TRANSSOLAR KLIMAENGINEERING

Technologies for energy efficient design
and thermal comfort in buildings
Stuttgart - Munich - New York

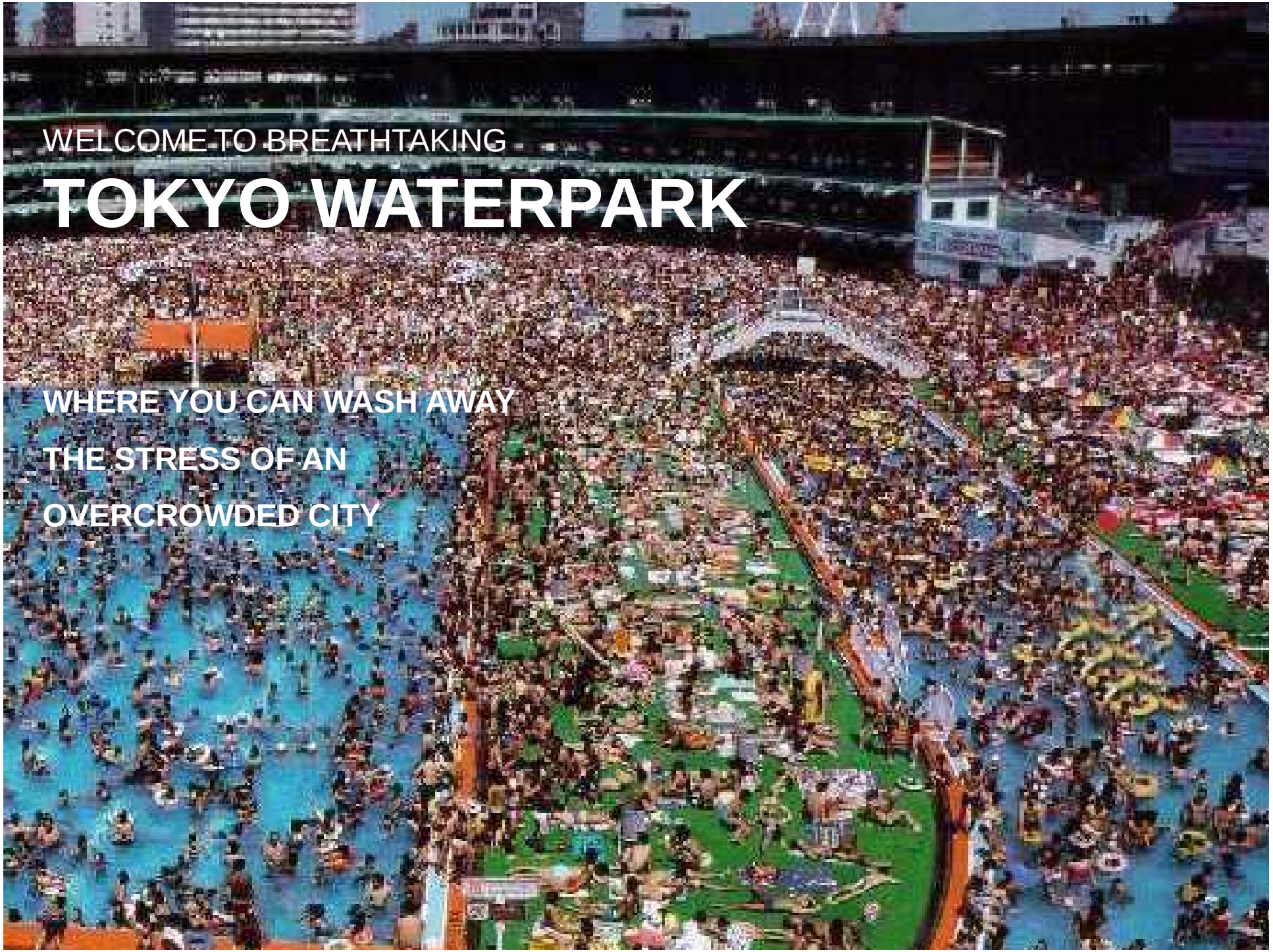
HIGH DENSITY
Challenges and Opportunities

Symposium on Sustainable Urban Design –
Case Studies and Design Workflows
Massachusetts Institute of Technology, May 6 2013
Matthias Rudolph

BY 2050

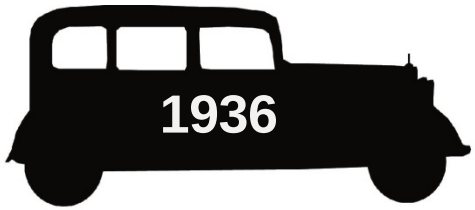
CO_2 TO ZERO

WE NEED TO REDUCE OUR EMISSIONS


WELCOME TO BREATHTAKING
TOKYO WATERPARK
WHERE YOU CAN WASH AWAY
THE STRESS OF AN
OVERCROWDED CITY

EFFICIENCY DRIVEN BY GADGETS

EFFICIENCY DRIVEN BY DESIGN



optimize …

source: Knippers Helbig

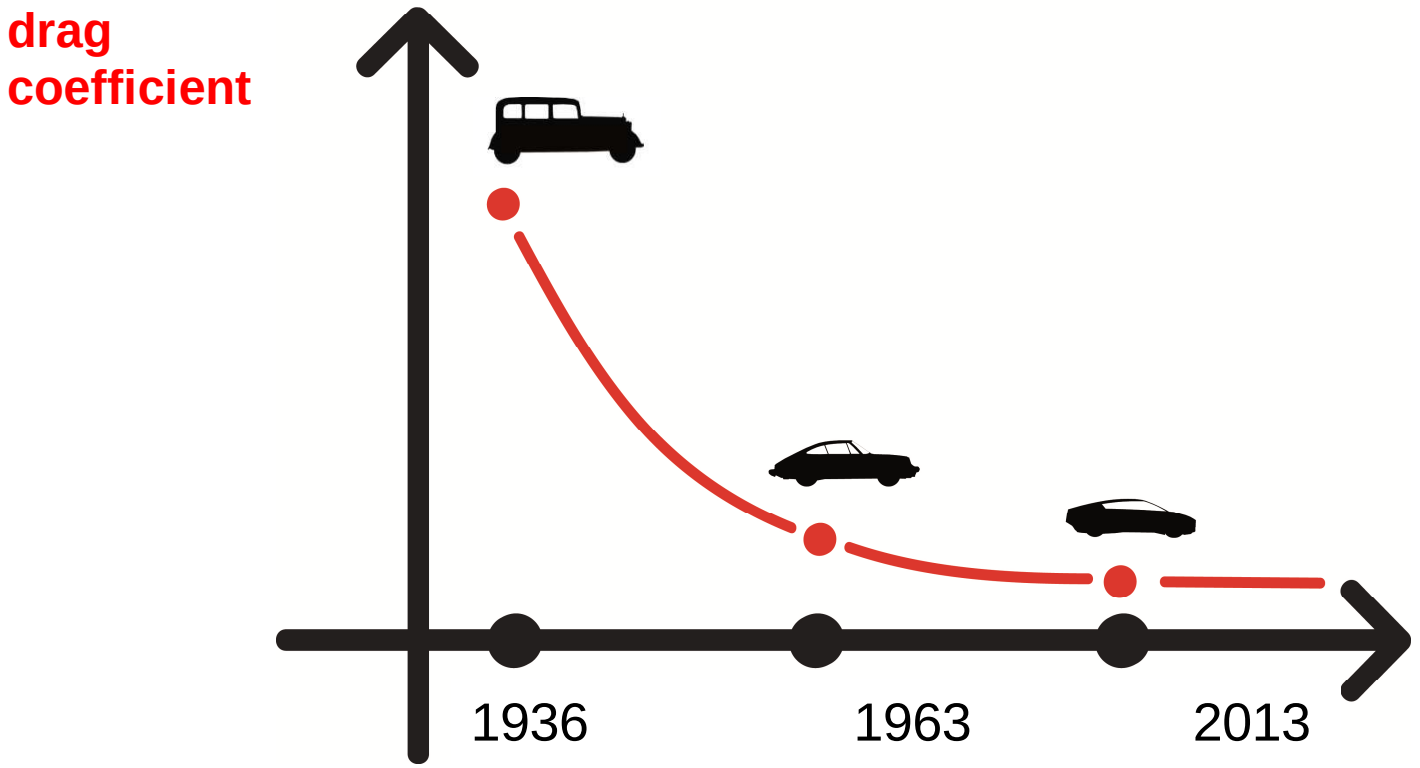
0,7

aerodynamic shape
drag coefficient

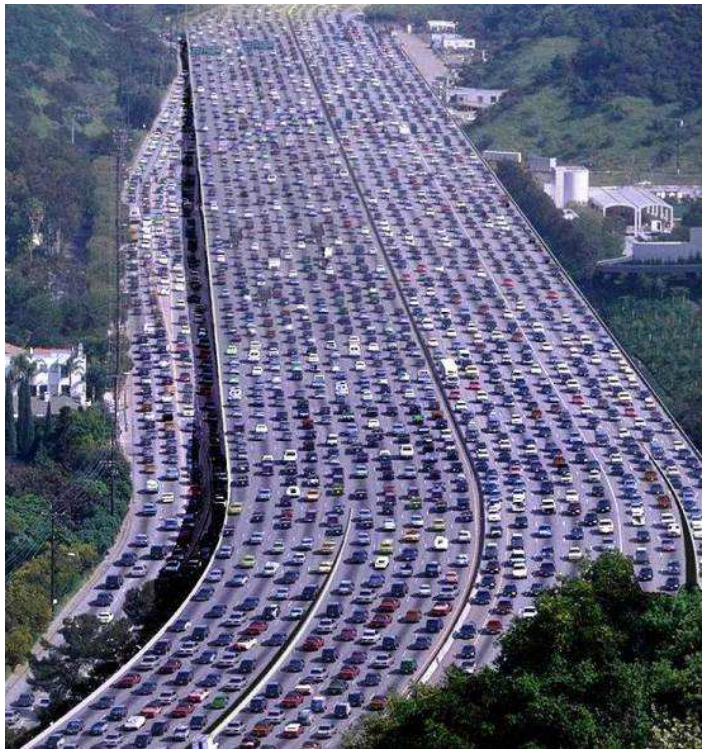
0,36

0,16

source: Knippers Helbig



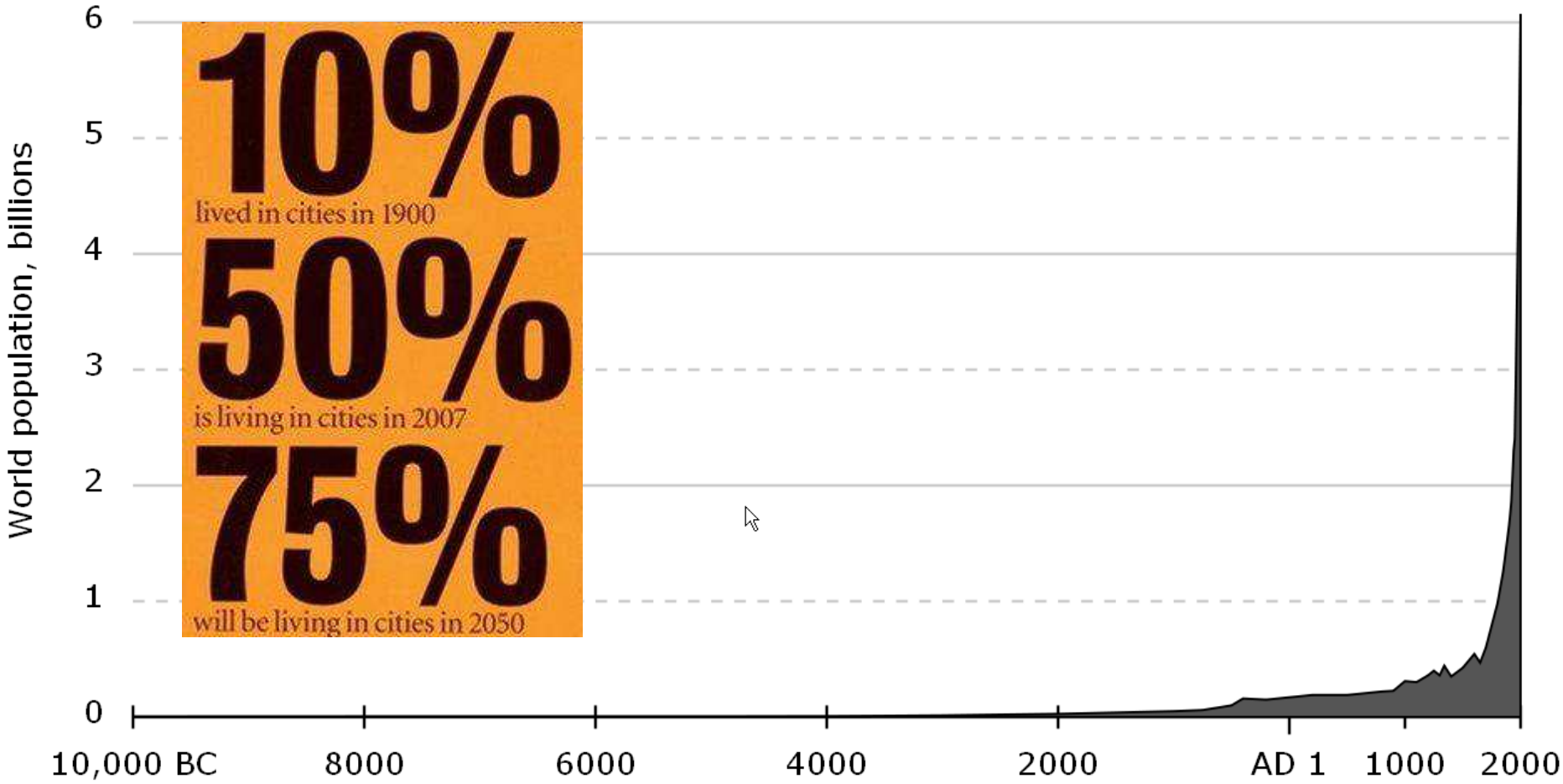
source: Knippers Helbig



source: Knippers Helbig


CITIES...

