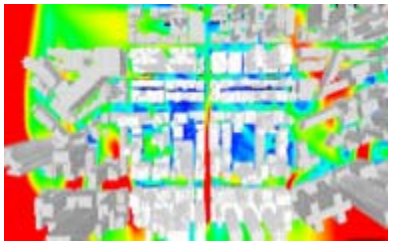
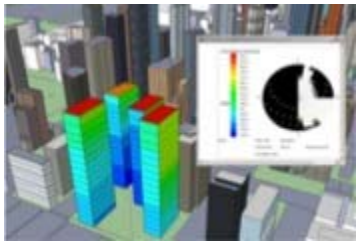
Can we achieve an
Energy Positive
Built Environment?

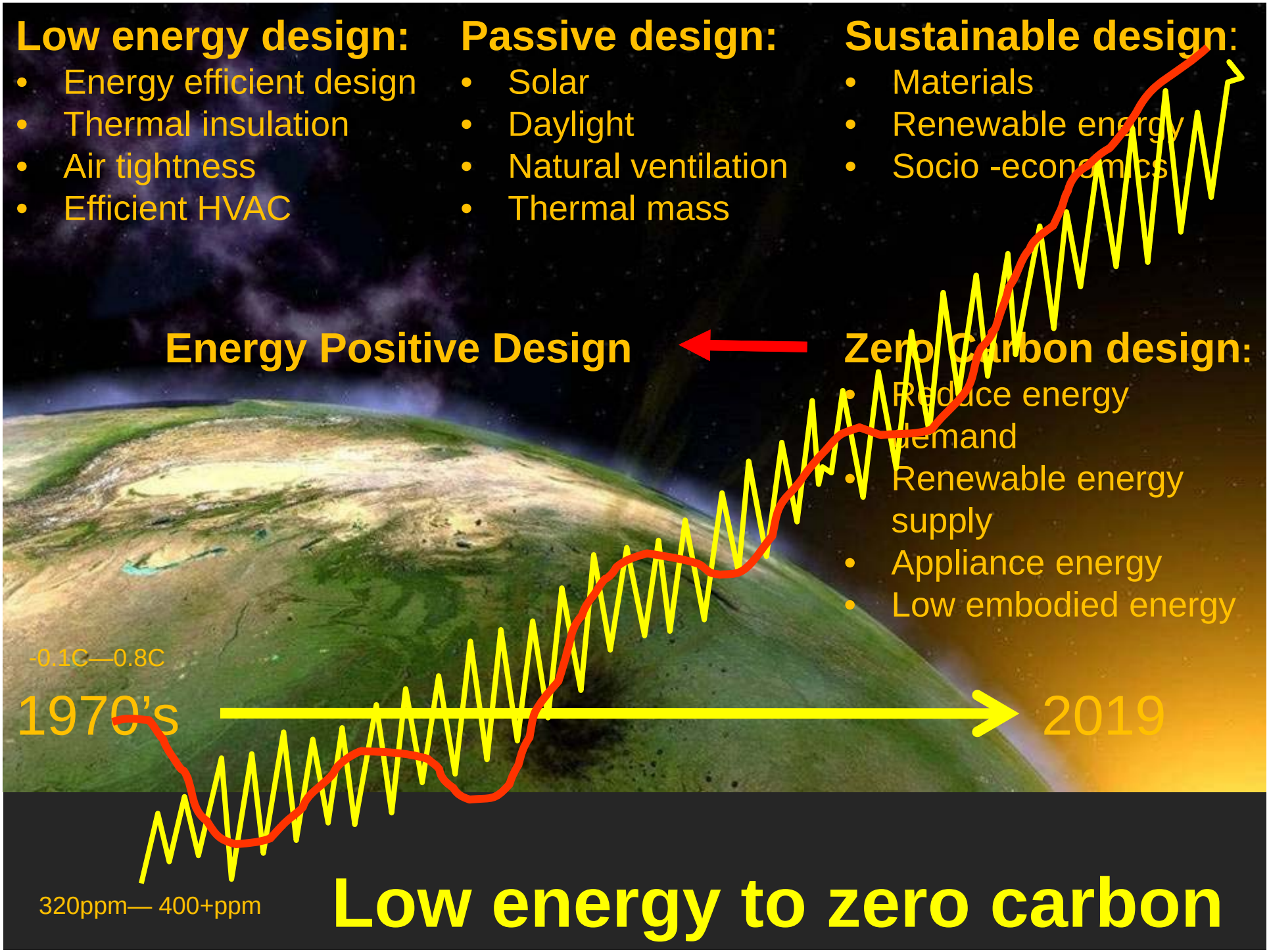
Phil Jones
Welsh School of Architecture









Low energy design:
• Energy efficient design
• Thermal insulation
• Air tightness
• Efficient HVAC
Passive design:
• Solar
• Daylight
• Natural ventilation
• Thermal mass
Sustainable design:
• Materials
• Renewable energy
• Socio -economics
Energy Positive Design
Zero Carbon design:
• Reduce energy demand
• Renewable energy supply
• Appliance energy
• Low embodied energy
-0.1C—0.8C
1970's
2019
320ppm— 400+ppm
Low energy to zero carbon

EUROPE

2020 Targets
- 20% cut in **greenhouse gas** emissions (from 1990 levels)
- 20% of EU energy from **renewab**
- 20% improvement in **energy**

2030 targets:
- Reducing greenho emissions by 40% (from 1990 levels)
- Increasing th of renewable energy to at least 27%
- Continued i ements in energy efficiency (at least 27%)

20% per decade

2040 targets:
- Reducing greenhouse gas emissions by 60%

EUROPE: ***Nearly Zero Energy Buildings (NZEBs)***

- The **Energy Performance of Building Directive (EPBD)** states that Member States shall ensure that new buildings occupied and owned by public authorities are NZEBs after December 31, 2018 and that all new buildings are NZEBs by December 31, 2020.

- A NZEB is a building that ***"has a very high energy performance with the nearly zero or very low amount of energy required covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby***".

- Implemented through **Building Regulations.**

(D'Agostino et al., Synthesis Report on the National Plans for NZEBs; EUR 27804 EN; doi 10.2790/659611)|

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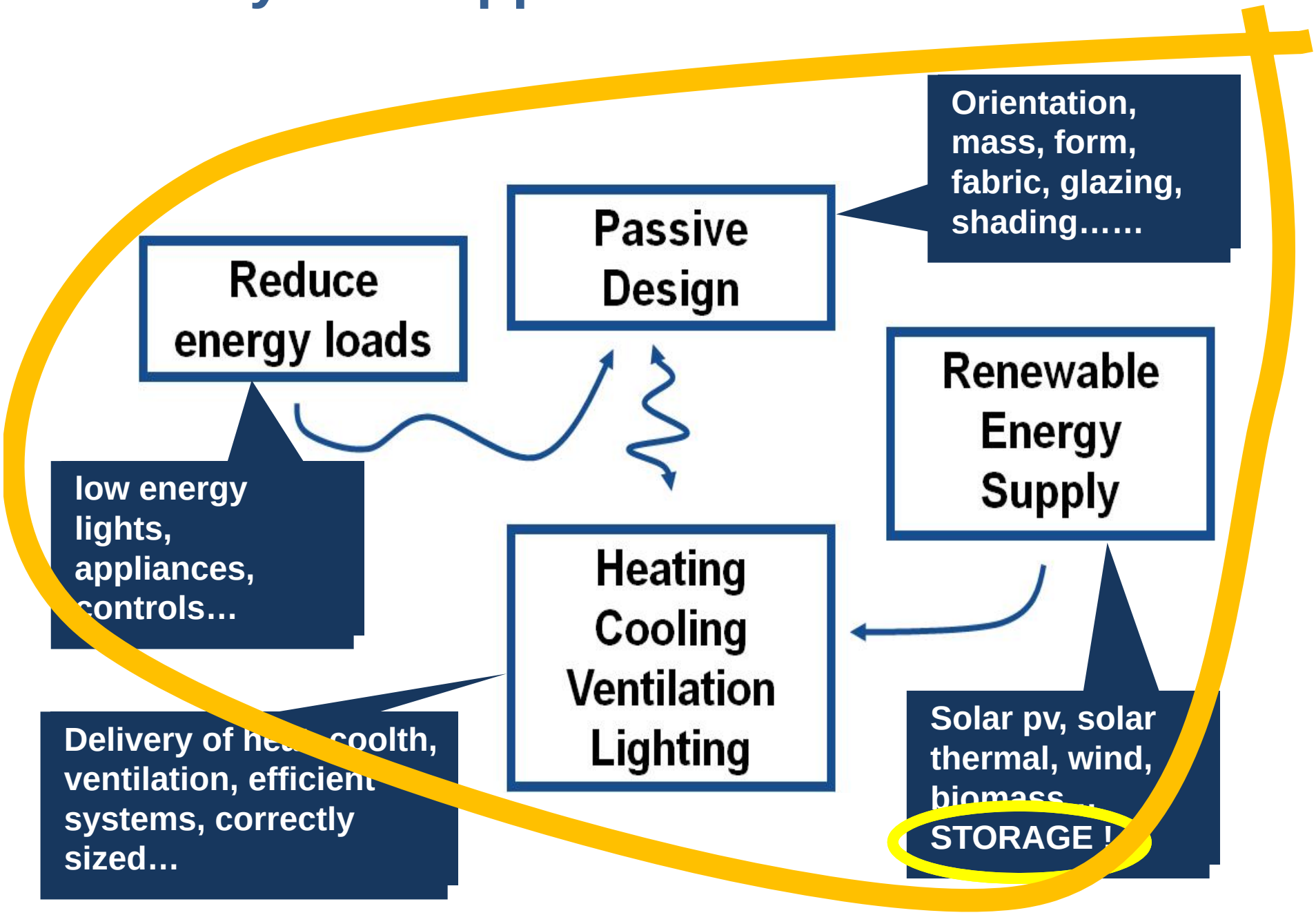
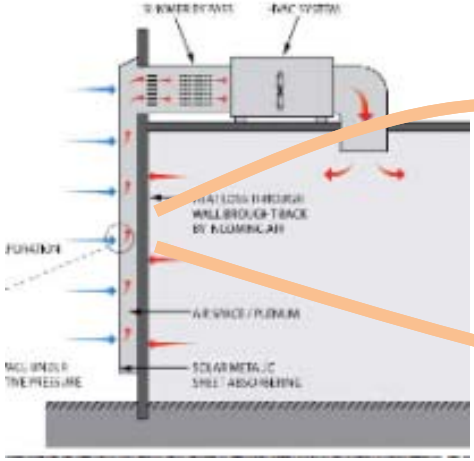
Whole System Approach



