

***Training on Energy Efficiency in Buildings  
of stakeholders in urban planning,  
construction and building***

***Organised by ECREEE***

**PRAIA, CABO VERDE, 9th-10th June 2014**

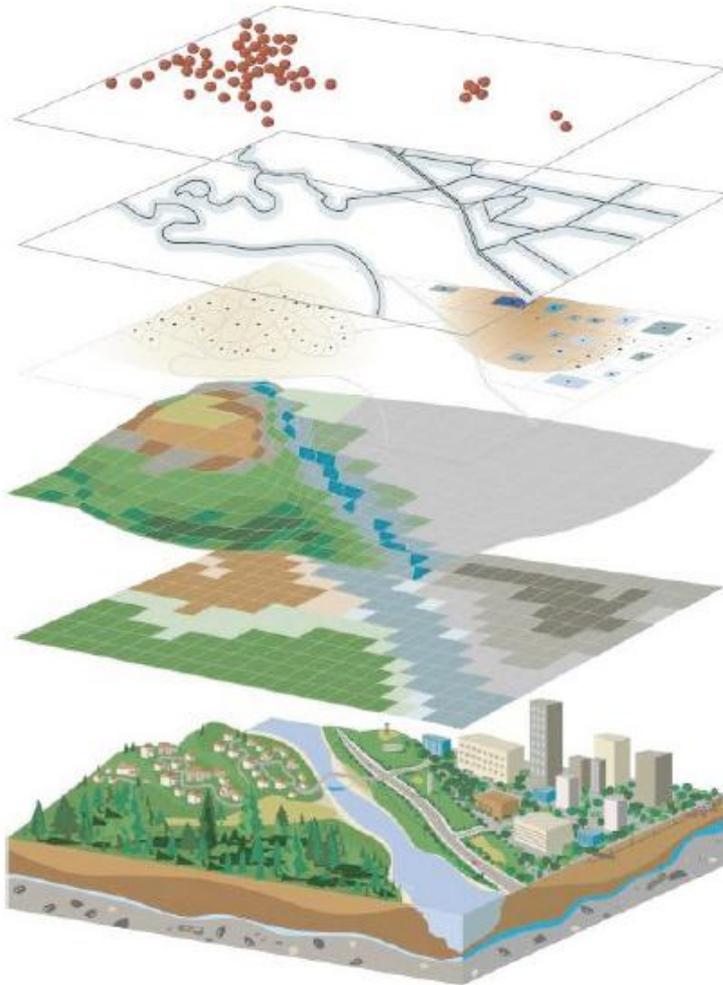
**SERA Sustainable Energy & Resources Availability**

**SUSANNE GEISSLER \_ CÉSAR FREITAS**

# *Urban Planning*

# Urban Planning

## Elements of urban morphology | relevance for energy efficiency



- > **Level one:** human beings and activities; interactions between.
- > **Level two:** street network; streets networks are a facility but also a constraint.
- > **Level three:** parcels; historic and administrative organization encouraging some forms of building.
- > **Level four:** topography of the site.
- > **Level five:** land use and repartition of activities. It affects people flows, housing allocation, and has an economic and social importance. It also determines the energy spent in transport.
- > **Level six:** three dimensions of the city. The solid and empty spaces determine air flow and sun penetration, and therefore the dispersion of pollutants and the temperature.

Serge Salat, (CSTB Urban Morphology Laboratory): Sustainable Arabic Urban Design at neighborhood scale, a Morphological Approach. Sustainable Architecture and Urban Development, Amman, 2010