MORE PEOPLE LIVE IN CITIES
WORLD POPULATION INCREASES CONSTANTLY
NEW CITIES / CITY EXTENSIONS ARE GROWING



URBAN PLANNING FACES NEW CHALLENGES
CRITERIA CURRENTLY UNDERGO CHANGES
RE-ASSESSMENT OF EXISTING CRITERIA
AND ADDITONAL GOALS

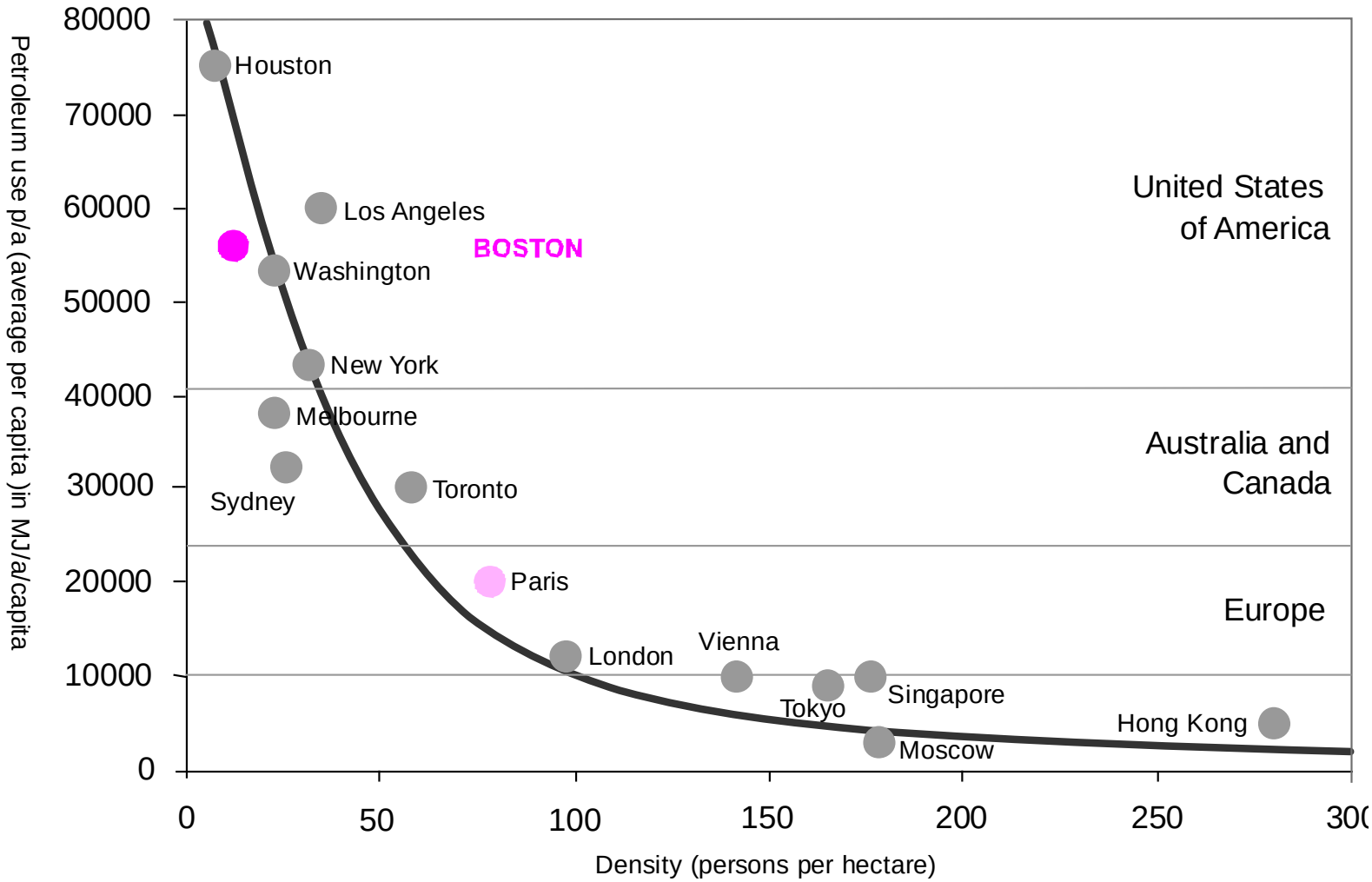
1. CARBON EMISSIONS

2. QUALITY OF URBAN LIFE

- QUALITY OF OUTDOOR ENVIRONMENT
- QUALITY OF INDOOR ENVIRONMENT

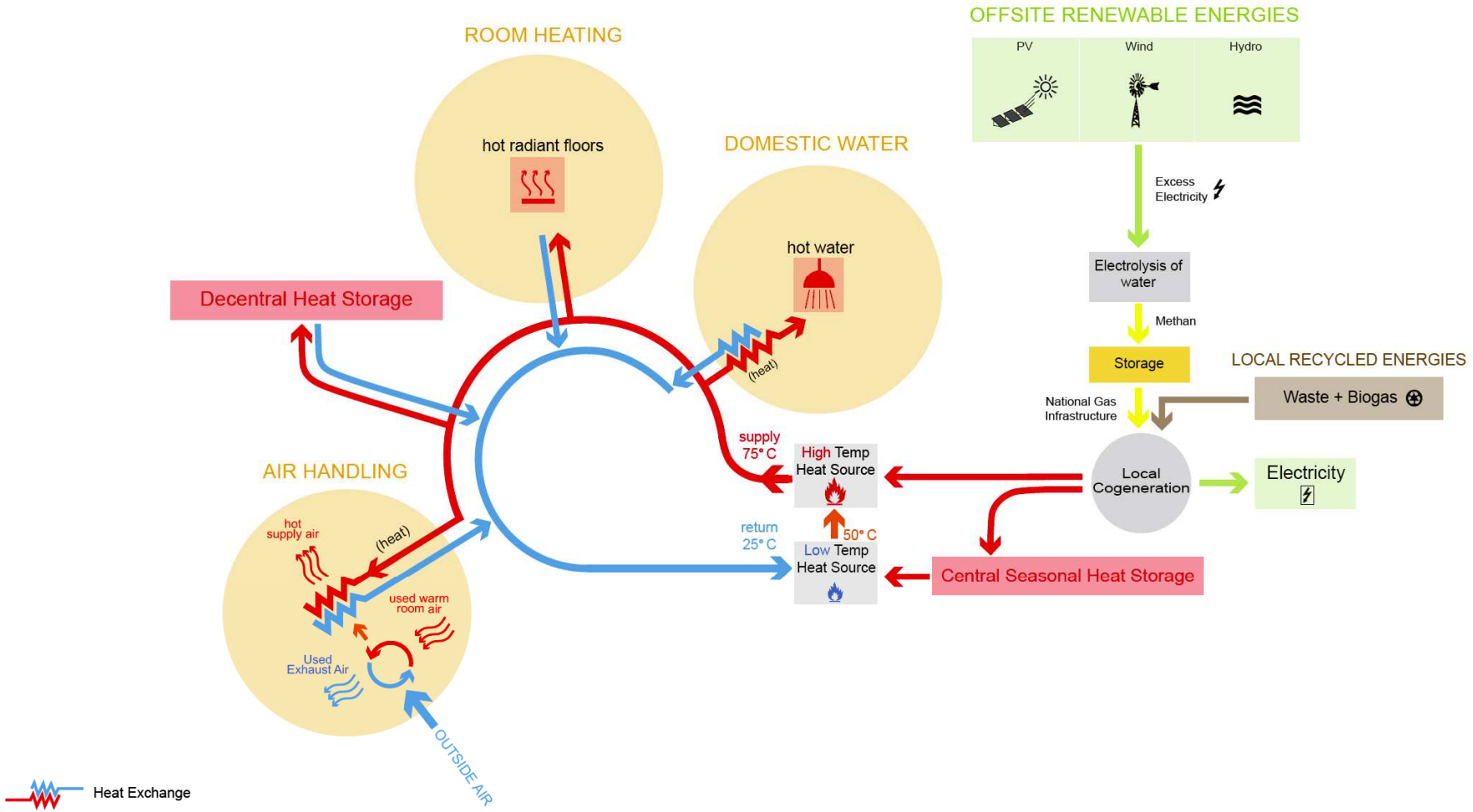
OPPORTUNITIES

DENSITY AND TRANSPORT ENERGY



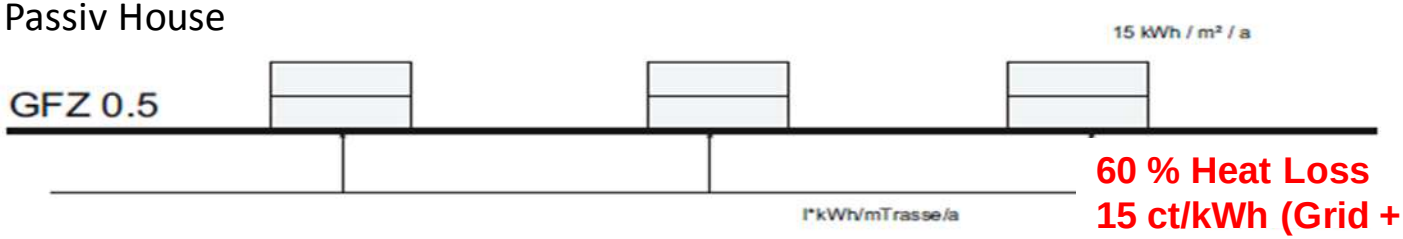
TRANSPORT AND URBAN QUALITY

DENSITY AND INFRASTRUCTURE



DENSITY AND INFRASTRUCTURE

Passiv House

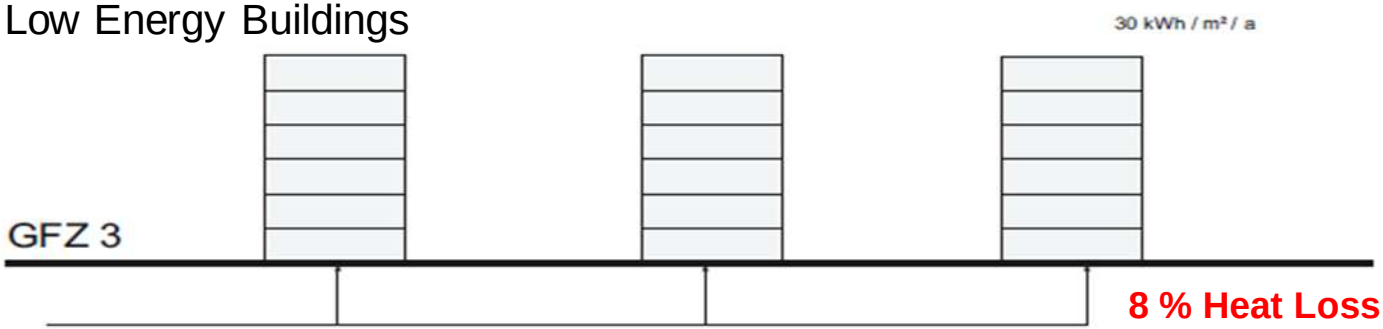


60 % Heat Loss
15 ct/kWh (Grid + Loss)

Low Energy Buildings

12 % Heat Loss
3.5 ct/kWh (Grid + Loss)