Energy Generating Building Envelopes

Solar PV and Solar thermal

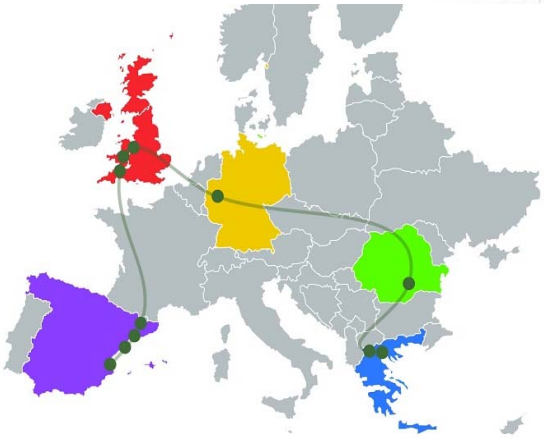
LCRI LOW CARBON RESEARCH INSTITUTE

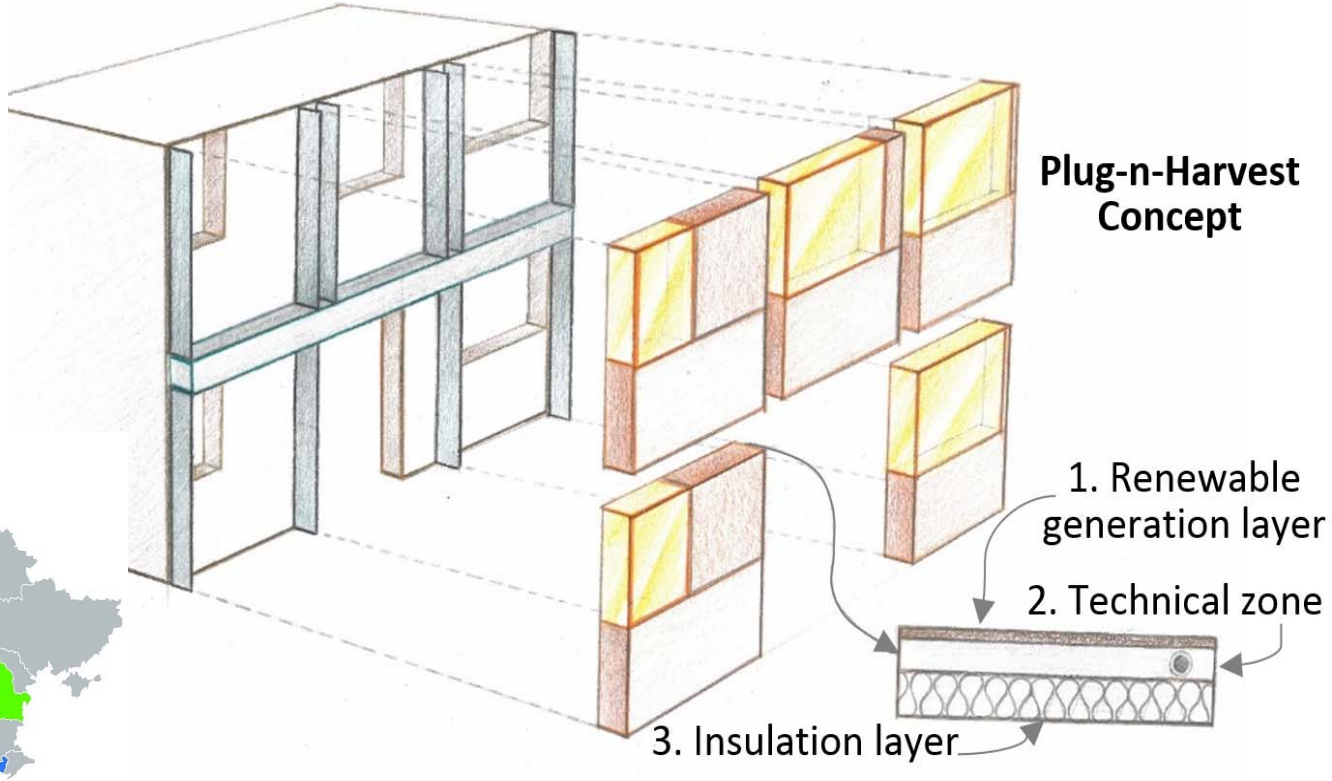


Cardiff University researchers completed energy-harvesting façade and roof retrofit in Tibet as part of its HABITAT Global Challenge Research project (August 2018).

Plug-n-Harvest

H2020 EeB-07-2017
EU contribution €6m
2017-2021





OPTIONS:





ENERGY POSITIVE

Housing

USE

- LOW COST

SYSTEMS A

REDU

REN

GE

PERFORMANCE
REPLICABILITY
AFFORDABILITY

4.3 KWP PV ROOF

AIR COLLECTOR

6.9 KWh BATTERY

HEATING SYSTEM

hefcw

ERDF

CARDIFF UNIVERSITY

PRIFYSGOL CAERDYDD

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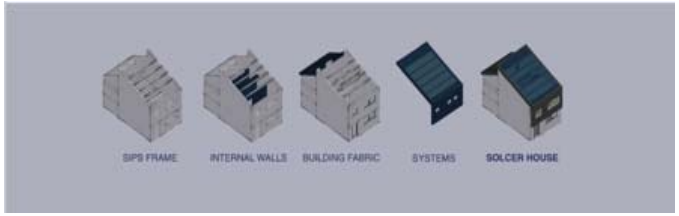
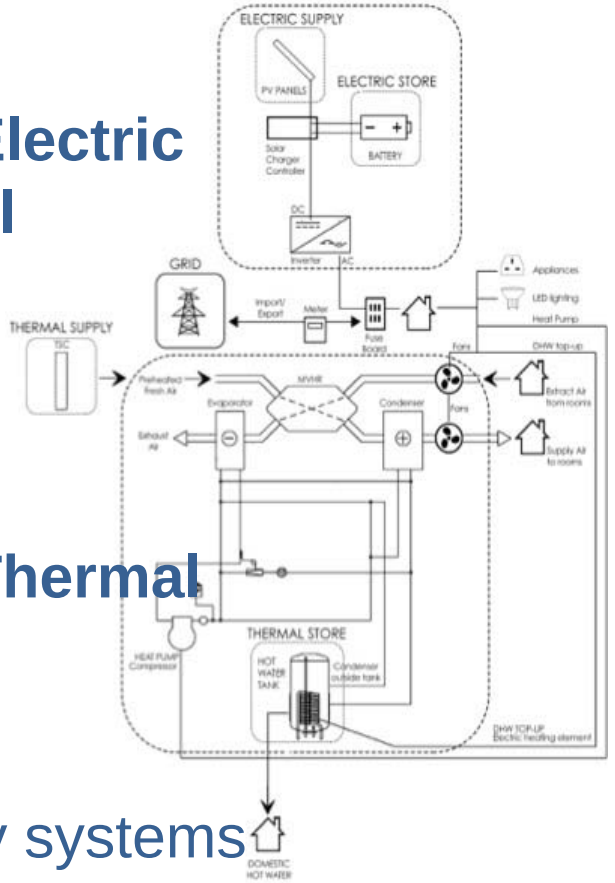


SYSTEM INTEGRATION

Electric al



Thermal

Technologies:

Thermal and electrical energy systems

Technologies and building design:

Renewable energy systems as construction elements

PV ROOF SYSTEM

Monocrystalline solar cells – Efficiency: cell 22%; Panel 15%

TRANSPIRED SOLAR AIR COLLECTOR

17m^2, temperature uplift up to 30^{o}C

VENTILATION HEATING SYSTEM

GENVEX COMBI

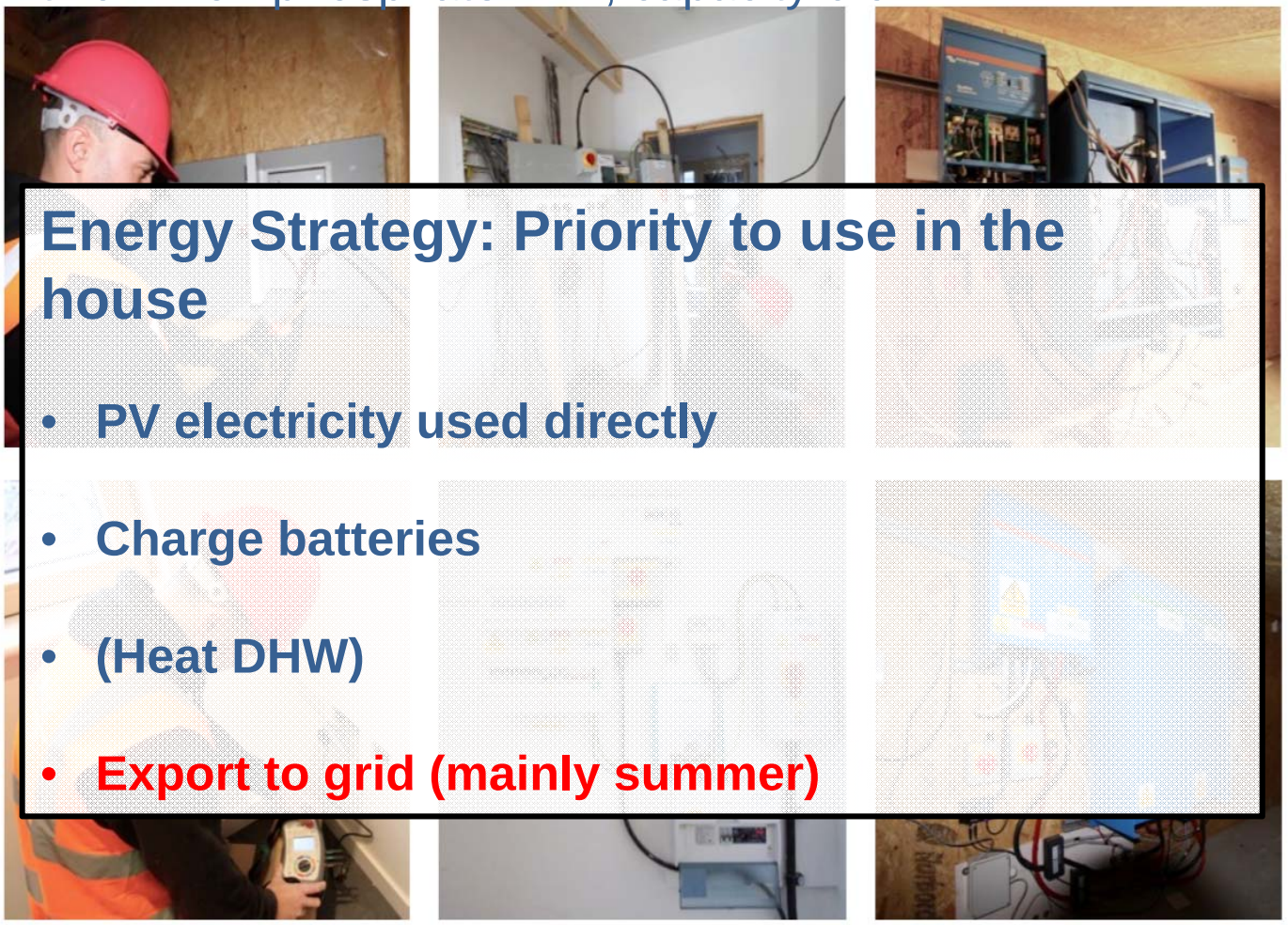
Heat pump

MVHR

Thermal water storage (185l)

BATTERY STORAGE

Lithium-iron phosphate LFP; capacity 6.9kWh



Energy Strategy: Priority to use in the house

- PV electricity used directly
- Charge batteries
- (Heat DHW)
- Export to grid (mainly summer)

SIPS ECO PANEL CONSTRUCTION

High insulation (0.14), airtight, recycled timber, fast construction

16 weeks construction programme

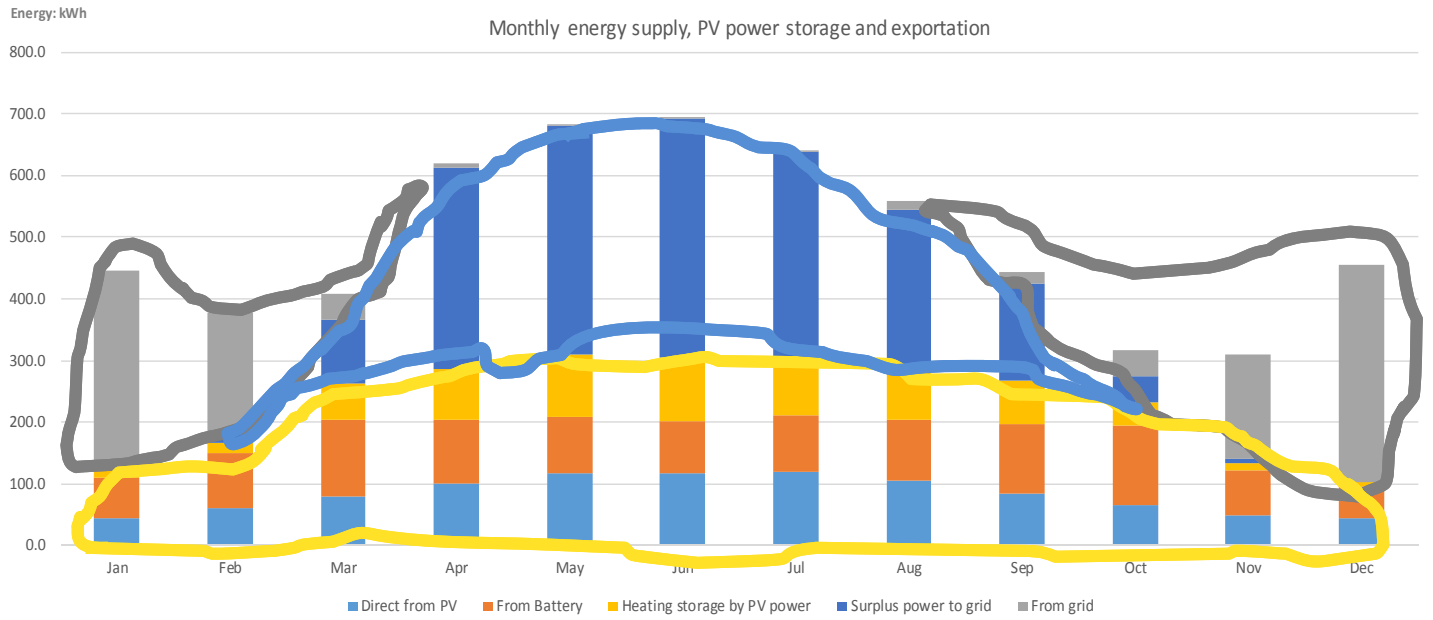
SOLCER: the energy positive house

COSTS £1,200/m²

Typical new house energy costs £780/year
SOLCER earns £166/year
Benefit £946/year

ENERGY POSITIVE PERFORMANCE

Annual self sufficiency rate: 75%
Annual power to grid/from grid ratio: 1.5



SOLCER low carbon Retrofits

Before retrofit

Whole House Deep Retrofits





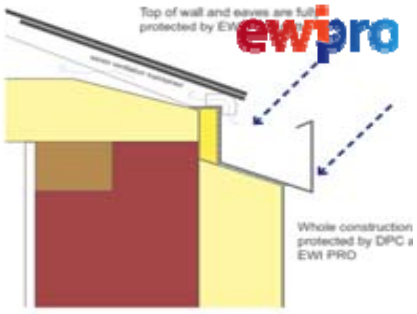
PV roof

Batteries

MVHR

EWI

Details



SOLCER low carbon Retrofits

Before retrofit

After retrofit

Energy savings £450/year
(average energy bill £1000/year)

Cost of whole house retrofit £25,000 and reducing

Multiple Benefits of Energy Retrofits

Job creation - 22 jobs / £1M spent.

Increased house value.

Reduces fuel [illegible]

[illegible] fuel poverty reduces [illegible]P.

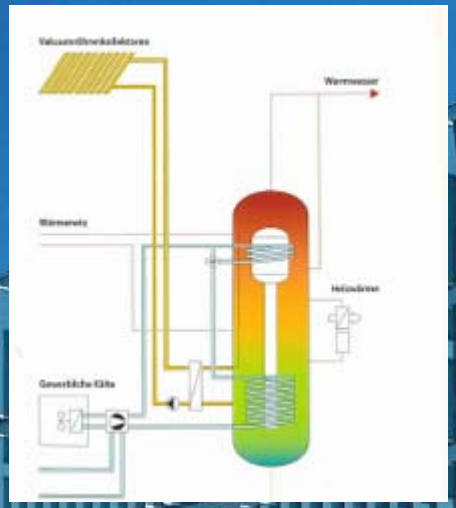
[illegible] value of £1 investment in energy retrofits yields a return of £4.

