## 4.432/4.433
## Modeling Urban Energy Flows

# Lisbon Gr.02

Spring 2017


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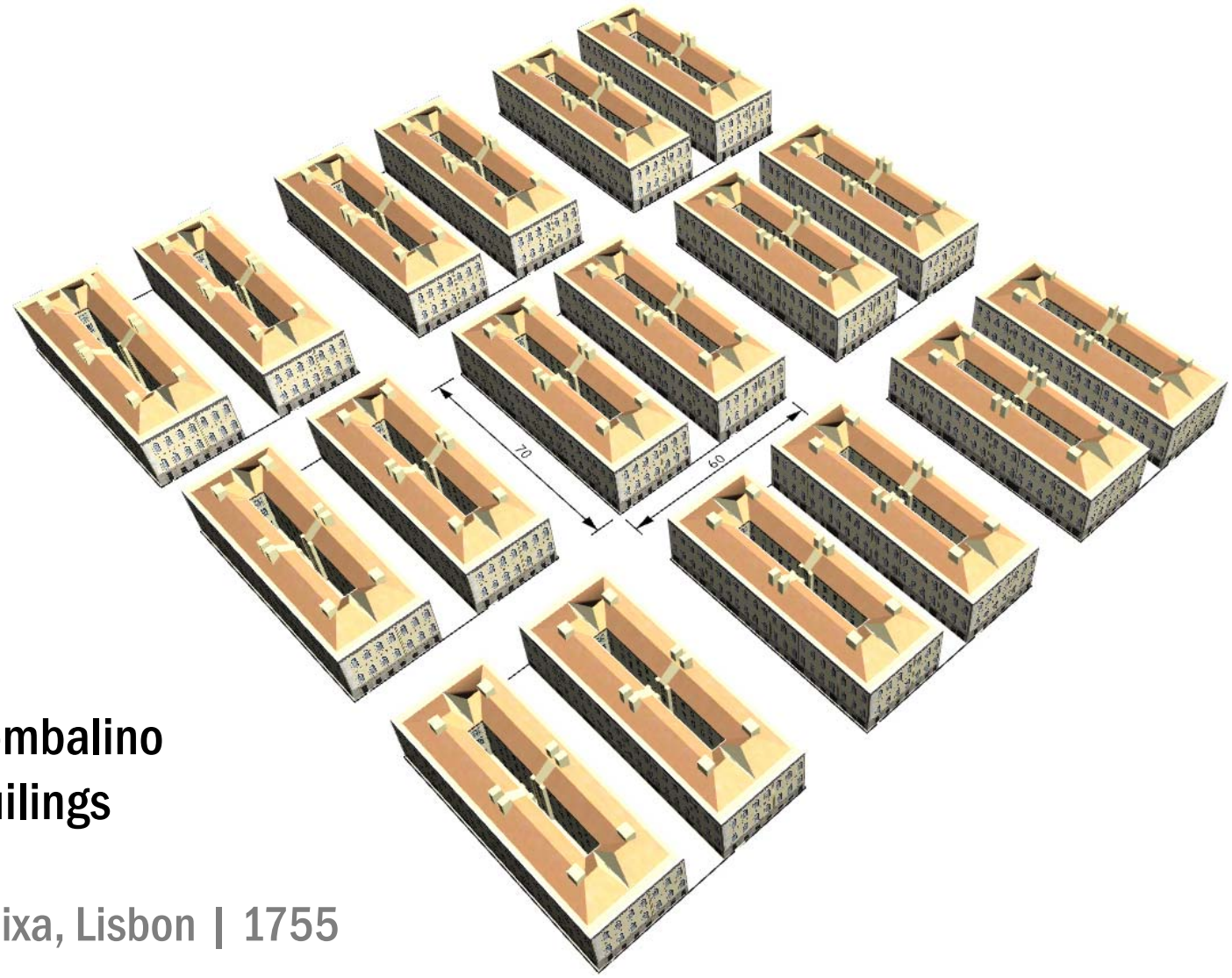
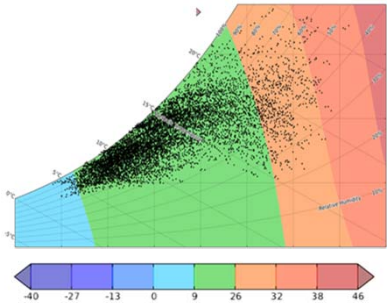
Google earth