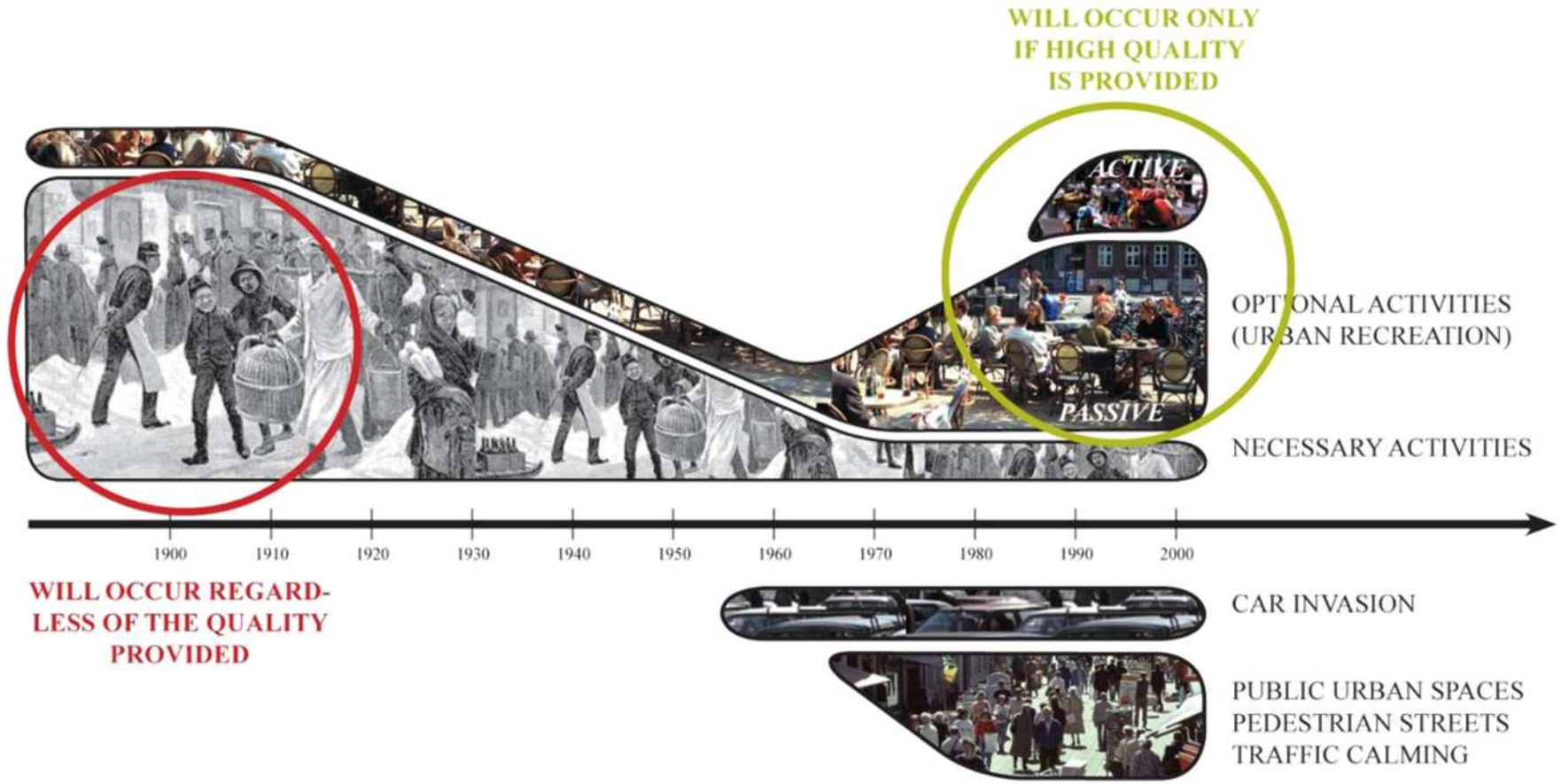
Low Energy Buildings



8 % Heat Loss
2.7 ct/kWh (Grid + Loss)

CHALLENGES

URBAN QUALITY AND STREET LIFE



source: Jahn Gehl Architectsa

OUTDOOR COMFORT

OUTDOOR COMFORT

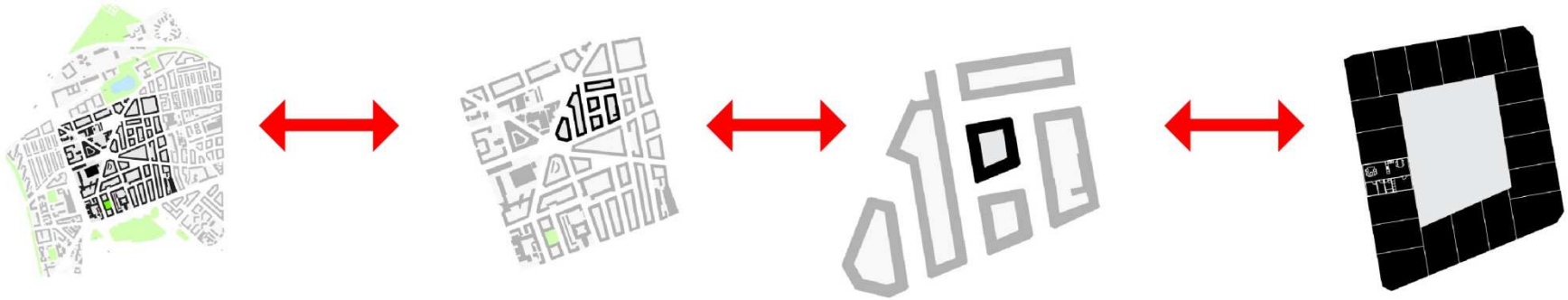

WIND
Photo: Panhandle Helicopter/ JR Hott

DAYLIGHT AND SOLAR ACCESS

PROCESS

IMPLEMENTATION OF DESIGN STRATEGIES

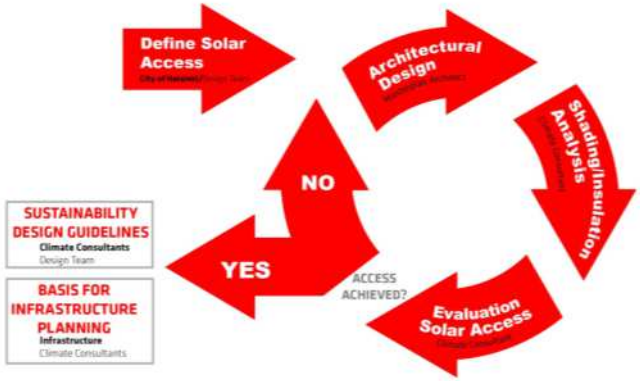
DEPENDENCY OF SCALE



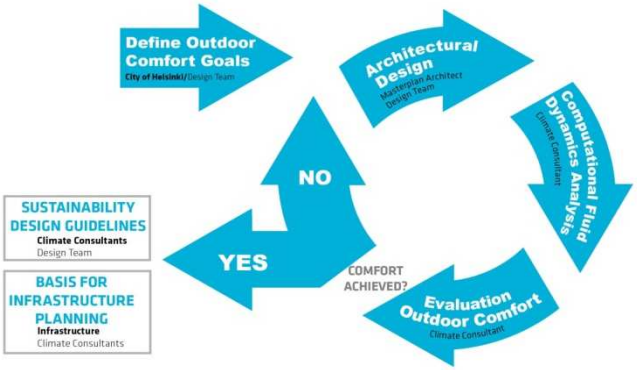
SOLAR ACCESS, DAYLIGHT
ENERGY INFRASTRUCTURE

IMPLEMENTATION OF DESIGN STRATEGIES

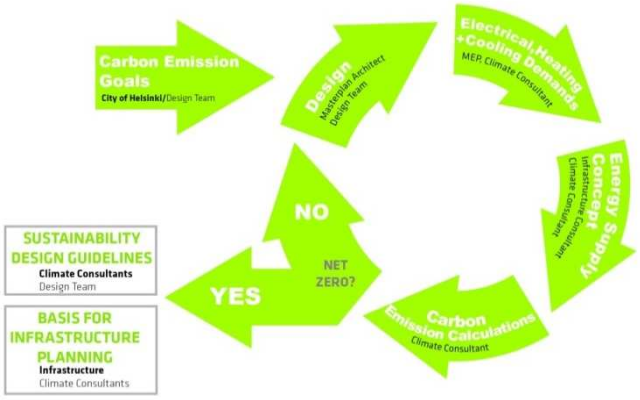
PERFORMANCE BASED PROCESS



DAYLIGHT SOLAR ACCESS



PEDESTRIAN COMFORT



CARBON EMISSIONS

INTEGRATED DESIGN TEAM

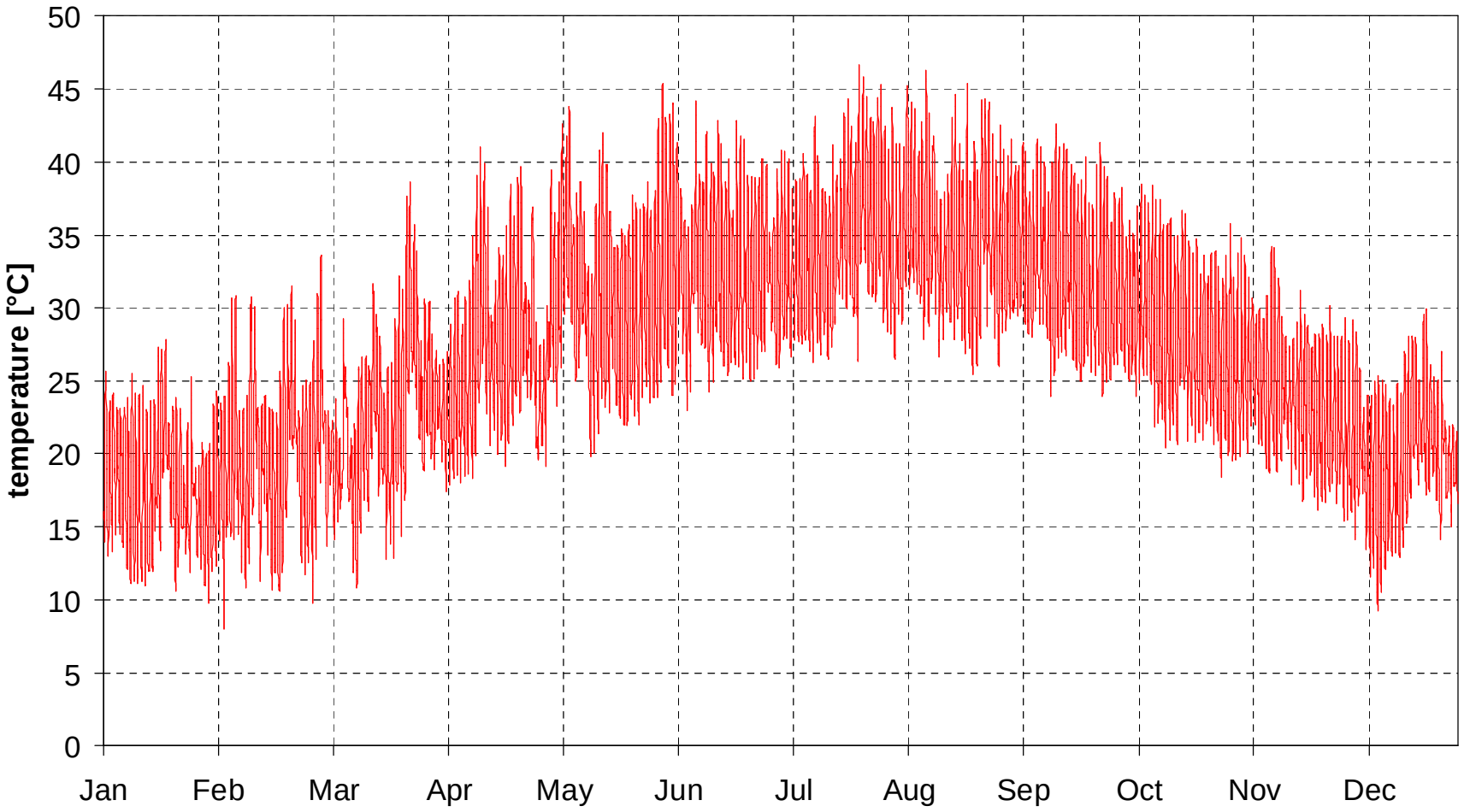
CASE STUDIES
MASDAR, ABU DHABI

MASDAR

Abu Dhabi, VAE

FOSTER & PARTNERS

OUTDOOR TEMPERATURE



OBJECTIVES

Sustainability objectives

- Create outstanding living and working conditions
- Provide excellent air quality and thermal comfort
- Create a zero carbon development
- Develop technical concepts and rethink the way of living
- Replace fossil power by solar power

City of short distances

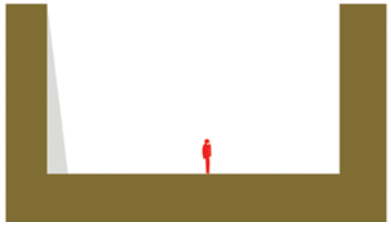
- City where living and working is close
- people walk instead of using he air conditioned car

DESERT

CENTRAL ABU DHABI

MASDAR - ARCADES

MASDAR – GREEN GARDENS



67 °C

71 °C

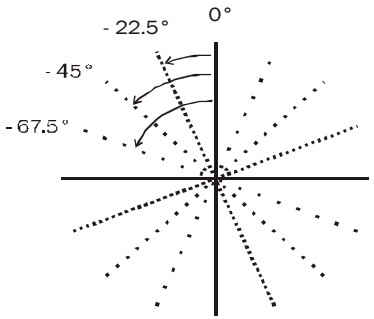
40 °C

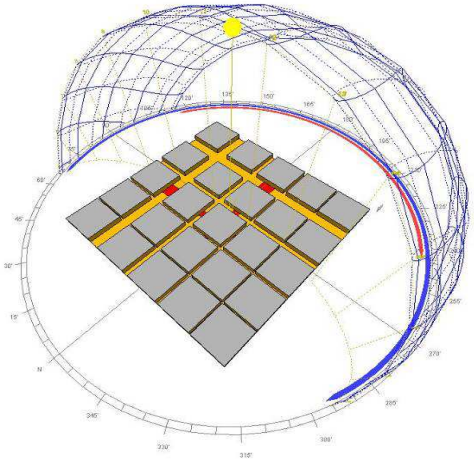
38 °C

TEMPERATURE

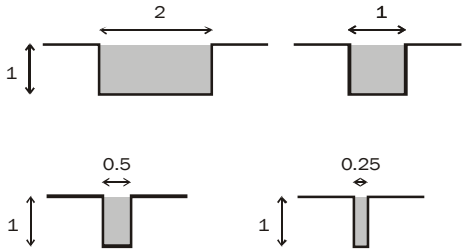
STREET WIDTH AND ORIENTATION

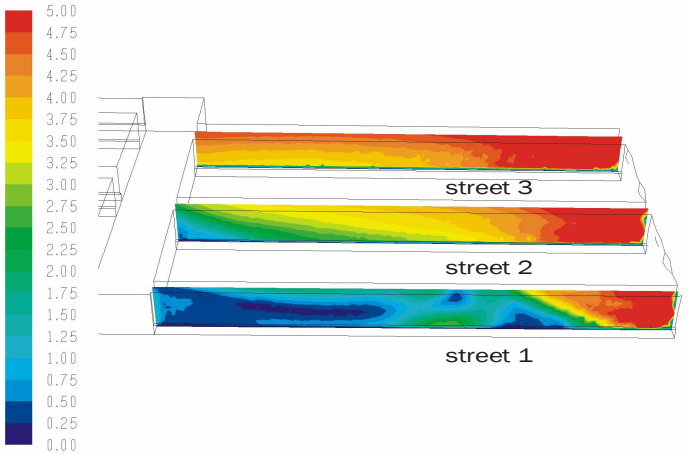
STREET
ORIENTATION





STREET
DIMENSION





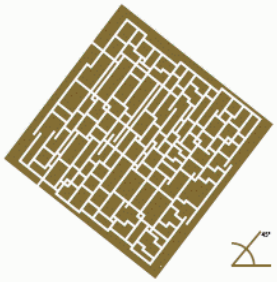
45° PROVIDES BEST MICROCLIMATE

North/South

The North-South orientation of streets allows sunlight penetration of the urban structure with a subsequent increase in cooling loads requirements.

