Architectural implications of Climate Engineering: Design Case Experiences

Prof. Dipl.-Ing. Matthias Schuler

Transsolar Energietechnik GmbH

Stuttgart
Munich
New York

http//:www.transsolar.com

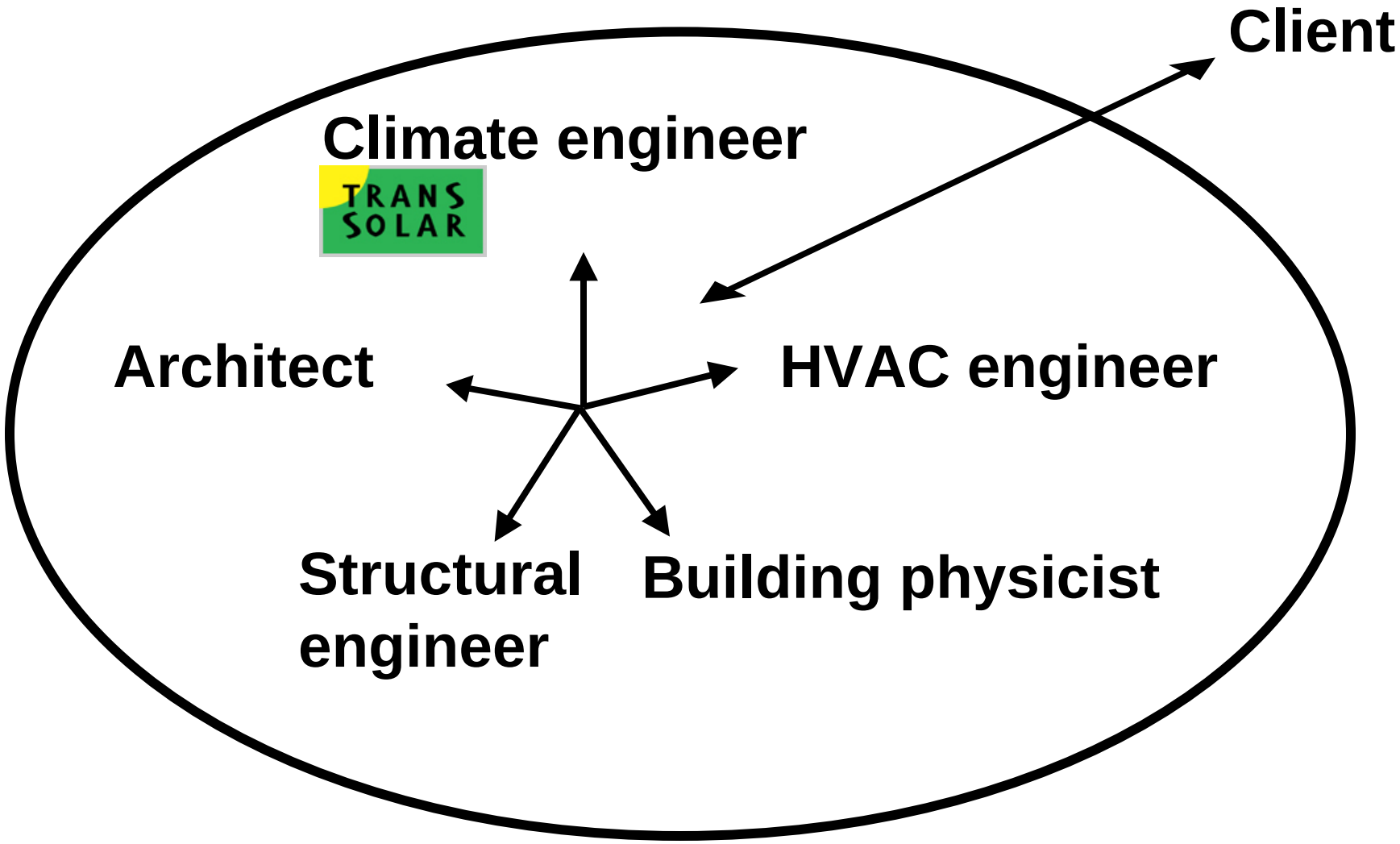
Architecture means the adaptation of the condition of a place to a given time by the willpower, desire and knowledge of certain human beings.

We never do this alone.

We always do it somewhere – certainly for some person or persons, but always also for everyone.

Louisiana Manifesto

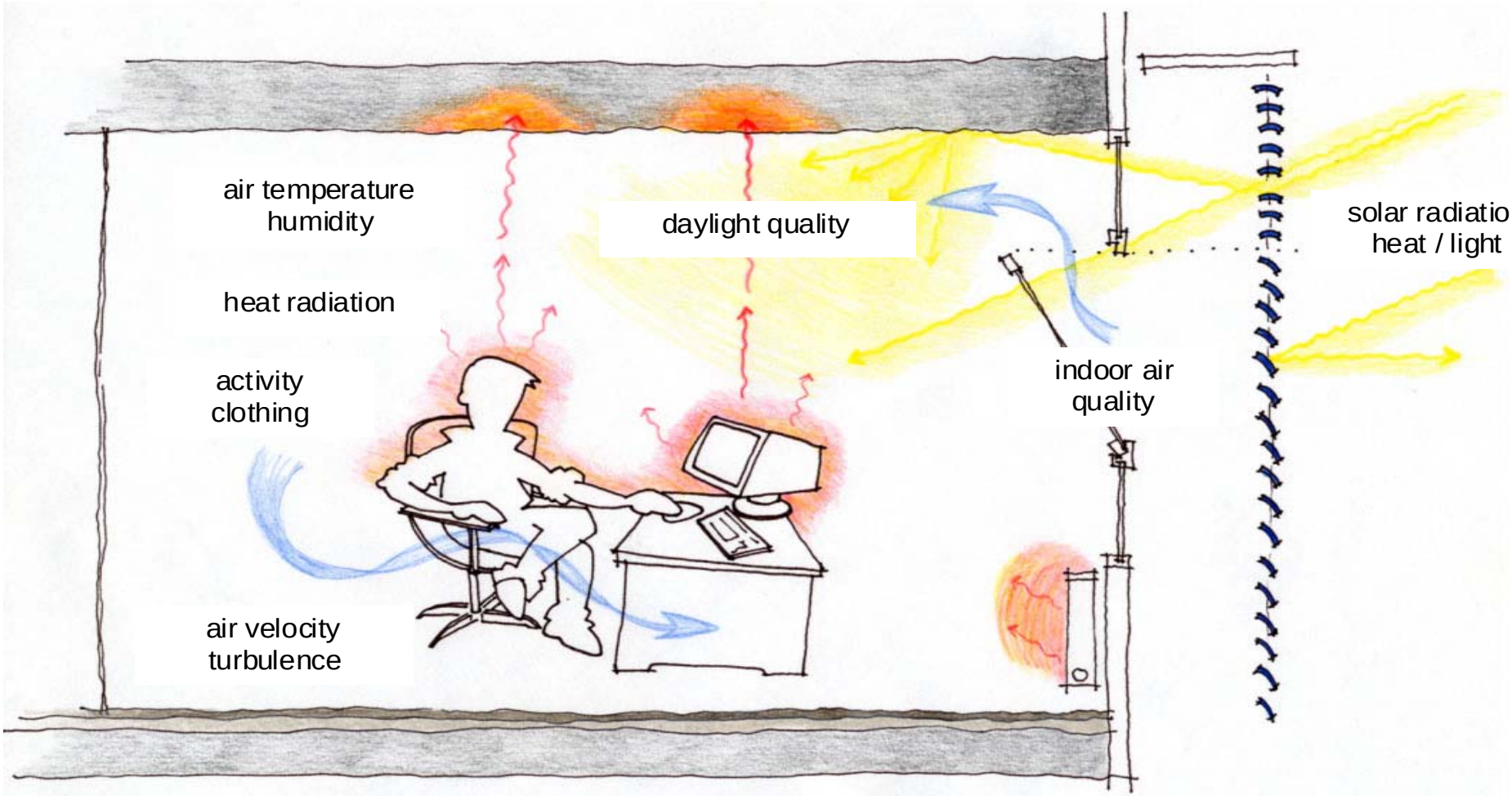
Jean Nouvel, June 2005


Client
Climate engineer
Architect
HVAC engineer
Structural engineer
Building physicist

- Analyzing the local identities of a location and site

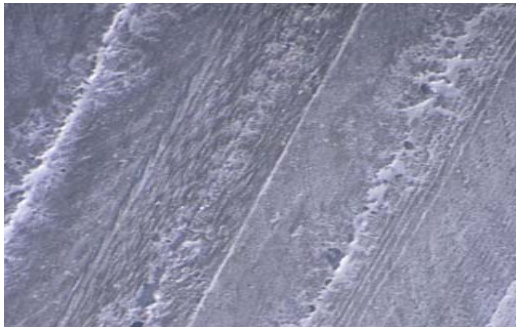
  - context
  - history
  - culture
  - program
  - users
  - neighborhood
  - flexibiliy

  - climate
  - ground
  - micro climate
  - local resources (energy, water, …)
  - materials



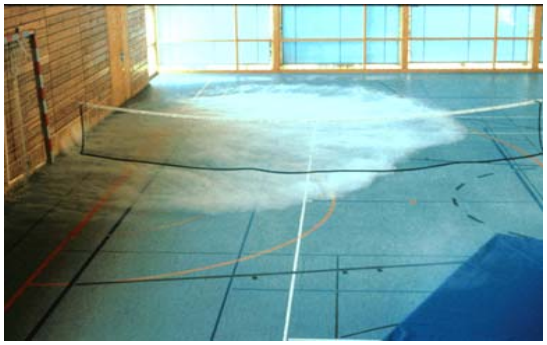
Parameters for thermal comfort

- Conduction

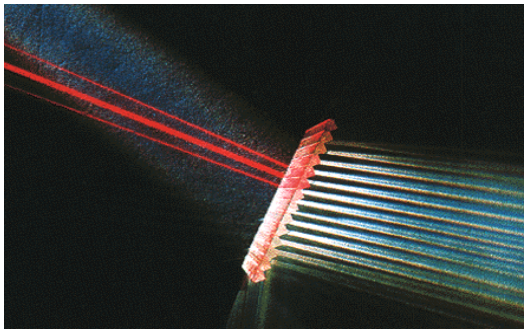


Evaporation

Convection



Transmission / Reflection



Stratification

Heat radiation

Design Team:

Architect:

Sanaa / Heinrich Böll

Structural engineer:

Bollinger + Grohmann

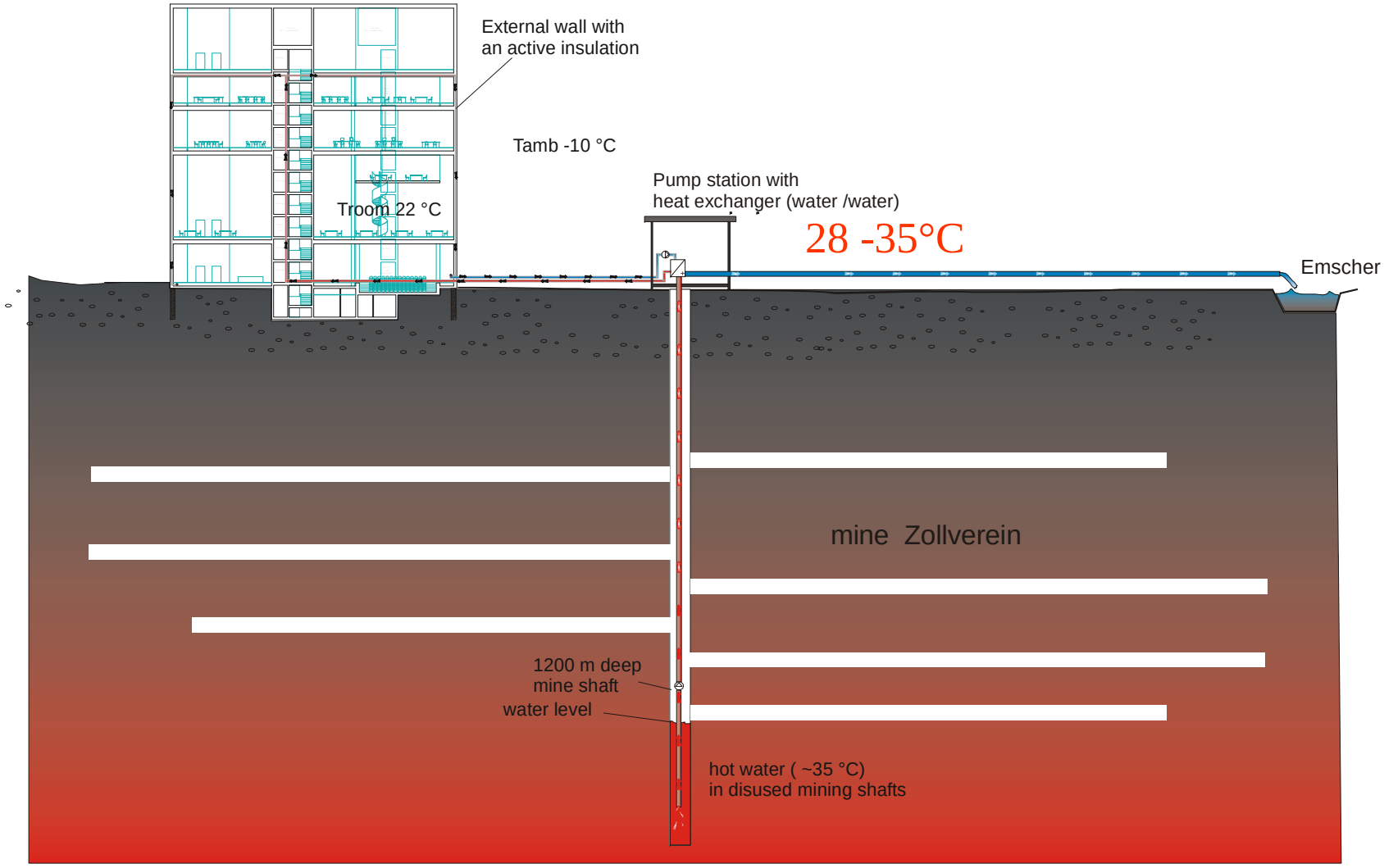
Technique coordination: Transplan

Climate engineer: Transsolar

MEP consultant: Winter Ingenieure

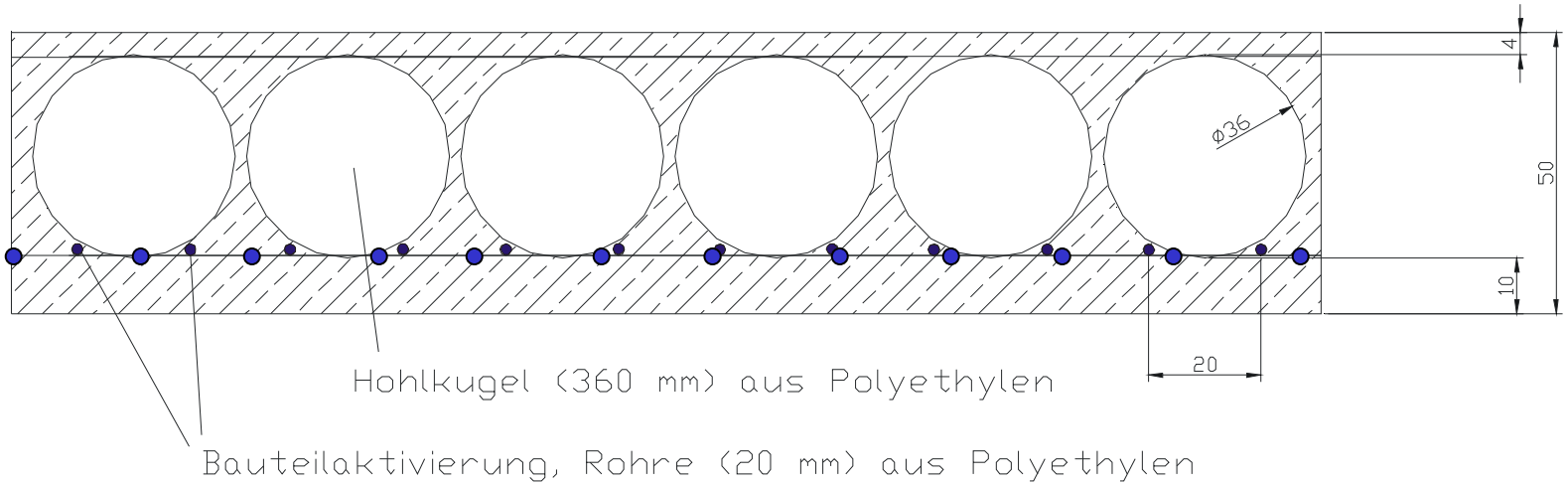
Building physics: Horstmann Berger

Zeche Zollverein - industrial heritage with new program

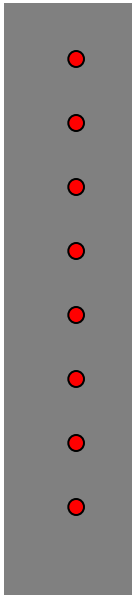


Mining water 600 - 1200 m³/h

Deckenaufbau
BubbelDeck mit Bauteilaktivierung
Projekt: Essen, Design School

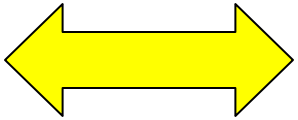


Monolytic concrete wall

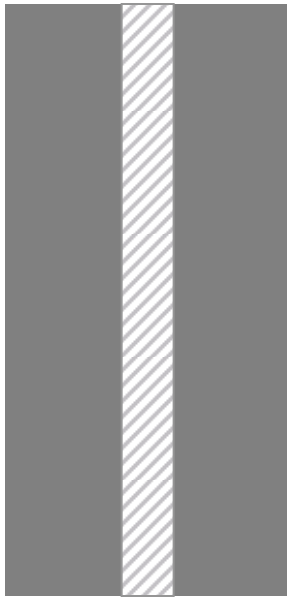


300

- **Active Insulation**



- **Double shell wall**



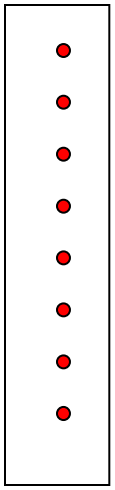
100

250 250

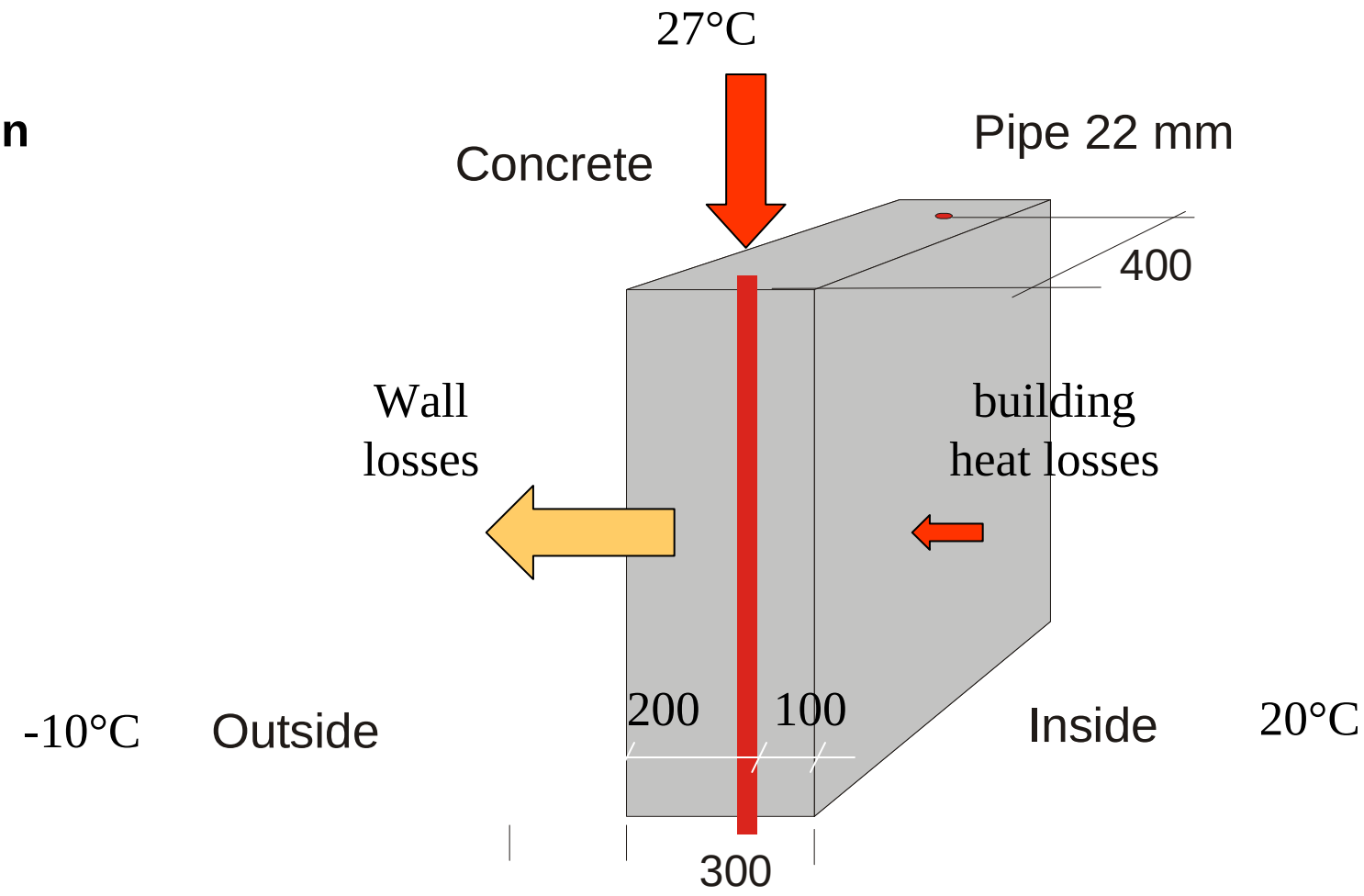
600

Double shell concrete wall with minimal insulation

	UK Average % of total CO2 emissions	UK Average in ton CO2/capital
Space heating in the home	3%	0.38
Hot water	4%	0.50
Appliances in the home	3%	0.38
Personal transport	18%	2.25
Embodied energy in home infrastructure	3%	0.38
Waste and consumer items	13%	1.63
Food	24%	3.00
Shared services (total energy for running schools, hospitals, financial services, etc)	12%	1.50
Shared infrastructure (energy for constructing schools, hospitals, roads, airports, etc)	20%	2.50
total	100%	12.5

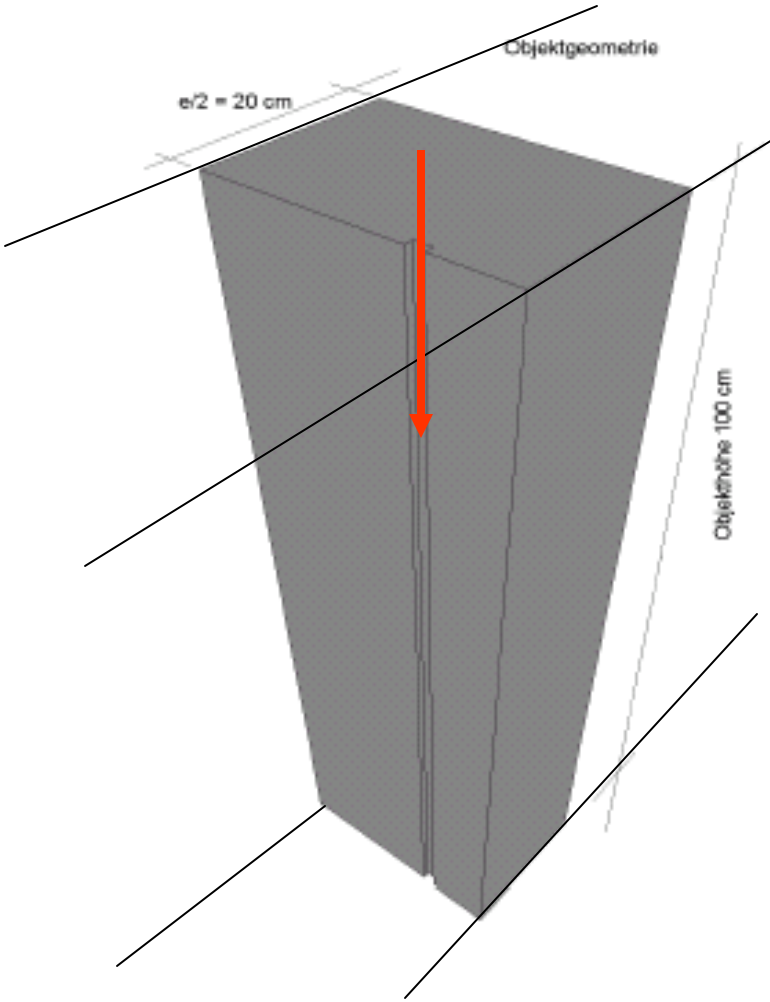


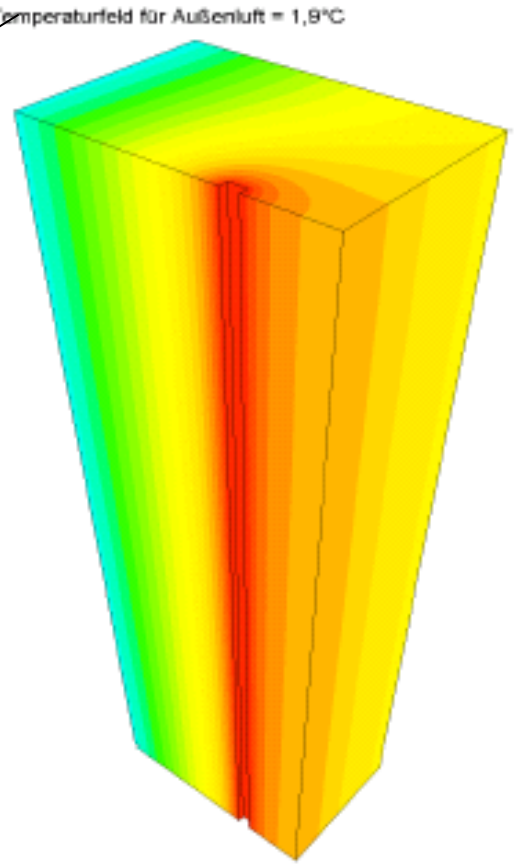
- **Active Insulation**



Wärmedurchgangskoeffizient ungedämmte Betonwand (d = 30 cm) i.V.m. Wandheizung

Abstand Heizleitungen e/2 = 20 cm; Leitungstemperatur 25°C; Leitungsquerschnittπ cm²;
Raumlufttemperatur 20°C; Wärmeübergangswiderstand innen R_{si} = 0,13 m²K/W;
Wärmeübergangswiderstand außen R_{se} = 0,04 m²K/W;