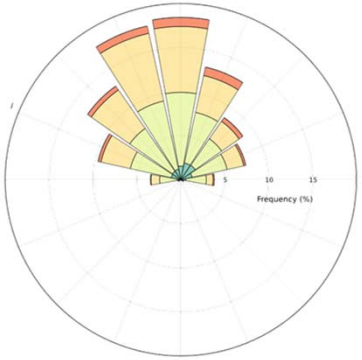

# Pombalino Builings

## Baixa, Lisbon | 1755

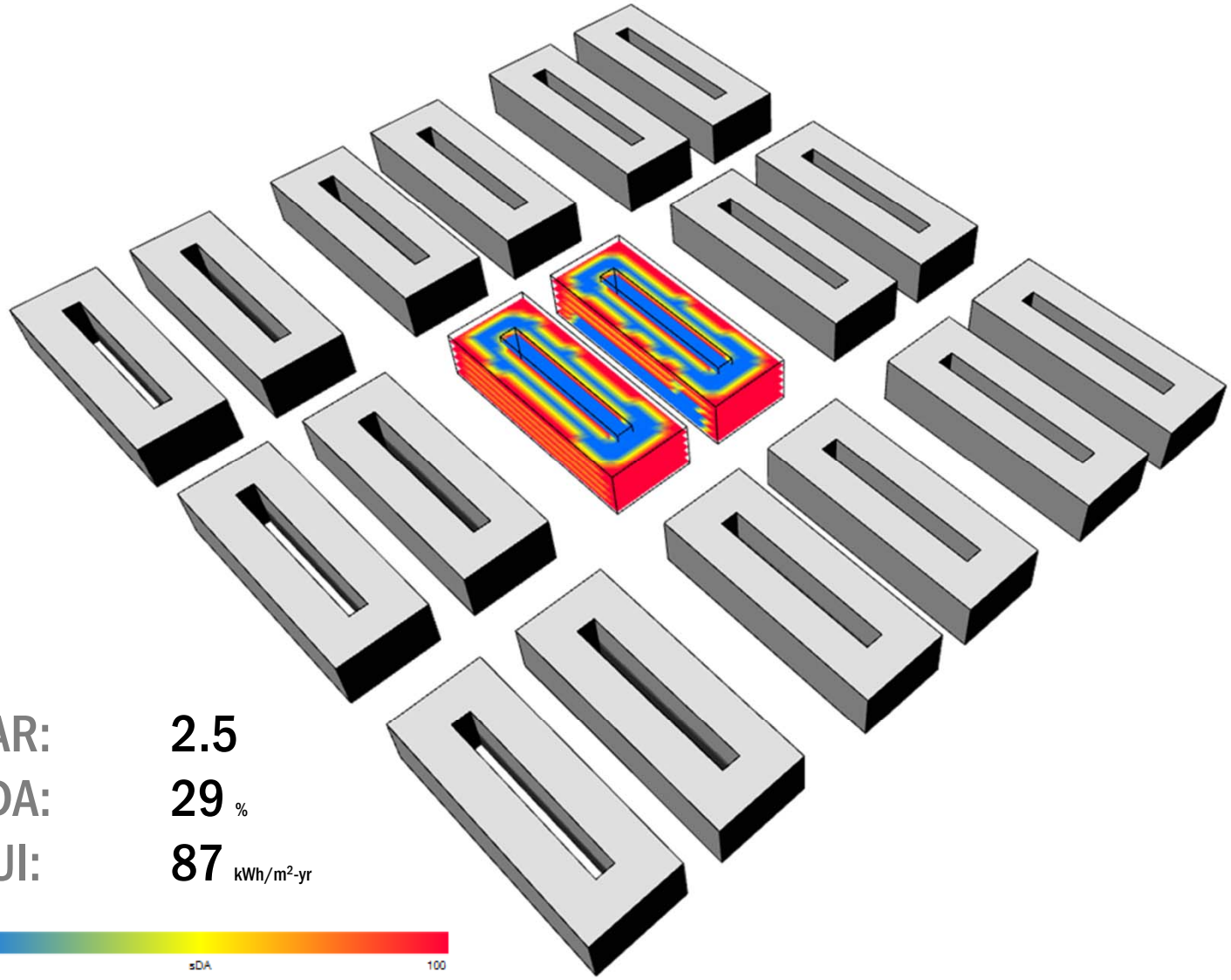

Location




Psychrometric Chart




Wind Frequency

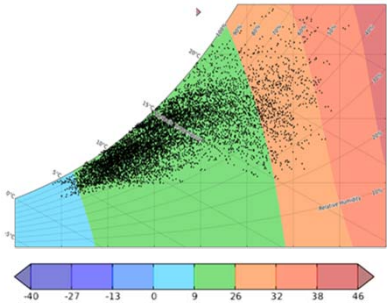



**FAR:** 2.5

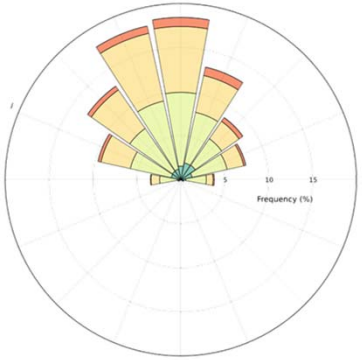
**sDA:** 29 %

**EUI:** 87 kWh/m²-yr

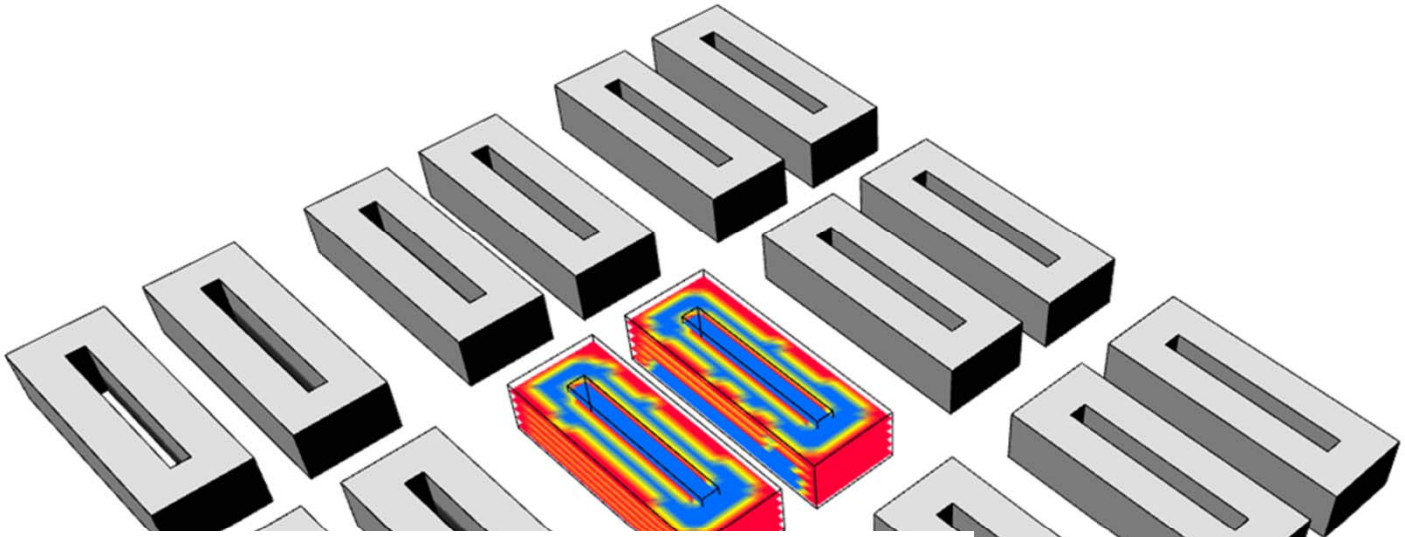

Location



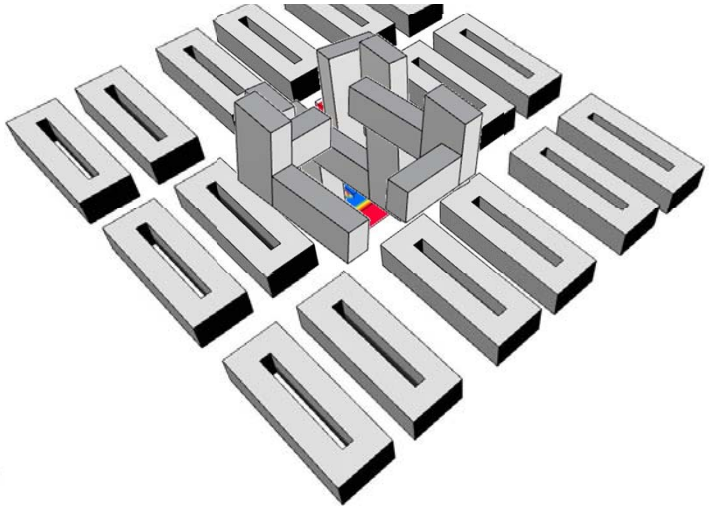

Psychrometric Chart




Wind Frequency



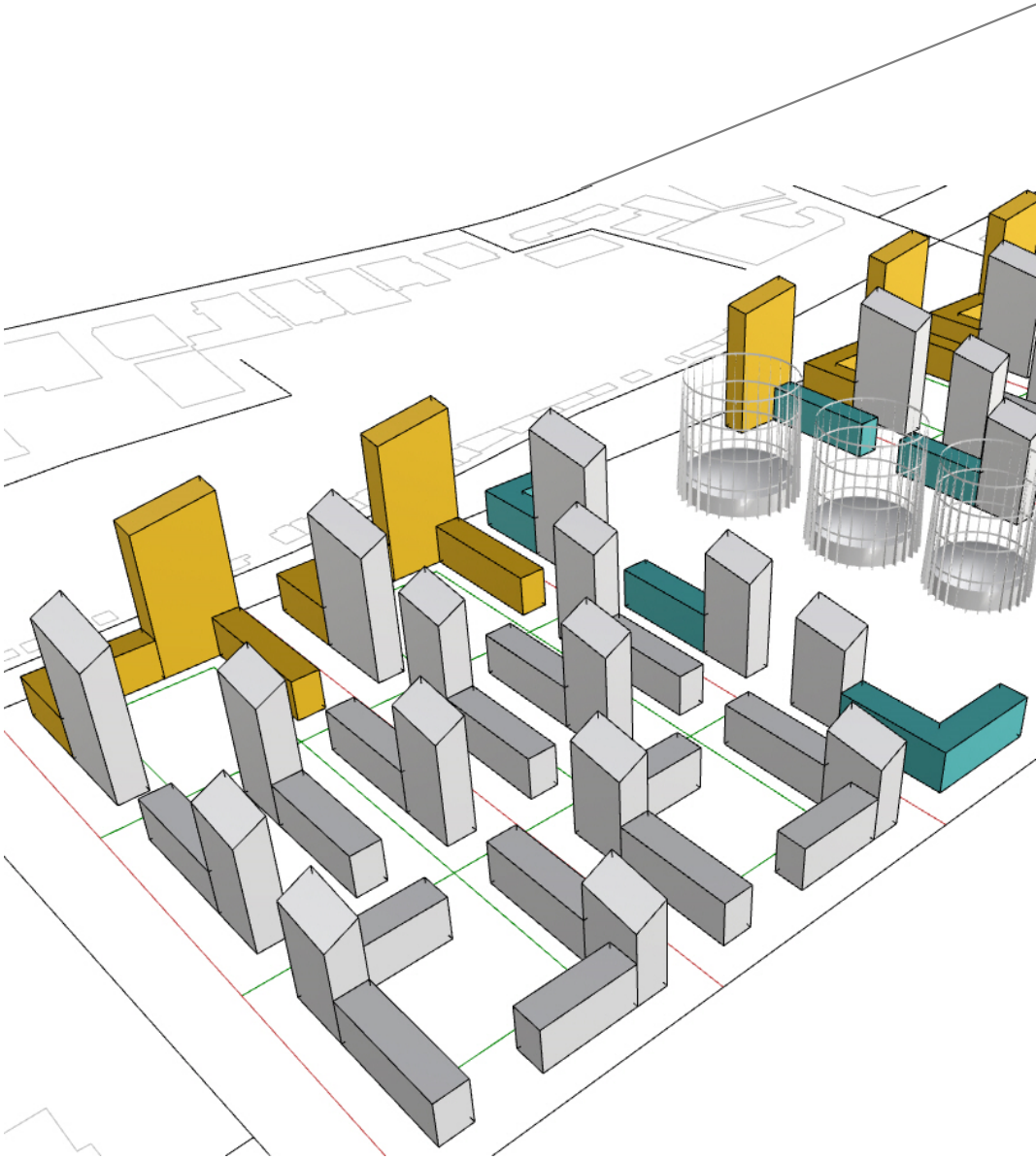
# PROTOBLOCK CONFIGURATION



# PROGRAM DISTRIBUTION

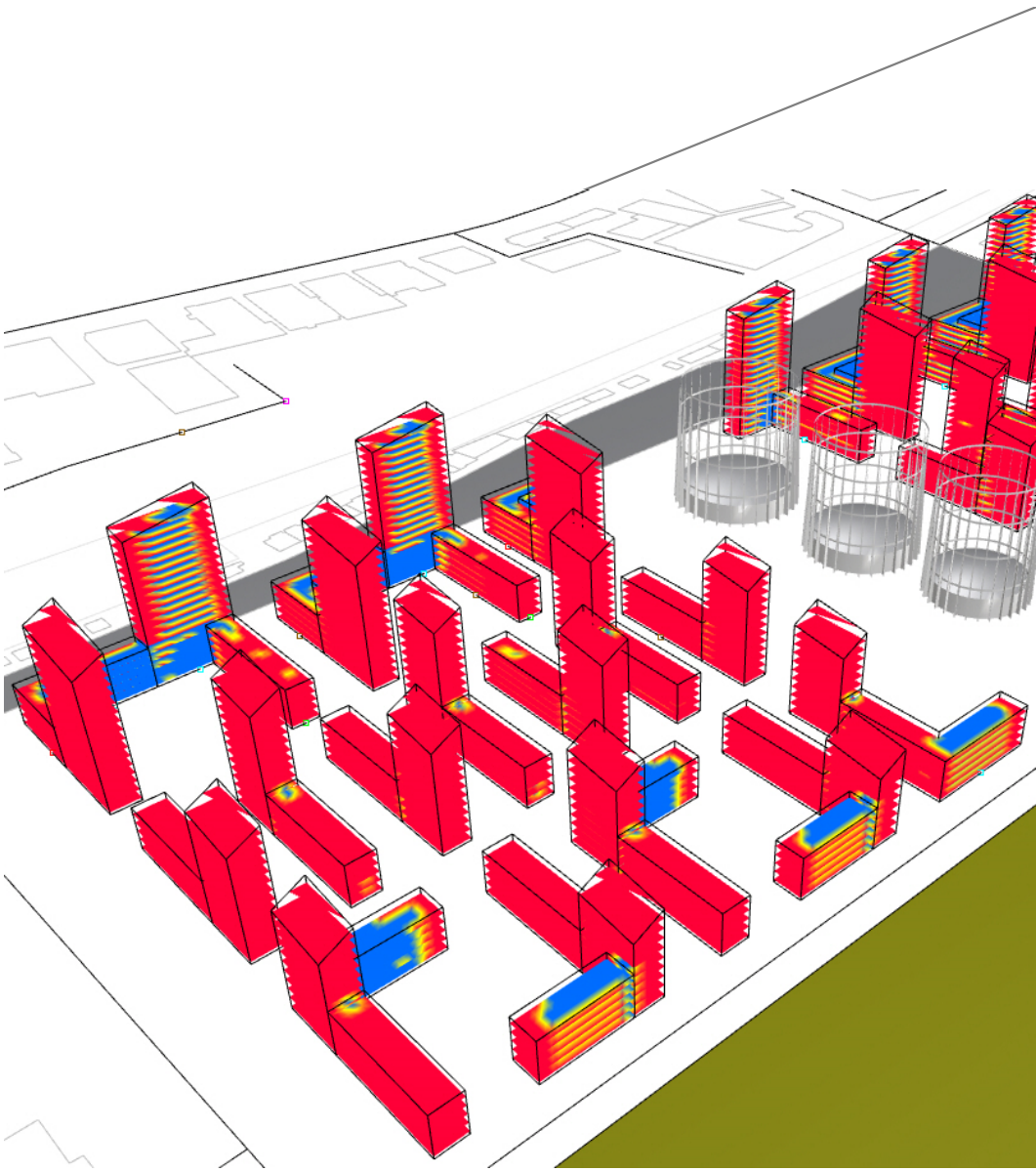
Residential Commercial Retail

| | |
|---|---|
| FAR: | ~~2.5~~3.2 |
| Residential: | 70% |
| Commercial: | 20% |
| Retail: | 10% |