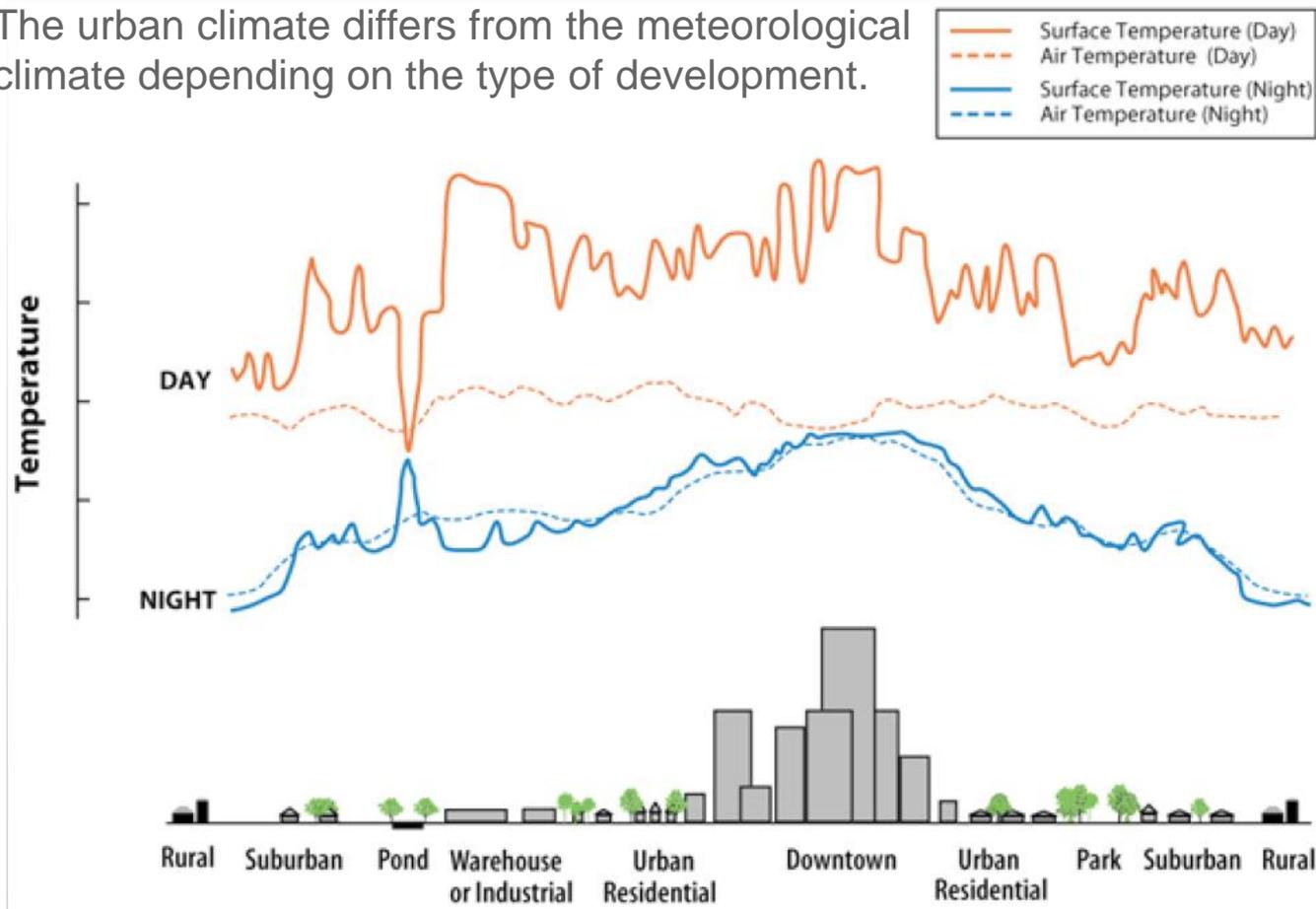
<http://urbanmorphologylab.com/proceedings/sustainable-arabic-urban-design-at-neighborhood-scale-a-morphological-approach-by-salat>

Source of picture: World Bank, Eco2 cities

# Urban Planning

## Urban climate I temperatures depends on type of development

The urban climate differs from the meteorological climate depending on the type of development.



Source: Dipl.-Ing. Sebastian Kupski Dipl.-Ing. Sabrina Campe Dipl.-Ing. René Burghardt, Klimaverständnis in ASL, Wintersemester 2013/14, FG Umweltmeteorologie, Universität Kassel, 11.11.2013 [http://www.uni-kassel.de/hrz/db4/extern/umet/cms/tl\\_files/Fachgebiet/Lehre/Seminar\\_Klima\\_ASL\\_WS1314\\_3.pdf](http://www.uni-kassel.de/hrz/db4/extern/umet/cms/tl_files/Fachgebiet/Lehre/Seminar_Klima_ASL_WS1314_3.pdf)

# ■ ■ Urban Planning

## ■ ■ Urban climate I urban heat islands

> “The term urban heat island describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C).”

> Heat islands can affect communities by increasing peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality.