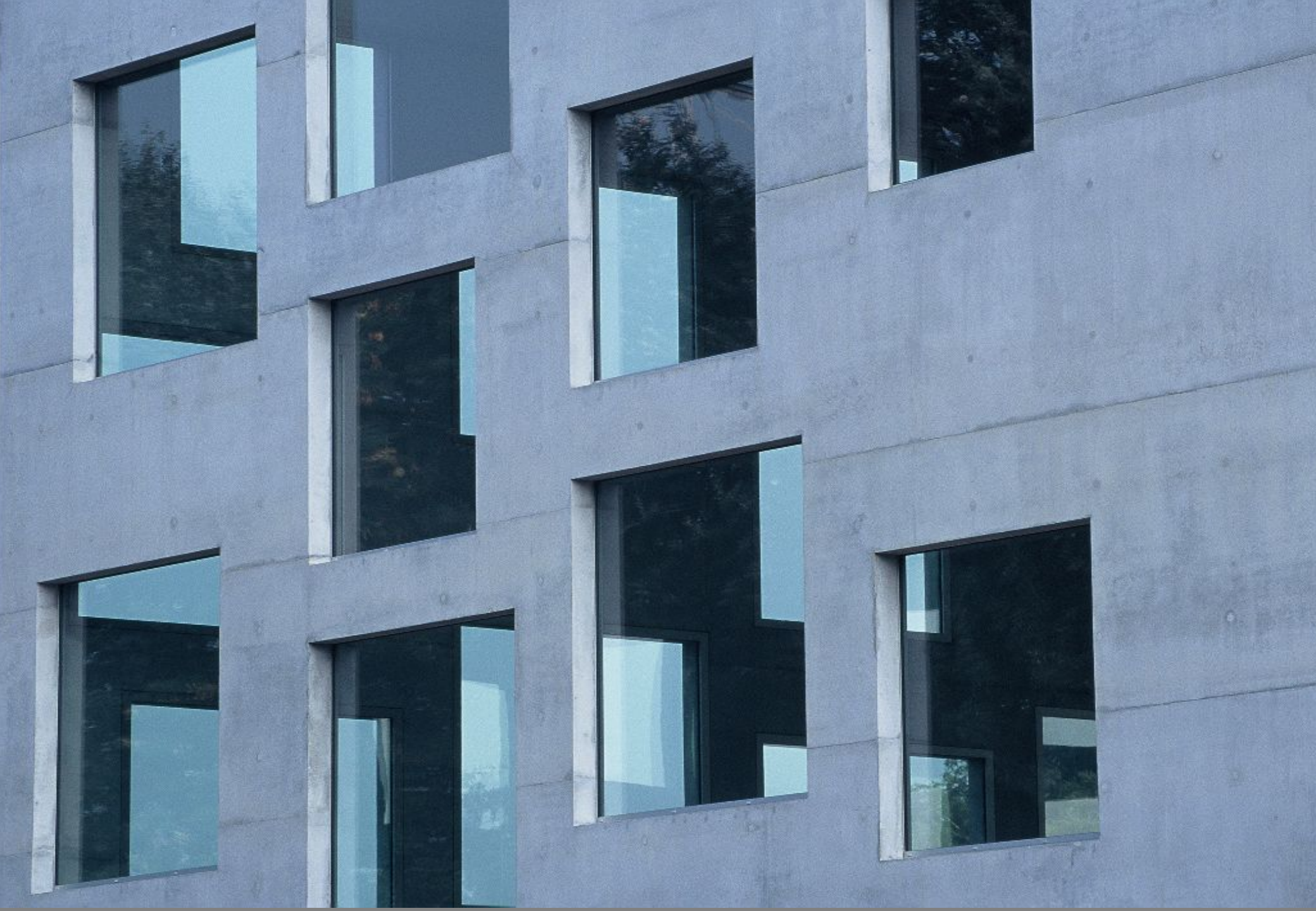


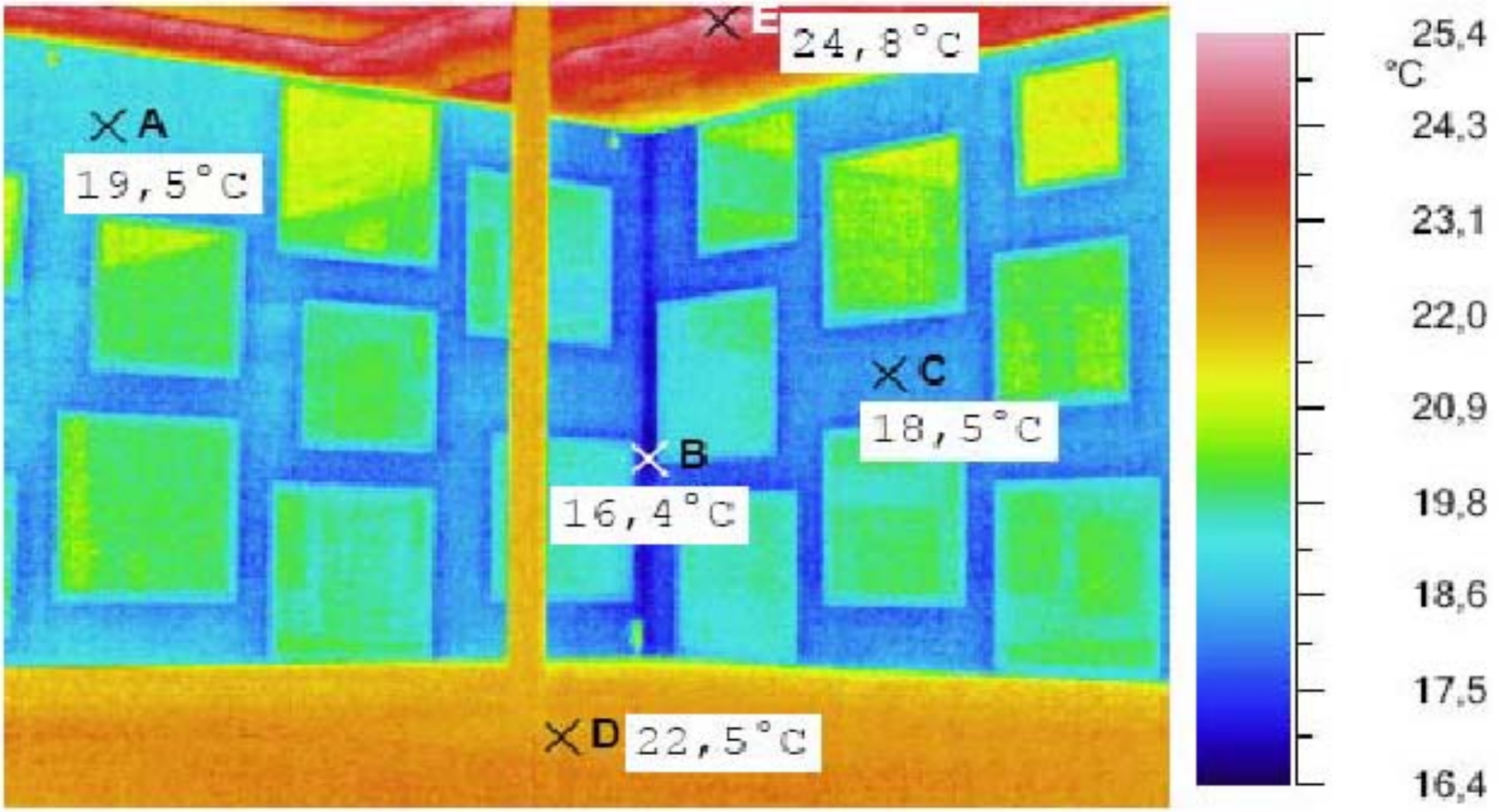


Piping around the windows

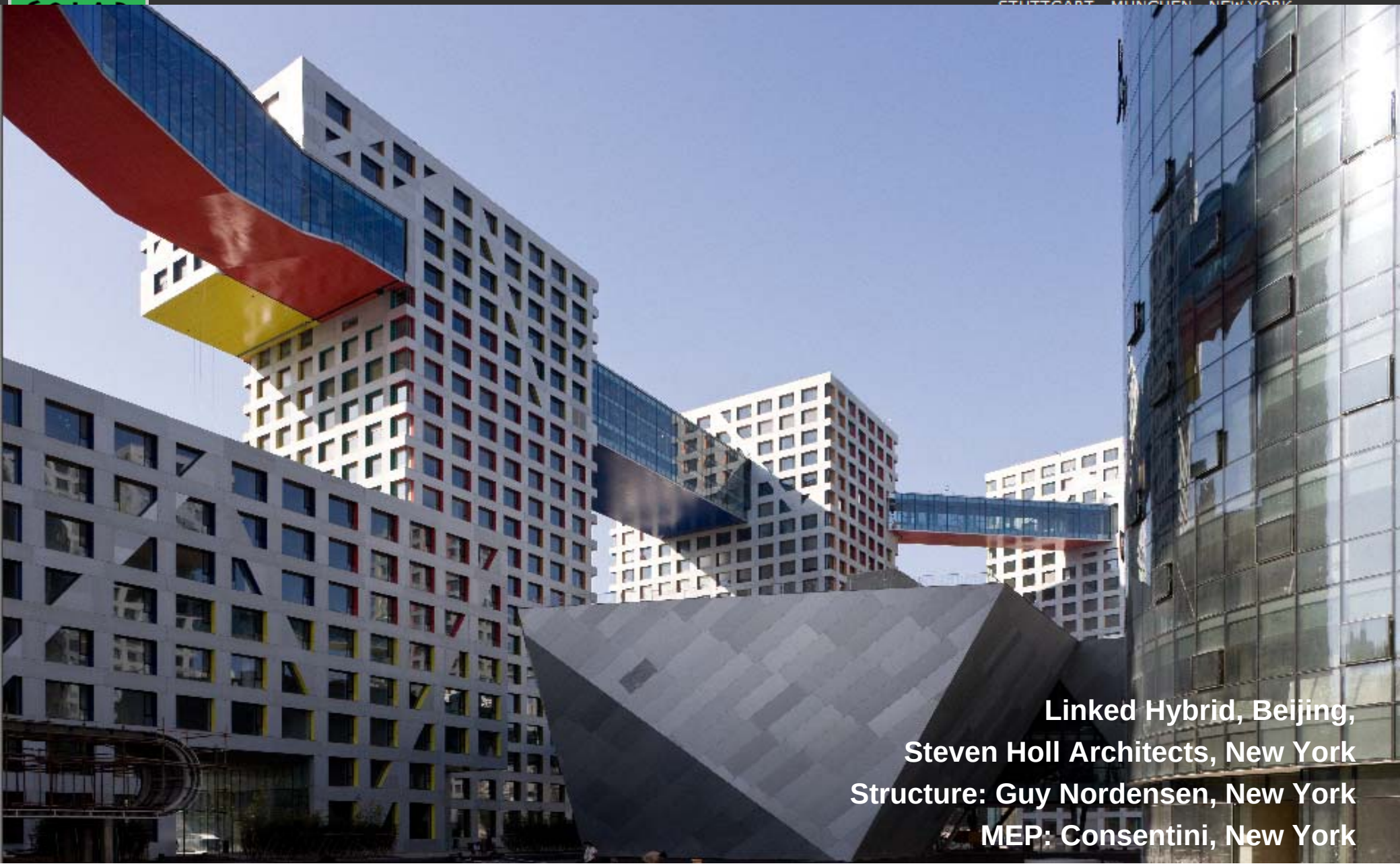
Active insulation under construction

Cavity slab to reduce the dead weight by 35%





Concept check by IR photographie, T-amb=11°C, T-room=20°C



Linked Hybrid, Beijing,
Steven Holl Architects, New York
Structure: Guy Nordensen, New York
MEP: Consentini, New York

Linked Hybrid, Beijing

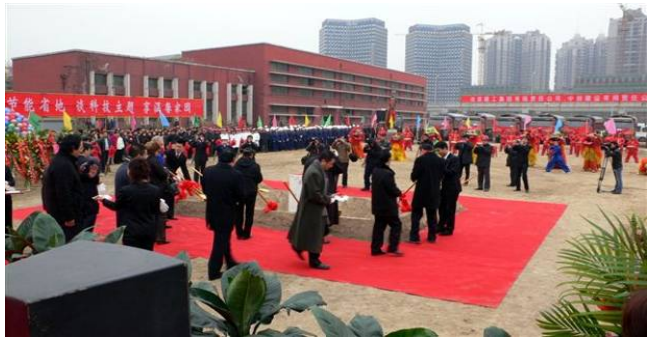
Linked Hybrid / Moma 3, Beijing

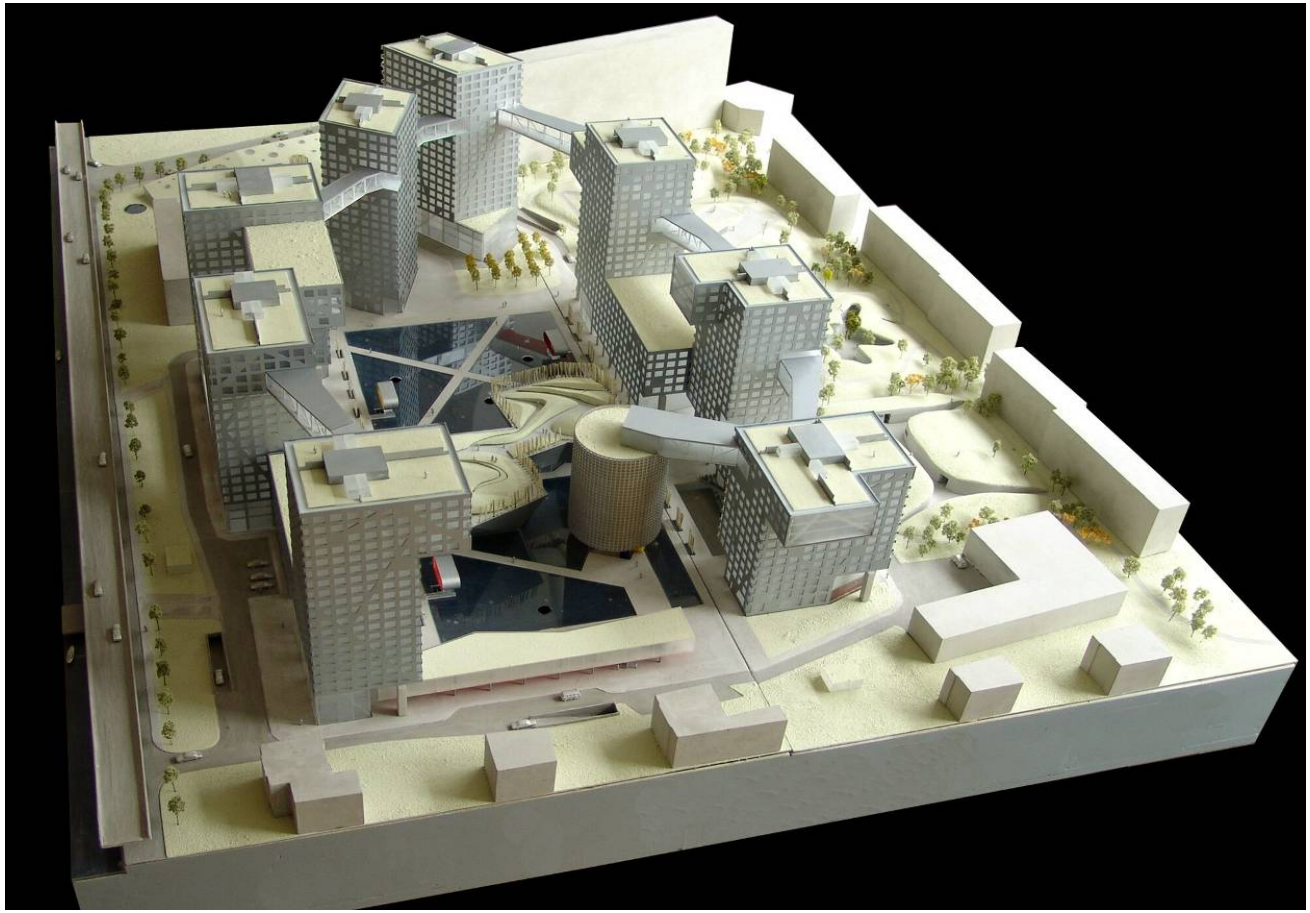
Linked Hybrid Complex, Beijing

8 linked Apartment Towers
+ Cinema, Hotel, Kindergarden, Galleries, Shops, Gym + Cafe

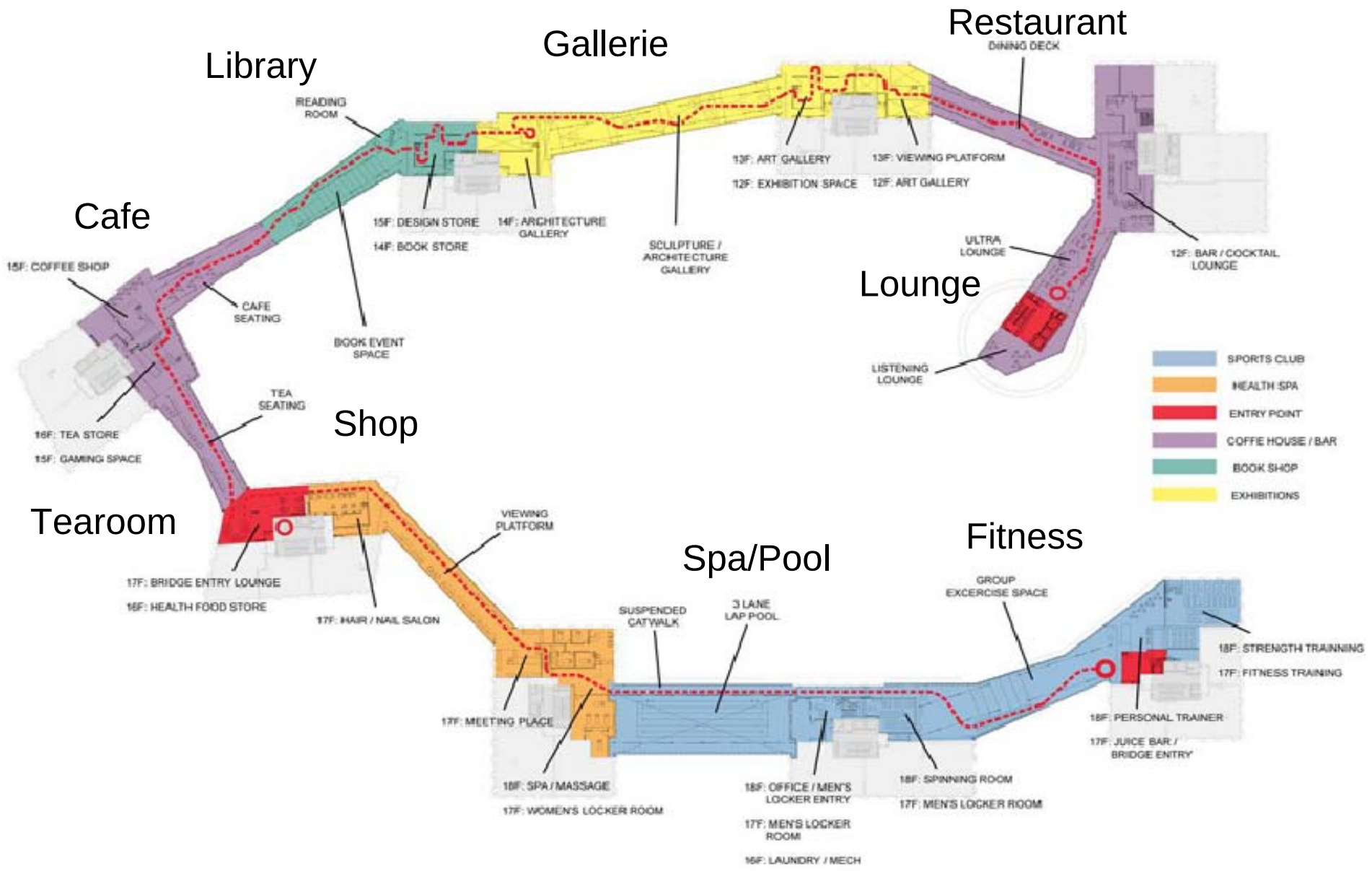
Total area: 160 000 m²
+ 50 000 m² parking