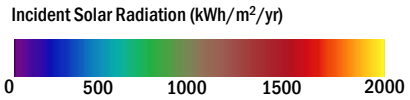


# DAYLIGHT PERFORMANCE

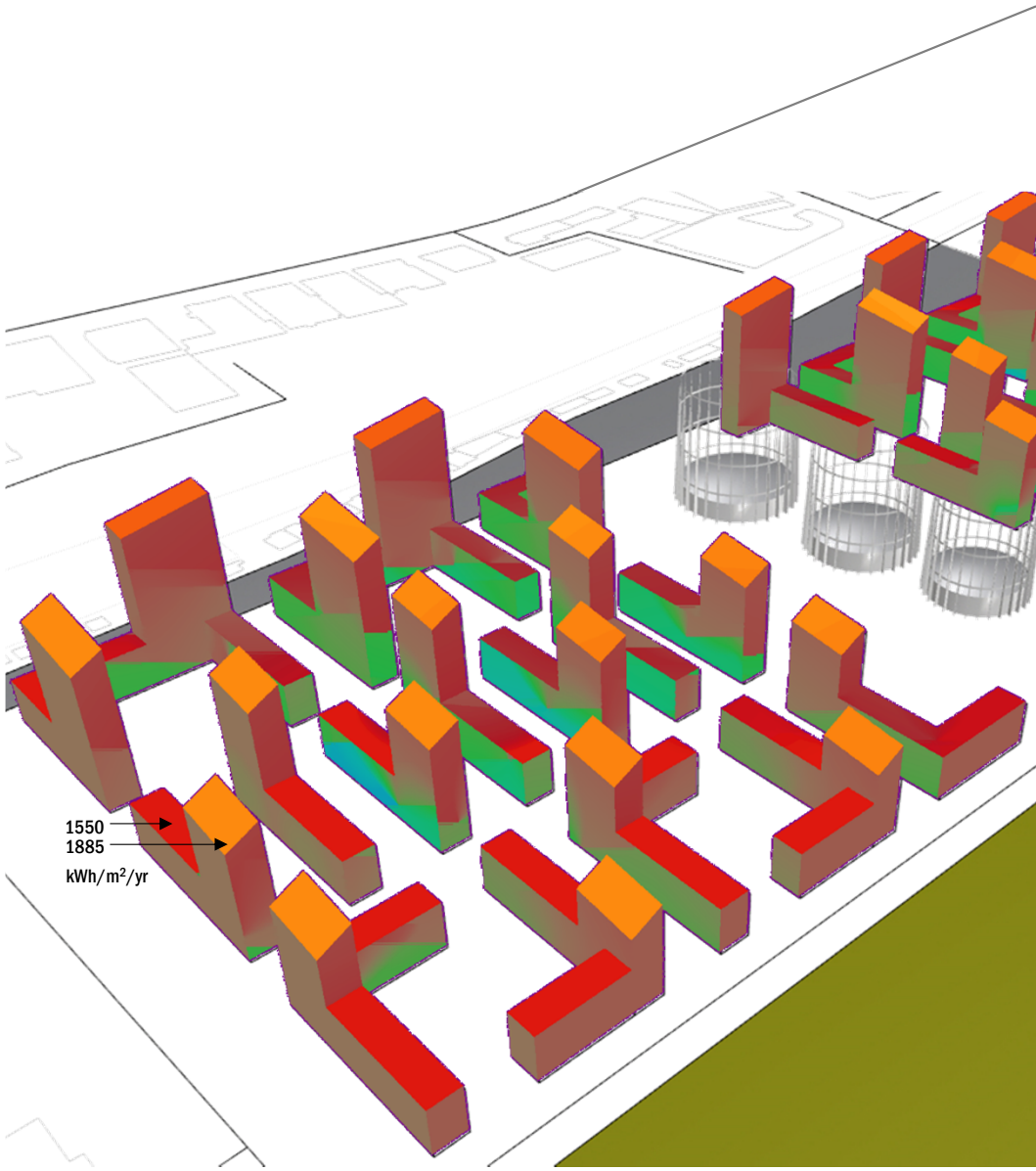

| | | | | |
|---|---|---|---|---|
| FAR: | ~~2.5~~3.2 | sDA: | ~~29~~ | 80% |
| Residential: | 70% | Cash Flow (CFO): | ~~36.56M~~ | 36.63M |
| Commercial: | 20% | Investment Yield: | ~~14.51%~~ | 14.54% |
| Retail: | 10% | Added Cash Flow: | ~~24.0~~ | 24.3$/m²/yr |



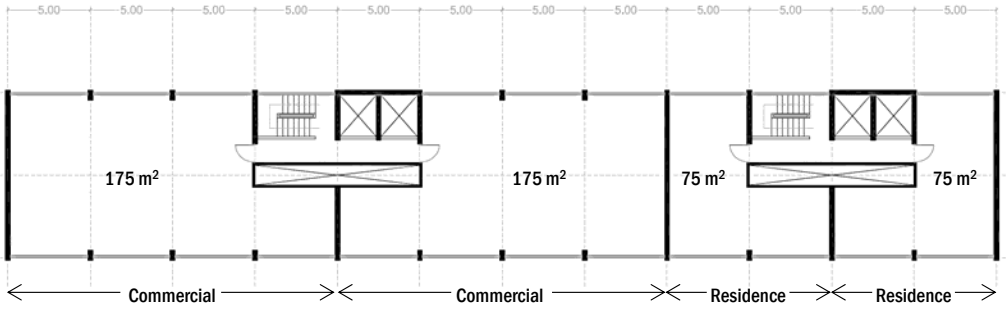
# ENERGY PERFORMANCE

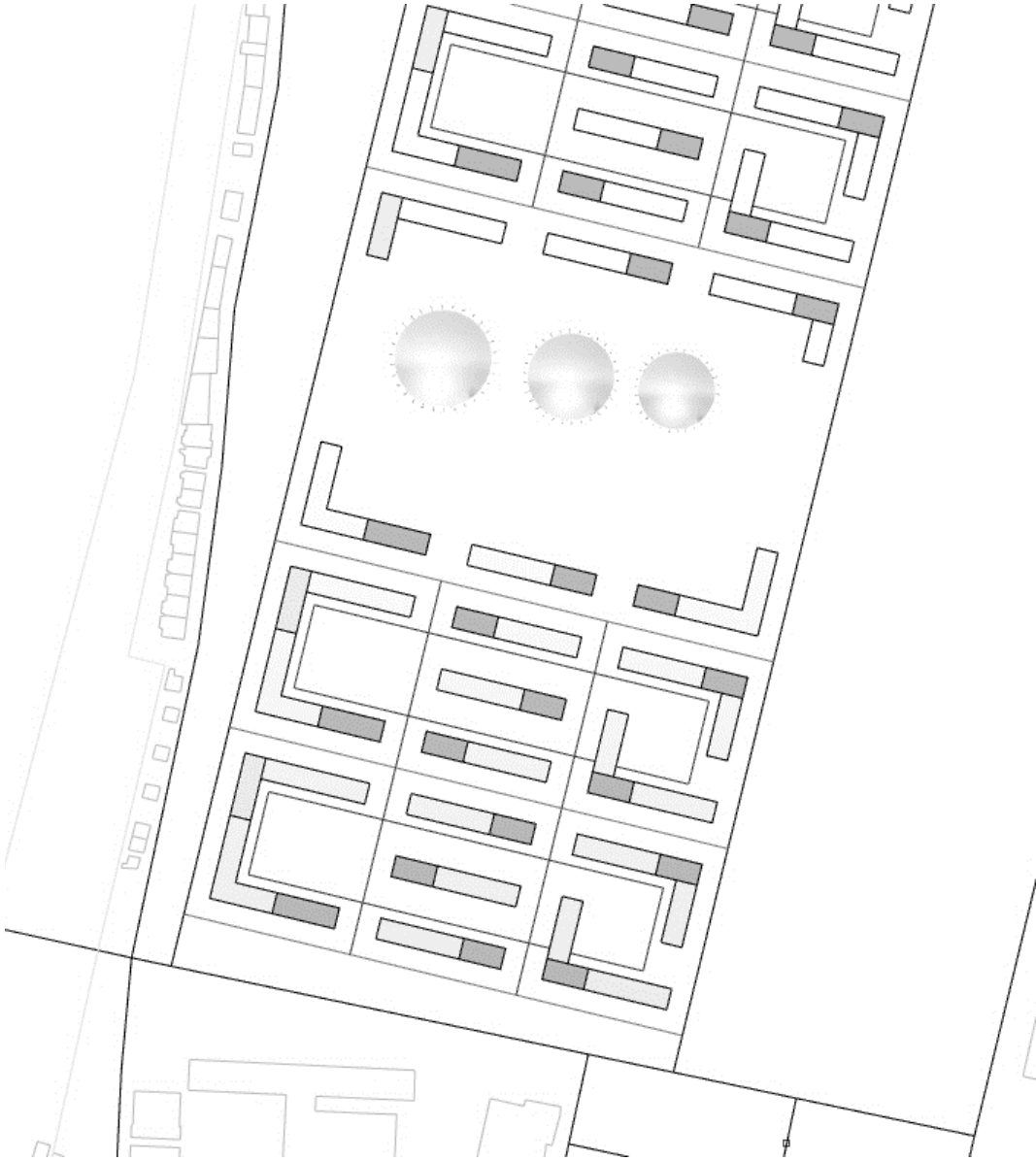



| | | | |
|---|---|---|---|
| FAR: | ~~2.5~~3.2 | sDA: | ~~29~~80% |
| Residential: | 70% | | |
| Commercial: | 20% | EUI: | ~~87~~75 kWh/m²-yr |
| Retail: | 10% | PV offset: | 30 kWh/m²-yr |



