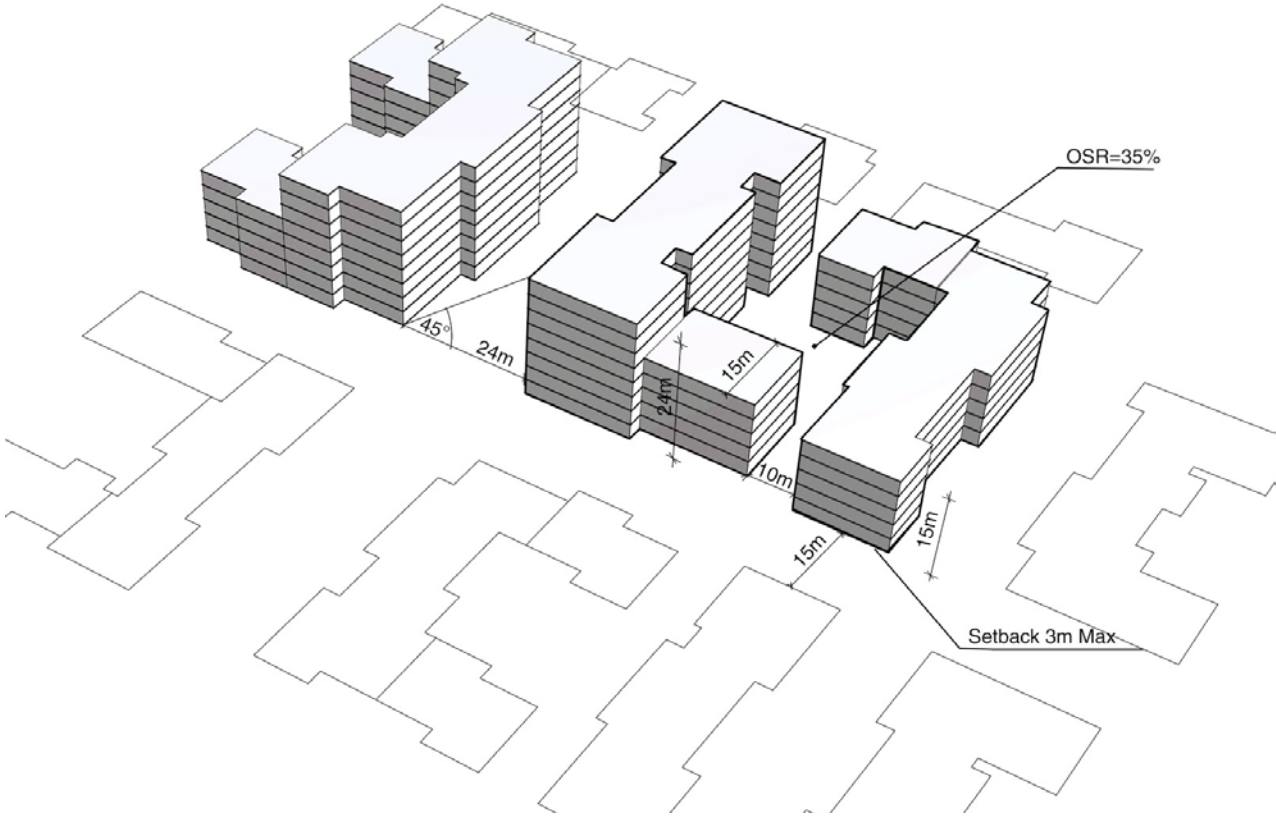
URBAN DAYLIGHT

Functional Distribution:

Upper levels are prioritized for office spaces.