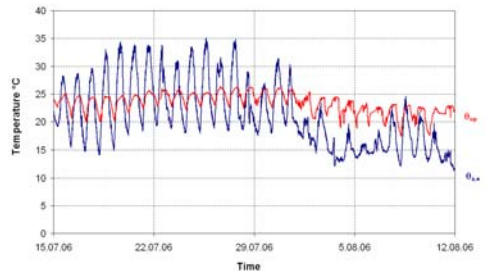
NEED MORE INCLUSIVE COST MODELS
SCALE - 50,000 RETROFITS A YEAR

ENERGY POSITIVE

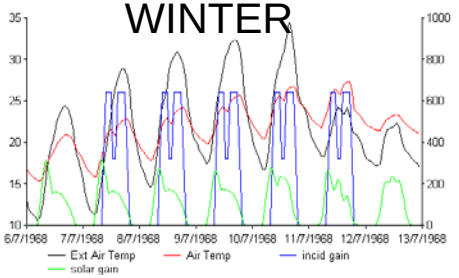
Offices

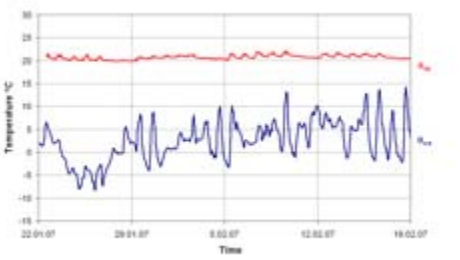
EMPA Zero Energy office, Zurich



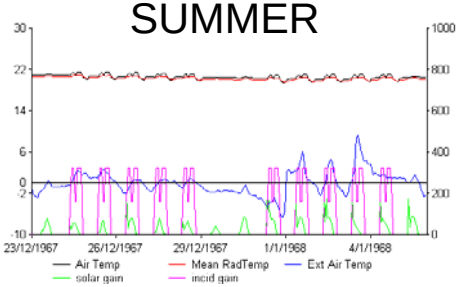


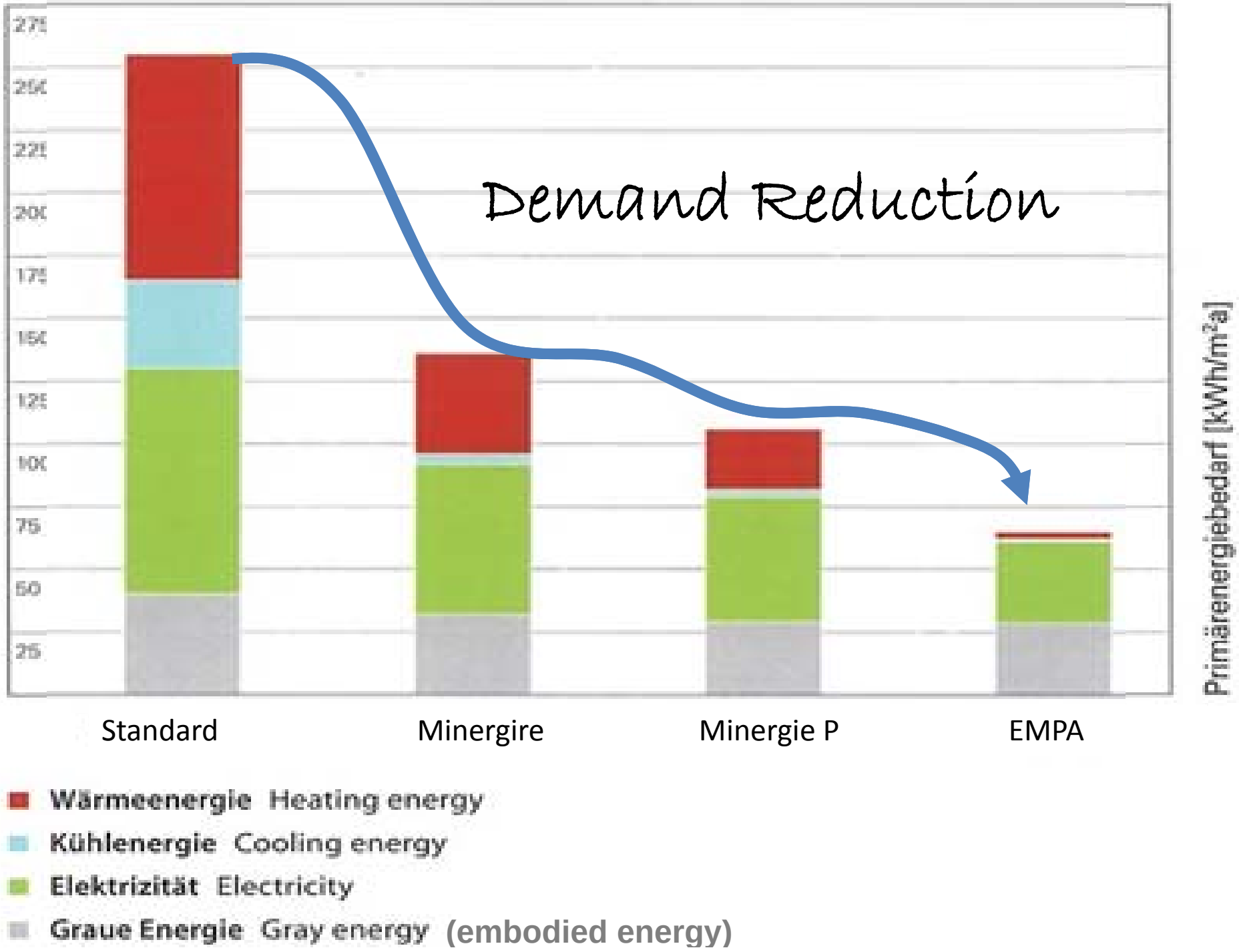
WINTER





SUMMER




Demand Reduction
Primärenergiebedarf [kWh/m²a]
Standard
Minergire
Minergie P
EMPA
Wärmeenergie Heating energy
Kühlenergie Cooling energy
Elektrizität Electricity
Graue Energie Gray energy (embodied energy)

Swiss sign agreement to build China's first zero-energy building

See in another language: 1

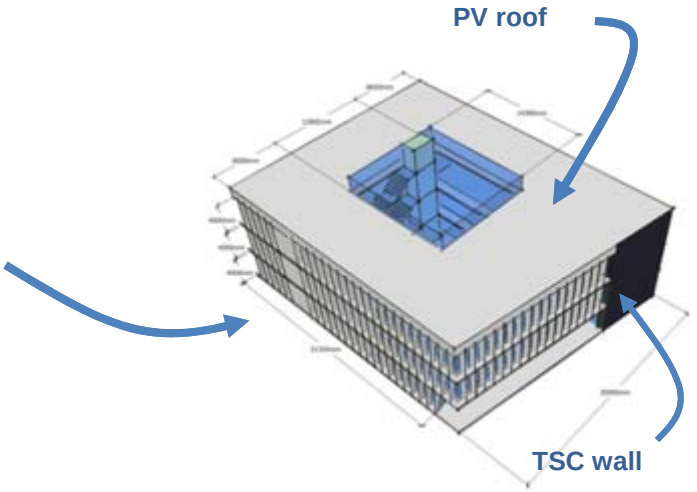
AUG 10, 2018 - 14:54

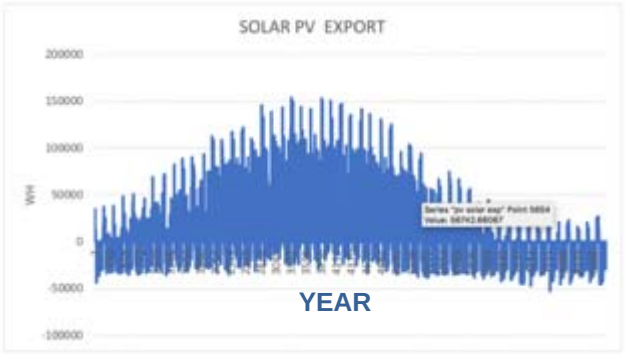
The technology is already well established in Switzerland by the Minergie A standard used in buildings like the Federal Institute for water supply, wastewater treatment and water pollution control (EAWAG).

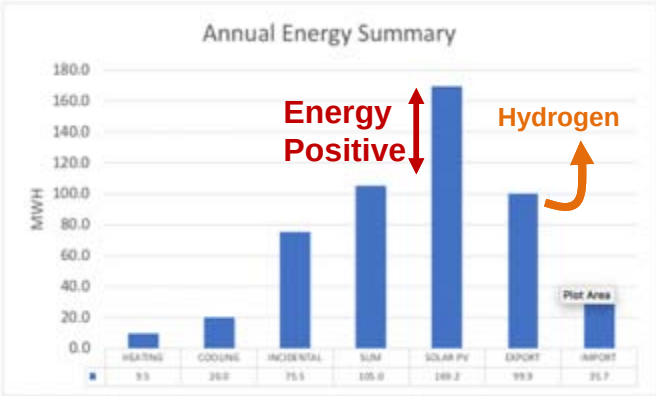
(Keystone)

Switzerland's minister for energy Doris Leuthard oversaw the signing of a declaration to build a zero-energy building in Beijing using Swiss cleantech technology.