# FUTURE SPACE FLEXIBILITY



# PROJECT OBJECTIVES: AUTONOMY

## Comfort

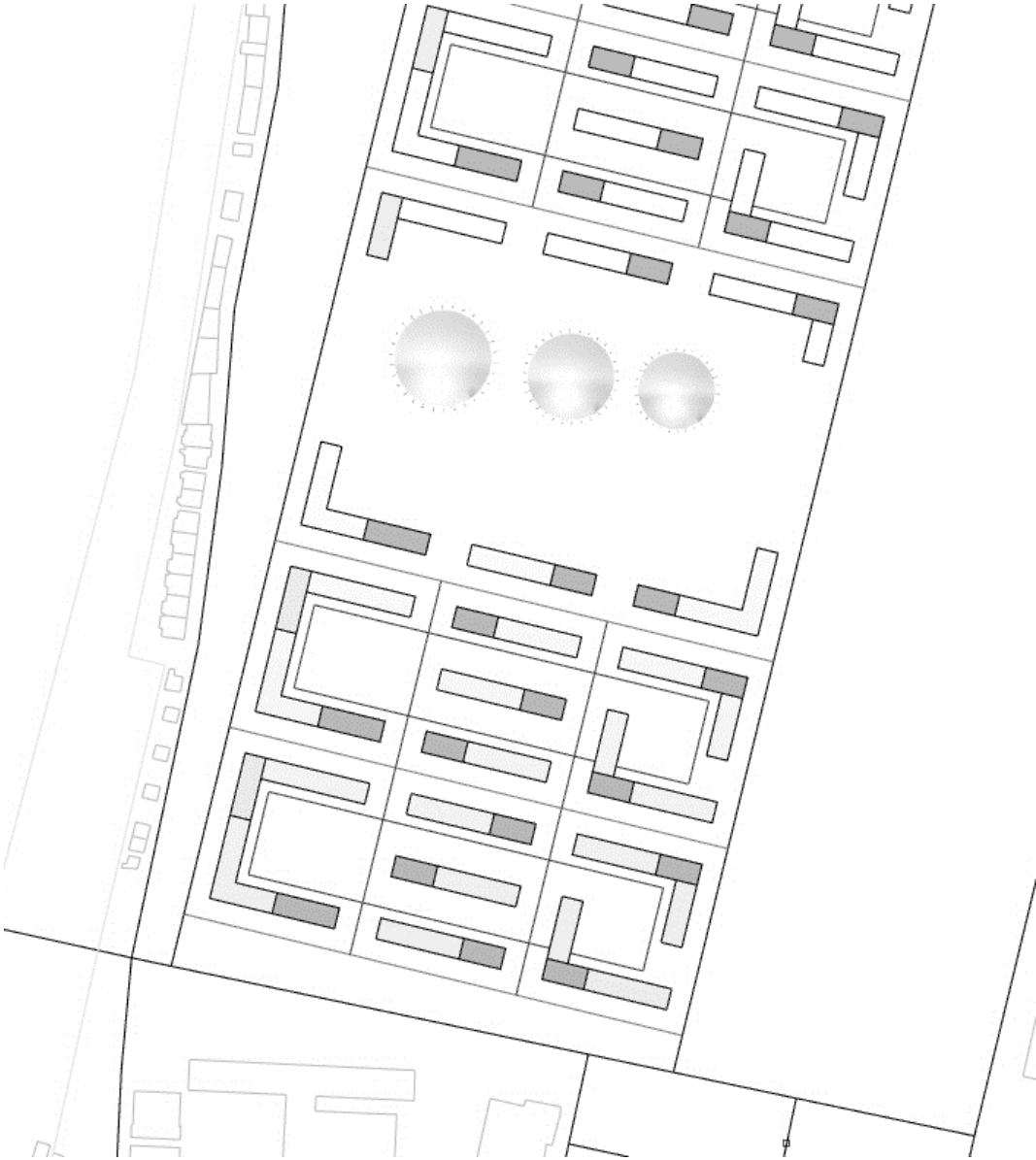
achieve thermal comfort entirely passively

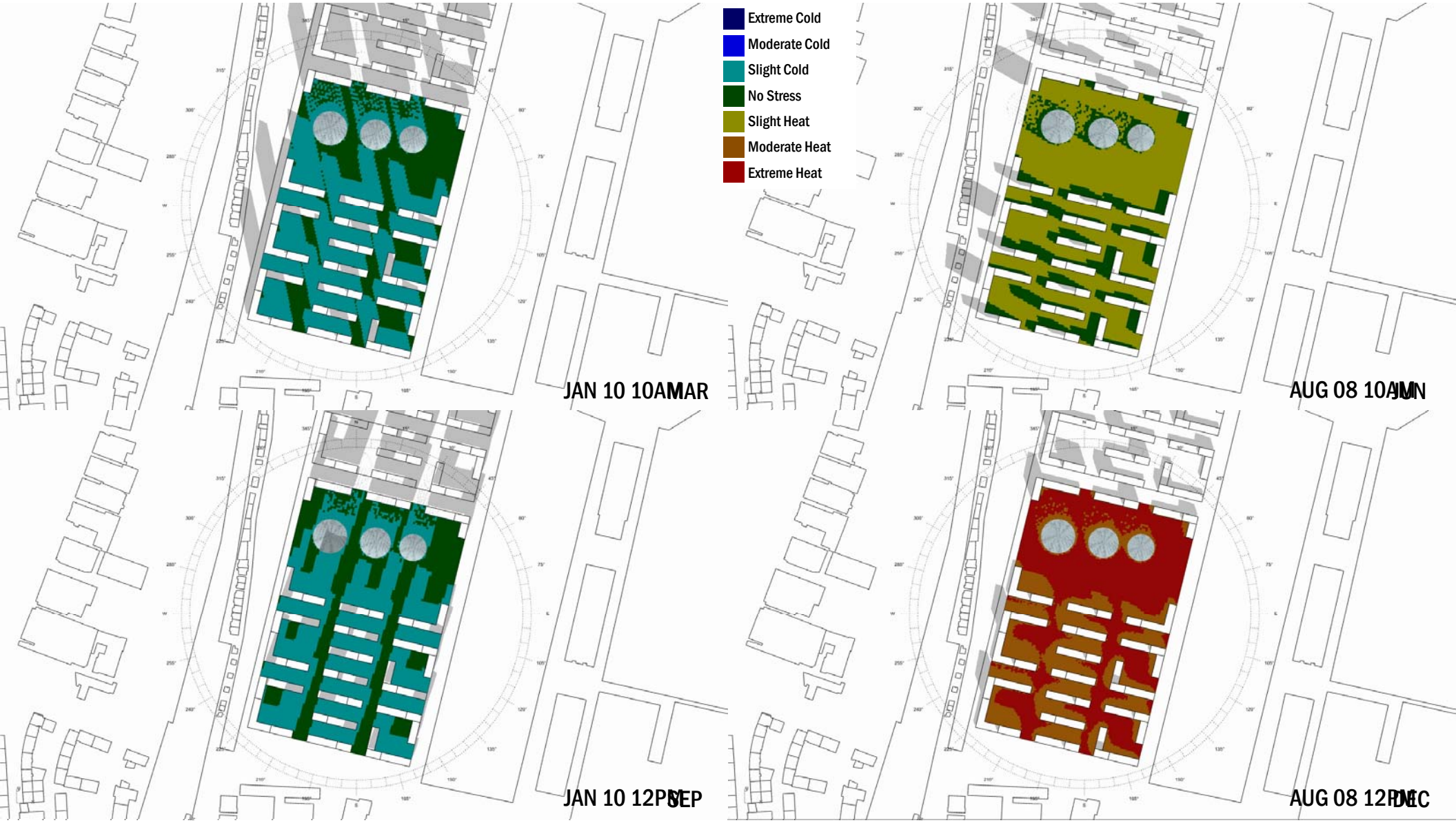
## Electricity

offset all annual electricity with renewables

## Water

eliminate domestic water heating energy




Extreme Cold
Moderate Cold
Slight Cold
No Stress
Slight Heat
Moderate Heat
Extreme Heat
JAN 10 10AM
MAR
AUG 08 10AM
JUN
JAN 10 12PM
SEP
AUG 08 12PM
DEC