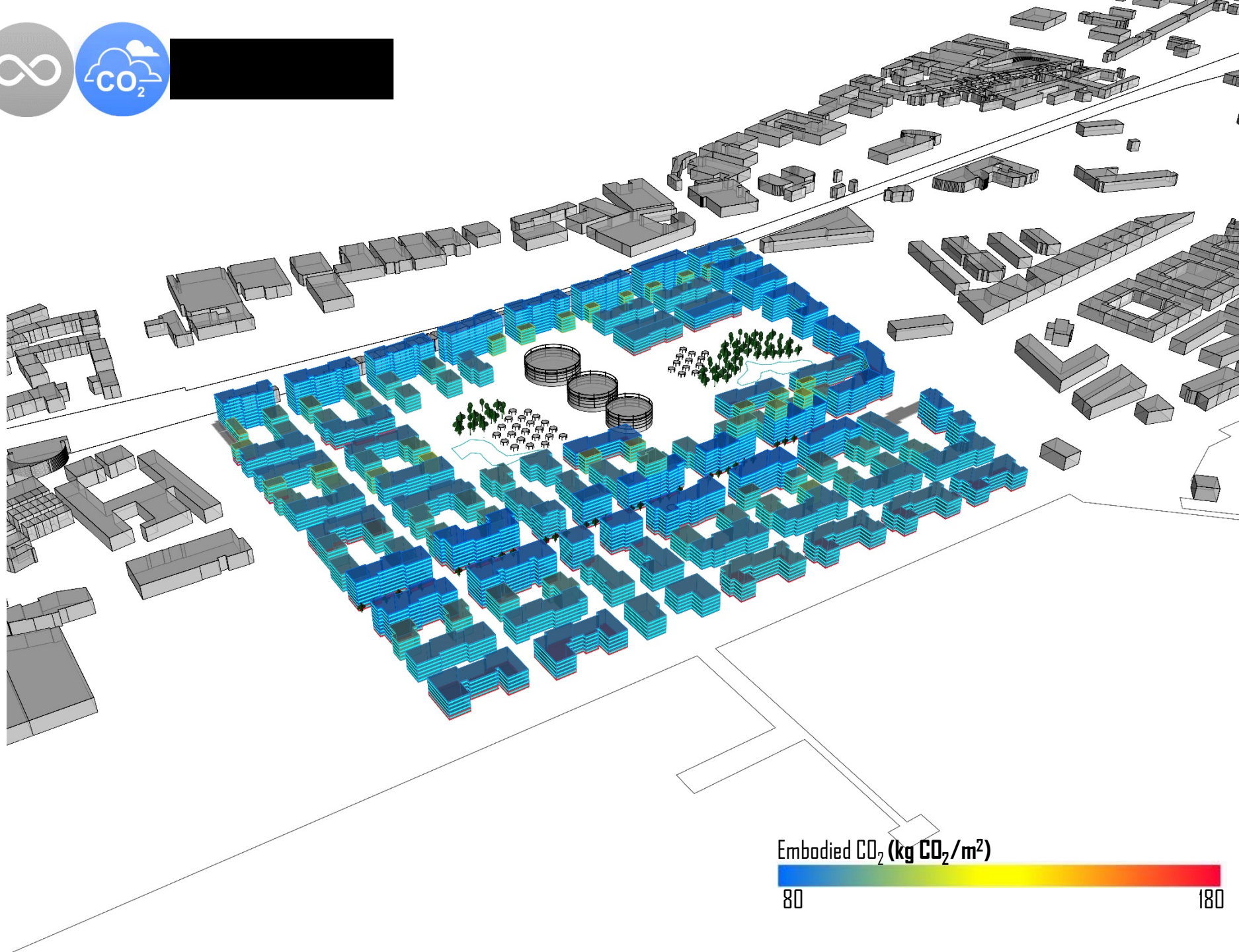
Building Depth: 12m – 18m



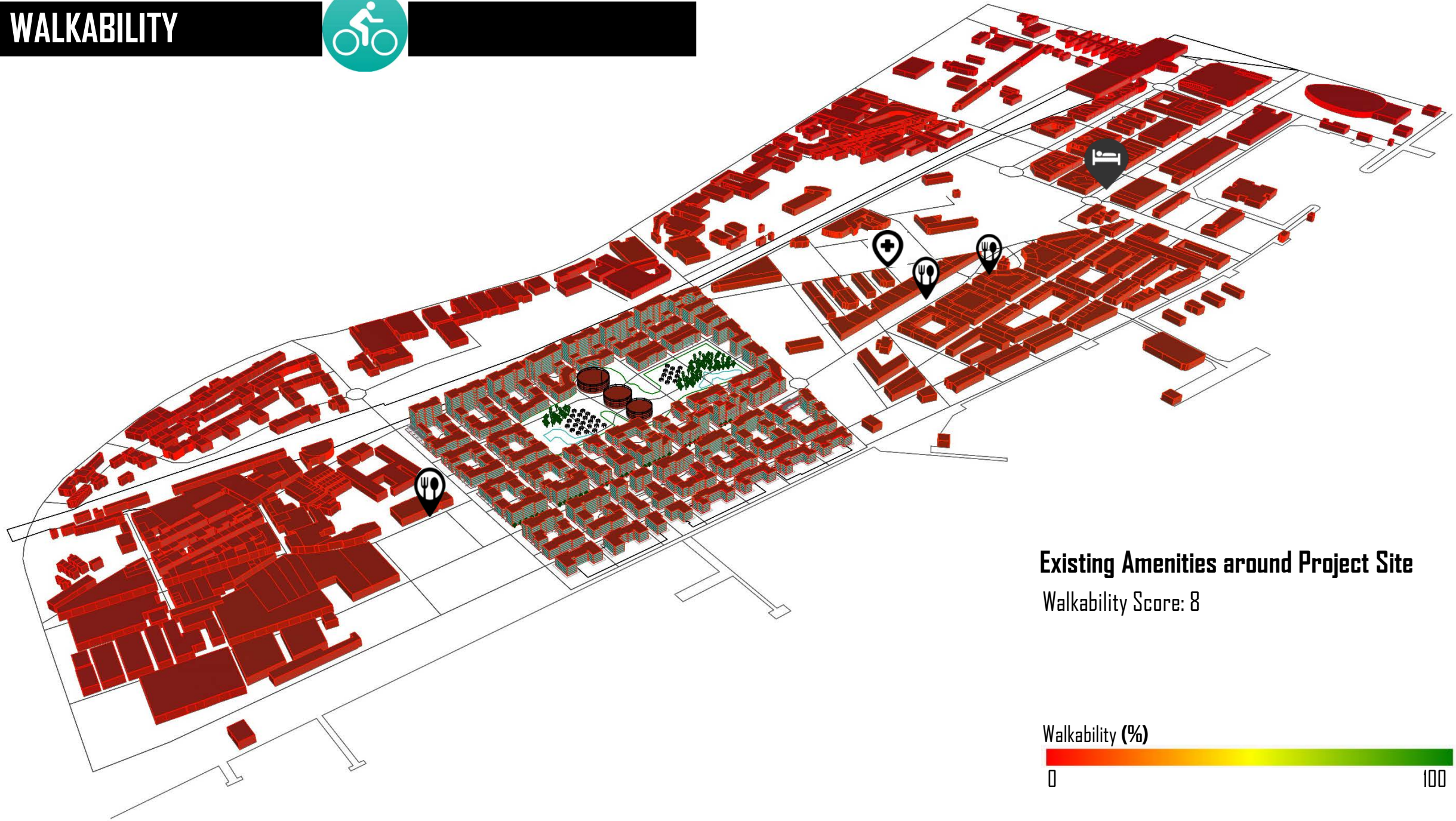
EMBODIED CO_2

Neighborhood Embodied CO_2
102 kg CO_2/m^2

Neighborhood Embodied Energy
1152 kWh/m^2



WALKABILITY