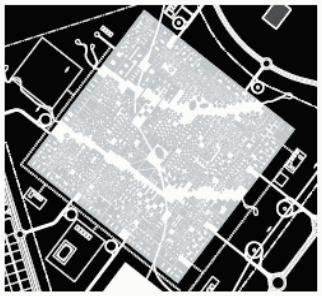
East/West

An East/West allignment also results in an increase in cooling load requirement due to the street exposure of external walls to sunlight



Northeast/Southwest

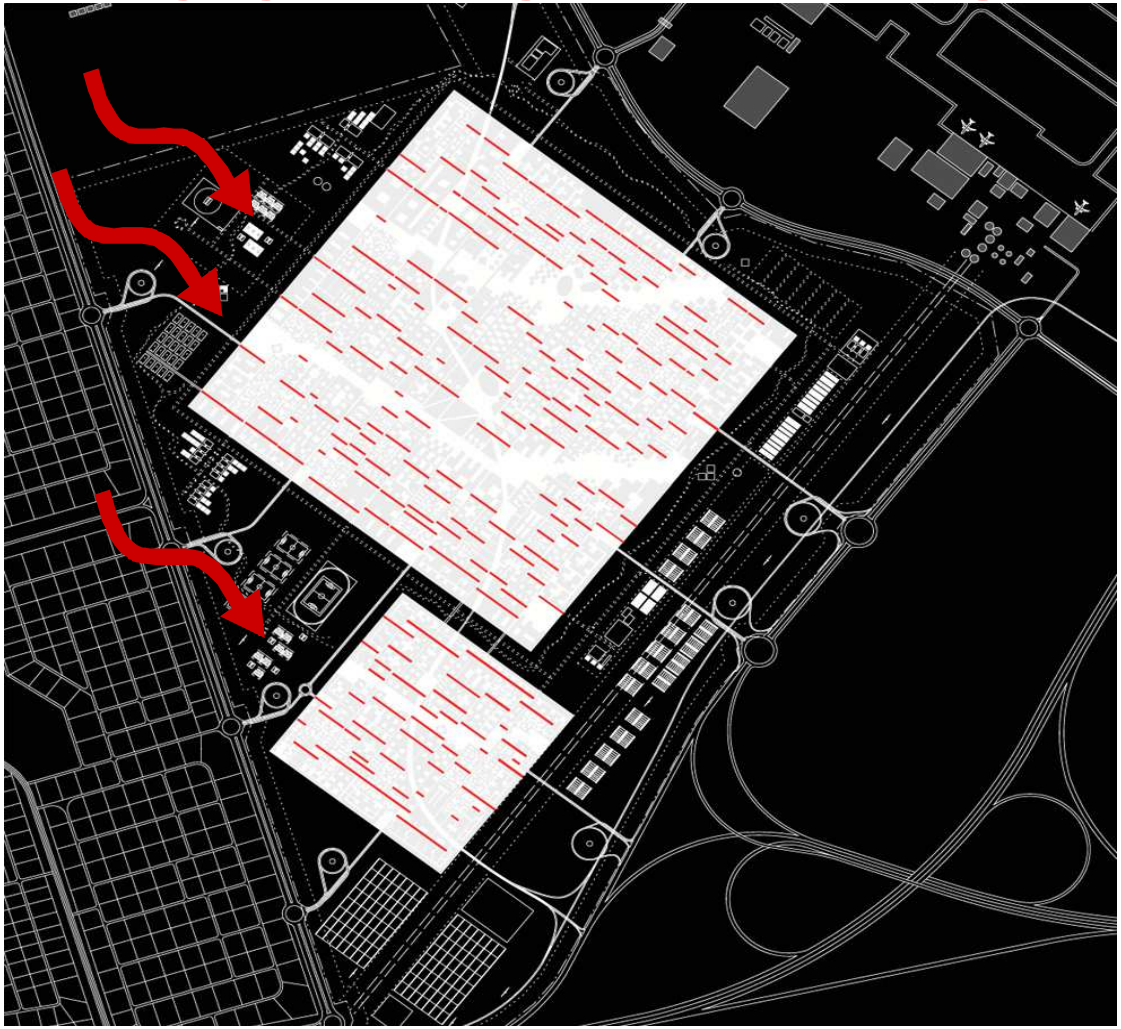
The diagonal grid provides optimal shading

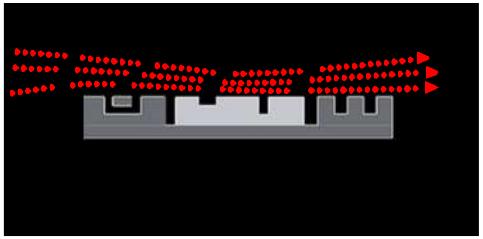


Northeast/Southwest

The northeast/southwest orientation of the city fabric provides optimal shading

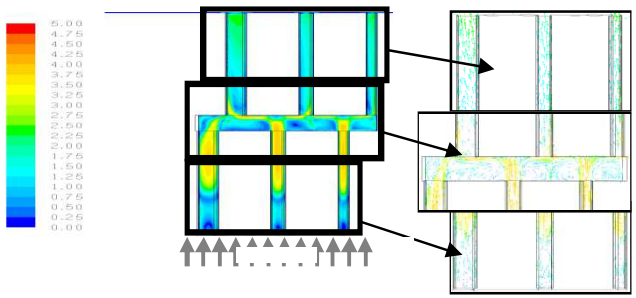
BLOCK HOT WINDS





Short Street below 75 – 100 m

✓ The hot wind remains above the street!