# SEASONAL OUTDOOR COMFORT

## Summer Comfort Zones

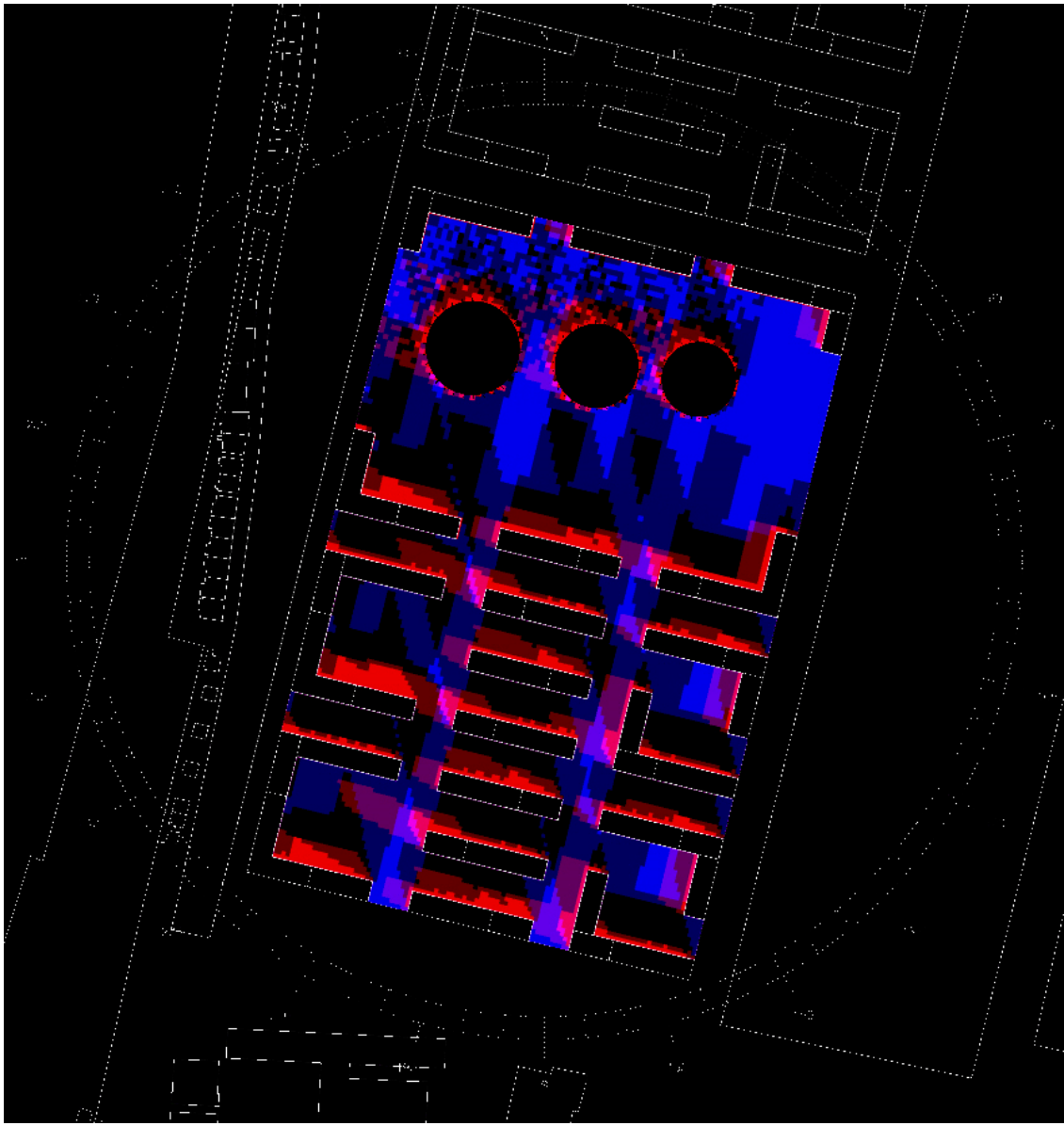
E-W Streets, North of Buildings

## Winter Comfort Zones

N-S Streets, South of Buildings

## Maximum Comfort Overlap

Street Intersections, West of Buildings



# STREET LAYOUT & HIERARCHY

Residential Commercial Retail

## Primeira Avenida

**Bus + Cars + Bikes + Pedestrians**

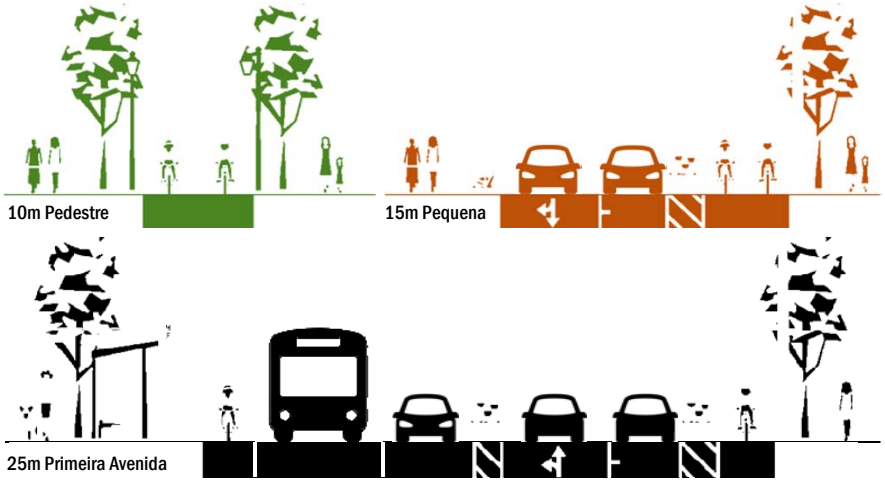
## Rua Pequena

**Cars + Bikes + Pedestrians**

## Pedestre

**Bikes + Pedestrians**

# STREET LAYOUT & HIERARCHY




# COMMUNITY CONNECTIVITY

Walkability Score

60 70 80 90 100

## Existing Walk Score: 79

Amenities Present but Points Deducted for Distance

## Existing Bike Score: 95

All Amenities within Biking Distance

# NEIGHBORHOOD AMENITIES





# NEIGHBORHOOD AMENITIES




# WALKER'S PARADISE


# NEIGHBORHOOD WALK SCORE

Walkability Score

60 70 80 90 100

## Proposed Walk Score: 98

Cash Flow (CFO): ~~36.63M~~ 37.85M

Investment Yield: ~~14.54%~~ 15.02%

Added Cash Flow: ~~24.3~~ 30.3$/m²/yr

# BASELINE ENERGY USE

Energy Use Intensity (kWh/m$^2$-yr)

0 30 60 90 120

| | | | |
|---|---|---|---|
| Site EUI: | 75 kWh/m$^2$-yr | PV offset: | 30 kWh/m$^2$-yr |
| Residential: | 60 kWh/m$^2$-yr | | |
| Commercial: | 100 kWh/m$^2$-yr | | |
| Retail: | 110 kWh/m$^2$-yr | | |