Construction Schedule:
Start: 2005
Finished: 2008





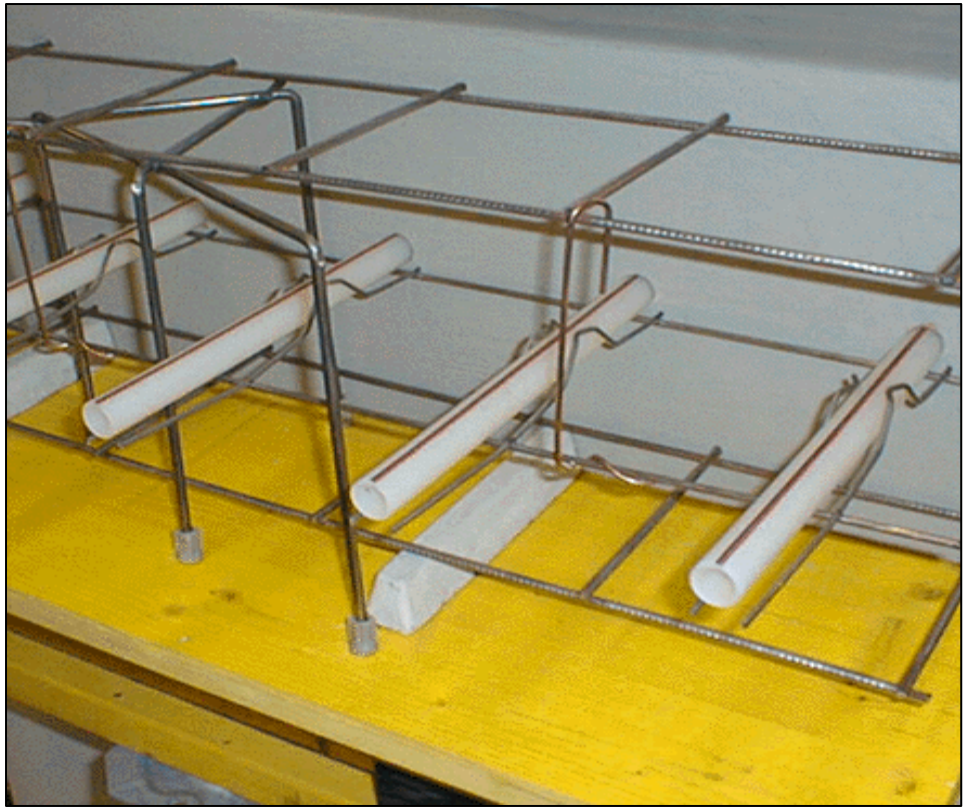
Linked Hybrid, Beijing, Site plan

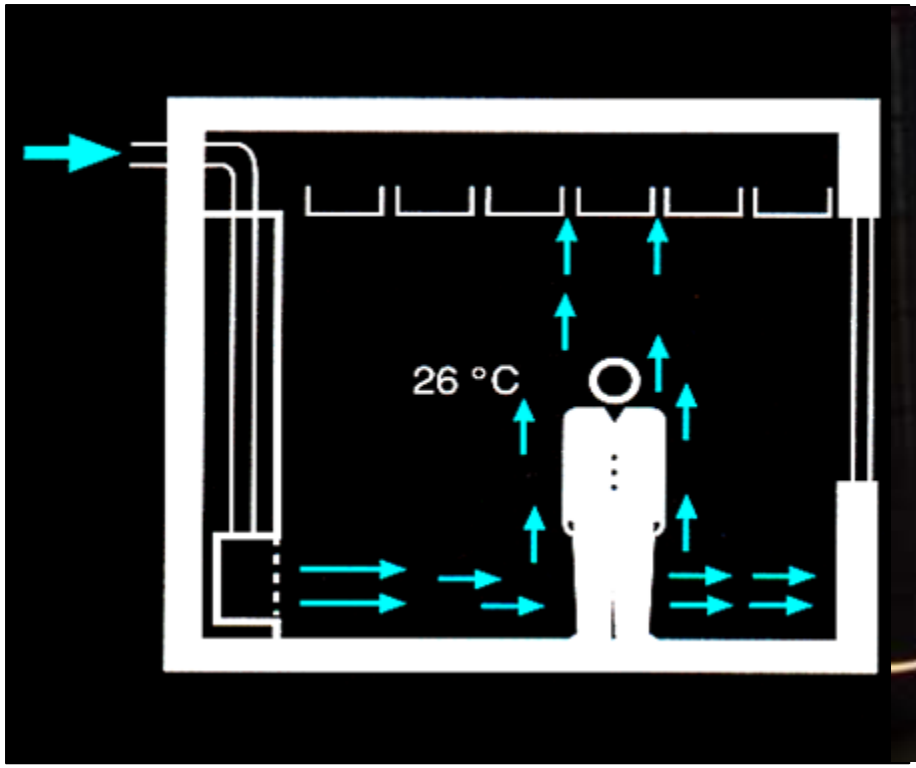


Linked Hybrid elevated bridge program

Radiant Cooling / Heating

Slab integrated radiant heating / cooling system

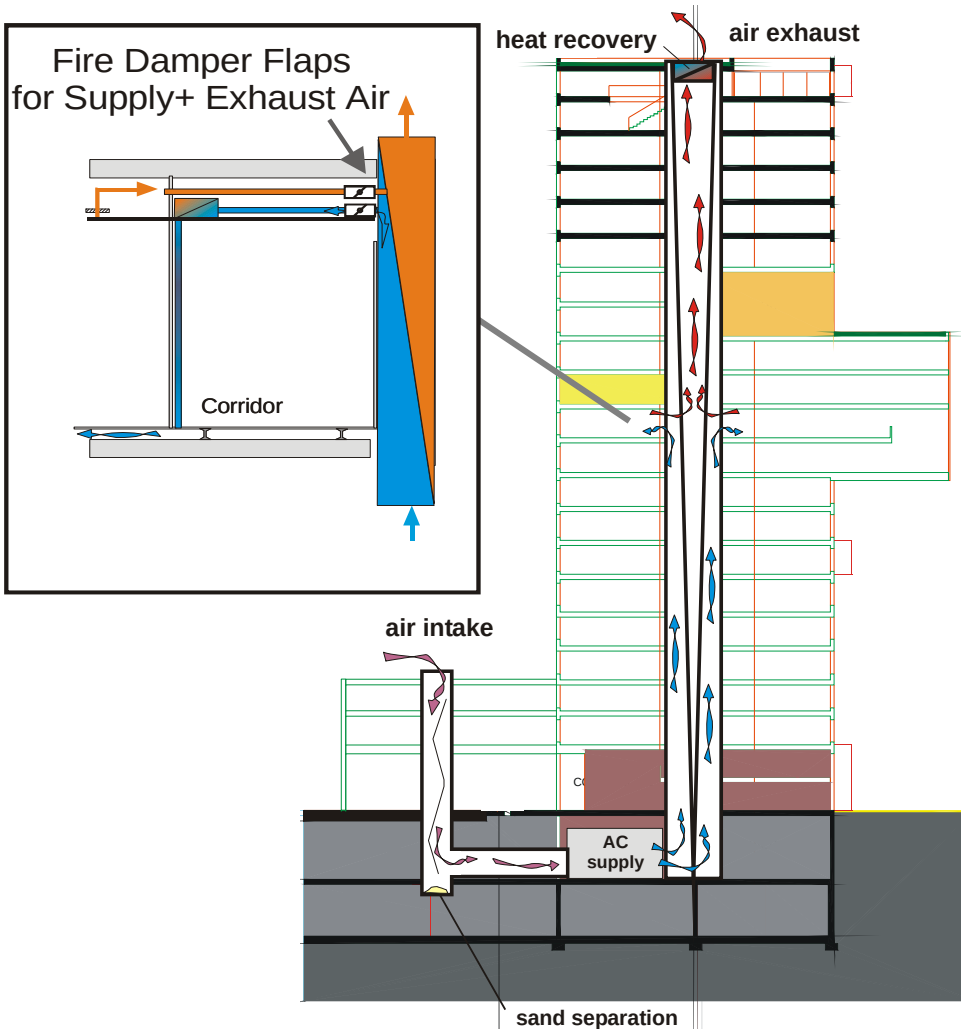




Displacement Ventilation

Δt_{supply} = 1 - 2 K

- low turbulence
- low mixing
- low cooling effect



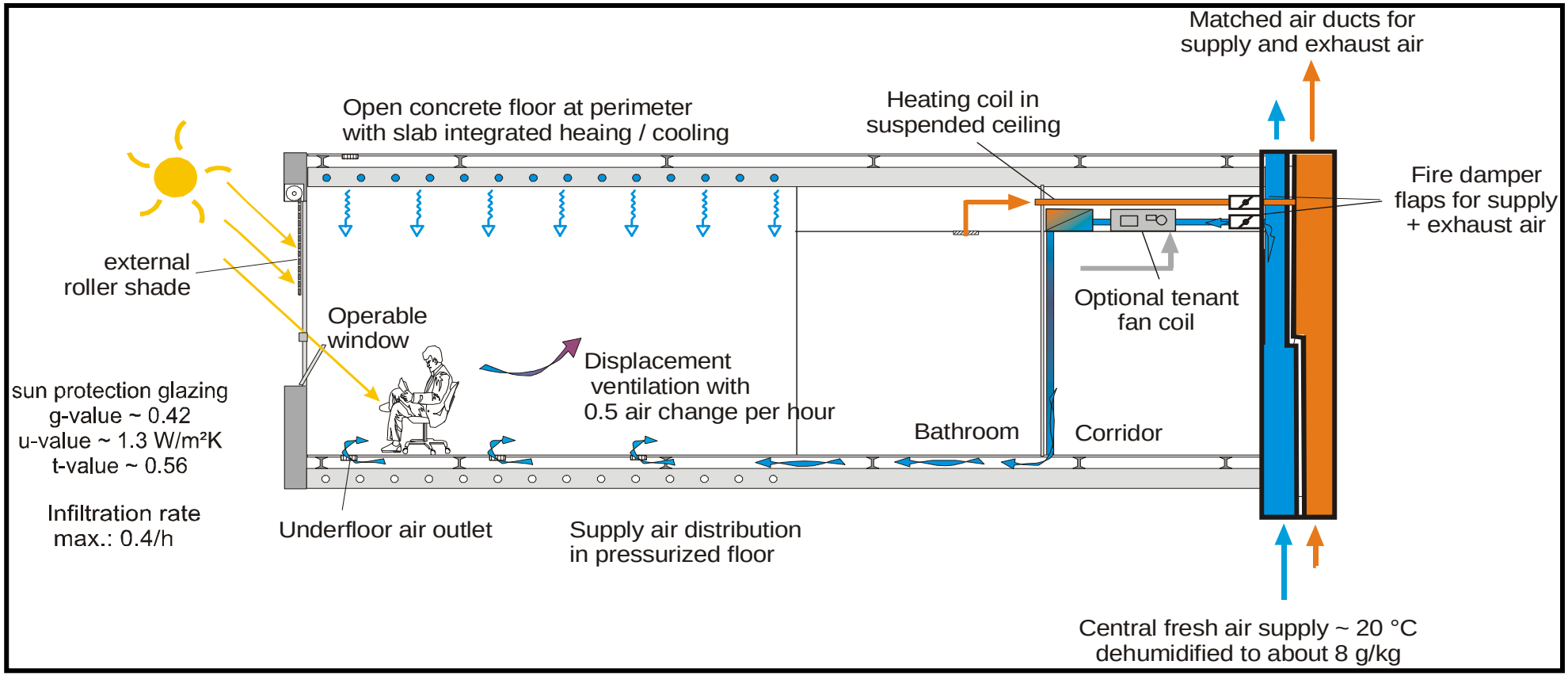
Ventilation Concept

Integrated shaft concept for supply and exhaust air

Feeding the supply air from the bottom and releasing the exhaust air at the top is minimizing total shaft area by an integrated supply and exhaust shaft concept

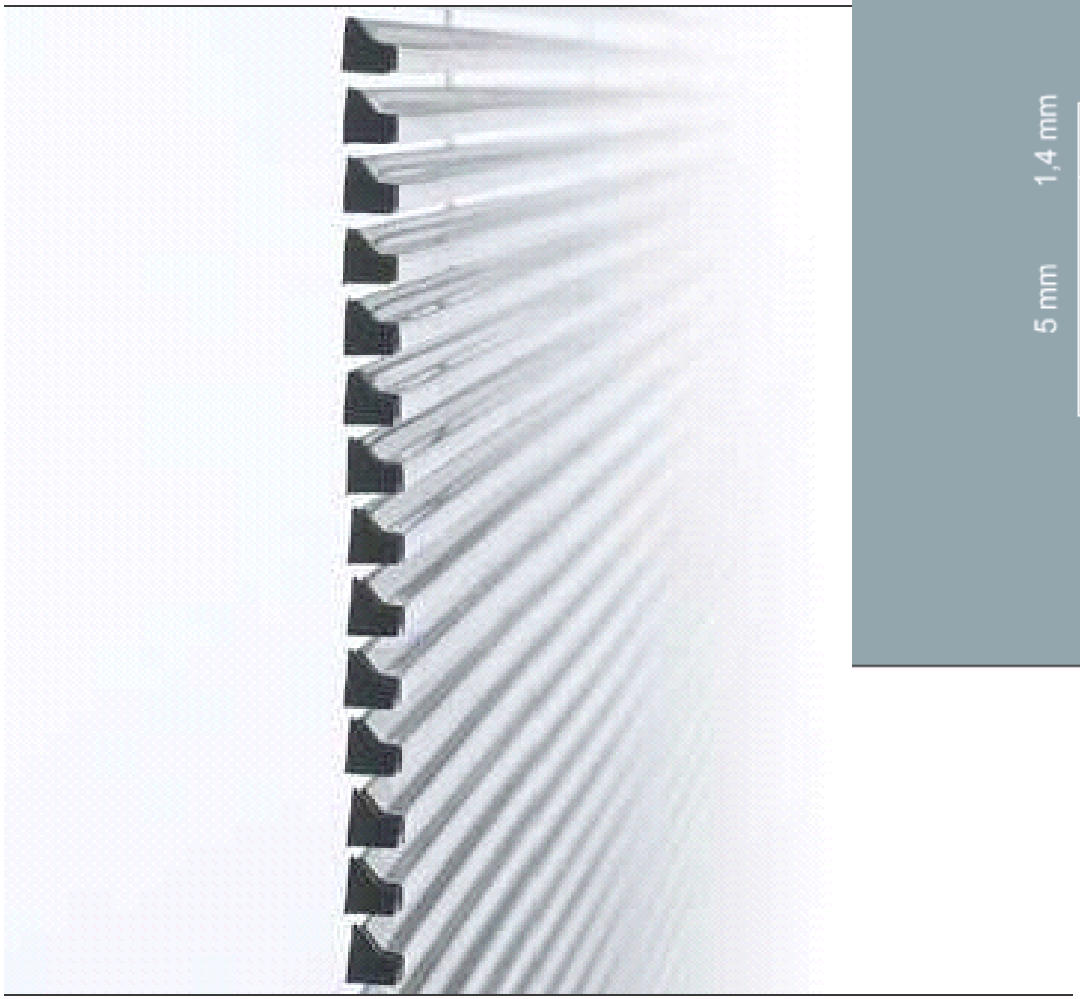
Fire damper flaps or supply and exhaust air are separating floor levels and apartments from each other

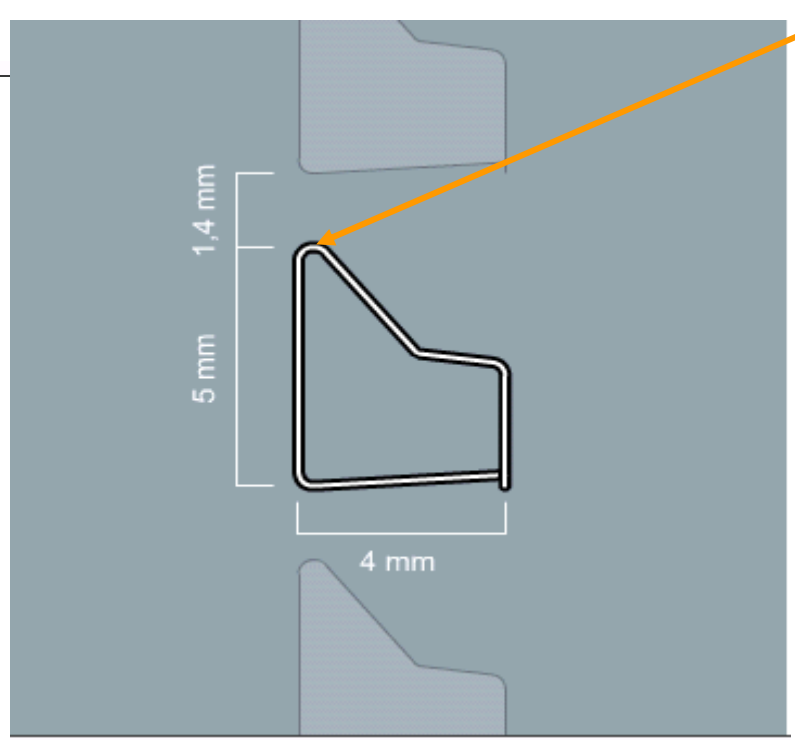
Climate and Energy Concept Apartments



Efficient External Shading but ?? Design, ?? visual connection

External Roller Shutter System
manually operated for
shading,
privacy,
and safety