Wind velocity profile[m/s] at 2m height above the ground

USE COOL WINDS

Night-time Cool Winds

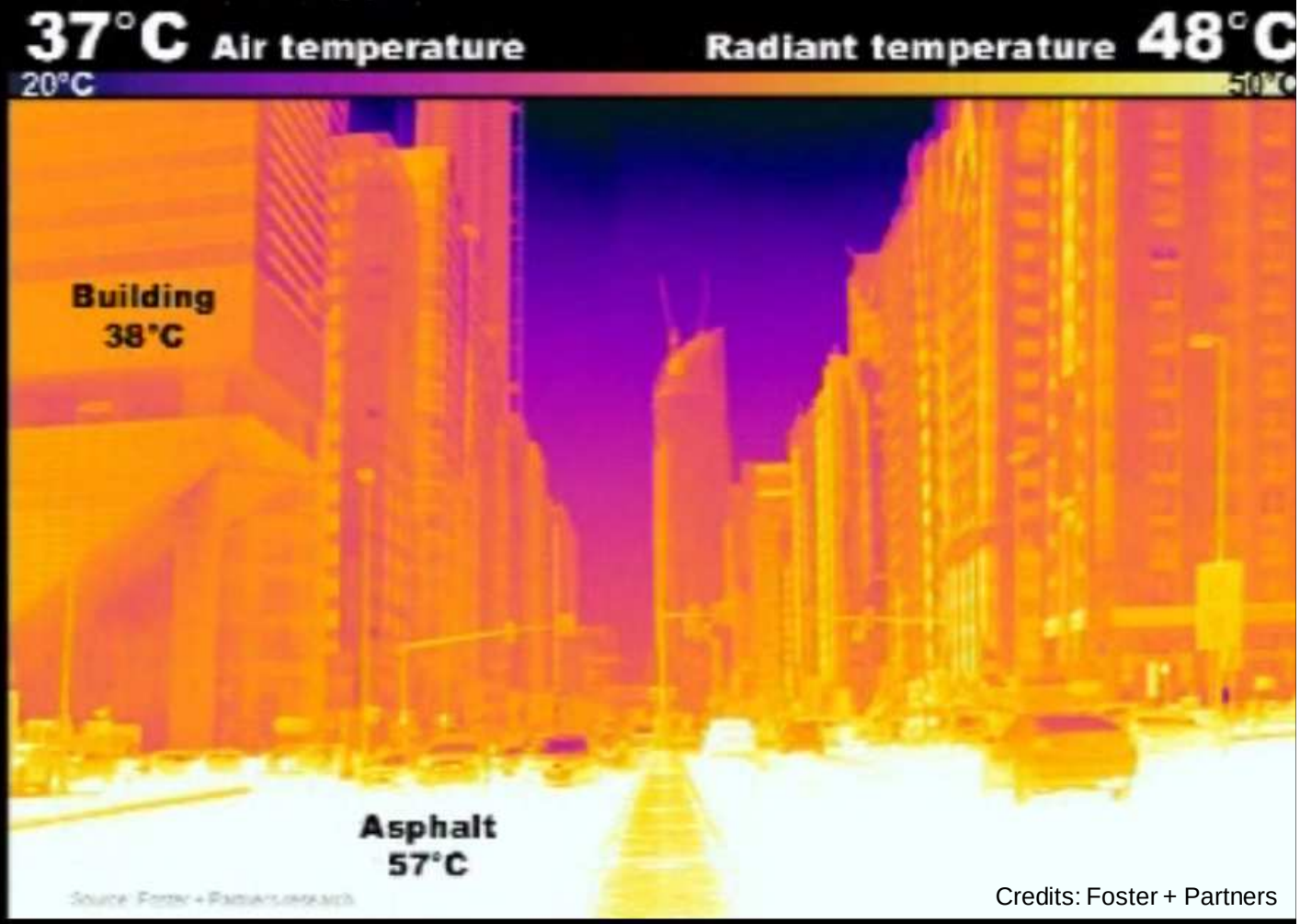
TAGESLICHT

ABU DHABI DOWNTON

Credits: Foster + Partners

INFRAROT

ABU DHABI DOWNTON



Credits: Foster + Partners

TAGESLICHT

MASDAR INSTITUTE

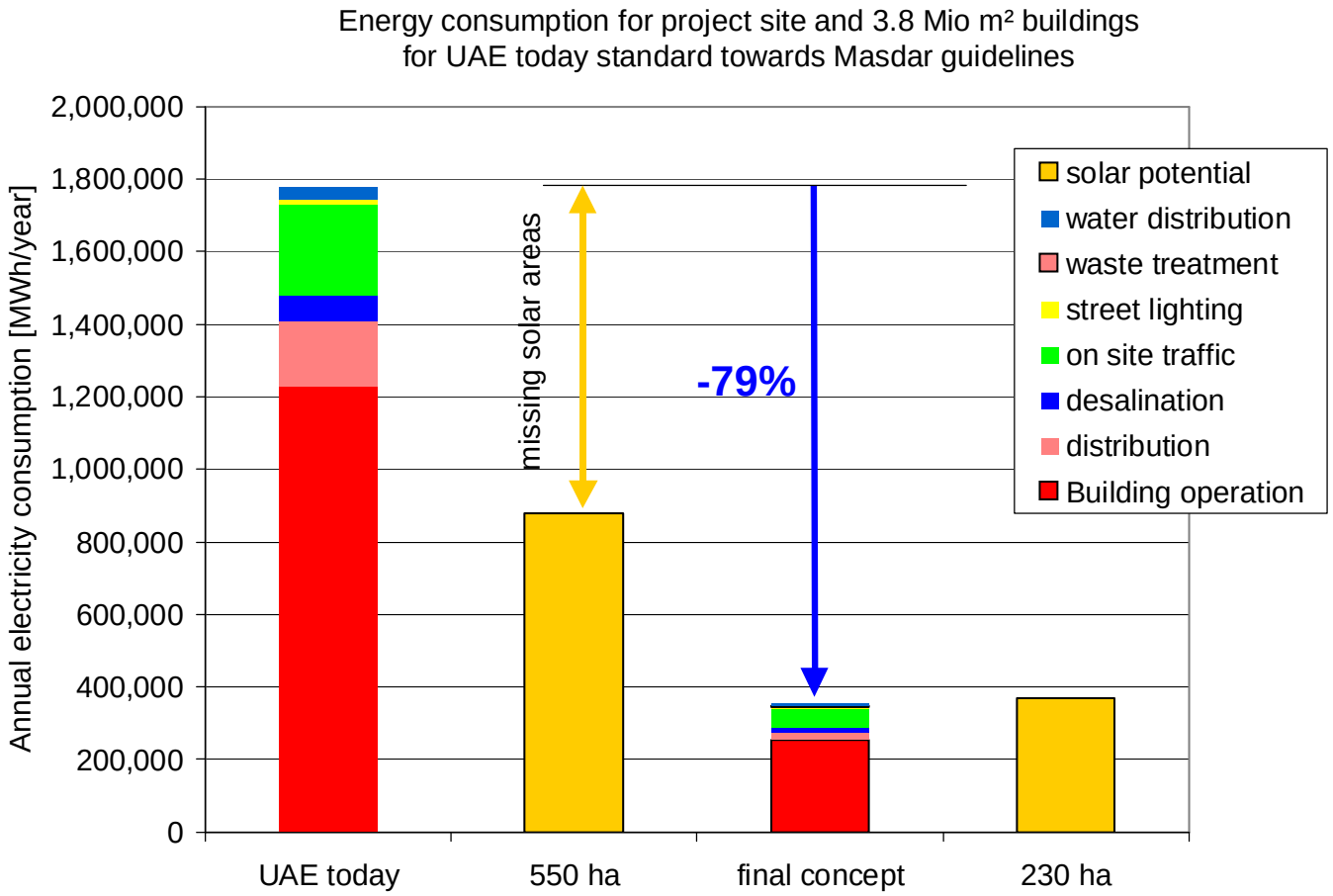
Credits: Foster + Partners

INFRAROT

MASDAR INSTITUTE

Credits: Foster + Partners

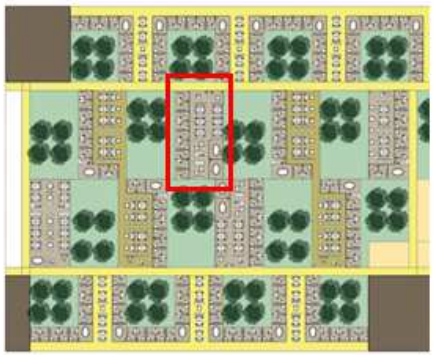
CARBON NEUTRAL CITY



ZONES ENERGY SIMULATION

Typologies
Commercial SEZ

Courtyard: 15 x 30 m²



peak loads (to gross footprint):

• sensible -	42.3 W/m²
• latent -	31 W/m²
• AHU -	1.3 W/m²
• equipment -	5.3 W/m²
• art. lighting -	9 W/m²

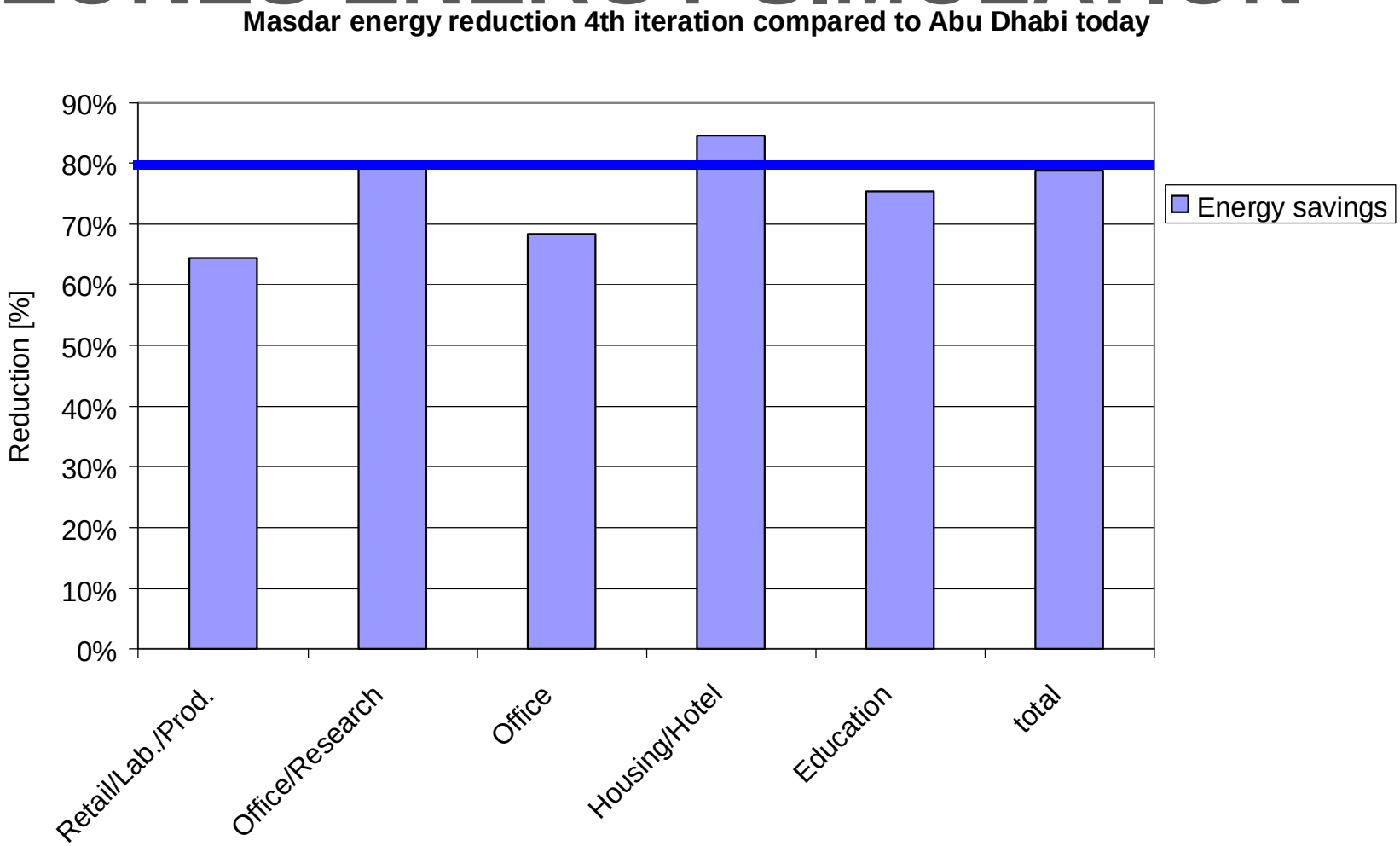
annual demands (to gross footprint)

• sensible -	94.8 kWh/m²/a
• latent -	50.5 kWh/m²/a
• electrical -	49.1 kWh/m²/a

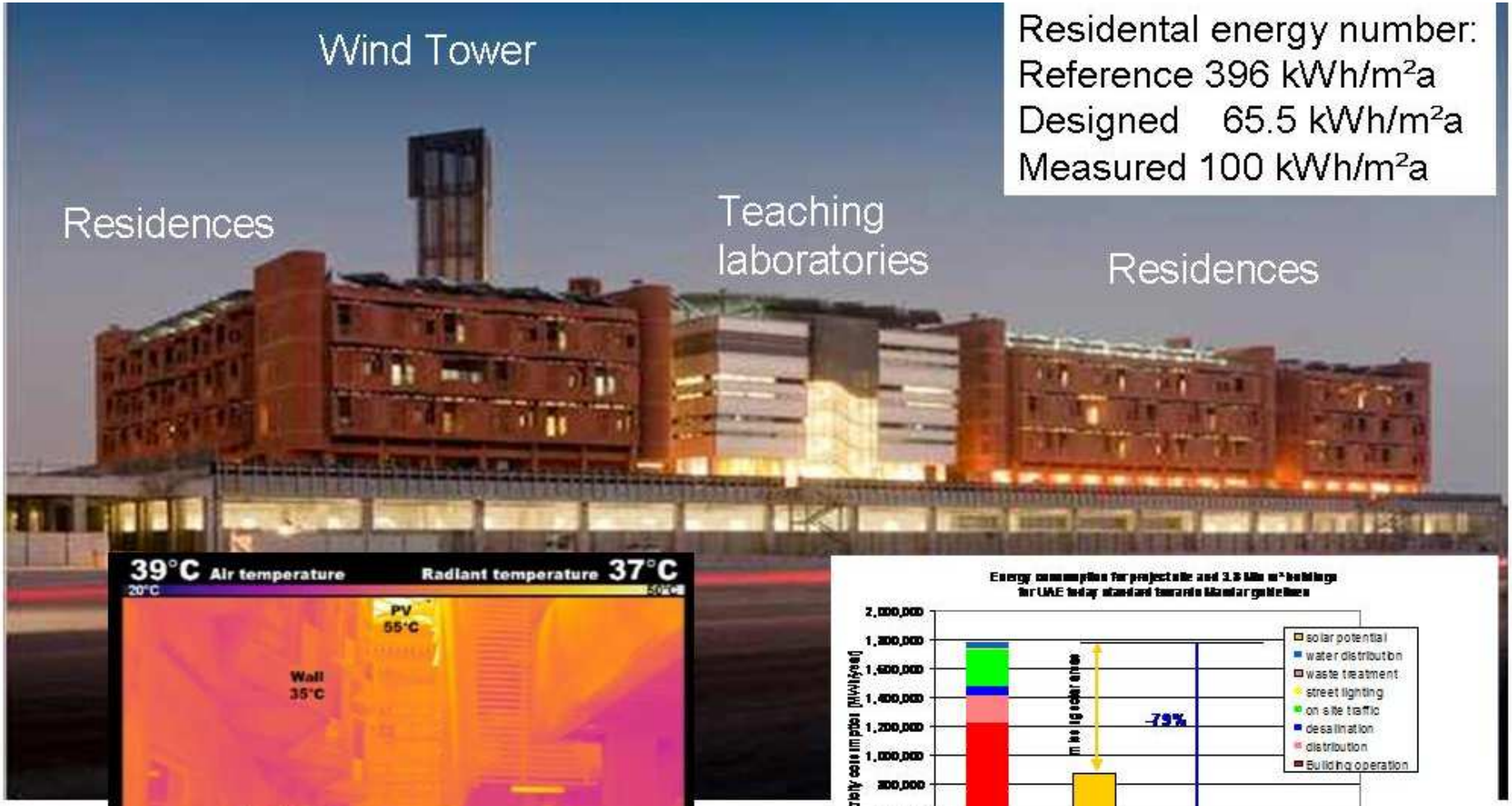
Office floors in 2. to 5. story; 3 m clearance;
25 % of total area as top floor area with roof

working hours -	8°° to 19°°; 6 days per week
operation of AHU -	24 h / 7 d; based on working area; working: 1.5 acr; non-working: 0.75 acr
artificial lighting -	operation controlled depending on outdoor illuminance; 10 W/m² based on net floor area
facade -	30% glass; neutral solar control glass 50/25; 20 % frame ratio; operable, exterior shading device; shading coefficient 0.3
facade -	opaque facade ratio of 70 %; 5 cm thermal insulation (outer surface)
roof -	20 cm thermal insulation (outer surface)
exposed ceiling -	as thermal mass
infiltration -	0.15 acr during working hours; 0.05 acr in non working hours
design temperature -	24°C / 65 % r. hum. daytime 28°C in non working hours
density -	20 m² per occupant
internal heat gains - (office equipment)	5.3 W/m² during working hours; 2.65 W/m² in non working hours
el. demand of AHU -	0.6 kWh/1,000 m³
sens. heat recovery -	80 %