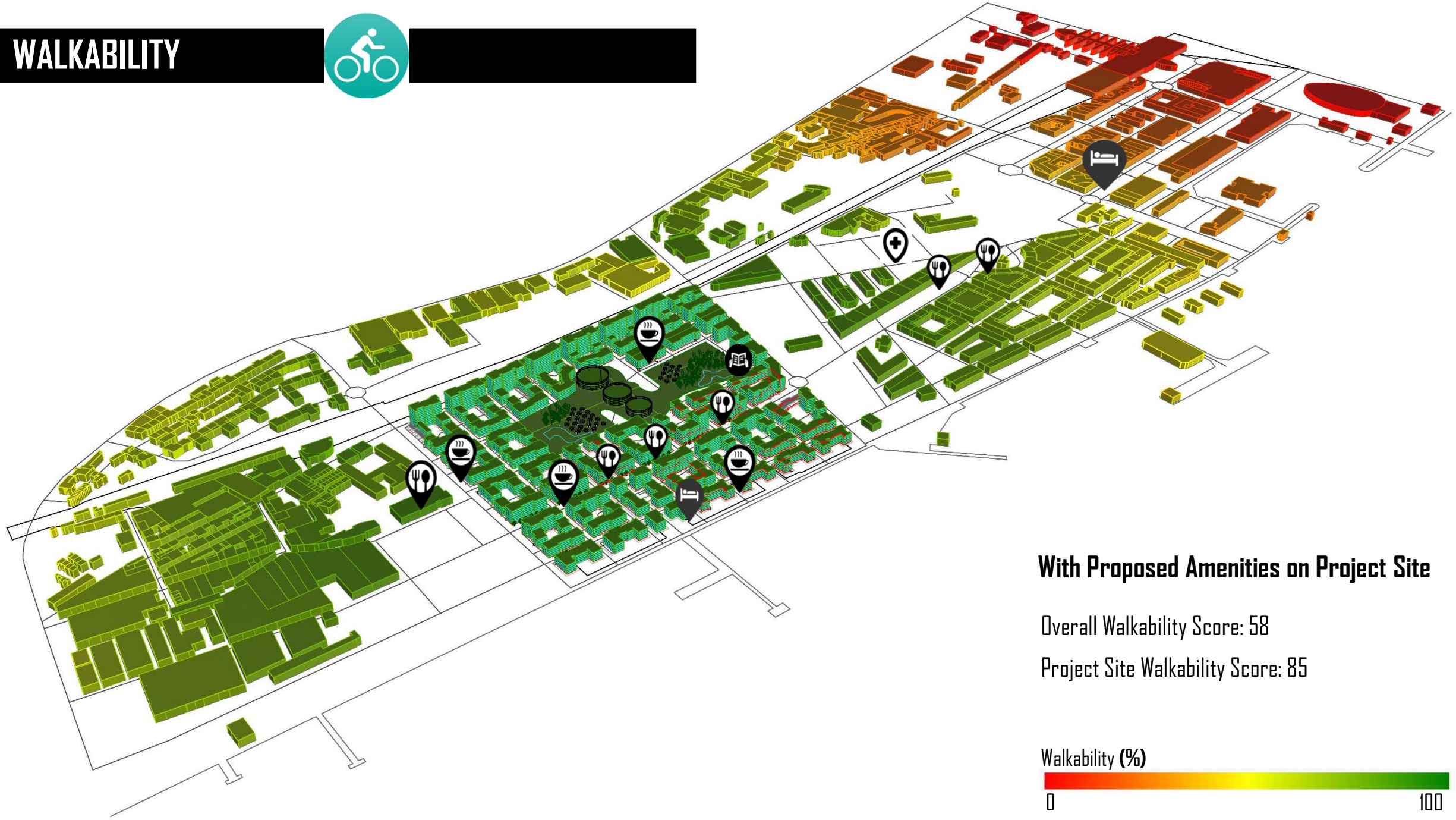
Existing Amenities around Project Site

Walkability Score: 8

Walkability **(%)**

0 100

WALKABILITY



With Proposed Amenities on Project Site

Overall Walkability Score: 58

Project Site Walkability Score: 85

Walkability **(%)**

0 100

FINANCIAL PERFORMANCE

PV INVESTMENT COST: $345/M^2*

Roof Top PV

Payback time: **11 years**

Façade c-Si PV (air preheating and electricity production)

Payback time: **15 years**

Façade a-Si PV (electricity production)