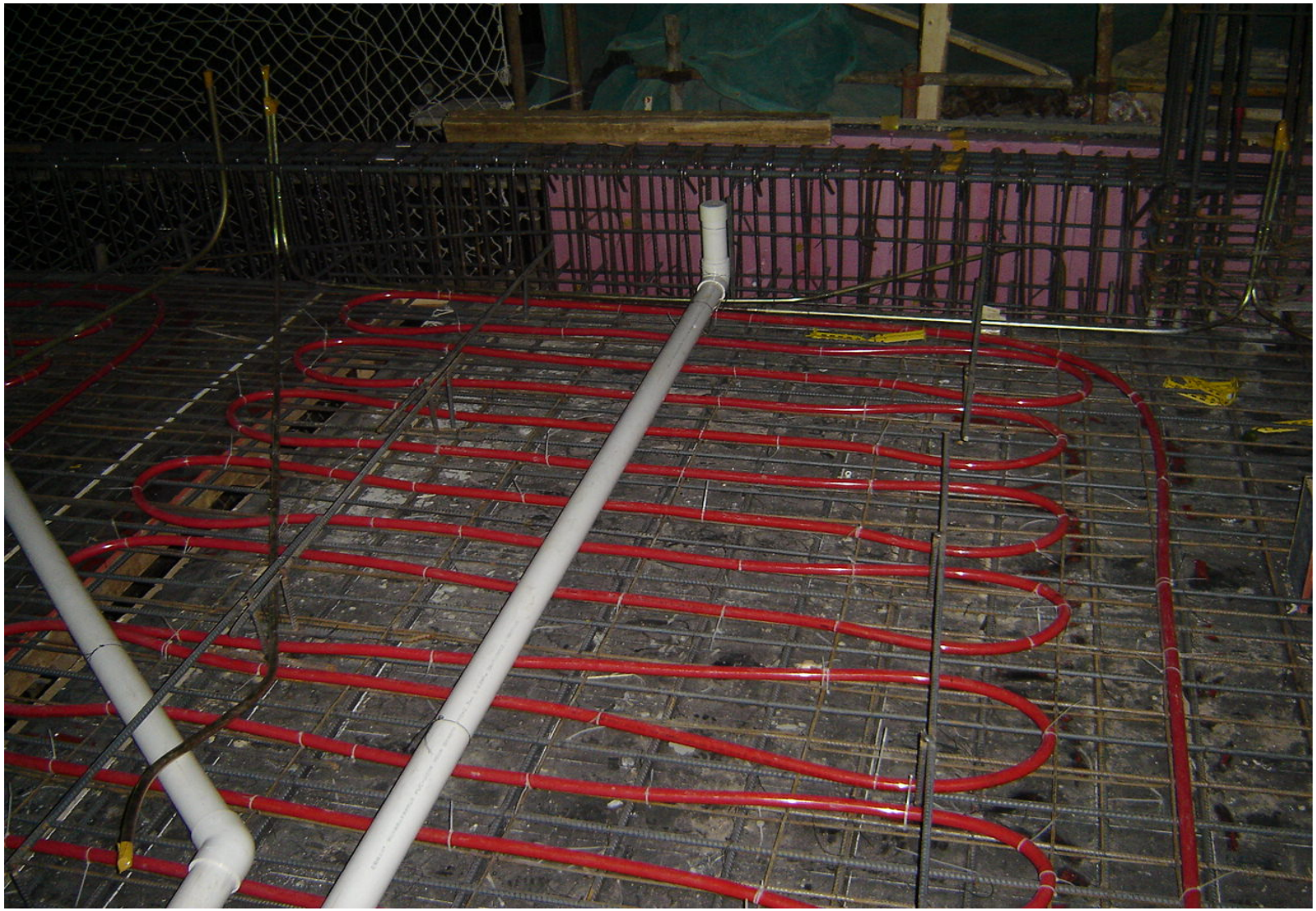




s_enn - Roller shade with geometrical selectivity

Linked Hybrid, Beijing, Mock-Up Apartment

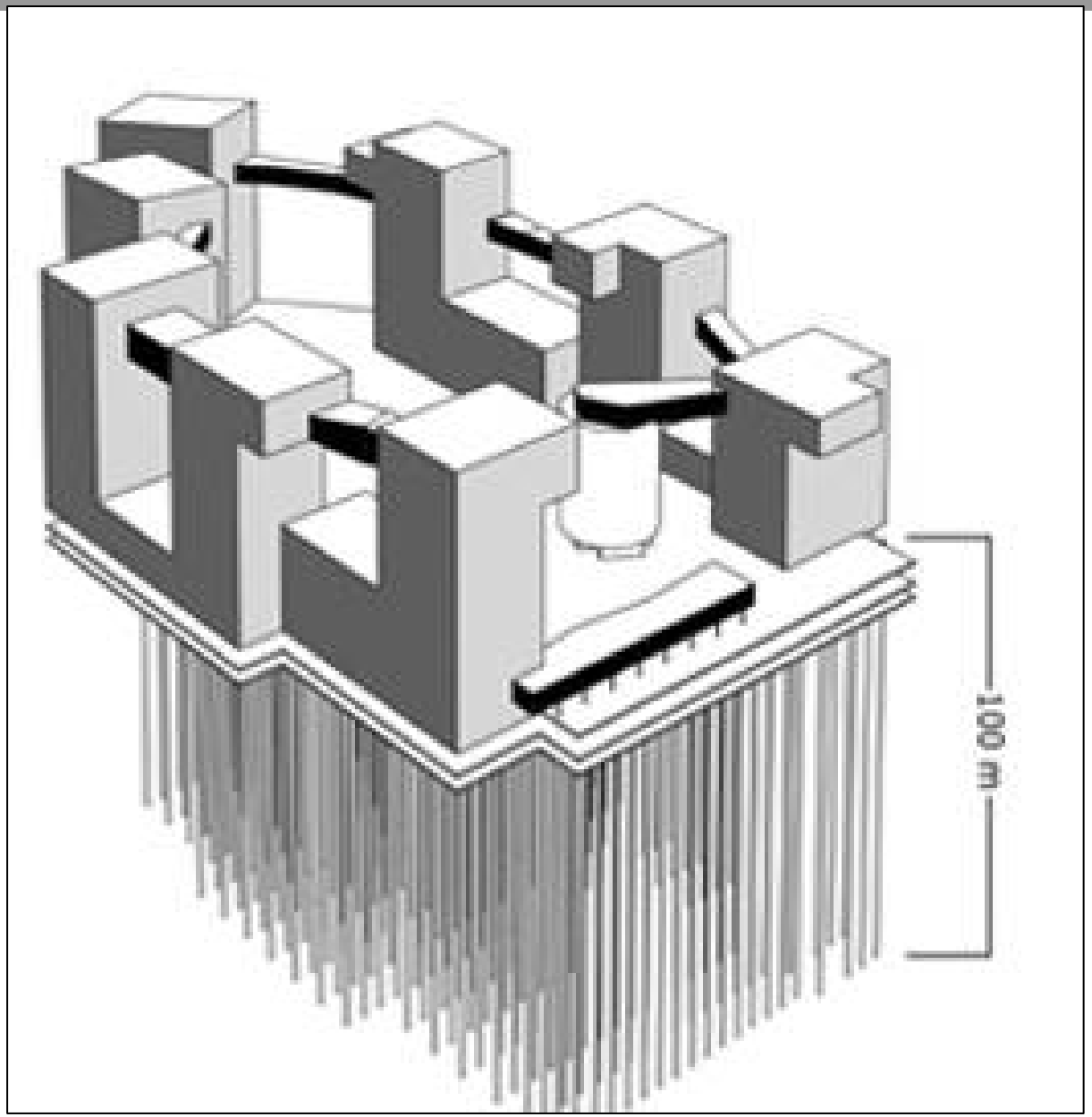
Linked Hybrid / Moma Apartment mock-up

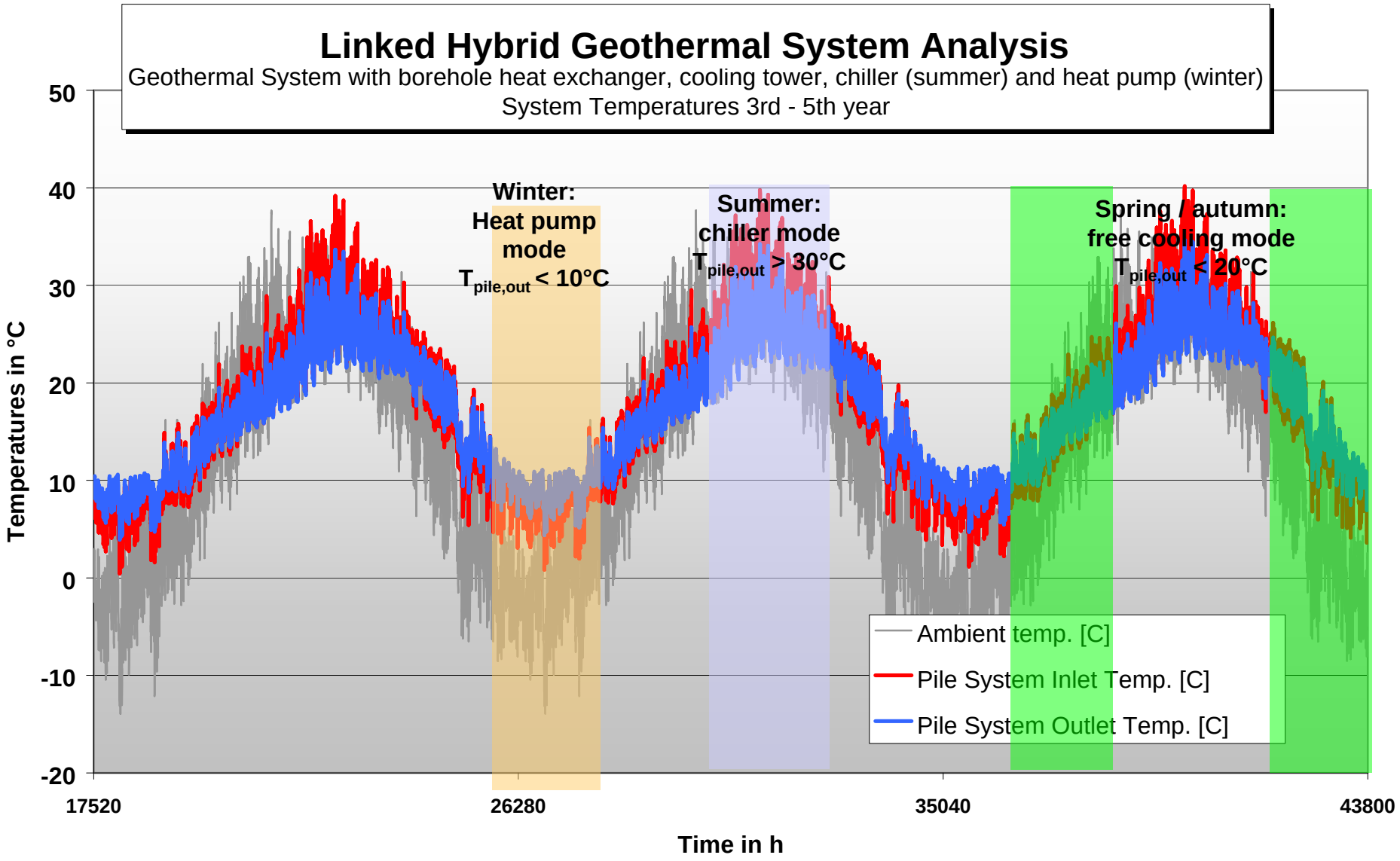


Slab integrated heating/cooling pipes and ventilation ducts

Geothermal System
600 2 -U-pipe Borehole HX
with 100 m depth

5 MW total heating power
2 MW total free cooling power




Linked Hybrid Geothermal System Analysis
Geothermal System with borehole heat exchanger, cooling tower, chiller (summer) and heat pump (winter)
System Temperatures 3rd - 5th year
Winter:
Heat pump mode
T pile,out < 10°C
Summer:
chiller mode
T pile,out > 30°C
Spring / autumn:
free cooling mode
T pile,out < 20°C
Ambient temp. [C]
Pile System Inlet Temp. [C]
Pile System Outlet Temp. [C]
Temperatures in °C
50
40
30
20
10
0
-10
-20
17520
26280
35040
43800
Time in h

Estimation of pool water balance / purification plant load

Average daily pool water balance:	
Extracted pool water:	- 278 m³/d
Average rain water:	+ 13 m³/d
Average evaporation:	- 23 m³/d
Purified exchange water:	+ 240 m³/d
Net fresh water need:	**+ 28 m³/d**

Average water load for purification plant	
Gray water from apartments:	+ 320 m³/d
Extracted pool water:	+ 278 m³/d
Total purification water load:	+ 598 m³/d
Plant purification rate:	86%
Total purified water gain:	**+ 514 m³/d**


DAEWOO

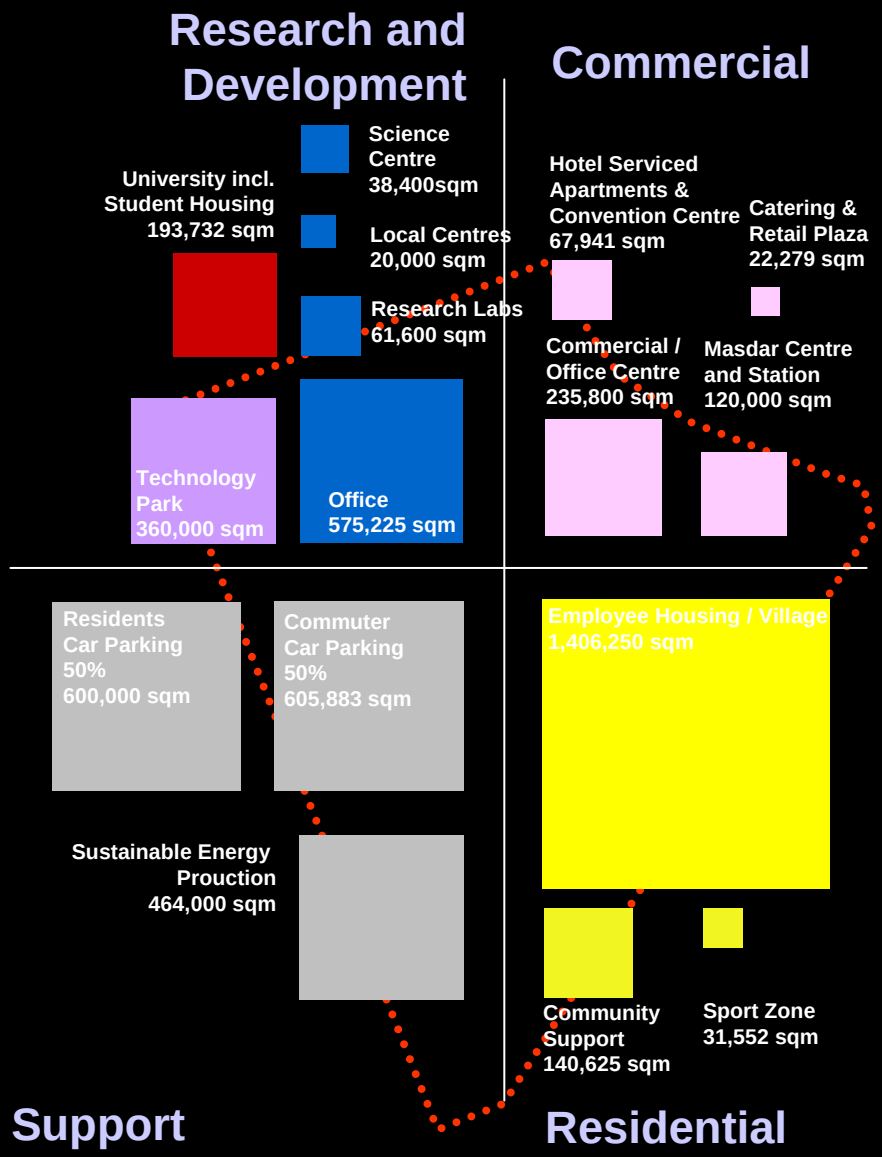
Matthias Schuler

Towards a sustainable city
with zero CO2 footprint and a future vision

Masterplan for Masdar City, Abu Dhabi

in collaboration with

Foster & Partners Architects, London
Traffic, Systematica, Milano
Infrastructure, water, waste, WSP, London
Energy concept, Transsolar, Stuttgart
MEP, Flack & Kurtz, Paris
Solar systems, ETA, Florence