ZONES ENERGY SIMULATION



ENERGY MONITORING



CASE STUDIES
HELSINKI, FINLAND


JÄTKÄSAARI PENINSULA
LOW TO NO DEVELOPMENT
HELSINKI, FINLAND
TALLINK
BIG ARCHITECTS

JÄTKÄSAARI PENINSULA
LOW TO NO DEVELOPMENT

HELSINKI, FINLAND

Original Jätkäsaari Masterplan

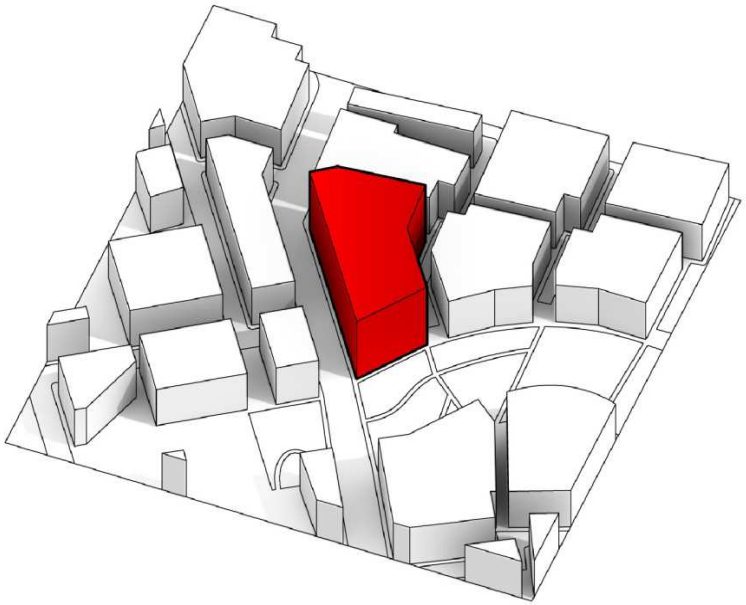
BIG ARCHITECTS

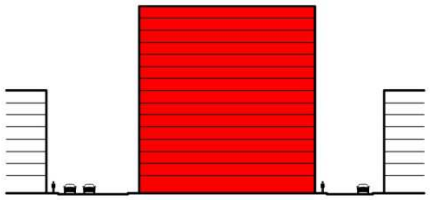
CLIMATE

HELSINKI, FINLAND

DAYLIGHT

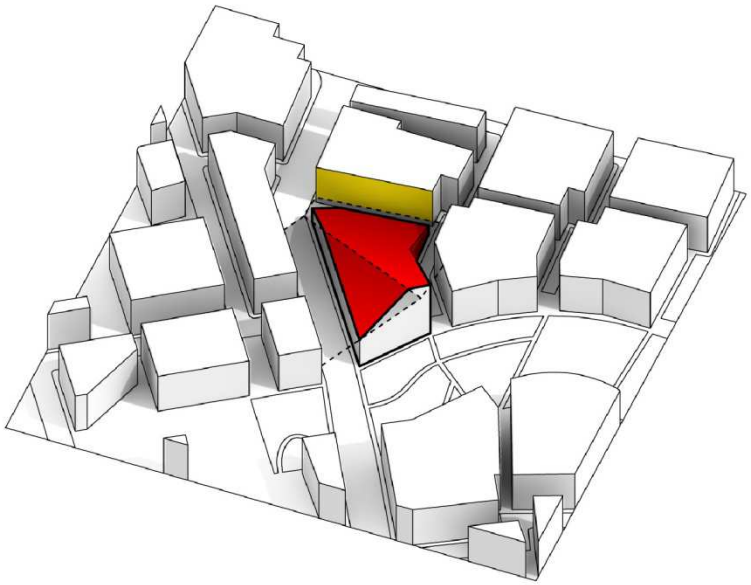
SOLAR EXPOSURE

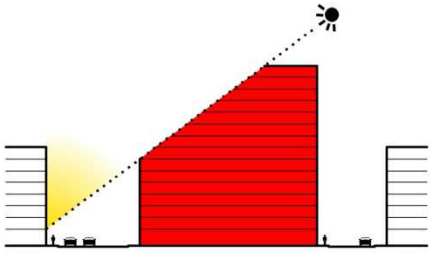




DAYLIGHT

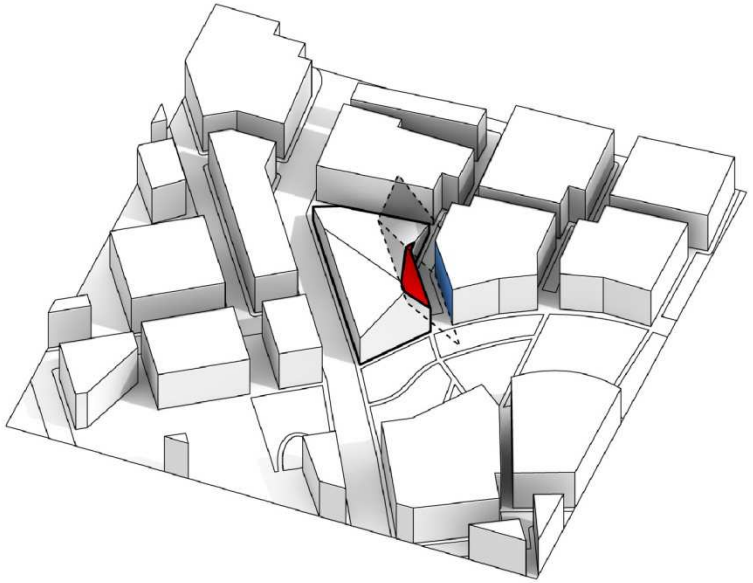
SOLAR EXPOSURE

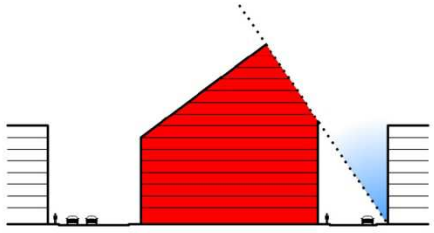




DAYLIGHT

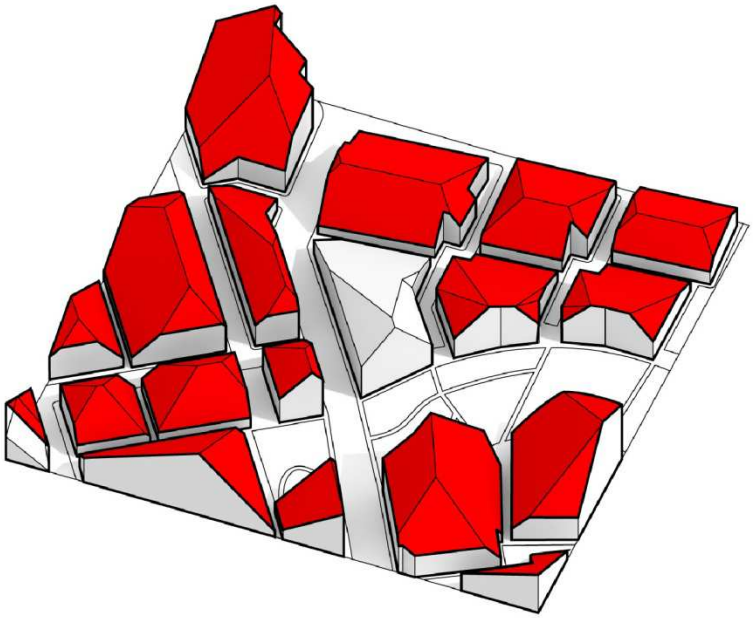
SOLAR EXPOSURE

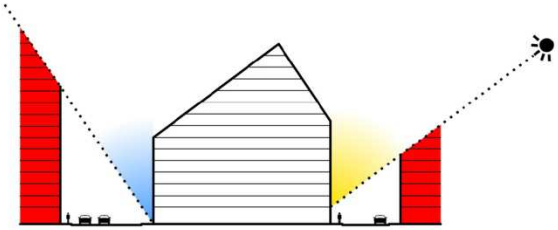




TAGESLICHT

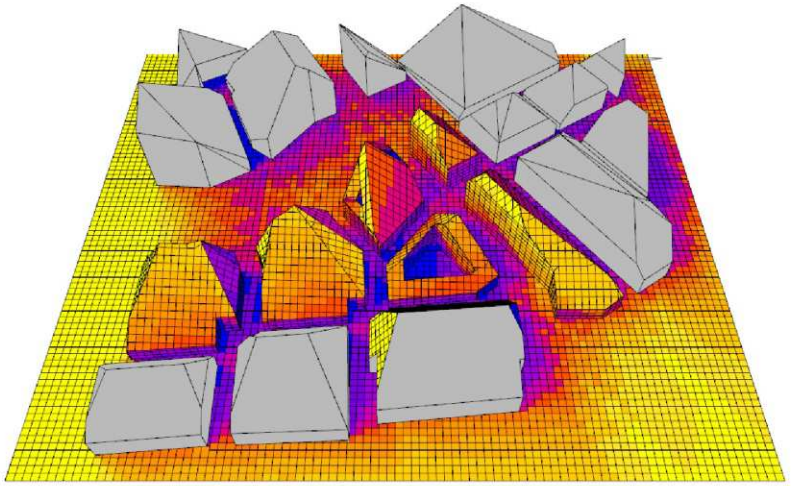
BESONNUNG



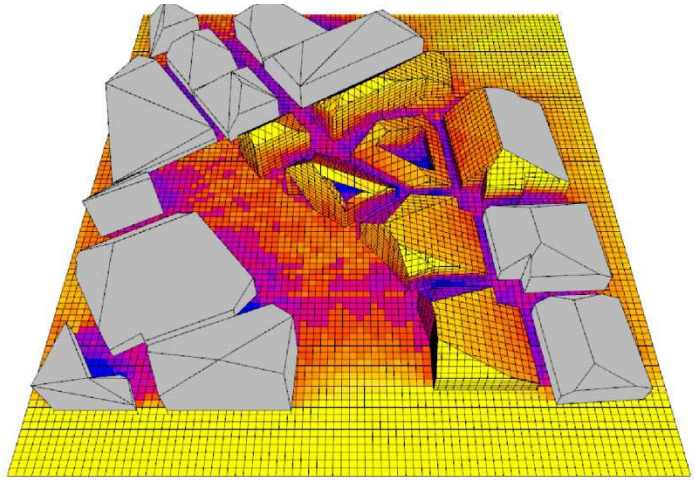


SOLAR EXPOSURE

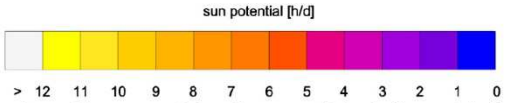
HOURS



View from the EAST

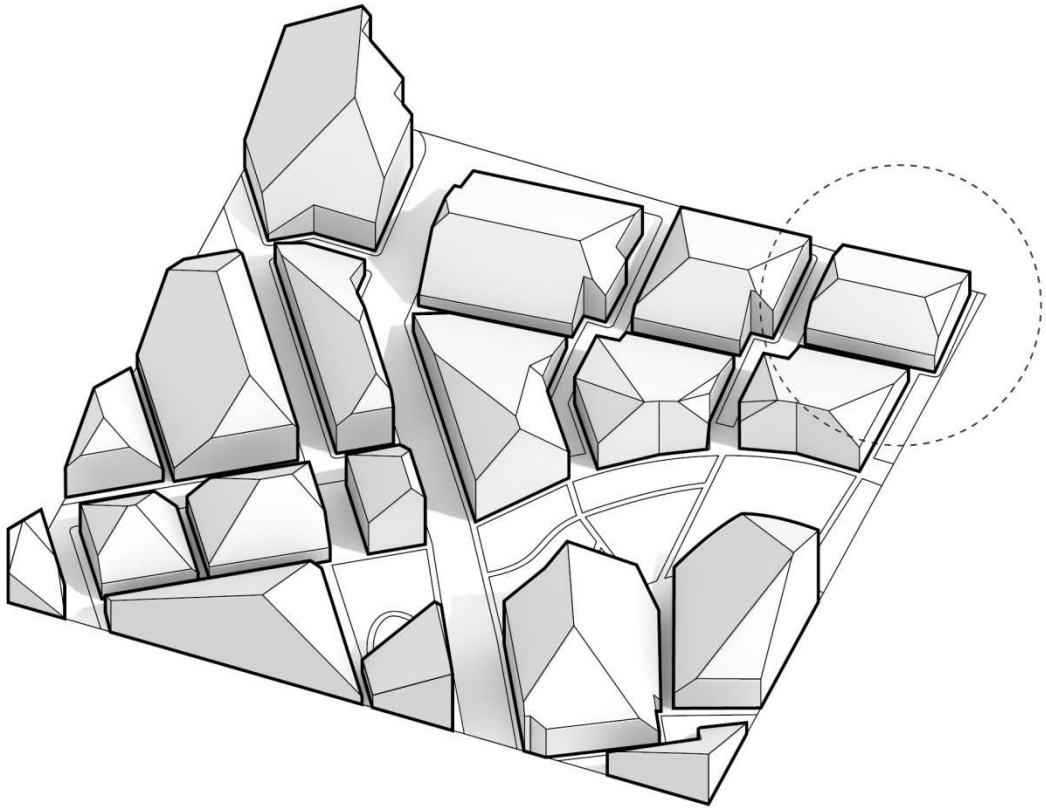


View from the SOUTH

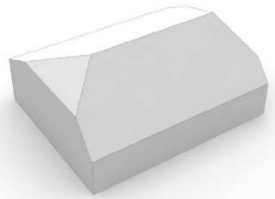


Number of hours receiving direct sunlight in [hours/day]
Maximum available hours of beam solar radiation on the not shaded plane: 11h