Energy Positive Office

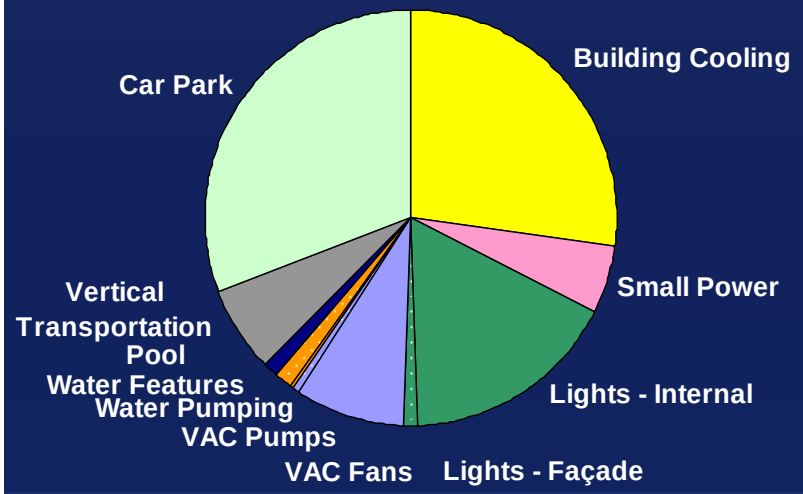


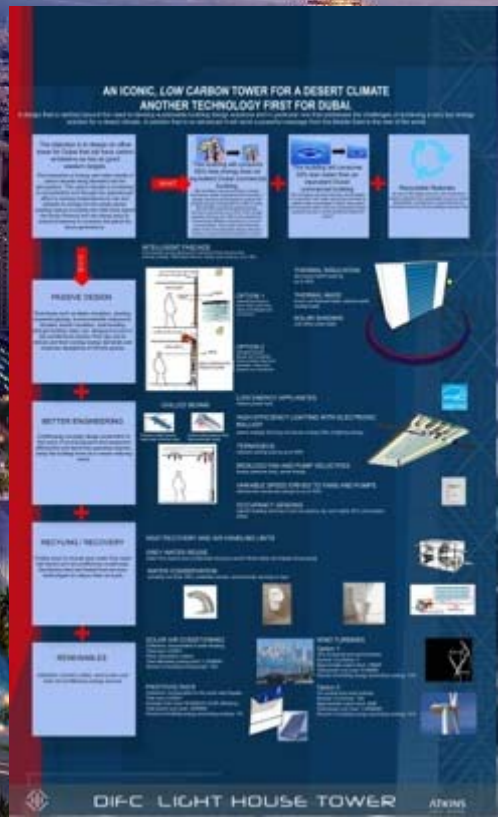




DIFC Lighthouse Tower Dubai

65% reduction in power consumption
35% reduction in water consumption

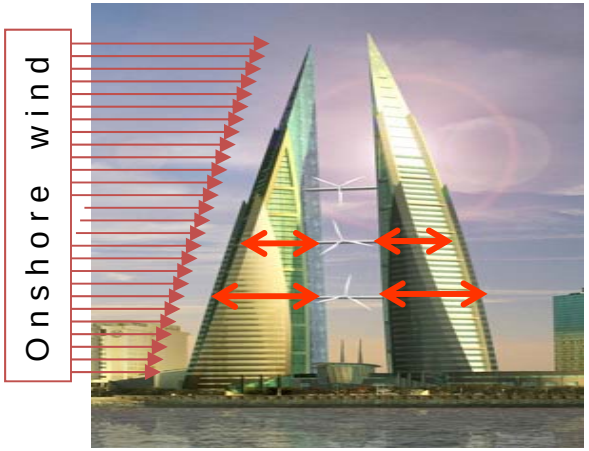




Localised Energy Supply

Bahrain World Trade Centre

Integrated wind turbines

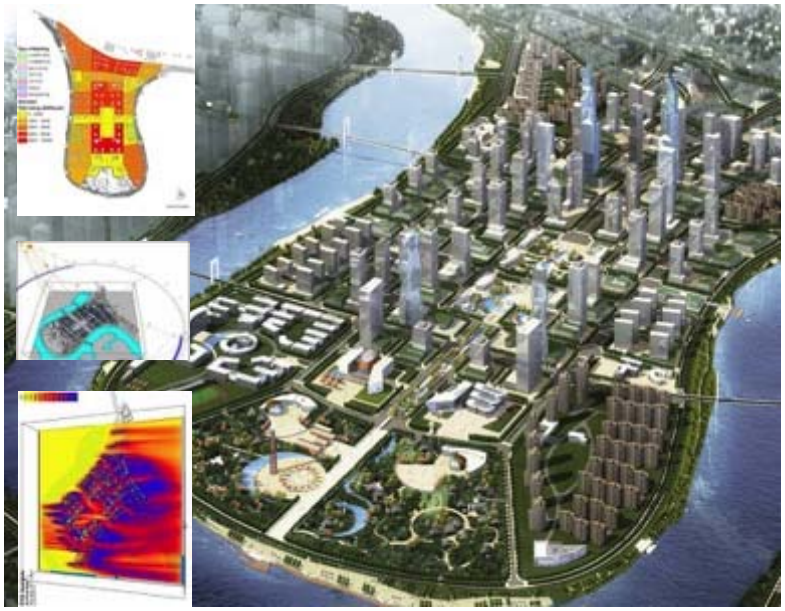


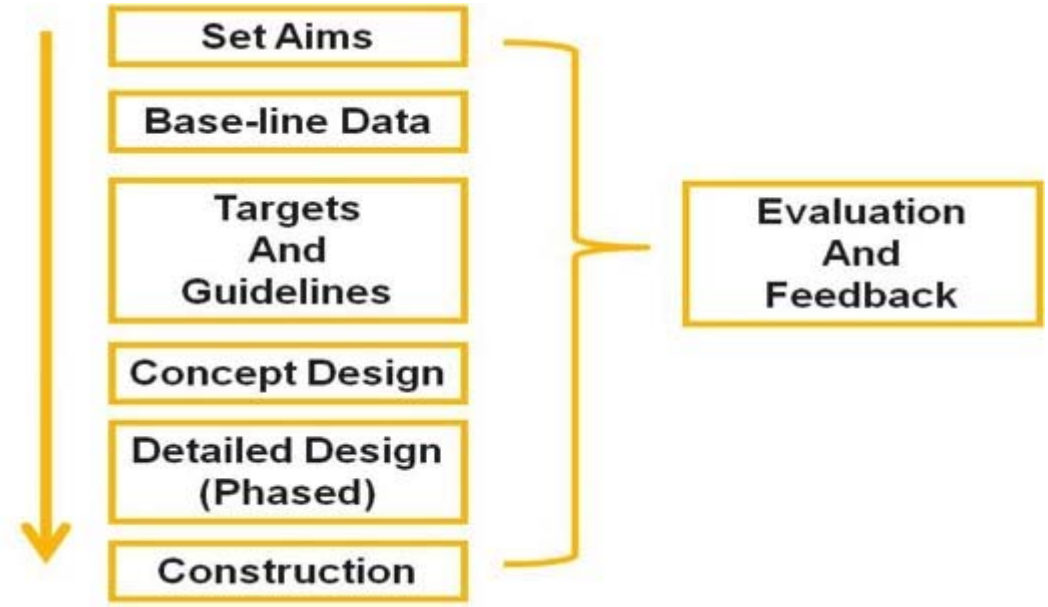
URBAN SCALE

New Developments

Sustainable Urban Master-planning

Tianjin

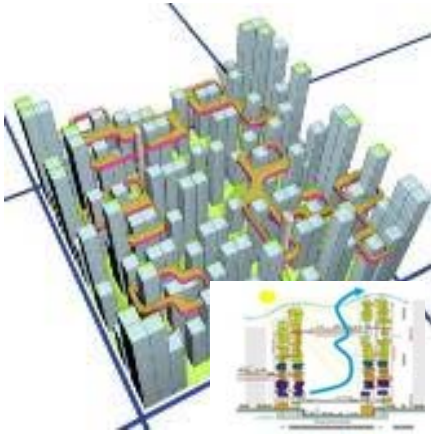




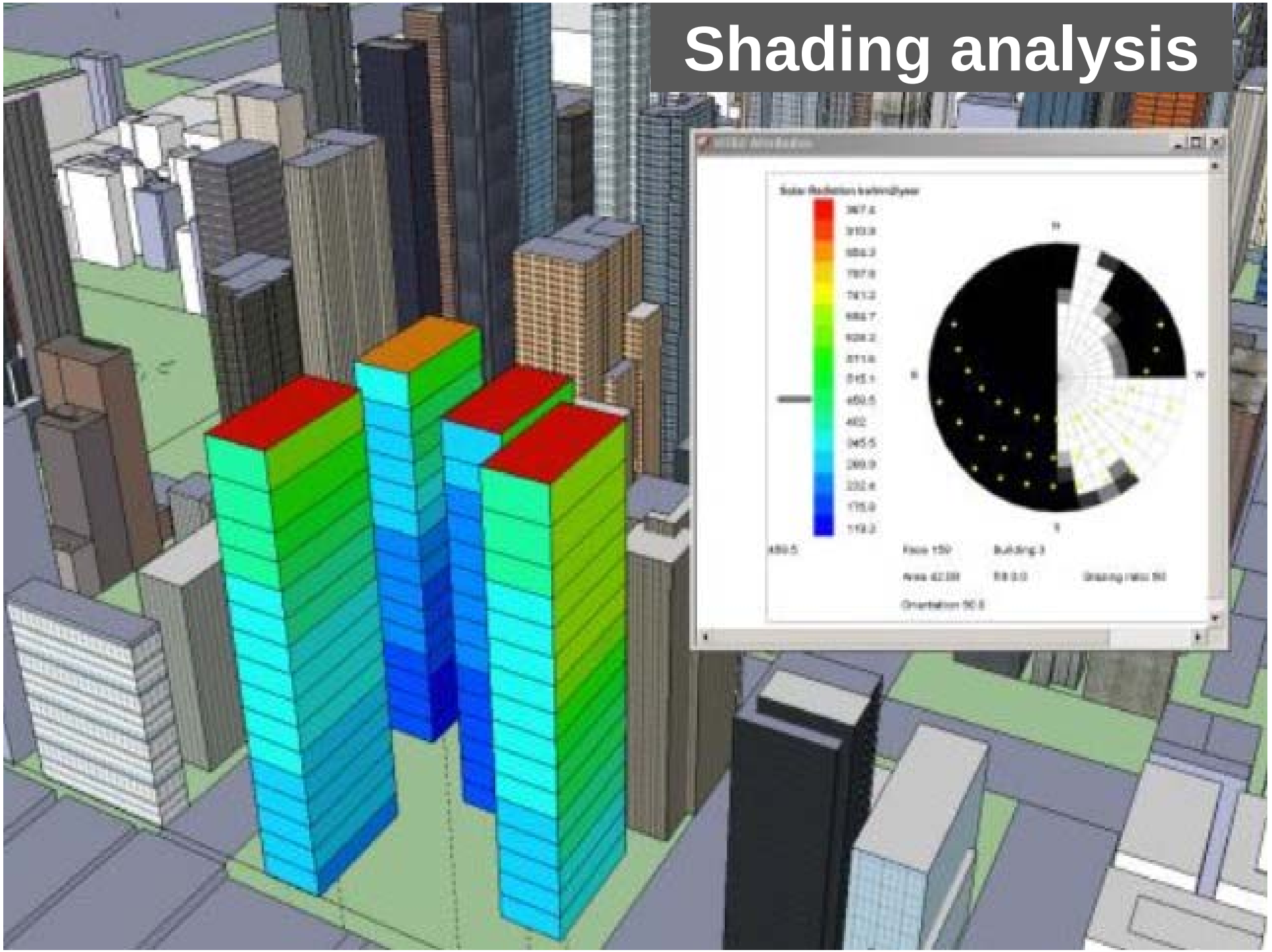