<http://www.epa.gov/hiri/>

# ■ ■ Urban Planning

## ■ ■ From heat islands to cool communities

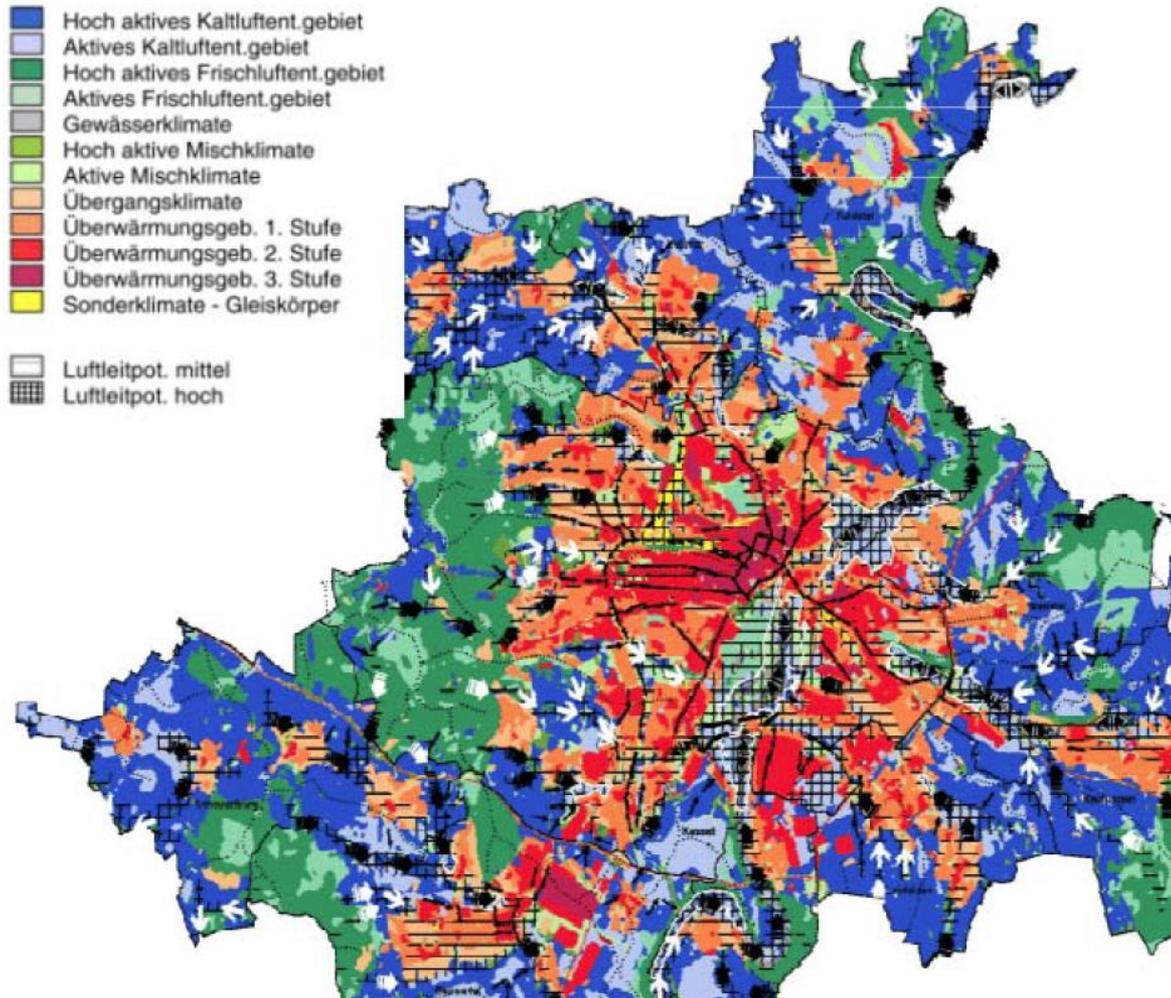
- > Cool roofing
- > Cool pavements
- > Cooling with trees and vegetation

... and other measures responding to the site specific situation

Source: Lisa Gartland: Heat Islands. Understanding and Mitigating Heat in Urban Areas. Earthscan 2008 (2011)

# Urban Planning

## Source of information | urban climate maps



Urban climate map, example  
Kassel in Germany  
(Katzschner et al. 2010)

### Color code:

Blue: Areas generating cool air

Dark green: Areas generating fresh air

### **Light red:**

Overheated area stage 1

### **Red:**

Overheated area stage 2

### **Dark red:**

Overheated area stage 3

Other colors: mixed

# ■ ■ Urban Planning

## ■ ■ Contributions to energy efficiency in buildings

Some factors determined by the urban plan:

> **Orientation** (of the city, streets and buildings)