University

Special Economy

Hotel

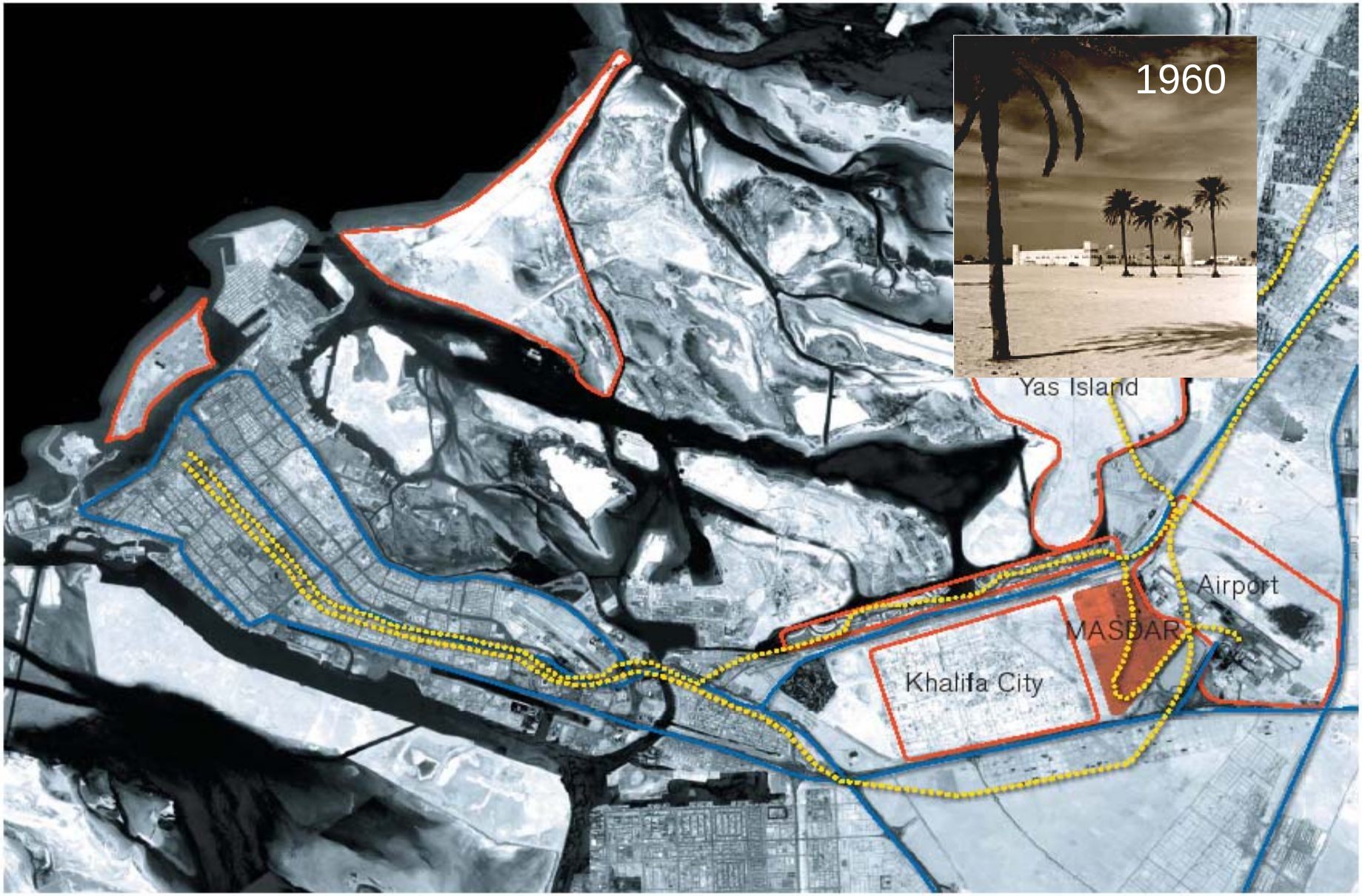
Retail

Community

Sport and Leisure

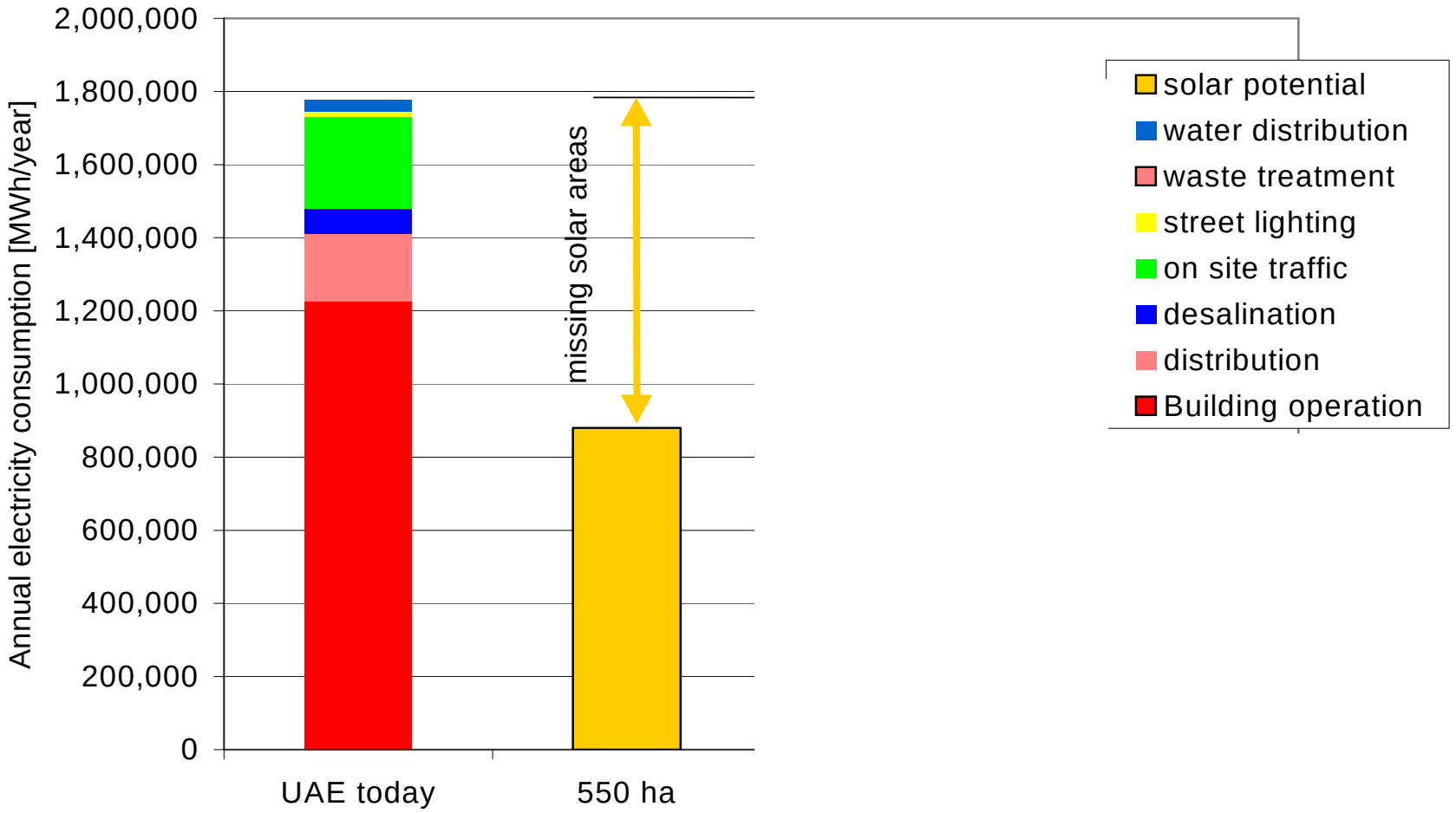
Car Parking

Energy Production

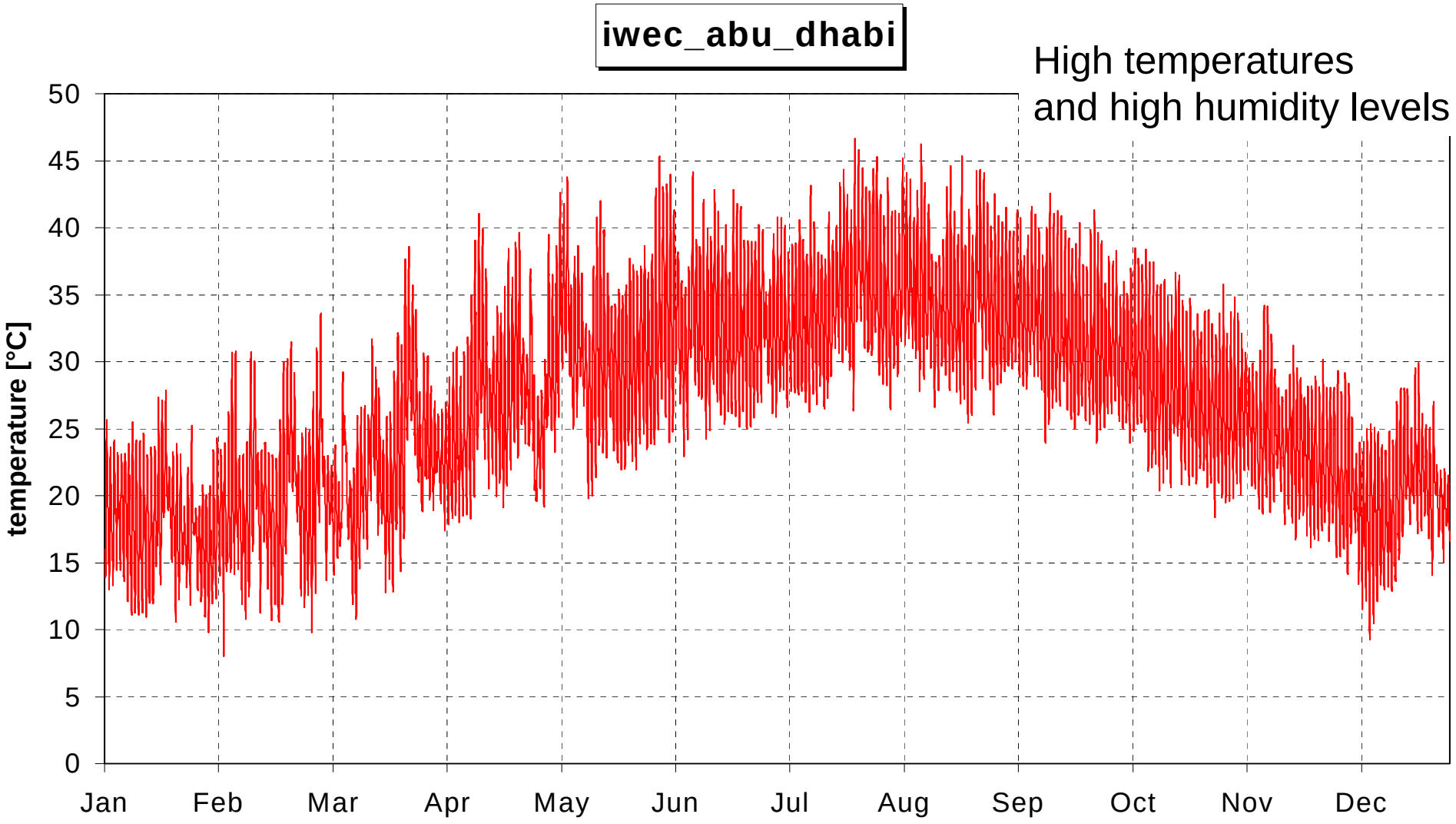


Abu Dhabi - from desert to a city in 40 years

Energy consumption for project site and 3.8 Mio m² buildings
for UAE today standard towards Masdar guidelines

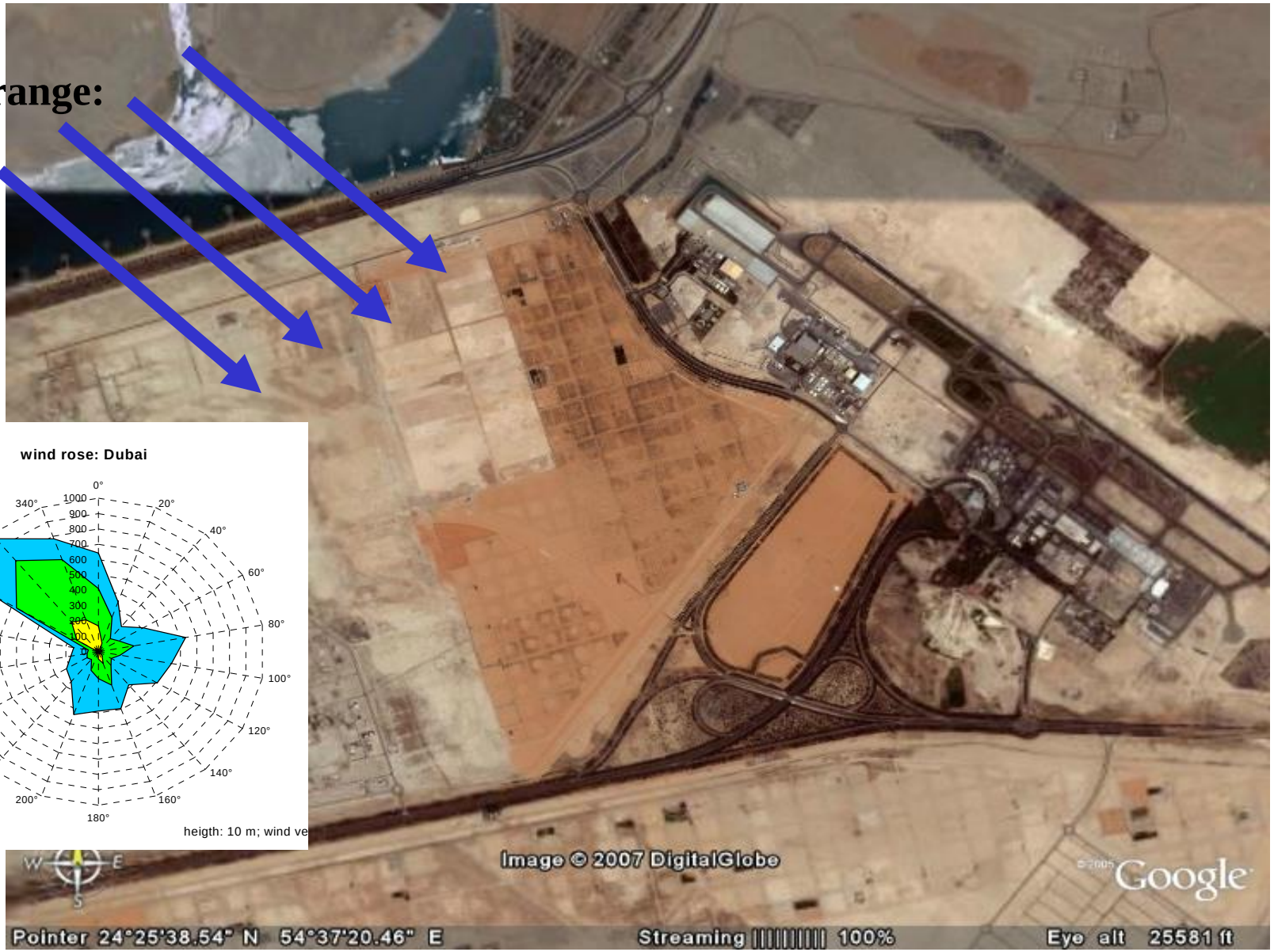


- A sustainable approach cannot be solved only by technical concepts, but demands a rethinking of the way of living.
- We have to learn from local natural adaptations, which minimizes energy and material consumption.
- This means a change in our daily behavior in respect of mobility, comfort expectations, water, energy and material consumption and waste production.
- All energy consumption must come from renewable sources and materials have to flow in a cycle.
- Due to the limited capacities of renewable energies, like sun, wind and geothermal, in the first essential step is to minimizing the demands and consumption.
- Urban density is one of the major approaches for a sustainable living.