Qatar

Ras al Khaimah

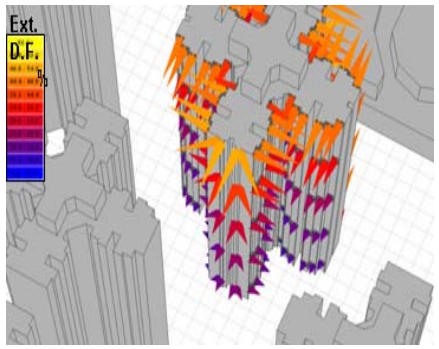
Hanoi

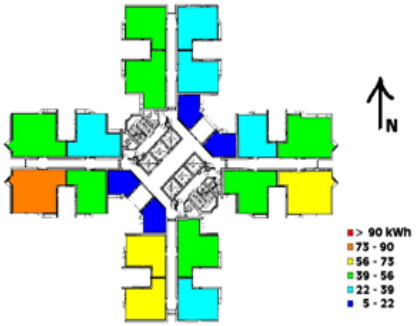


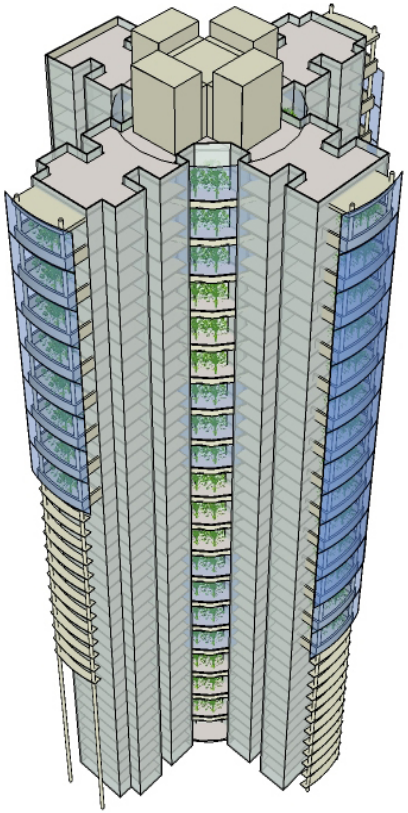
Shading analysis

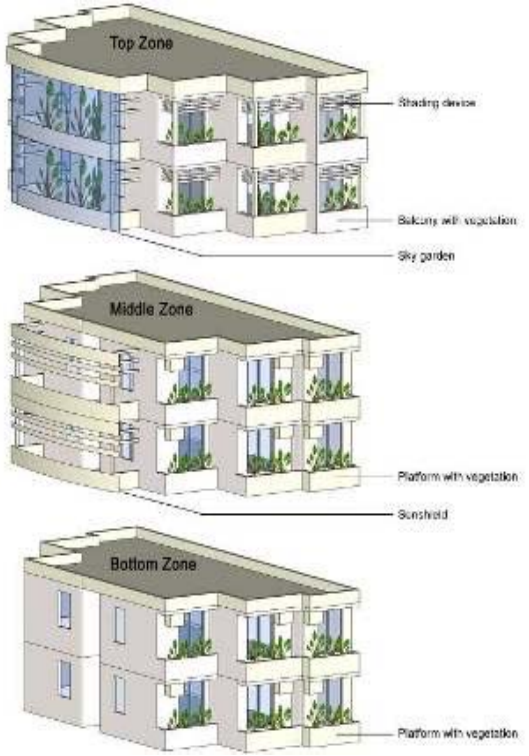


High Rise

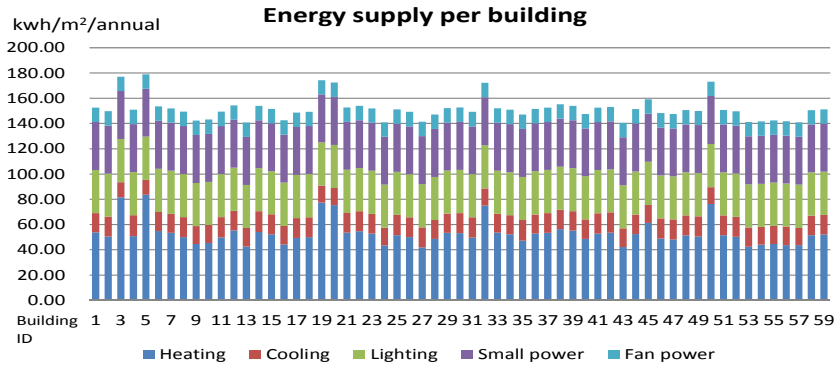

Ext.
D.F.

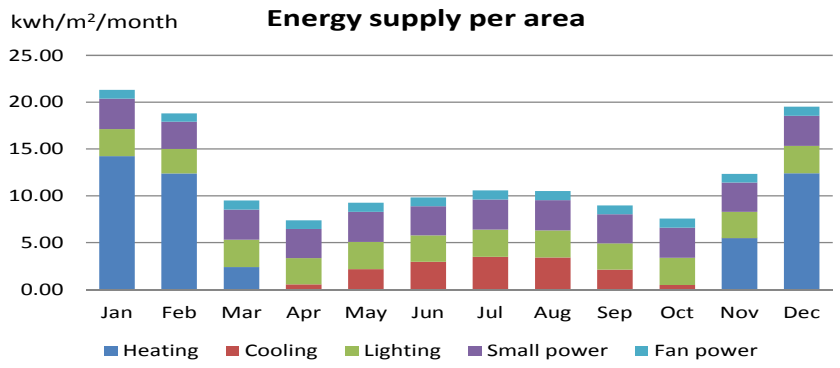

N
> 90 kWh
73 - 90
56 - 73
39 - 56
22 - 39
5 - 22



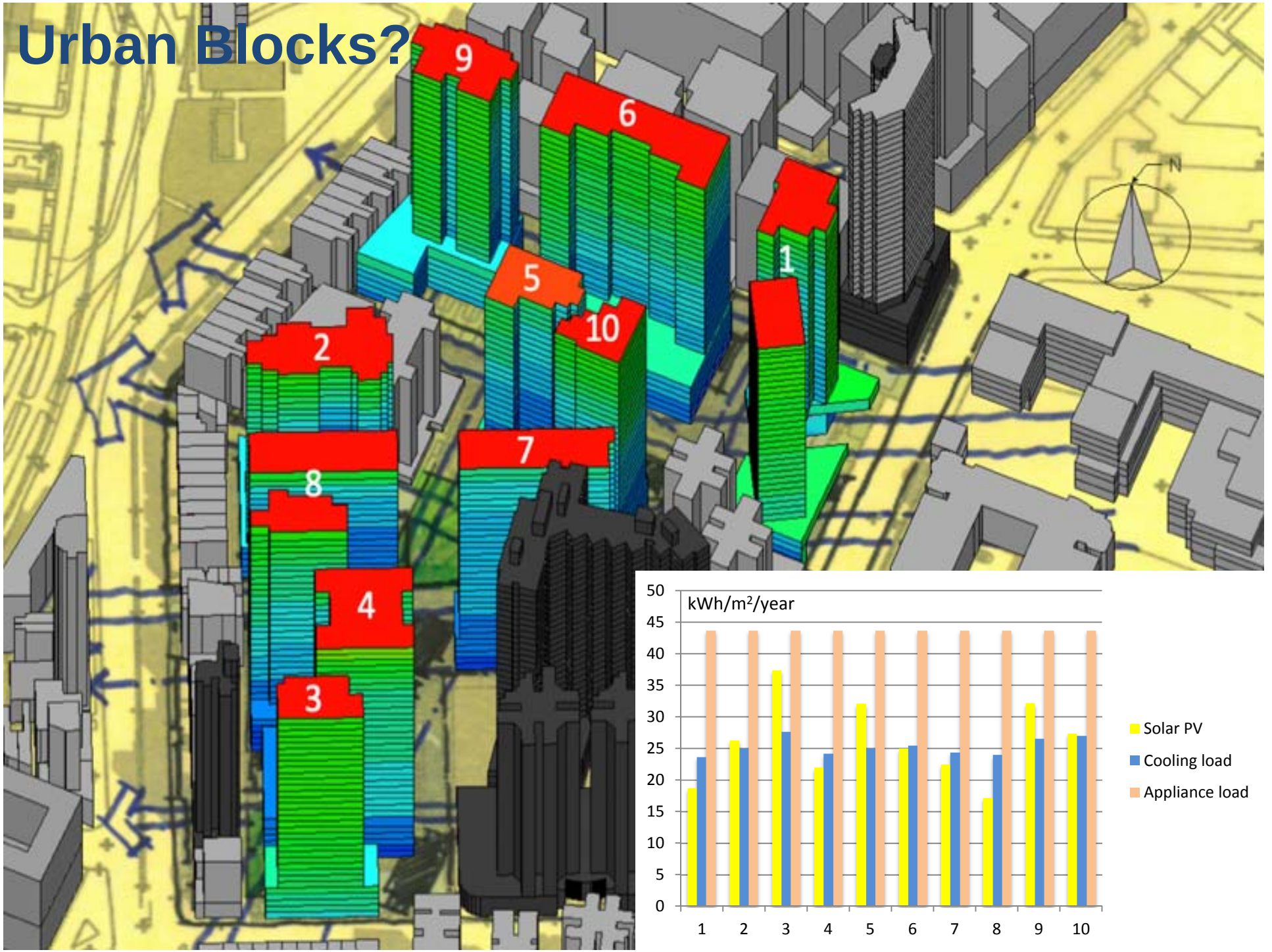

Top Zone
Shading device
Balcony with vegetation
Sky garden
Middle Zone
Platform with vegetation
Sunshield
Bottom Zone
Platform with vegetation