Payback time: **28 years**

*Verberne et al, 2014

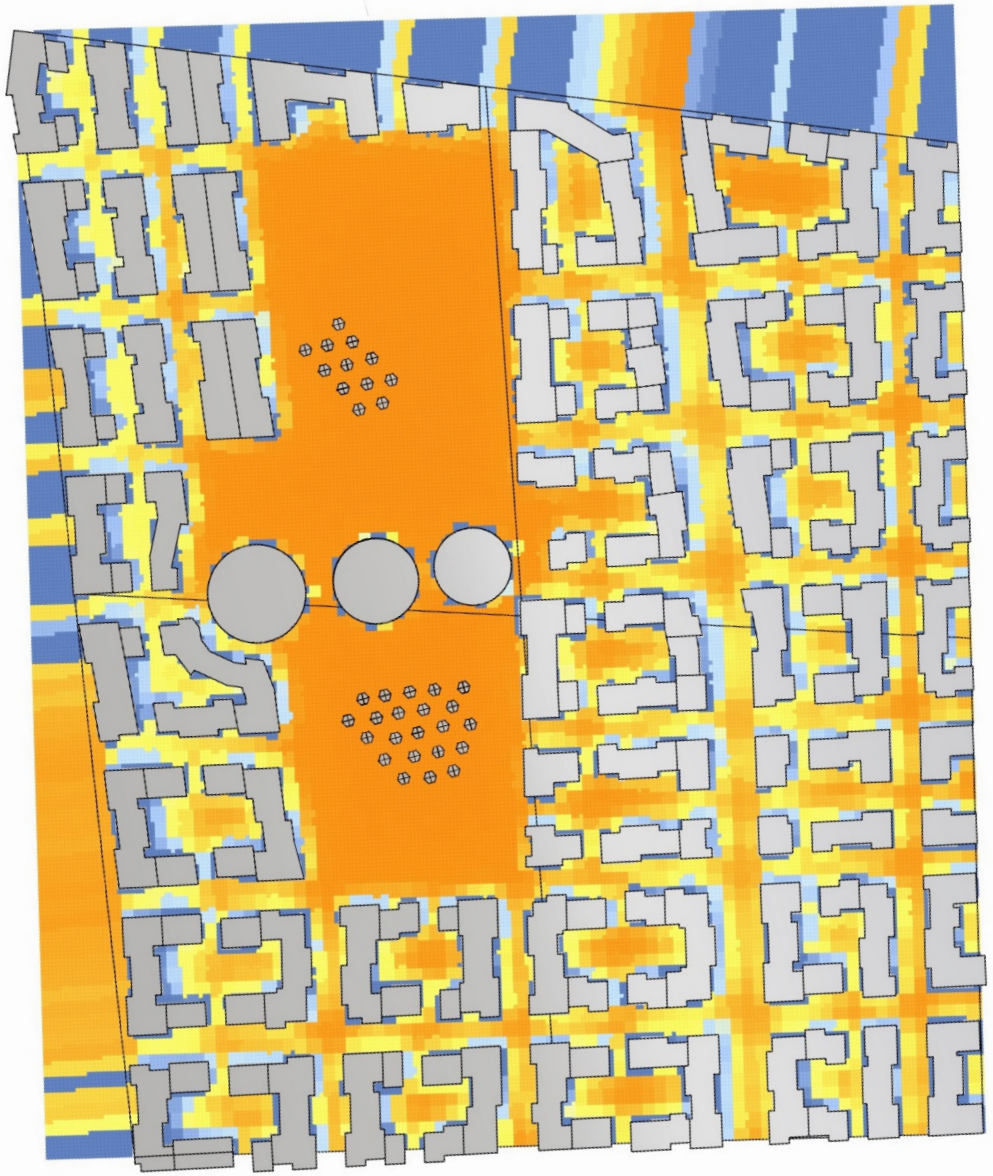
OVER ALL FINANCIAL PERFORMANCE

ROI (Return of Investment)