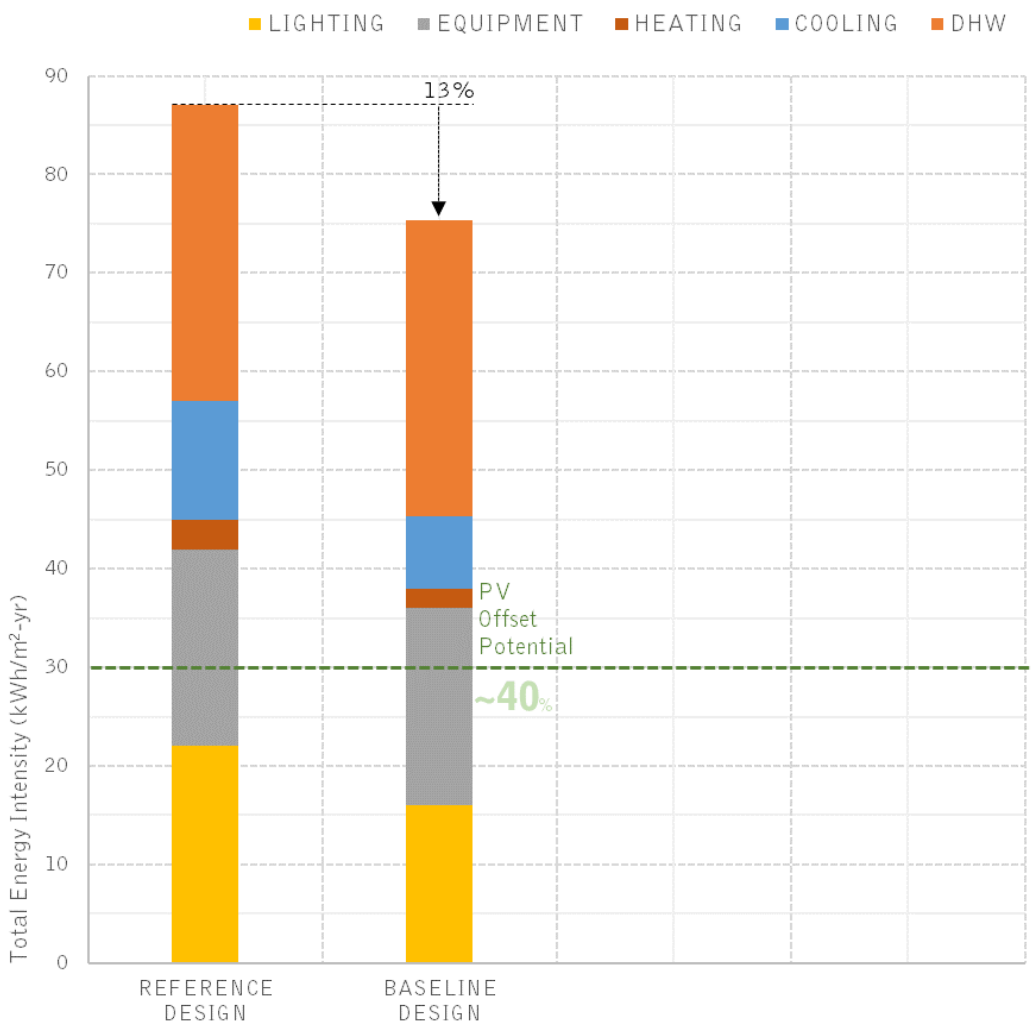
# ENERGY USE CHARACTERIZATION

**Site EUI:** 75 kWh/m²-yr  **PV offset:** 30 kWh/m²-yr

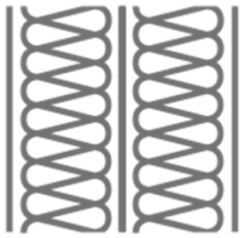
Lights / Equipment: 38 kWh/m²-yr

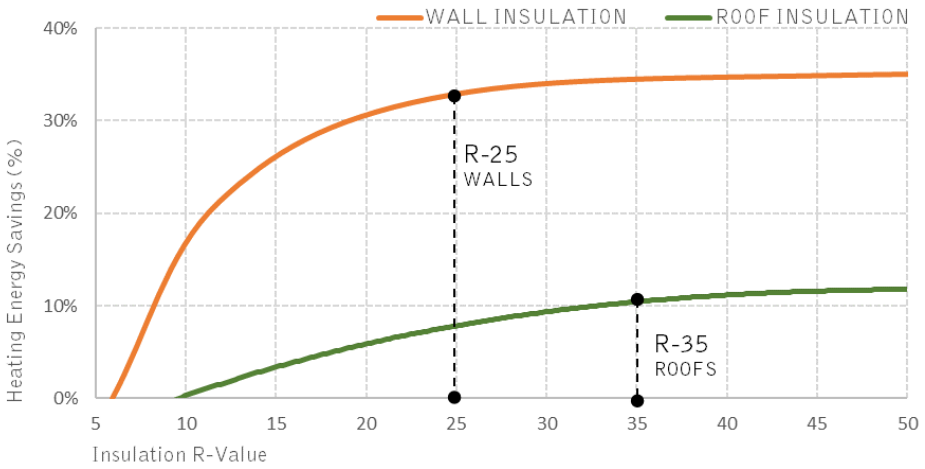
Heating / Cooling: 07 kWh/m²-yr

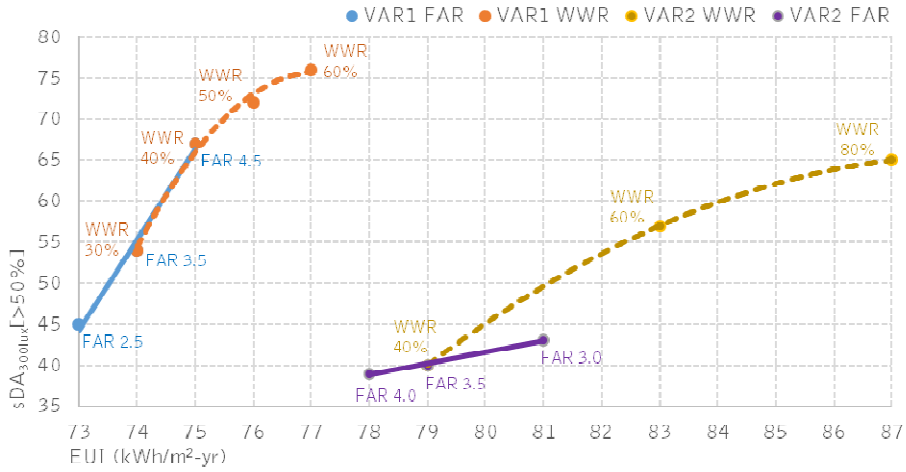
Domestic Hot Water: 30 kWh/m²-yr



# OPTIMIZE BUILDING ENVELOPE





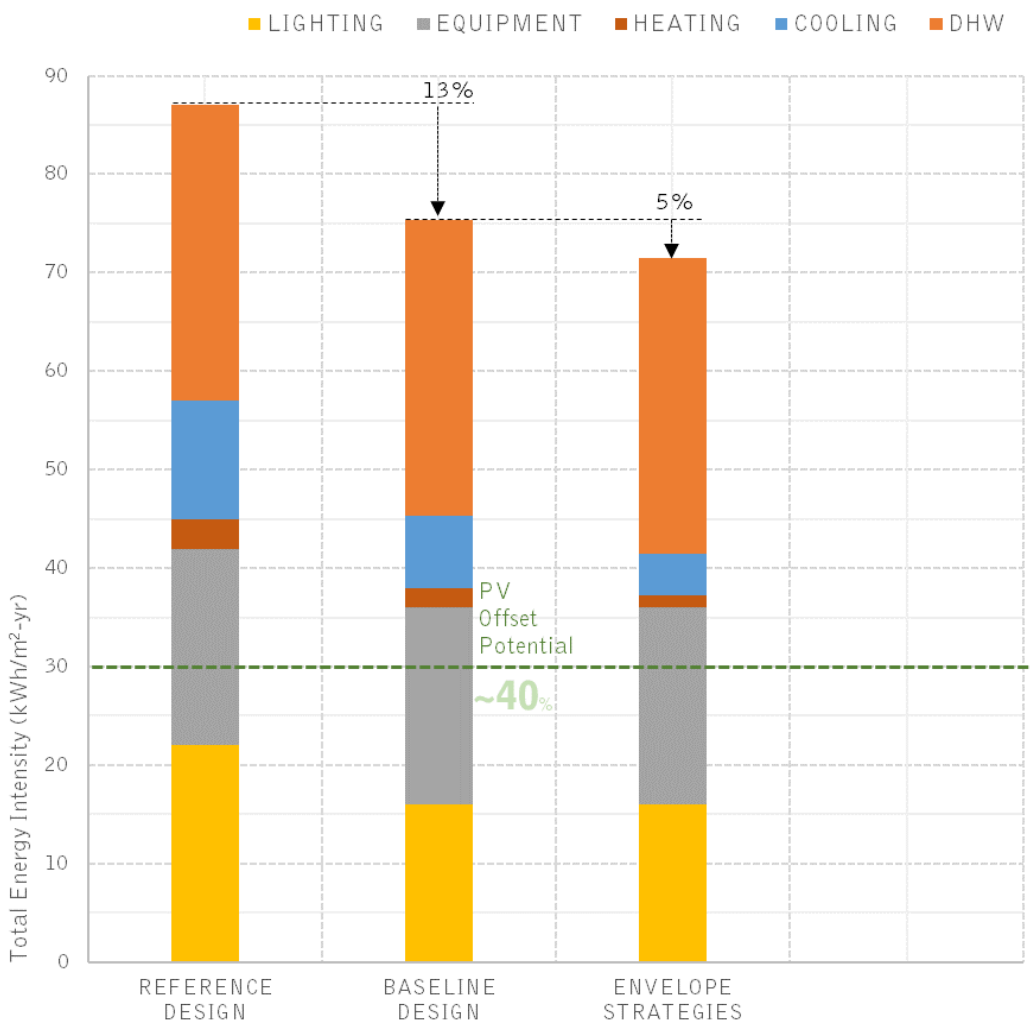
# IMPROVED ENVELOPE

**Site EUI:** ~~75~~72 kWh/m²-yr **PV$_{offset}$:** 30 kWh/m²-yr

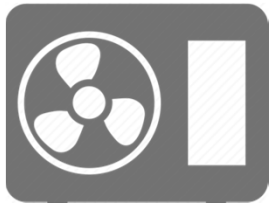
Lights / Equipment: 38 kWh/m²-yr

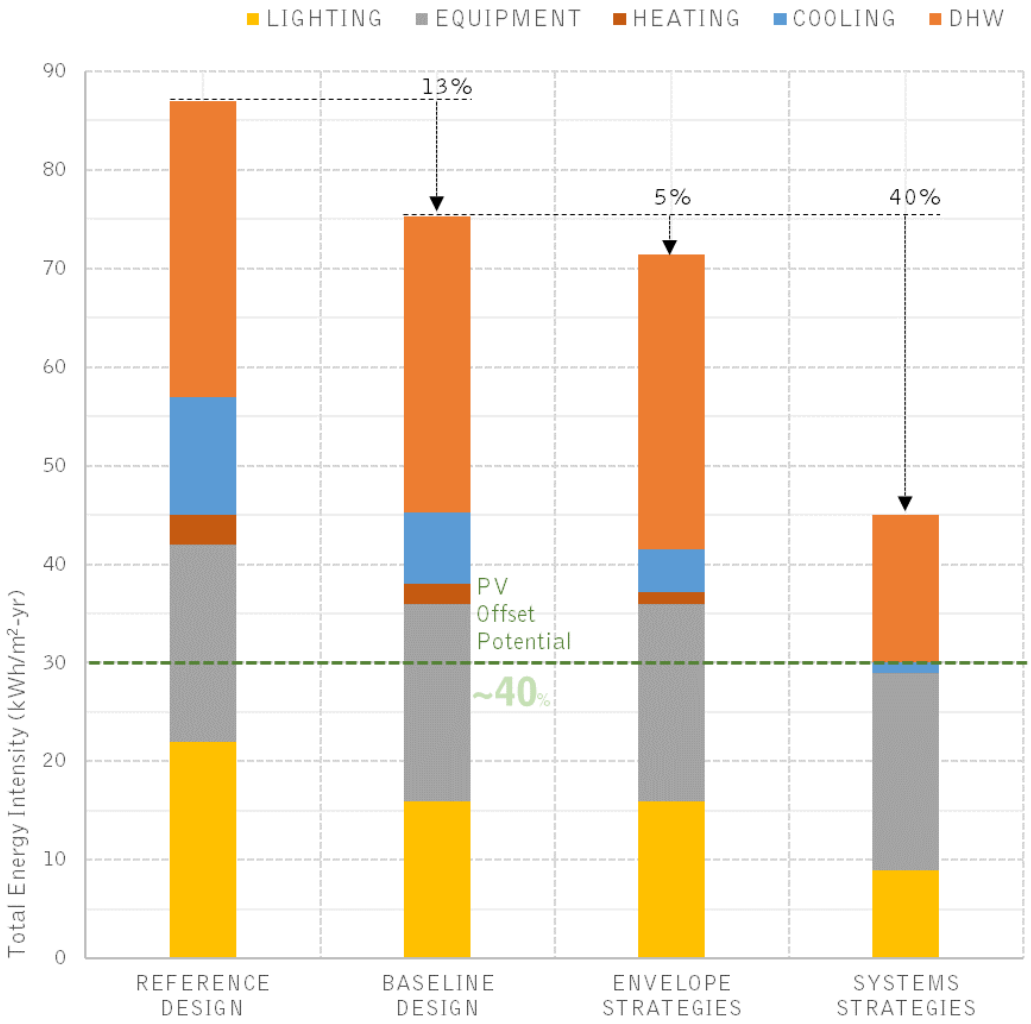
Heating / Cooling: ~~07~~04 kWh/m²-yr

Domestic Hot Water: 30 kWh/m²-yr



# ELECTRICITY, WATER EFFICIENCY





# NET ZERO ELECTRICITY

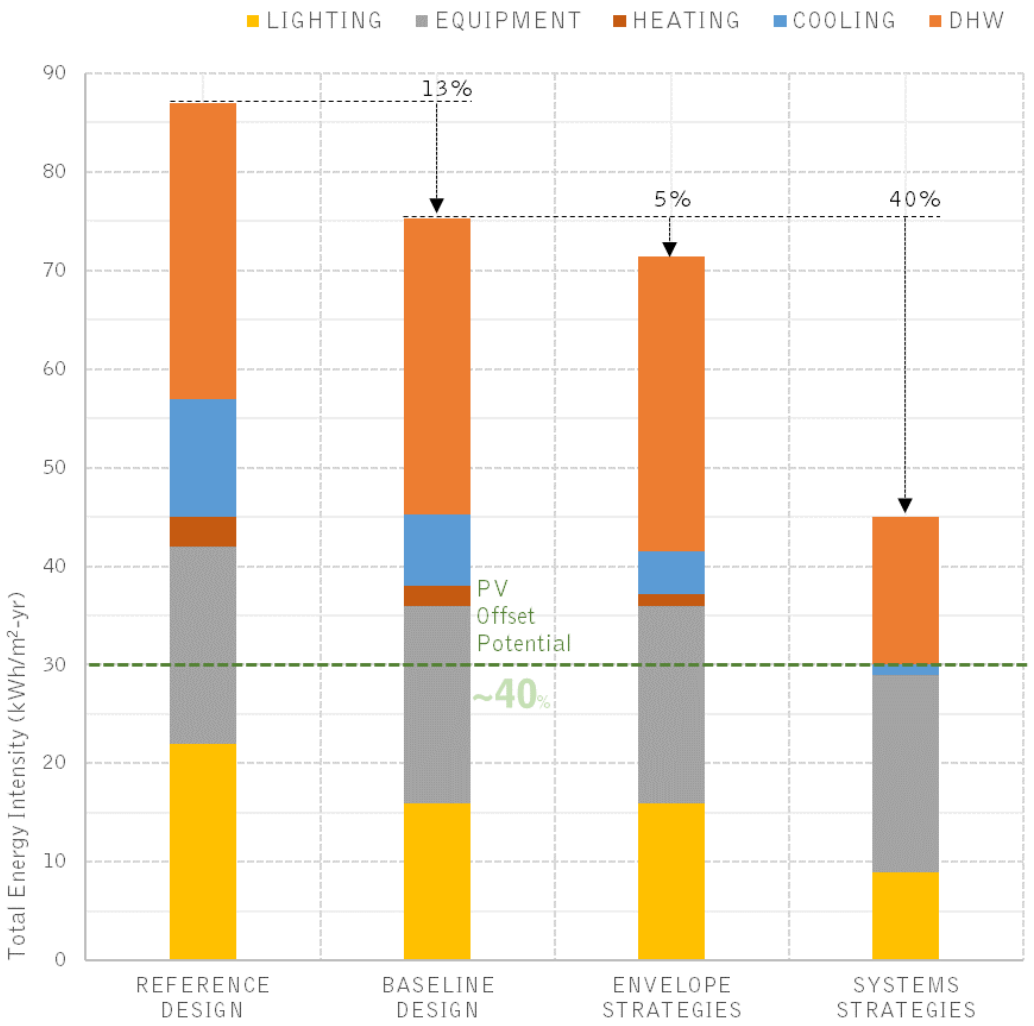
**Site EUI:** ~~72~~45 kWh/m²-yr

Lights / Equipment: ~~38~~29 kWh/m²-yr

Heating / Cooling: ~~04~~01 kWh/m²-yr

Domestic Hot Water: ~~30~~15 kWh/m²-yr

**PV$_{offset}$:** 30 kWh/m²-yr



# DOMESTIC WATER HEATING

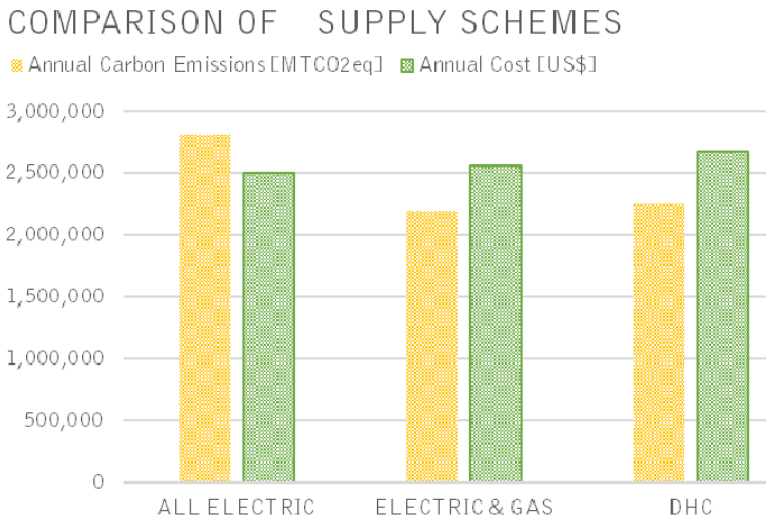
Site EUI: ~~72~~45 kWh/m²-yr

Lights / Equipment: ~~38~~29 kWh/m²-yr

Heating / Cooling: ~~0~~401 kWh/m²-yr

PV offset: 30 kWh/m²-yr