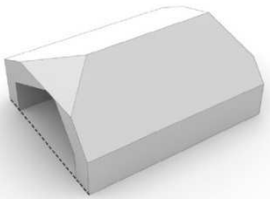
3D BUILDING ENVELOPE



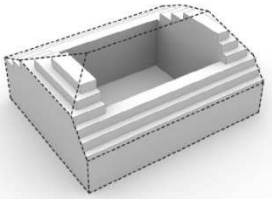
TYPOLOGIE



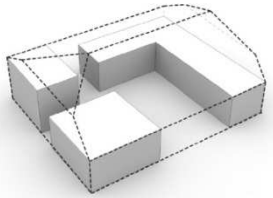
SOLID



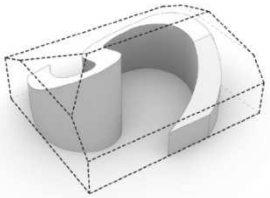
VOID



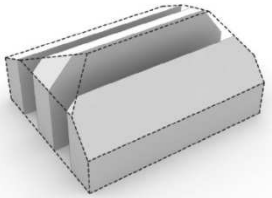
STEPPED COURTYARD



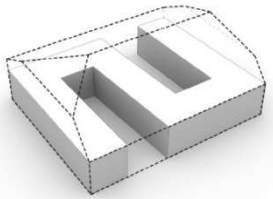
CONTEMPORARY BLOCK



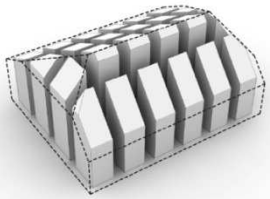
SNAKE



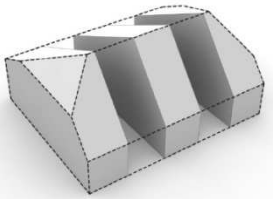
LONG SLABS



OPEN COURTYARDS



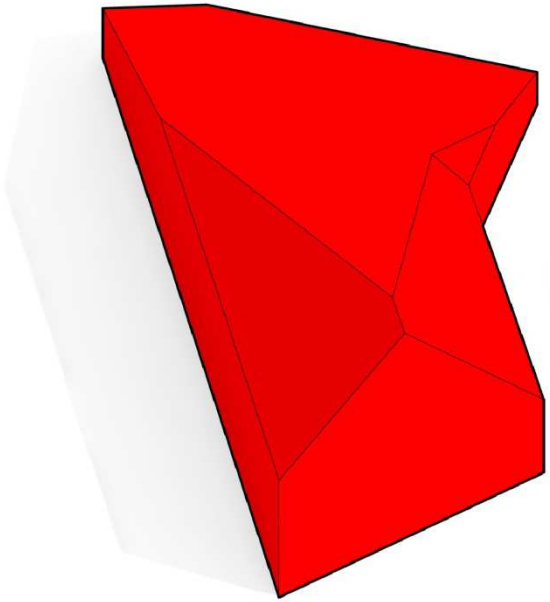
LITTLE TOWERS



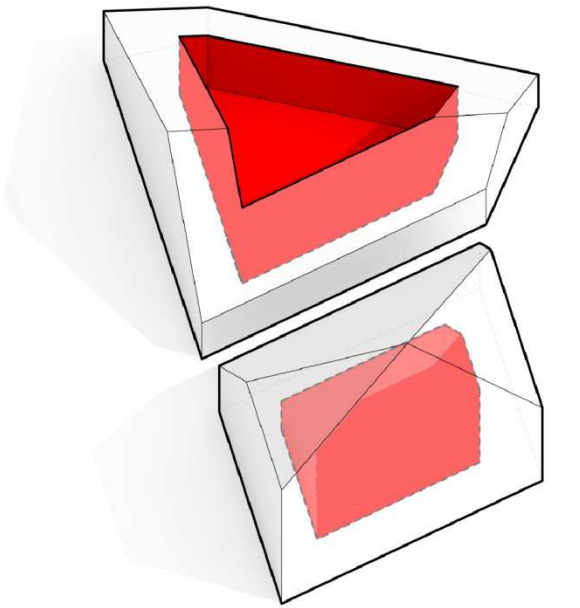
SHORT SLABS

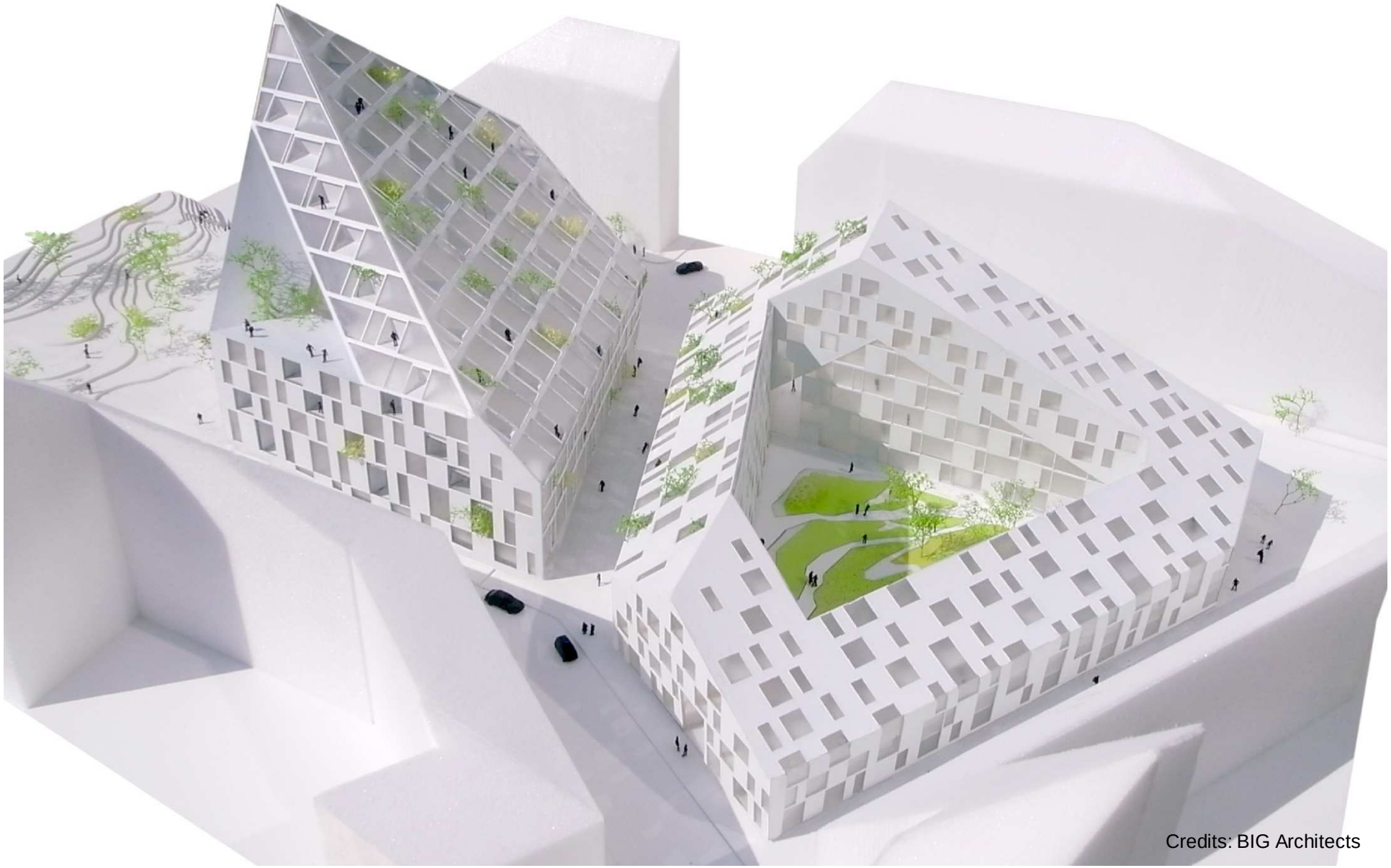
SITRA

HEADQUARTERS



ATRIUM | INNENHOF





Credits: BIG Architects

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CARBON NEUTRAL CITY

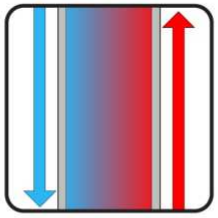
PASSIVE STRATEGIES

Wind Mitigation

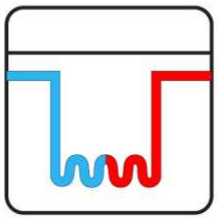
Passive Heating

Natural Ventilation

SERVICE STRATEGIES



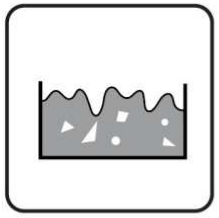