Without daylight premium: 10%

With daylight premium: 14%

OUTDOOR COMFORT



Summer average hottest hour- August

At 1300hrs

Summer- August

Out doorTemp: 31°C
Global Radiation: 850Wh/sq.m

Result: Strong Heat Stress

Shoulder Season- April

Out doorTemp: 20°C
Global Radiation: 680Wh/sq.m

Result: No thermal Stress

Winter- December

Out doorTemp: 14°C
Global Radiation: 450Wh/sq.m

Result: No thermal Stress

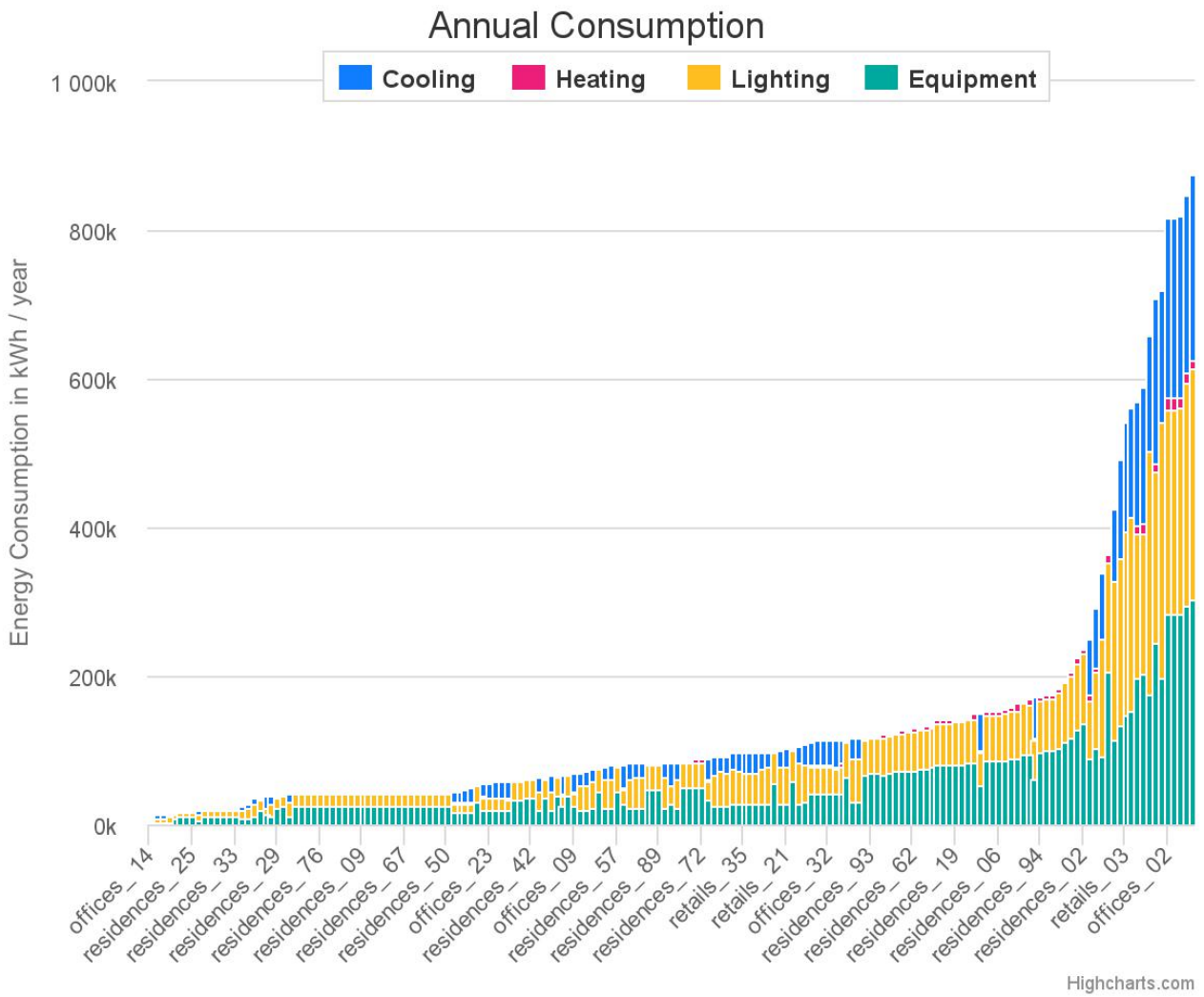
Buildings create shading for comfortable outdoor walkways.