Annual hourly outdoor temperature profile

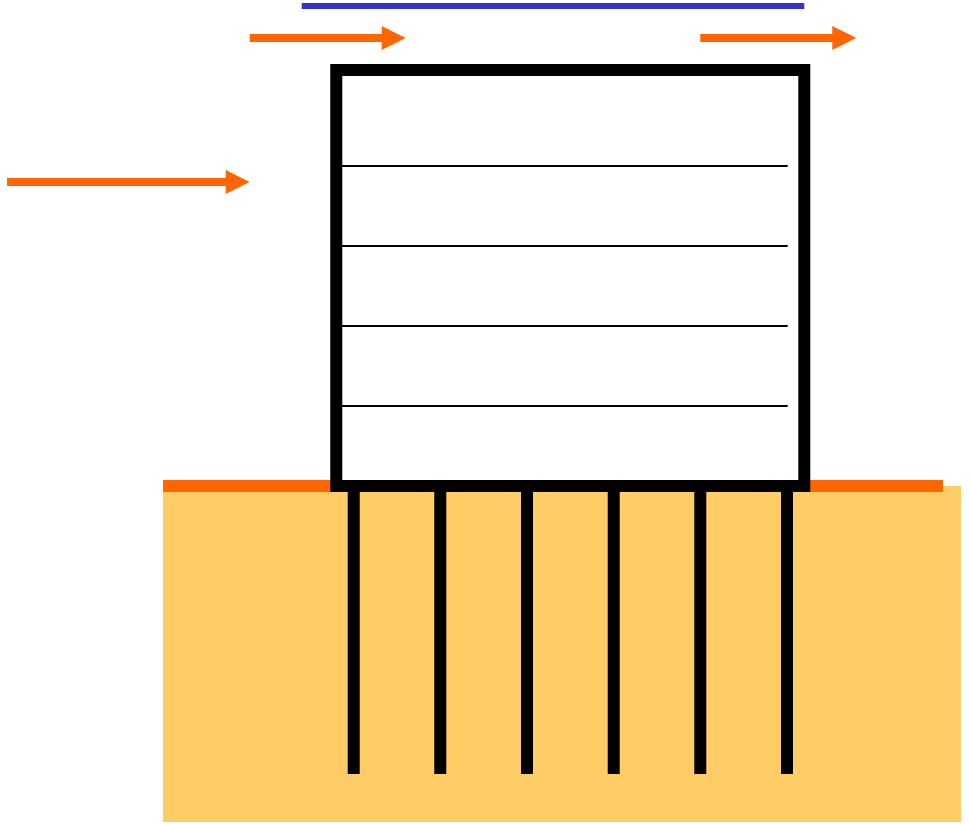
Sea water temperature range: 15 - 34°C

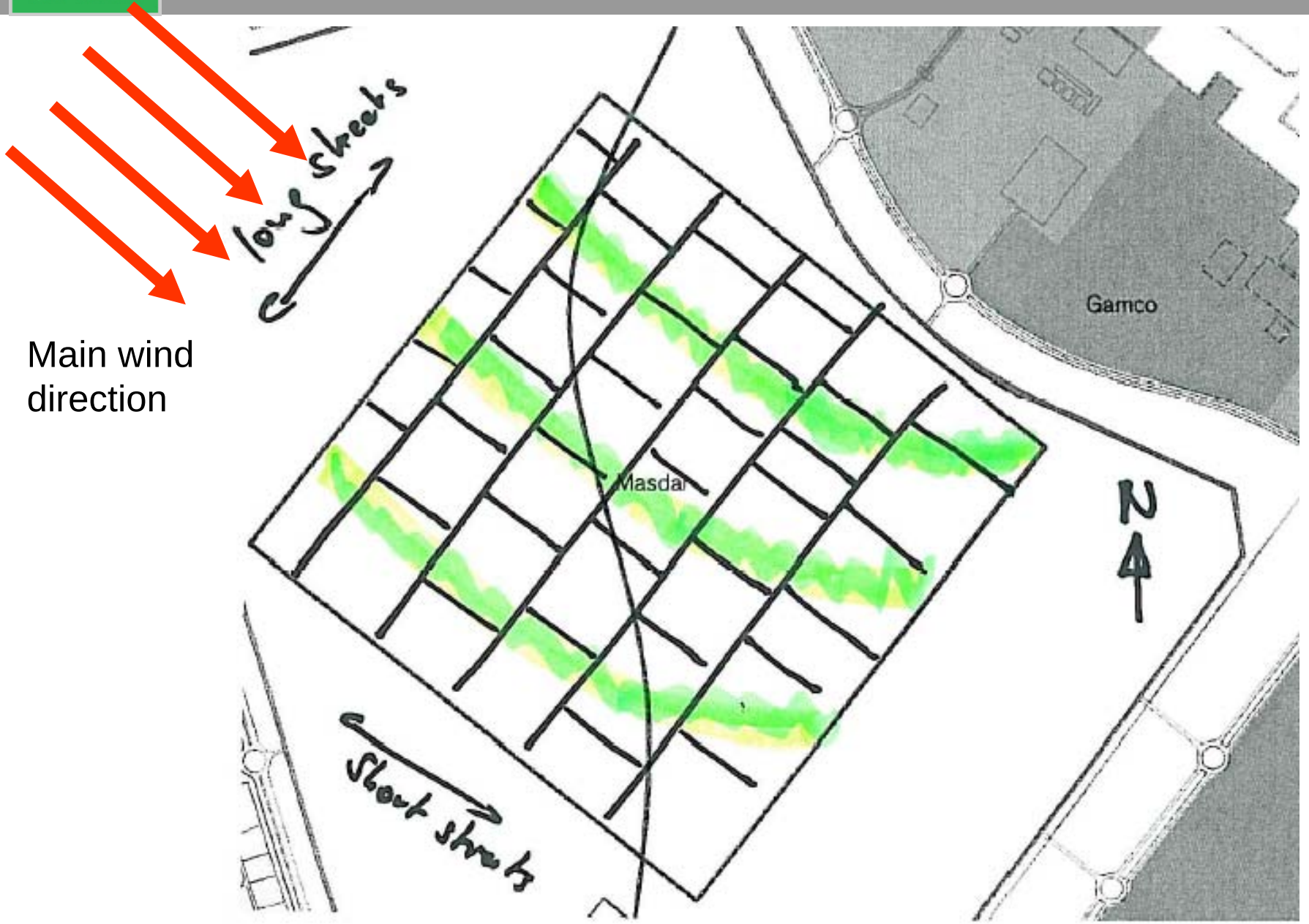


Black beetles:
drinking the dew in the morning, collected on his back

Dorkas gazelle:
Survive for months without drinking,
water collection through wet grass feeding in the morning,
kidneys work with minimal water consumption for decontamination

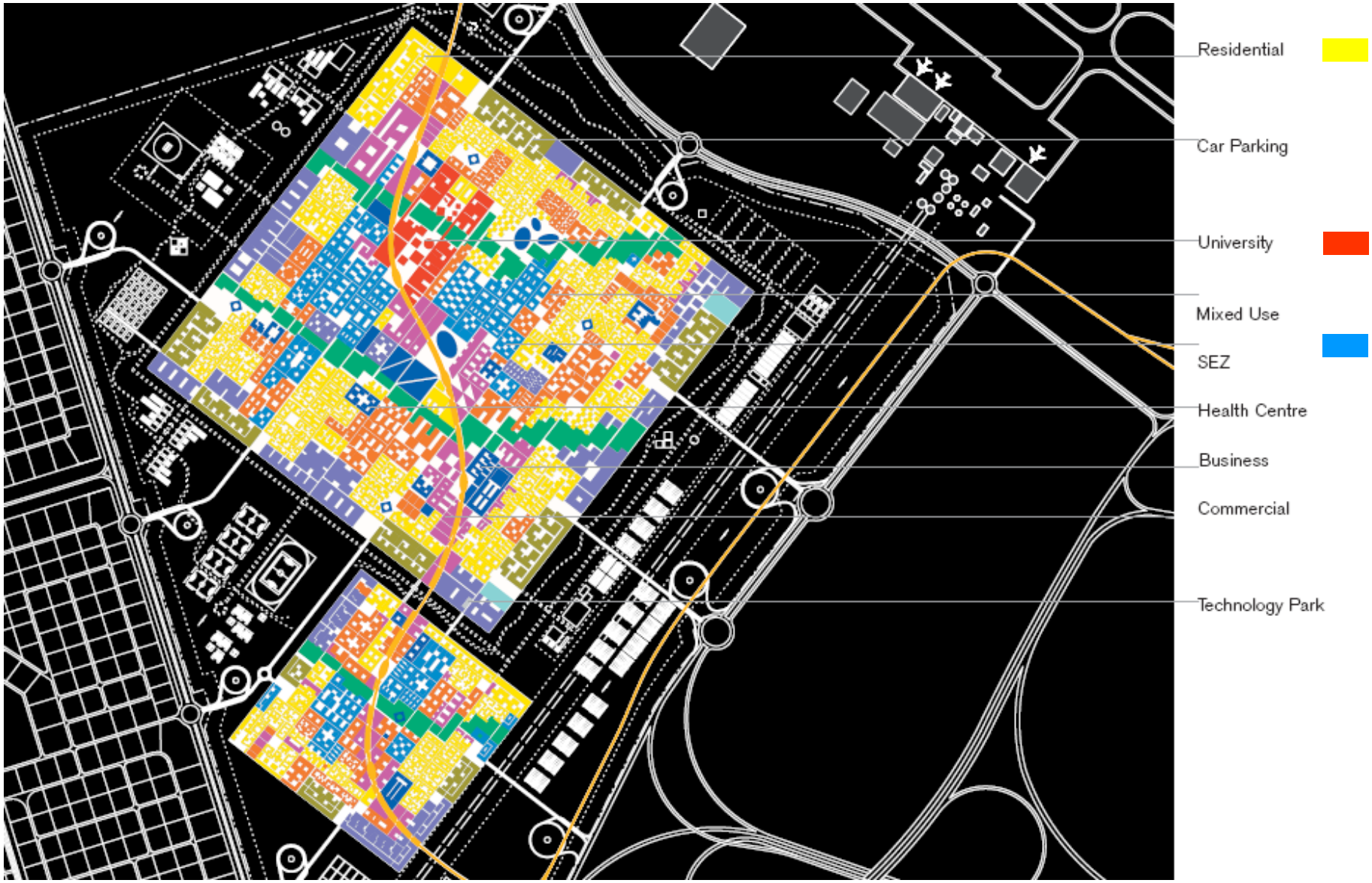
- General: The head in the fire, the feet in the water
- shadowing by ventilated roof
- living from the fruits - roof integrated energy collection
- layering below the shadow roof
- using the ground for energy buffering





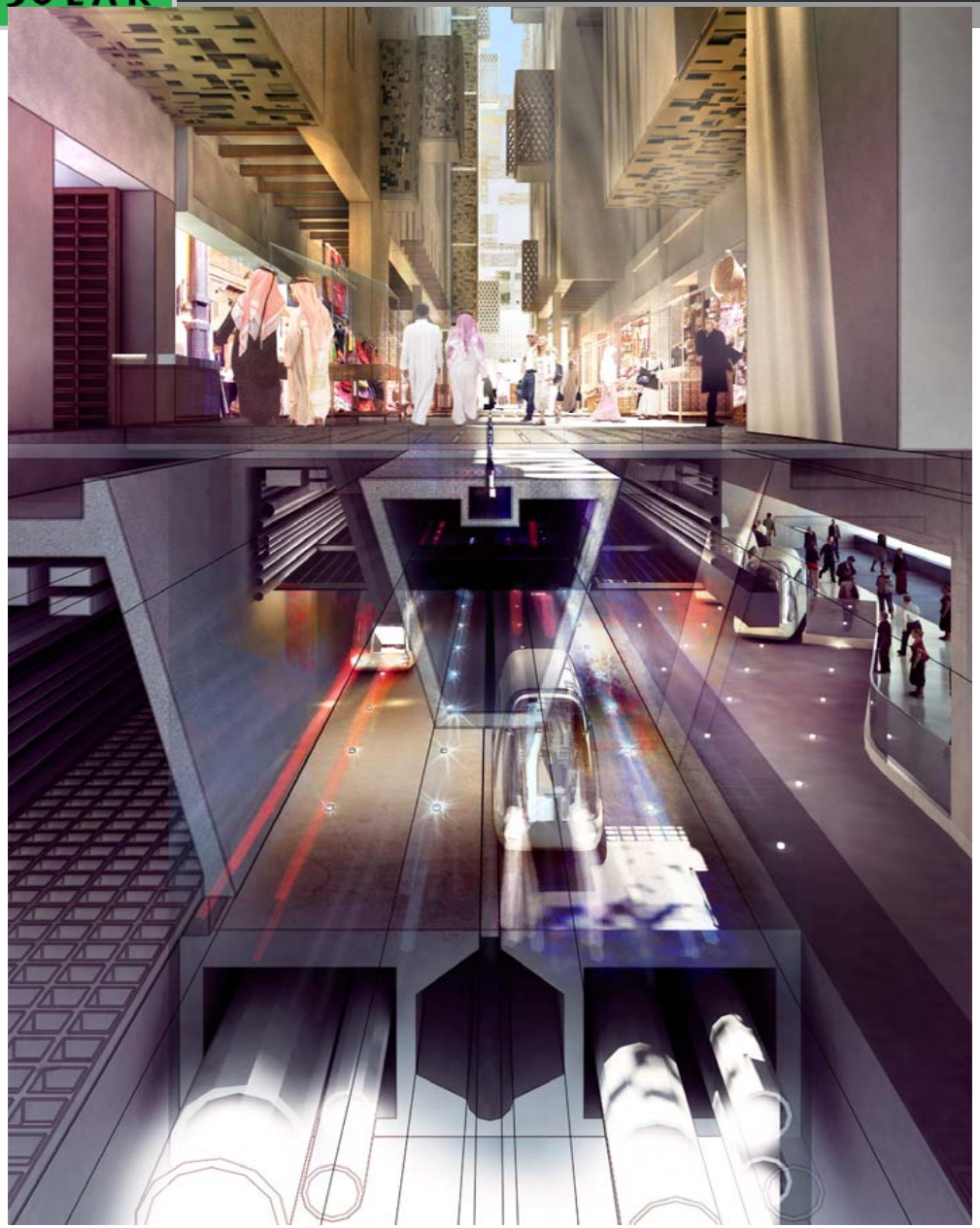
Recommendations: Wind parallel streets not longer than 75 m

Masdar City - the new hub for research and development of renewable energy components



City program around the university MIST (Masdar Institut of Science and Technology)

Light Rail Transport(LRT) and Personal Rapid Transport (PRT)