Heat Exchangers



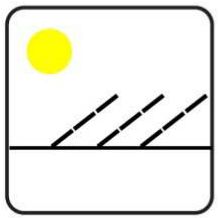
Geothermal

Radiant Heating

SUPPLY STRATEGIES



Waste

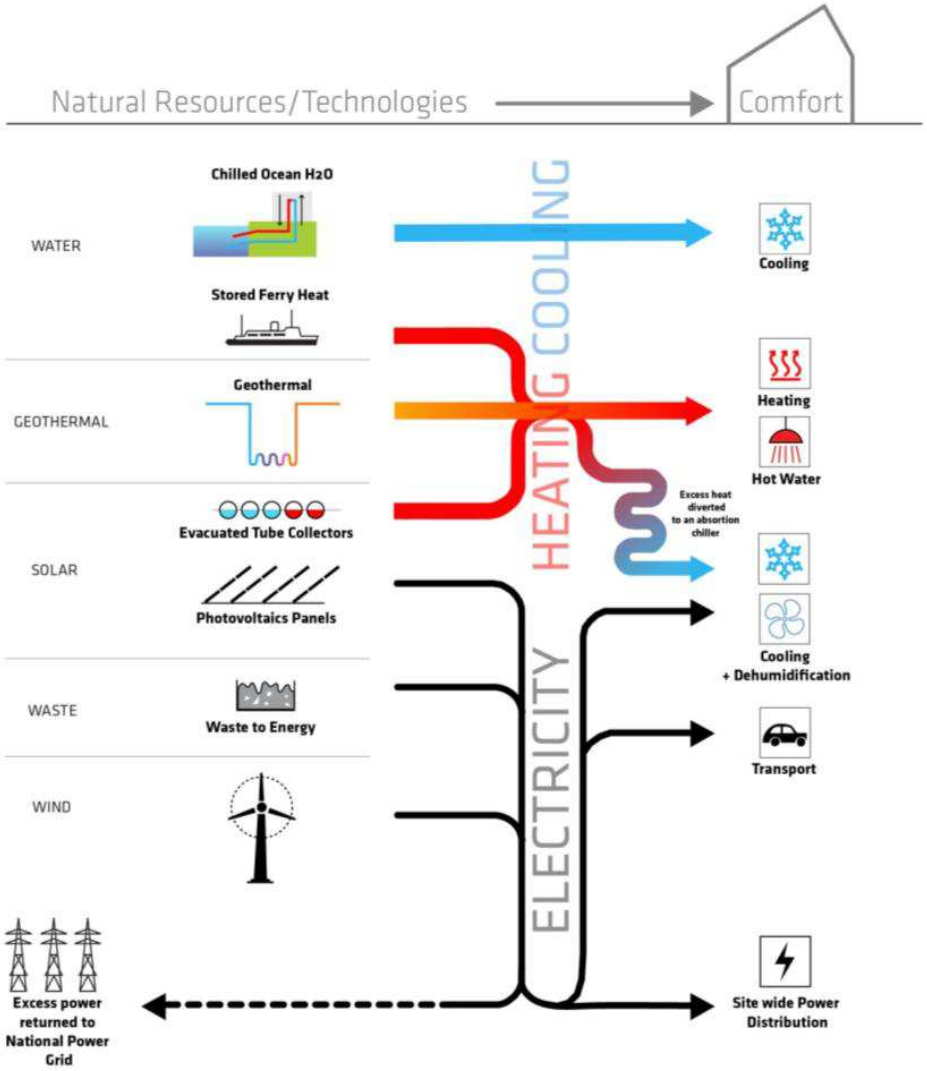


Solar

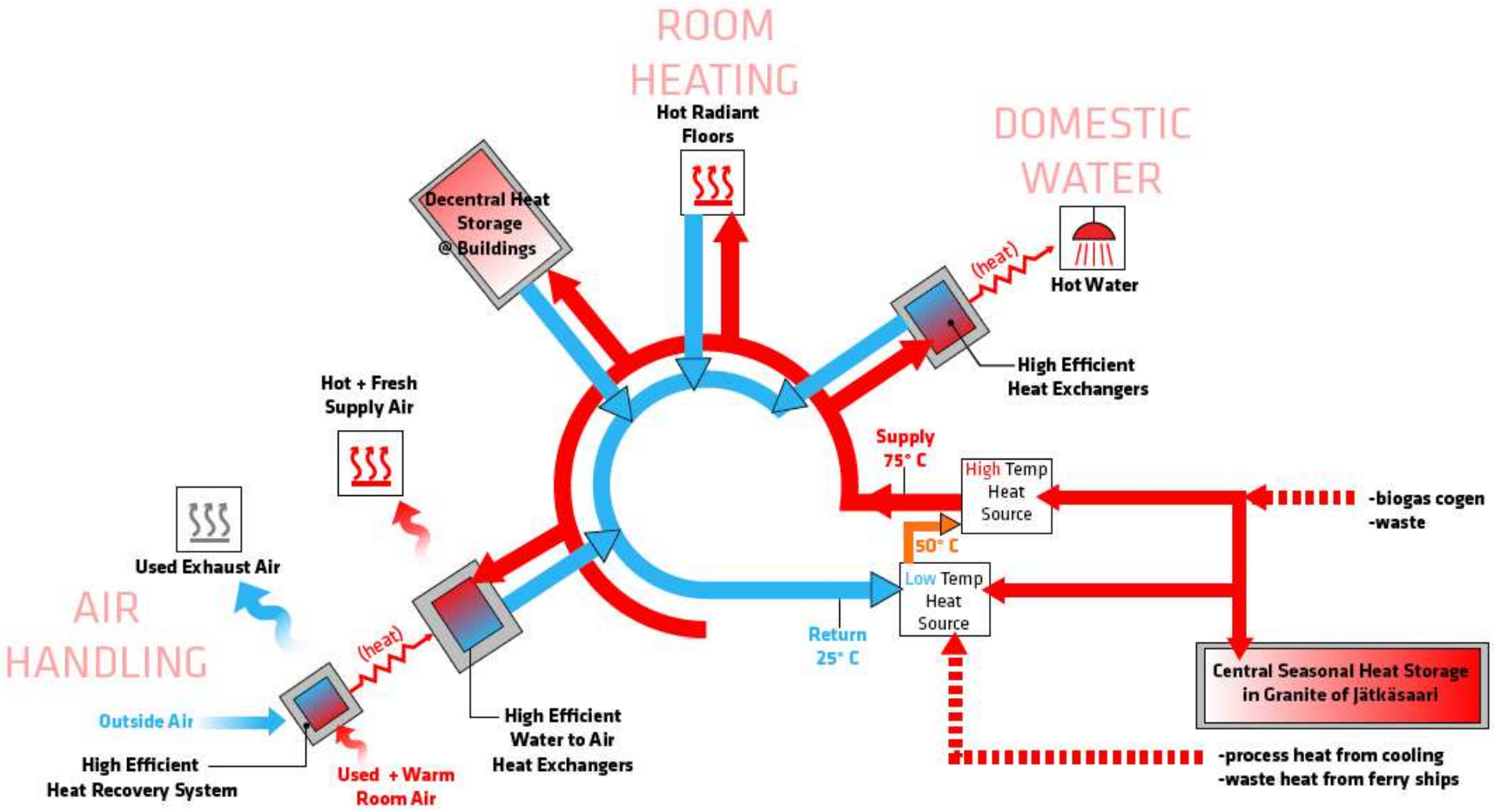
Wind

TACTICS

MULTIPLE ENERGY SOURCES

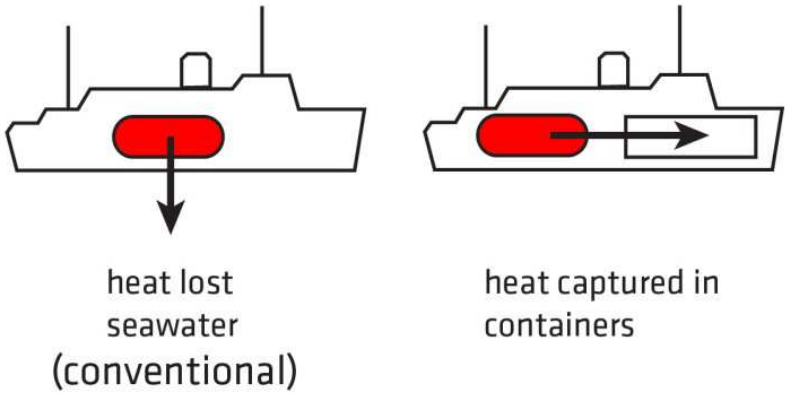


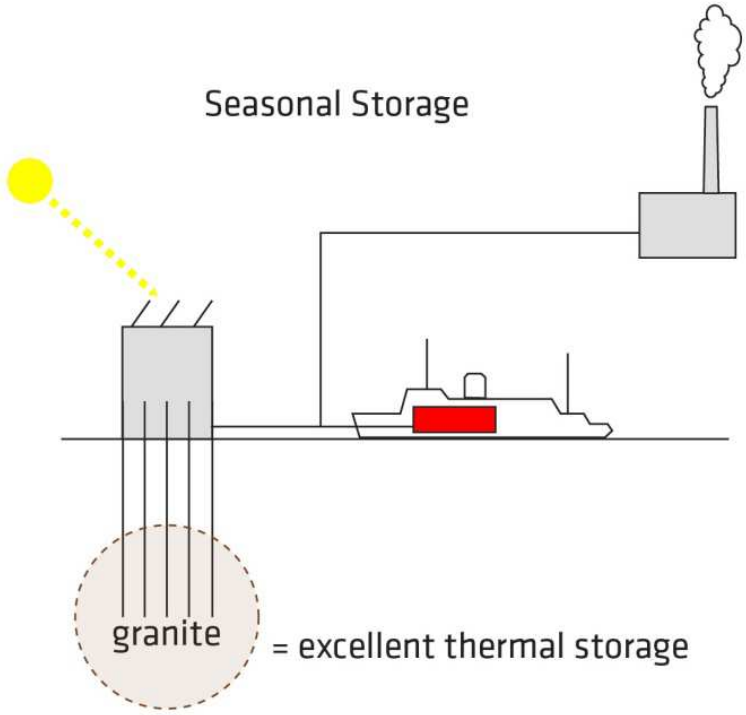
LOW CARBON INFRASTRUCTURE



SITE

ENERGY ASSETS

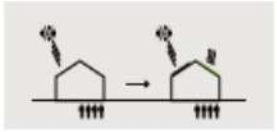


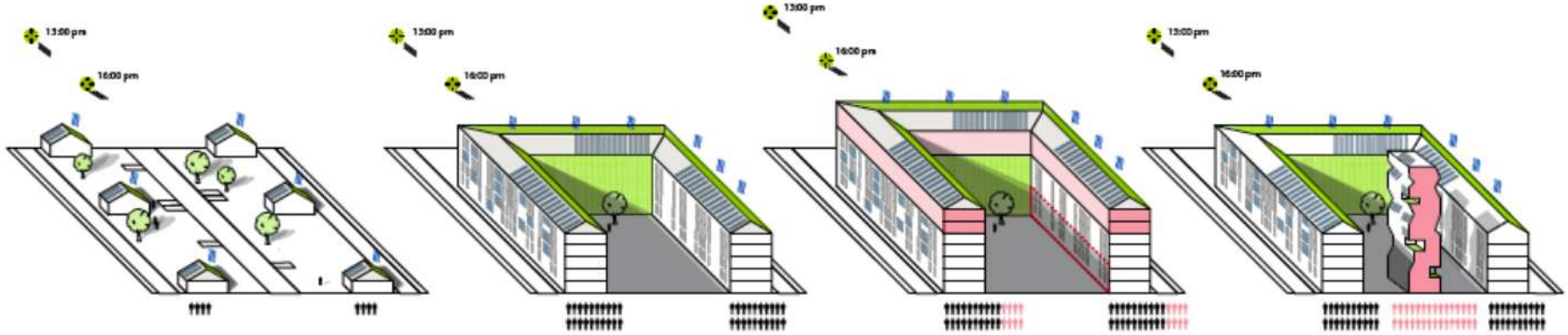


OUTLOOK

GRAND ADJUSTMENTS

DESIGNING DENSIFICATION

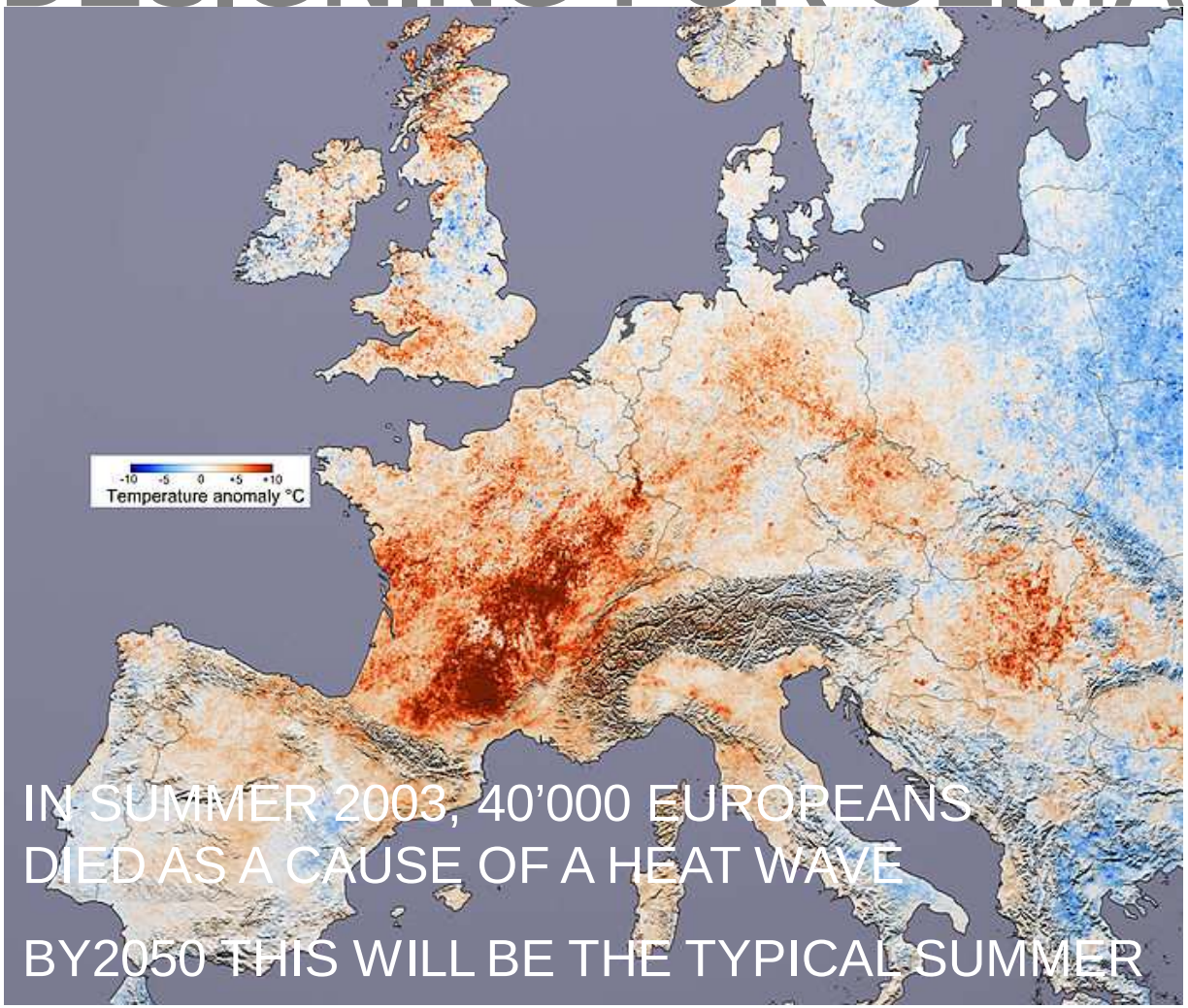




Solar access optimized densification

Solar access optimized densification

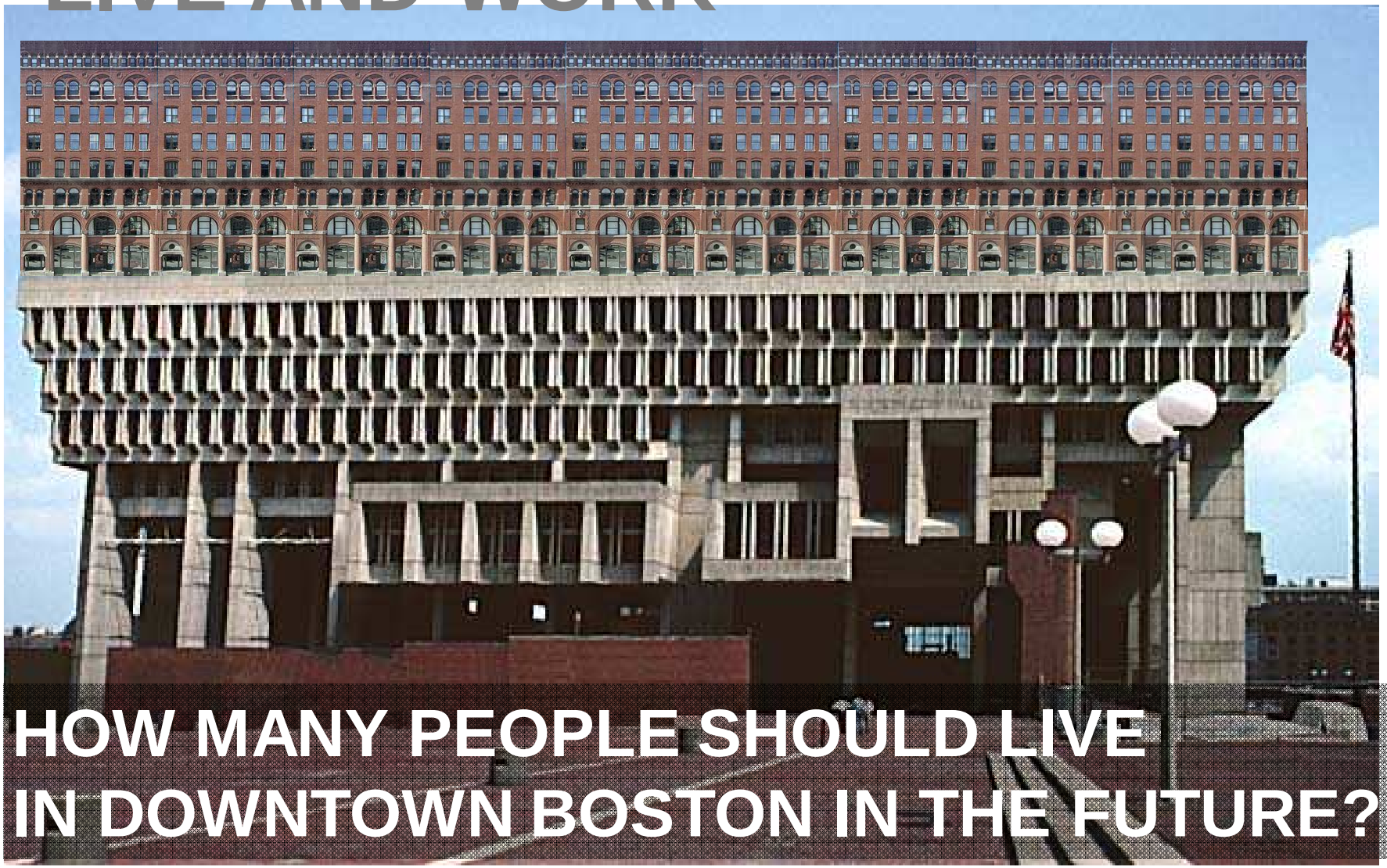
DESIGNING FOR CLIMATE CHANGE



IN SUMMER 2003, 40’000 EUROPEANS DIED AS A CAUSE OF A HEAT WAVE

BY2050 THIS WILL BE THE TYPICAL SUMMER

LIVE AND WORK



HOW MANY PEOPLE SHOULD LIVE IN DOWNTOWN BOSTON IN THE FUTURE?

Forecasting is very difficult, especially about the future !

Mark Twain

Questions?