UTCI (**°C**)

25 — No thermal stress

35 — Strong heat stress

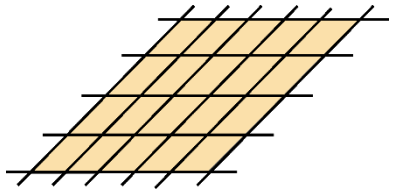
UMI DASHBOARD



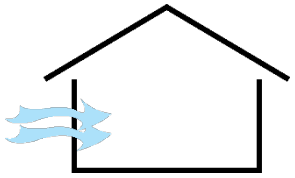
NATURAL VENTILATION + PV METRIC

CURRENT TIME

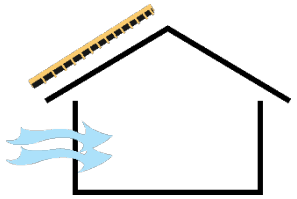
PV Score



NV Score



PV+NV Score



15

%

PV PRODUCTION/ EUI

100

%

NATURALLY VENTILATED HRS/ COMFORT HRS

58

%

AVERAGE SCORE OF NATURAL VENTILATION AND PV PRODUCTION

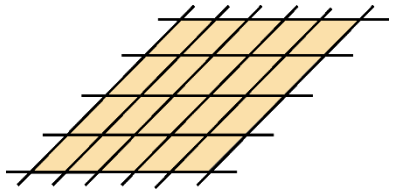
IMPORTANCE WEIGHT

Similar importance weight is given for natural ventilation and PV electricity production.

NATURAL VENTILATION + PV METRIC

2080

PV Score



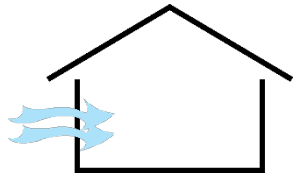
13

%

PV PRODUCTION/ EUI

(importance weight - 1)

NV Score



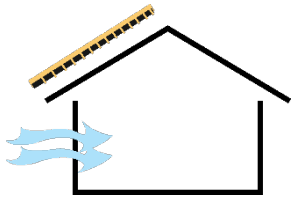
86

%

NATURALLY VENTILATED HRS/ COMFORT HRS

(importance weight - 2)

PV+NV Score

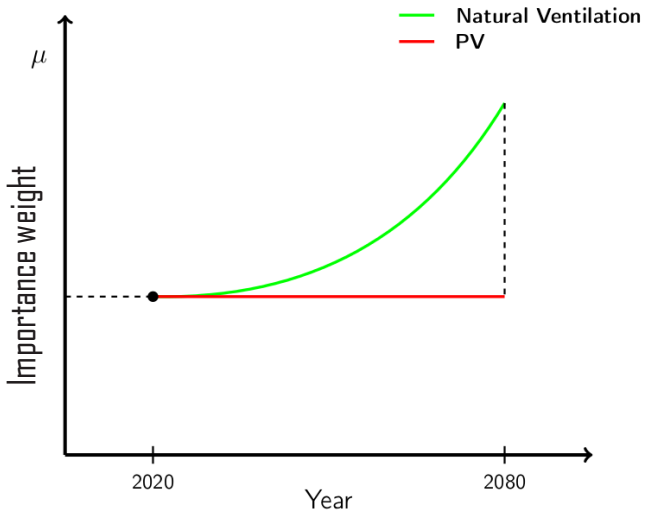


62

%

AVERAGE SCORE OF NATURAL VENTILATION AND PV PRODUCTION

Similar importance weight is given for natural ventilation and PV electricity production.



NV-PV Score:

$$\frac{(\text{PV Score}^* \text{ PV Importance weight}) + (\text{NV Score}^* \text{ NV Importance weight})}{\text{total weight}}$$

PVENT LISBON

Land area (m2)	**243,500**
Building area (m2)	**390,000**
Residents (pp/m2 land)	**0.029**
Workers (pp/m2 land)	**0.055**

82
kWh/m2y
OPERATION ENERGY

1152
kWh/m2
EMBODIED ENERGY (50y)

795
kgCO2/m2
BUILDING GHG EMISSIONS (50y)

36
% DA
DAYLIGHT AREA

85
% WS
WALKABILITY SCORE

14
% ROI
FINANCIAL RETURN (1y)

CONCLUSIONS

Lisbon's Mediterranean climate has good potential for natural ventilation.

Current Climate: 92% of the year (overheated hours 690 hrs)

2080: 80% of the year (overheated hours 1380 hrs)

Current buildings to consider increased cooling loads in changed climate

Current Cooling Load: 10kWh/m^2

2080: 20kWh/m^2

BIPV can be used to preheat air in Winter

Heating Load Reduced to 0kWh/m^2 during sunshine hours

OBRIGADO!