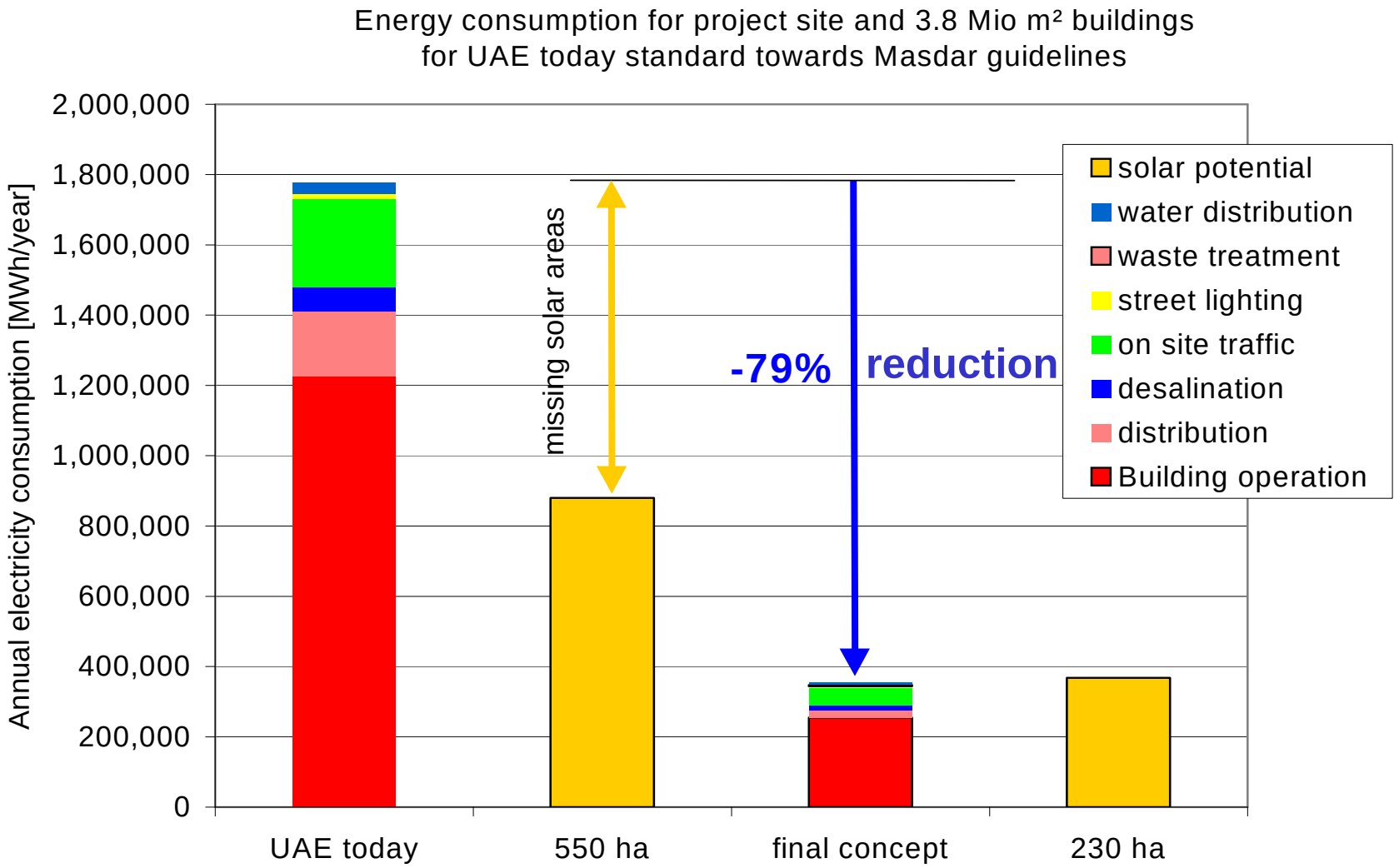
Buildings

Pedestrian level

Services

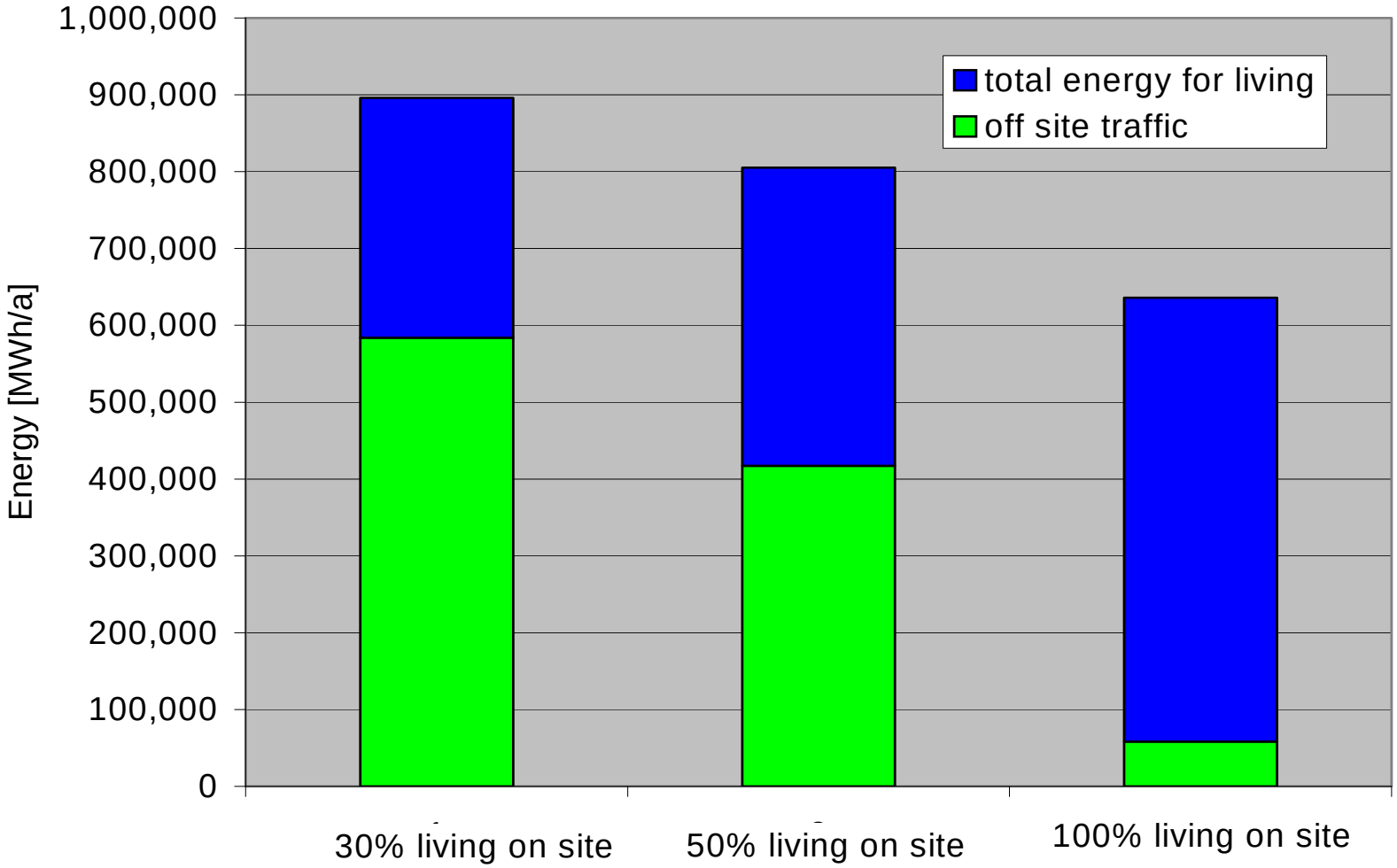
Personal Rapid Transport

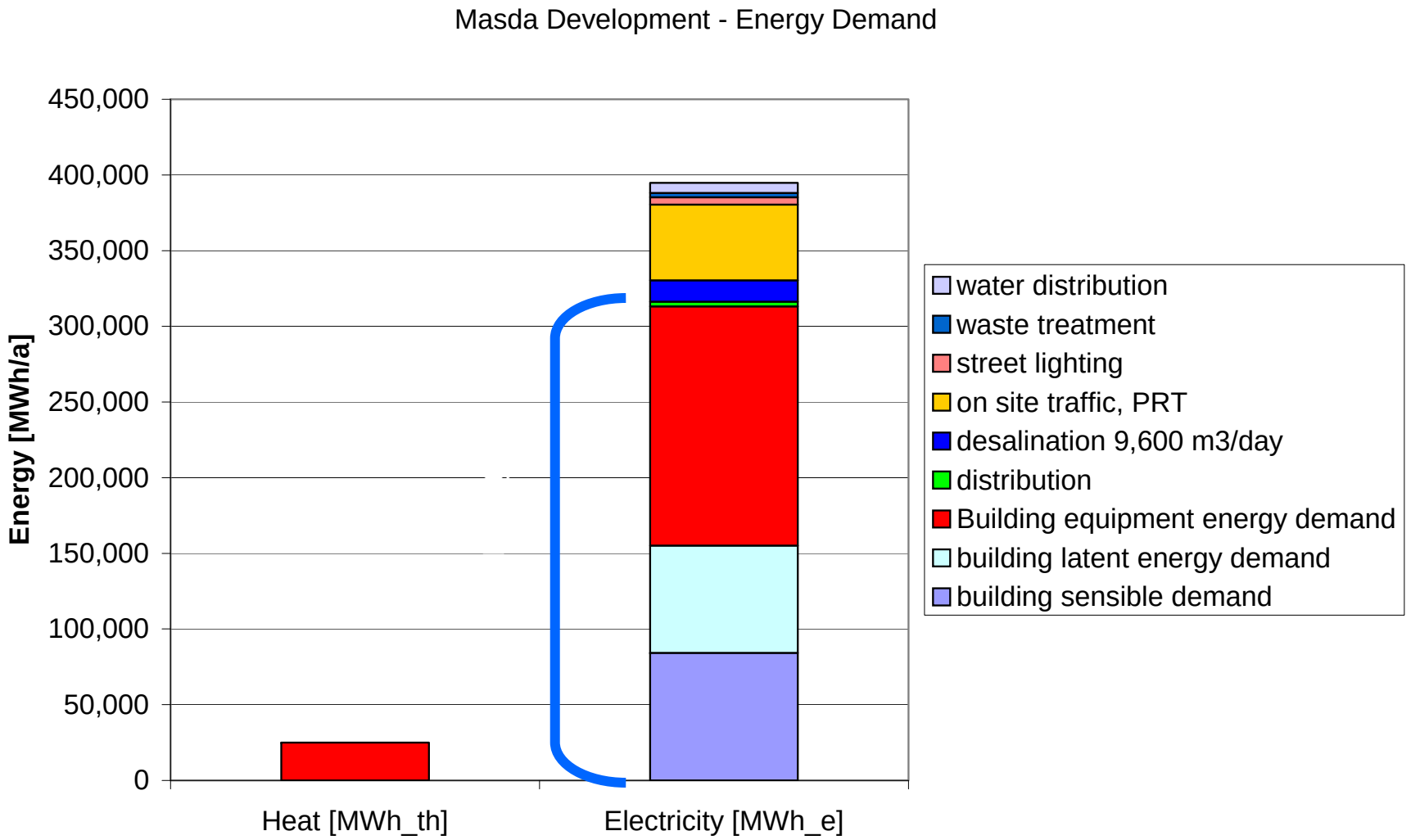
Main Infrastructure



Energy efficiency is prime strategy

Total energy consumption of the whole Masdar Development for mobility and living, depending on ration of people living on site





All energy by electricity but domestic hot water - large square

Masdar City Masterplan


PRT

Masdar City is under construction – University scheduled to open in February 2010

- The world needs examples
- Urban densities up to 180 Pers./ha
- City for the people not for the cars
- Public transportation replacing individual mobility
- Efficiency for energy and resources is 80% of the bill
- Economical evaluation for at least 30 years
- 22 bill $ for a city project for 100.000 people
  with CO2 neutral operation,
  with education, research and production of innovative products

Toronto's Central Waterfront

- 800 hectares
- 70% in public ownership

The Lower Don Lands Development

Development Scale Requirements

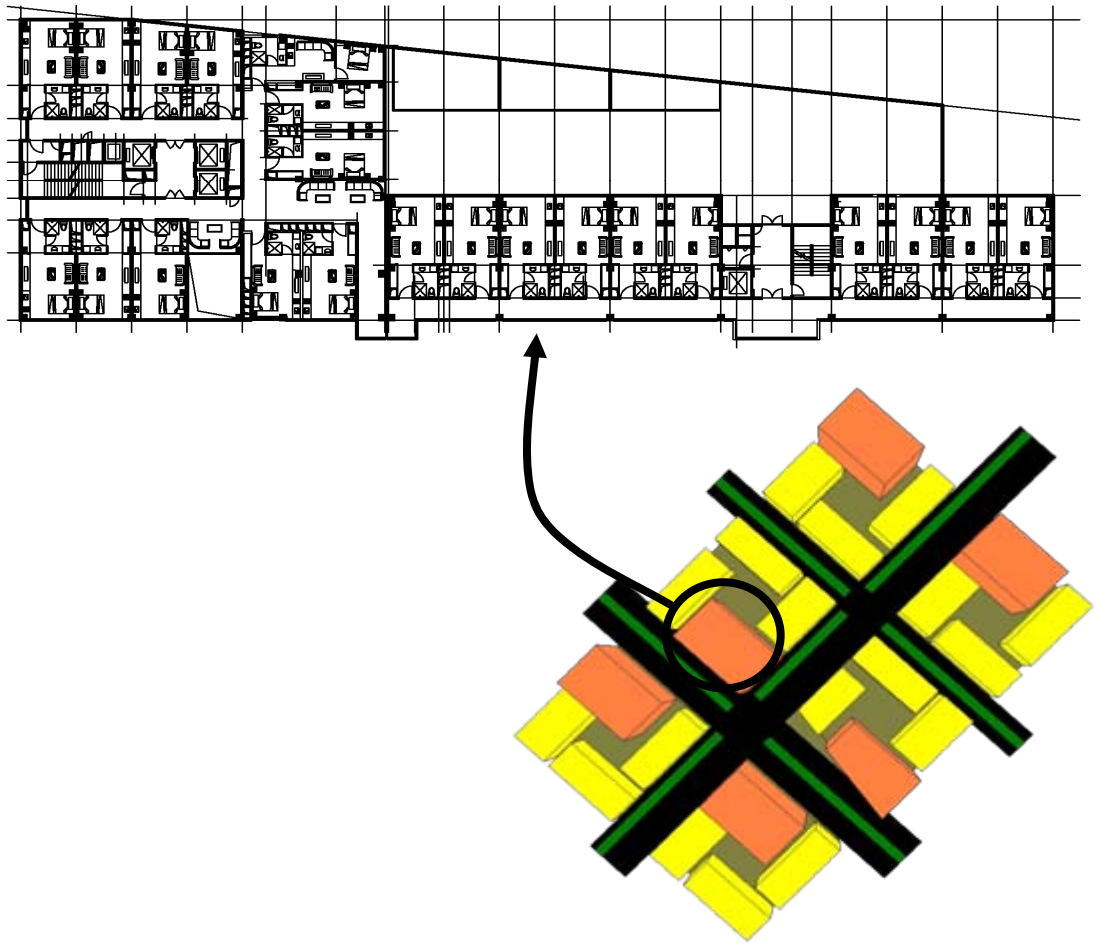
- Energy supply network
- Energy generation
- Waste management plan
- Food supply plan
- Water supply network
- Water treatment plan
- Traffic (motorized or not)

Block Scale Requirements

- Solar access
- Site access
- Energy delivery
- Stormwater flows

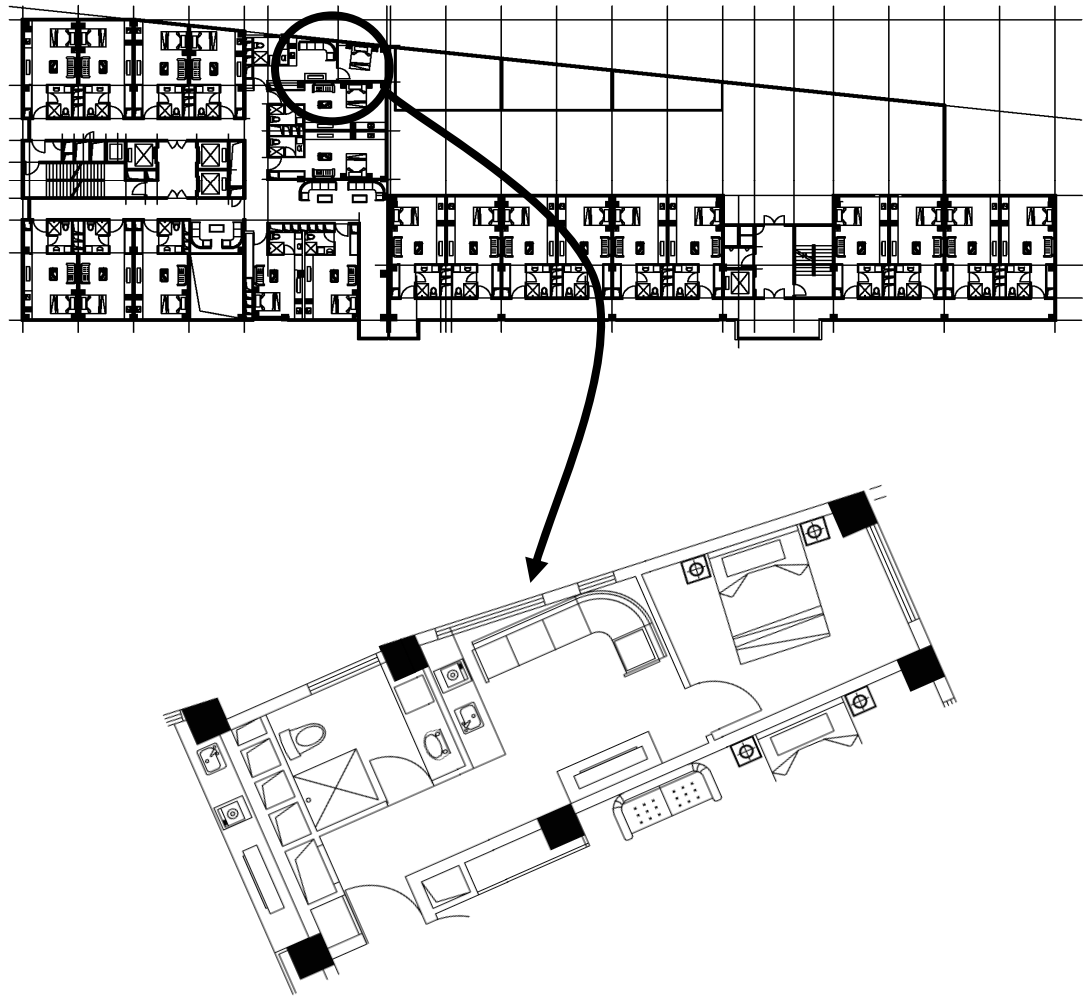
Building Scale Requirements

- Façade performance
- Building systems
- Daylight access
- Waste storage
- Local energy generation
- Water efficiency
- Materials efficiency



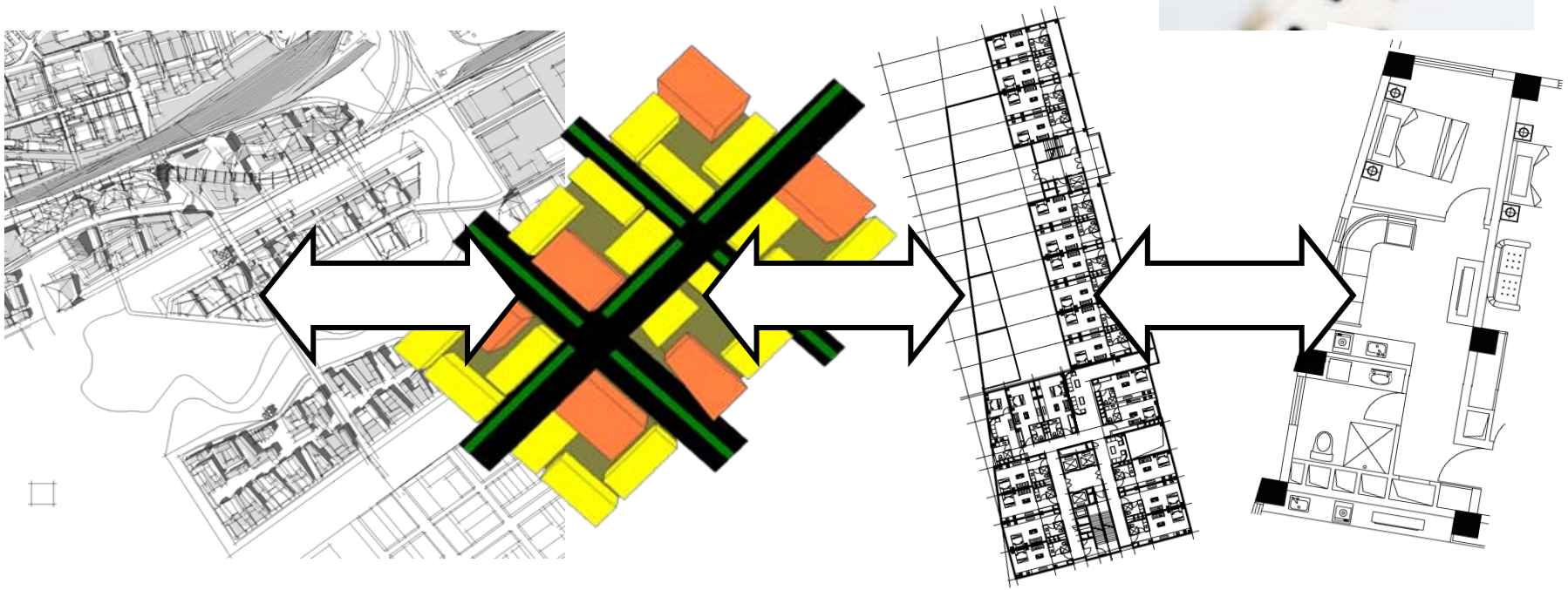
Unit Scale Requirements

- Indoor comfort
- Daylighting
- Waste separation



Scale Dependency

- Each scale is dependent on successful implementation of strategies at all other scales
- Example: Sufficient daylighting cannot be achieved in residential if the site plan doesn't allow daylight penetration



„In all the counting and evaluation, we should not forget about the urban and architectural quality, done by architects, not by evaluators“
Steven Holl, Knut Hamsun Center, Hamaroy

	UK Average % of total CO2 emissions	UK Average in ton CO2/capital
Space heating in the home	3%	0.38
Hot water	4%	0.50
Appliances in the home	3%	0.38
Personal transport	18%	2.25
Embodied energy in home infrastructure	3%	0.38
Waste and consumer items	13%	1.63
Food	24%	3.00
Shared services (total energy for running schools, hospitals, financial services, etc)	12%	1.50
Shared infrastructure (energy for constructing schools, hospitals, roads, airports, etc)	20%	2.50
total	100%	12.5