Large Scale Urban Developments Energy Modelling





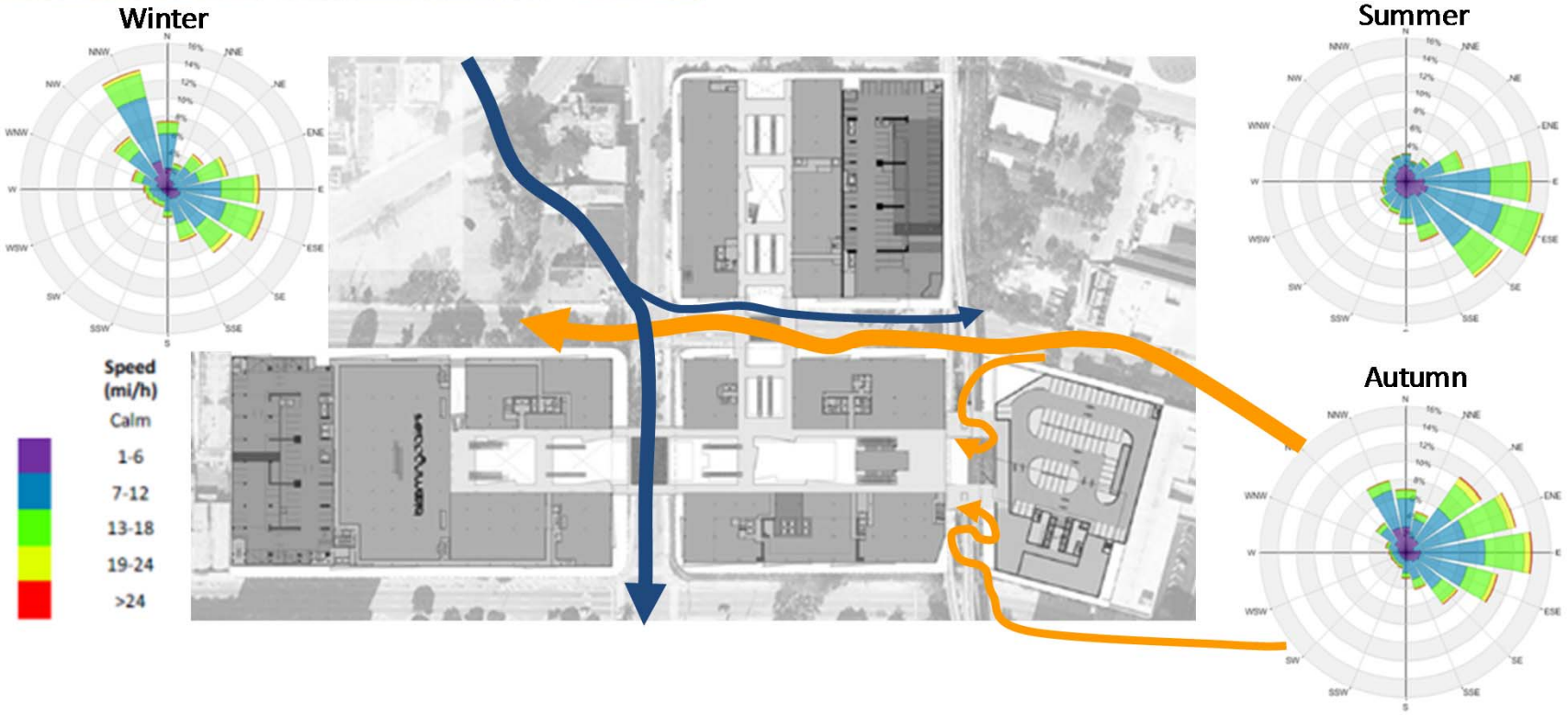
Urban Blocks?



TRANSITIONAL SPACES

MALLS, ENTRANCES, FOYERS.....

Miami: Brickell Center



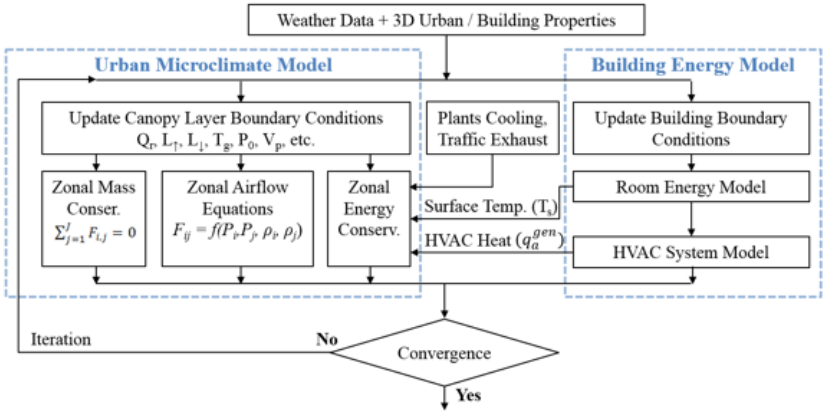
Park View Green, Beijing

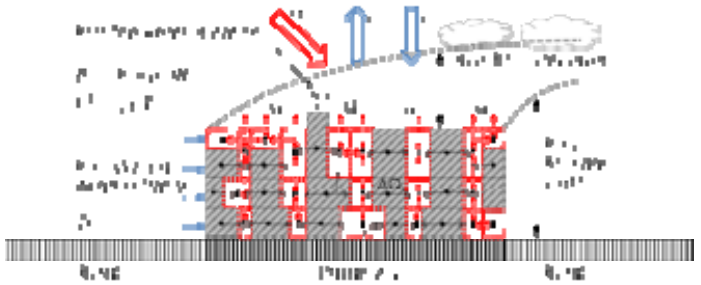
Plants and Architecture

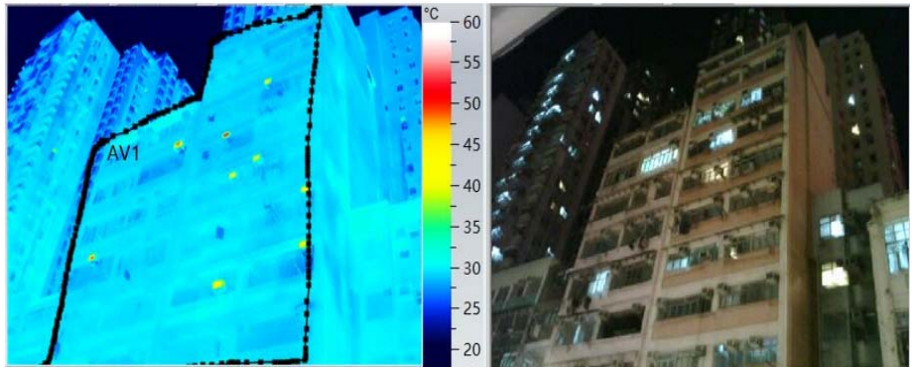
URBAN HEAT ISLAND
MICRO-CLIMATE
GREEN WALLS ROOF
BIOMATERIALS
INDOOR ENVIRONMENT

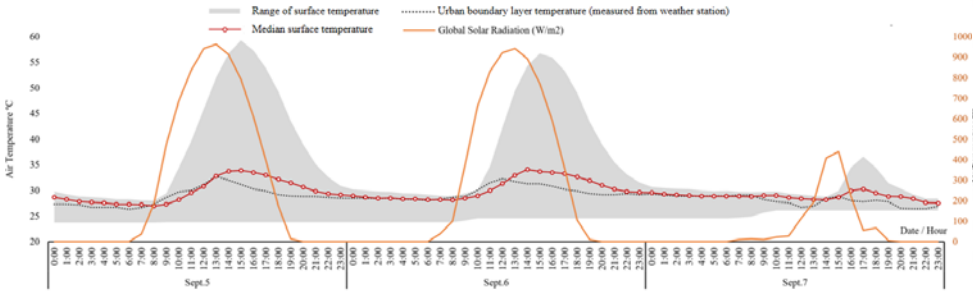
OUTSIDE SPACES

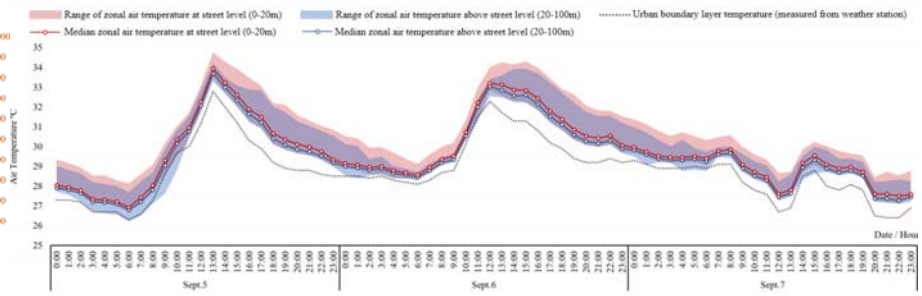
An Integrated Model for Urban Microclimate & Building Energy