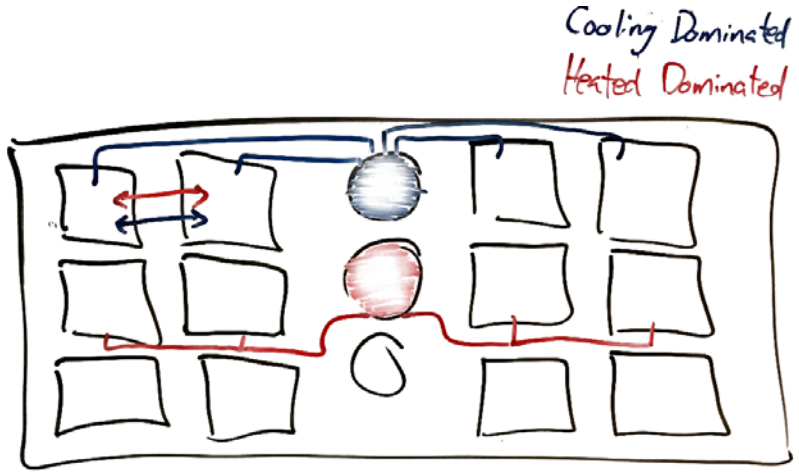
Domestic Hot Water: ~~30~~15 kWh/m²-yr




# PROGRAM USE DIVERSITY

## Seasonal Hot Water Storage

**Utilize Tanks to Store Rejected Heat from Commercial/Retail Cooling**



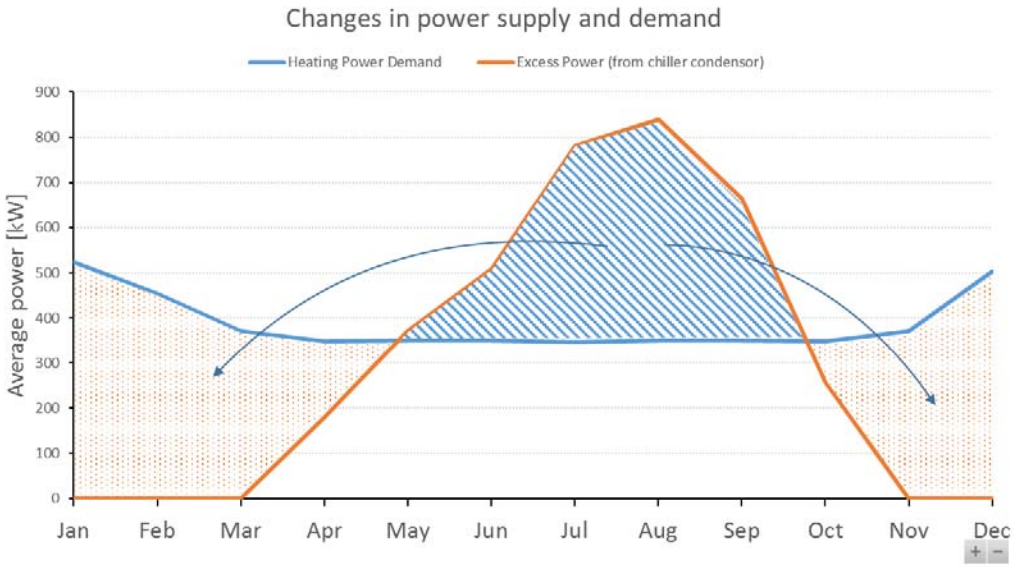
# DISTRICT ENERGY SYSTEMS

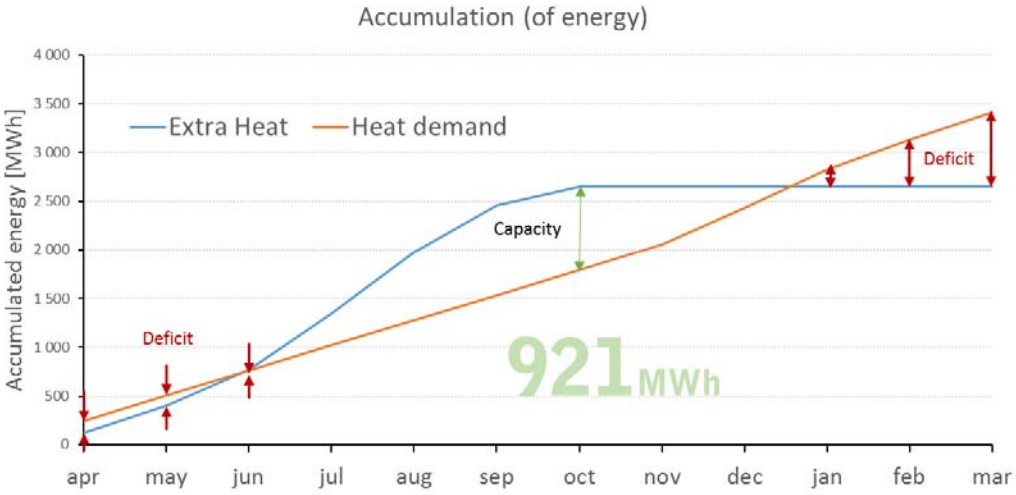
## Seasonal Hot Water Storage

Utilize Tanks to Store Rejected Heat from Commercial/Retail Cooling

## Tank Energy Storage Capacity

**921 MWh based on Seasonal Changes in Power Supply and Demand**



# EXISTING TANKS TO STORE HEAT

## Seasonal Hot Water Storage

Utilize Tanks to Store Rejected Heat from Commercial/Retail Cooling

## Tank Energy Storage Capacity

921 MWh based on Seasonal Changes in Power Supply and Demand

## Tank Water Storage Volume

12,000 $m^3$, Roughly two Tanks on Site covers 45% of DHW needs

# SEASONAL HOT WATER STORAGE

**Site EUI:** ~~75~~45 kWh/m²-yr

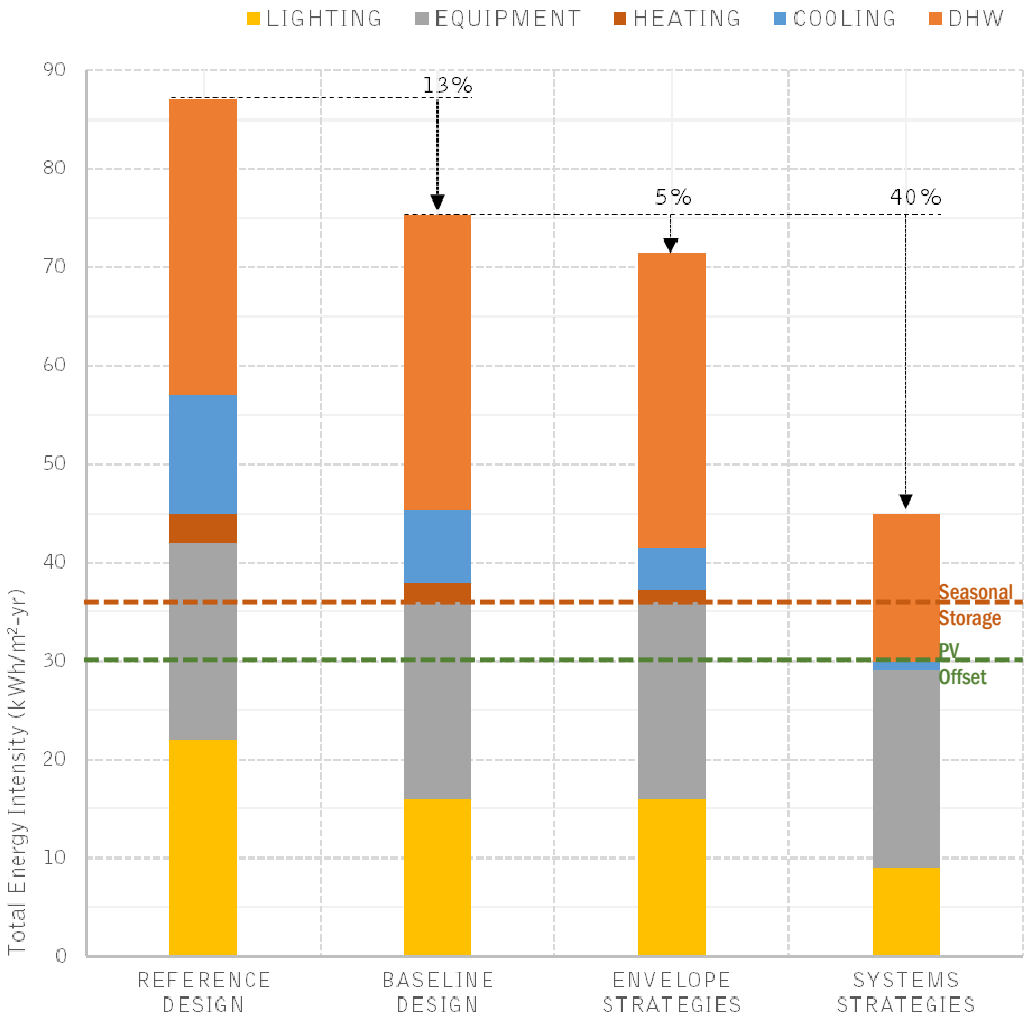
Lights / Equipment: ~~38~~29 kWh/m²-yr

Heating / Cooling: ~~07~~01 kWh/m²-yr

**Domestic Hot Water:** ~~30~~15 kWh/m²-yr

**PV$_{offset}$:** 30 kWh/m²-yr

**Tanks:** 07 kWh/m²-yr



# LOCAL HEAT vs DISTRICT HEAT

## Flat Plate Solar Collectors

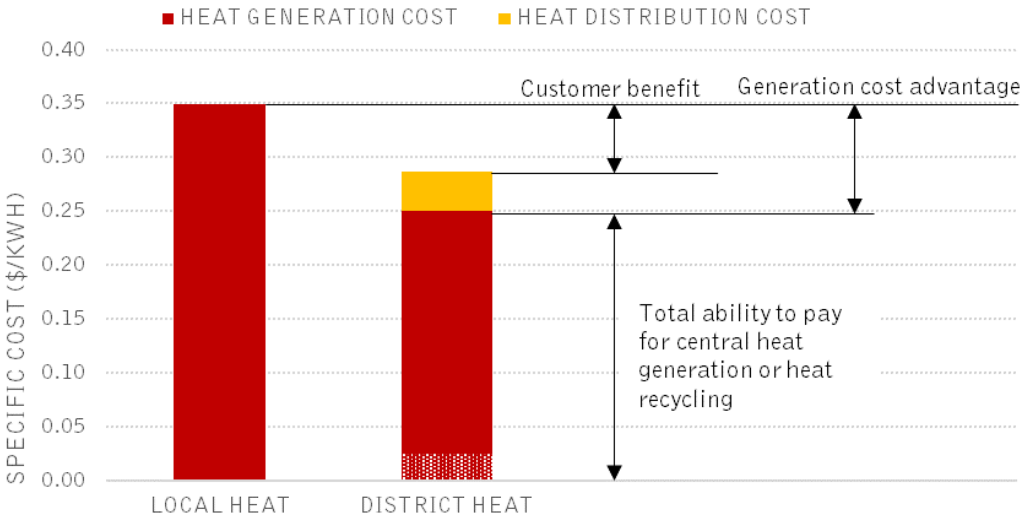
6,000m$^2$ for all DHW needs, Initial investment $1,000/m$^2$ panels

## District Solar Thermal Collectors

Cost of insulated buried pipes, linear heat density, pipes economics

## Preliminary Cost Comparison

Local: DHW @ $0.35/kWh | District: DHW+Heat @ $0.29/kWh



# CONCENTRATED SOLAR COLLECTORS

## District Solar Thermal Collectors

Cost of insulated buried pipes, linear heat density, pipes economics

## Preliminary Cost Comparison

Local: DHW @ $0.35/kWh | District: DHW+Heat @ $0.29/kWh

## Concentrating Solar Collectors

**Install Collectors on Two Tanks to meet remaining DHW needs**

# NET ZERO ENERGY

**Site EUI:** ~~75~~45 kWh/m²-yr

Lights / Equipment: ~~38~~29 kWh/m²-yr

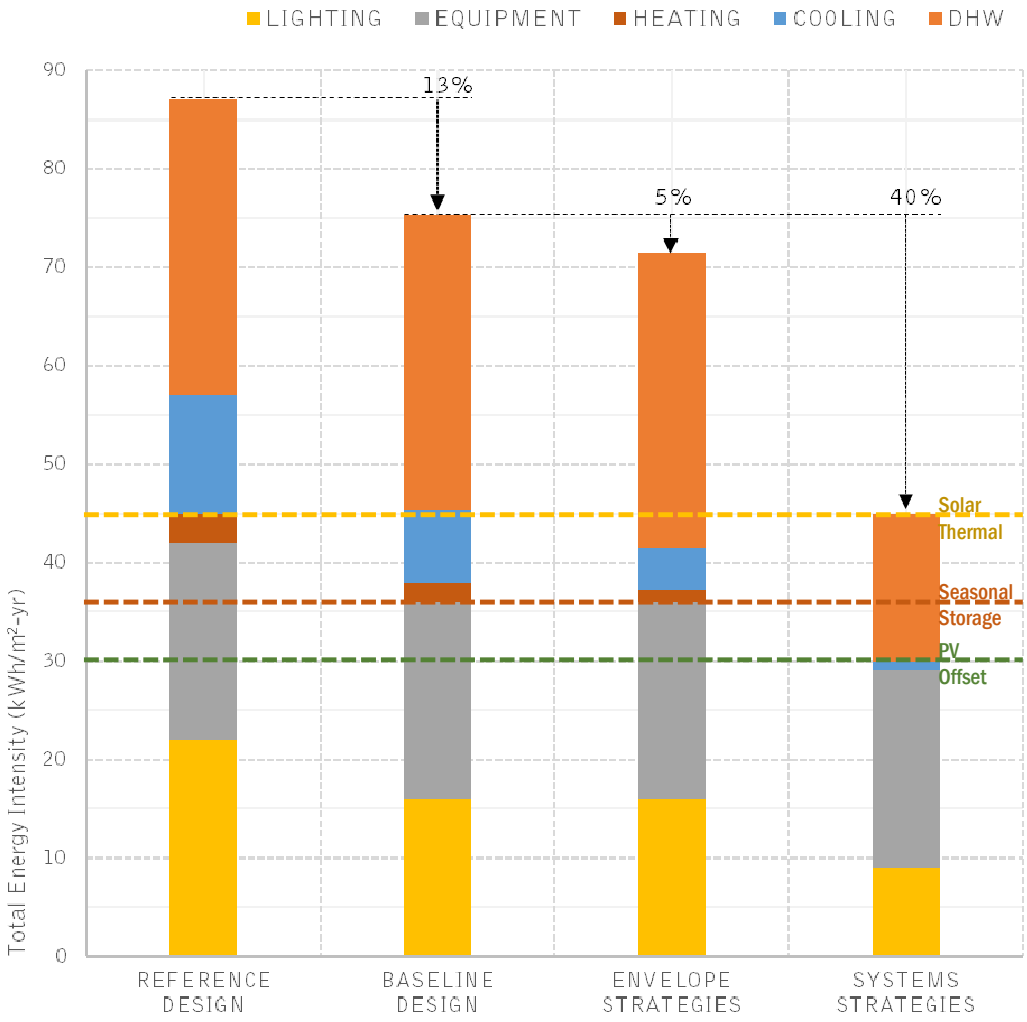
Heating / Cooling: ~~07~~01 kWh/m²-yr

**Domestic Hot Water:** ~~30~~15 kWh/m²-yr

**PV$_{offset}$:** 30 kWh/m²-yr

**Tanks:** 07 kWh/m²-yr

**Solar:** 08 kWh/m²-yr



# autônomo

Comfort

achieve thermal comfort entirely passively

Electricity

offset all annual electricity with renewables

Water

eliminate domestic water heating energy

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