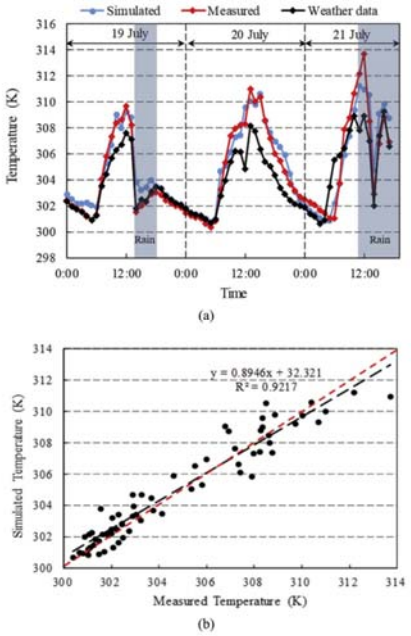




Surface temperatures

Air temperatures

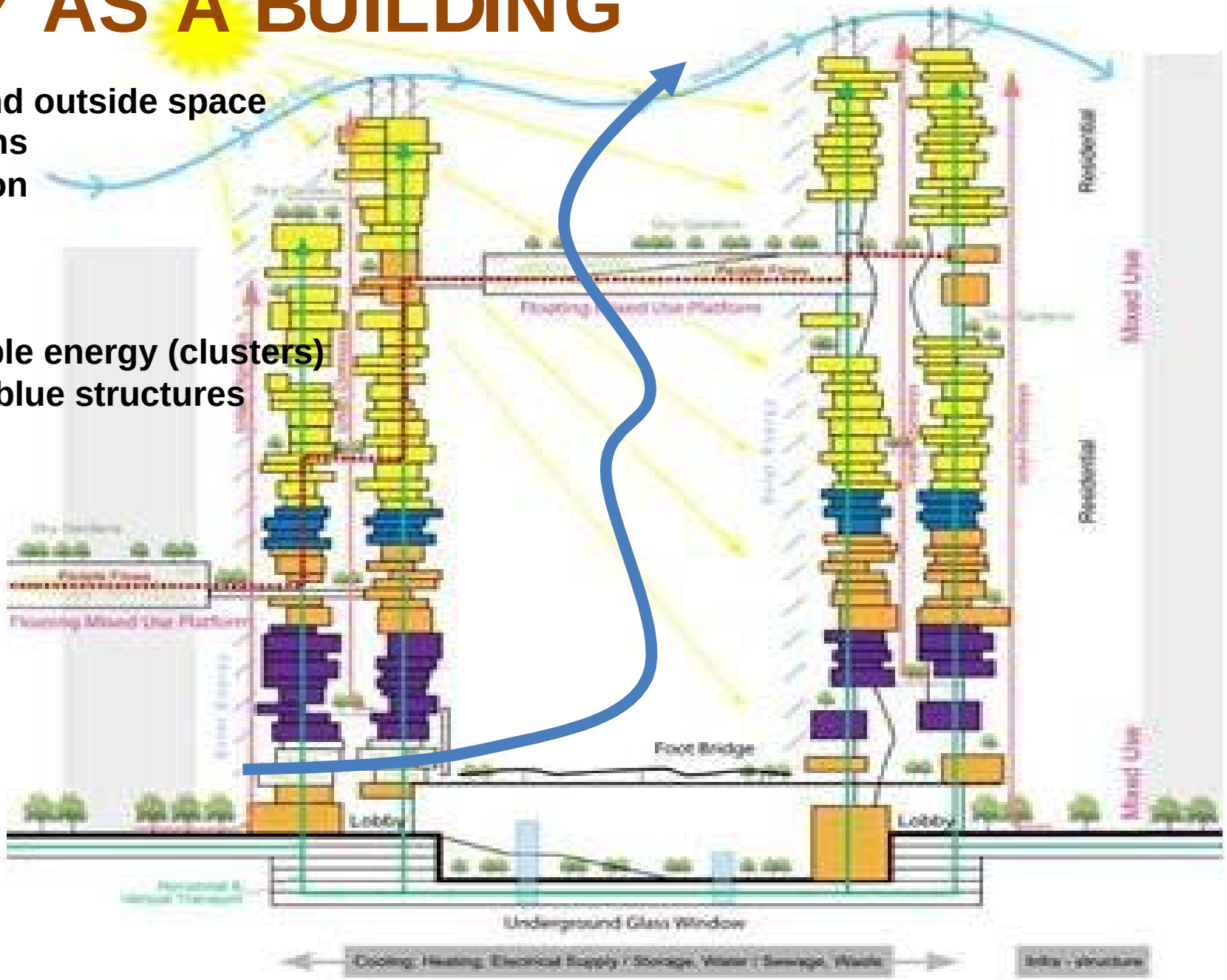
Model Testing on a Scale Concrete City (Guangzhou)



A zonal model for assessing street canyon air temperature of high-density cities
Weihui Liang, Jianxiang Huang, Phil Jones, Qun Wang, Jian Hang
Building and Environment Vol 132, 15 March 2018, Pages 160-169

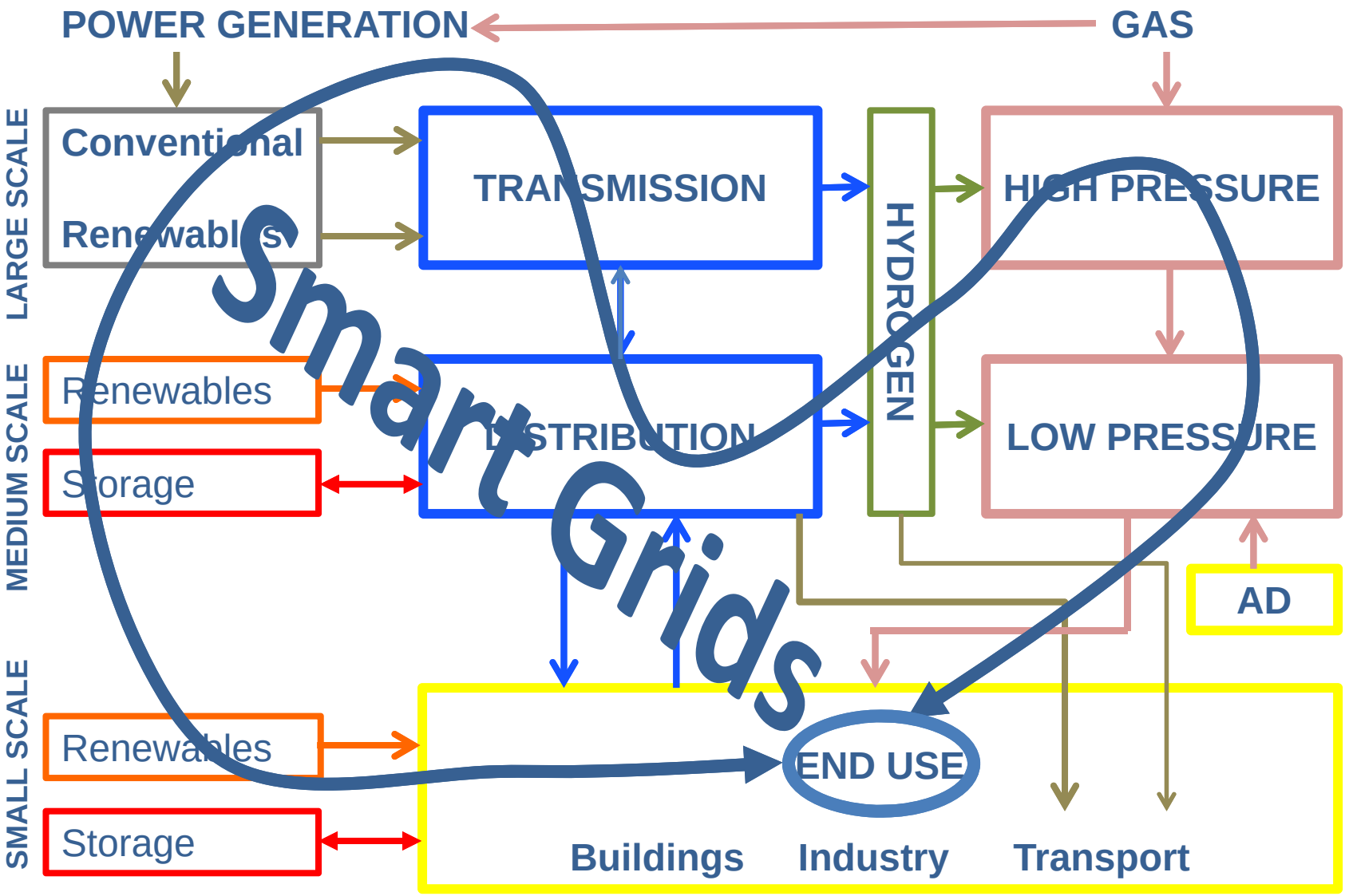
CITY AS A BUILDING

Inside and outside space
Heat gains
Ventilation
Cooling
Daylight
Noise
Renewable energy (clusters)
Green + blue structures



Range of performance

INTERNET OF ENERGY



SUMMARY

We have technologies - but not mainstream enough

We have knowledge and tools - but not widespread enough

We have done small scale – but not large scale and variation

We have to link to future energy systems

Modularisation can help deliver