> with regards to the sun and prevailing winds (natural ventilation and cooling)

> **City and buildings' form**

> **Natural resources: sun and wind**

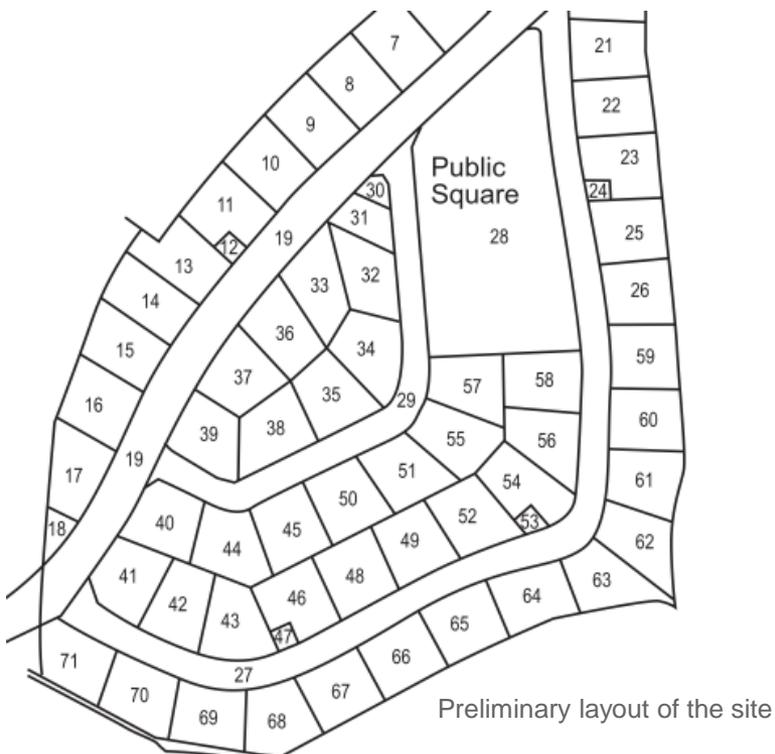
> Option for a little compressed occupation - the access to the sun and the winds for all buildings is facilitated (regardless of the choice of low or high densities)

> Ensuring the buildings the right of access to the sun makes it possible to implement an efficient policy of using solar heating for hot water preparation (shower). In some climates, the access to natural ventilation is very important for the passive thermal comfort in buildings. In addition to the establishment of a solar envelope, the position of the building on the ground should not harm the penetration of winds within the mesh. Urban planning can take advantage of natural resources to improve the thermal and light conditions of the buildings. Thus, it reduces the need for active systems, consequently obtaining a reduction in energy use.

# Urban Planning

## Contributions to energy efficiency in buildings

> Layout of the site, taking orientation and wind flow into account (use or prevent, depending on the local conditions)



Source: Eco-housing Guidelines for Tropical Regions; UNEP RRCAP; Bangkok, Thailand, December 2006

# ■ ■ Urban Planning

## ■ ■ Contributions to energy efficiency in buildings

### > Density

> The most compact cities and with higher density use less energy, because of less dependence of citizens on automobiles, and can decrease the portion of land occupied by the city (preserving more green areas and proofing less soils).

However, large densities may contribute to climatic changes at the micro level:

> shape and height of buildings have direct influence on the winds and on access to sun resources. When the wind penetration in the urban grid is impaired, there is a local temperature rise.

The decrease in the sky view factor hinders the absorption of heat waves emitted by buildings at night. This fact is related to the formation of the urban heat island. Along with increasing temperature, there is also increased consumption of energy to maintain thermal comfort inside the buildings in warm climates.

# ■ ■ Urban Planning

## ■ ■ Contributions to energy efficiency in buildings

### > **Mobility**

> The design and organization of the city directly influence the movement of persons and goods.

> The urban planner can contribute by reinventing the concept of public transport, restructuring planning processes, infrastructure development and management of mobility, by providing solutions to the competition between the transport of passengers and goods, by anticipating solutions to congestion between cities, and by proposing options for the mobility of people and goods.

### > **Aggregate energy (Embodied energy)**

> Aggregate energy is the one that was consumed during the production of building materials.

> Factors such as little use and little development of new technologies, waste of materials, low professional qualification, and low quality of life of workers result in the low global energy efficiency in this sector.

> Energy efficiency of the elements that make up the urban environment is also related to efficiency and environmental impact, at the building level and at the urban scale.

# Urban Planning

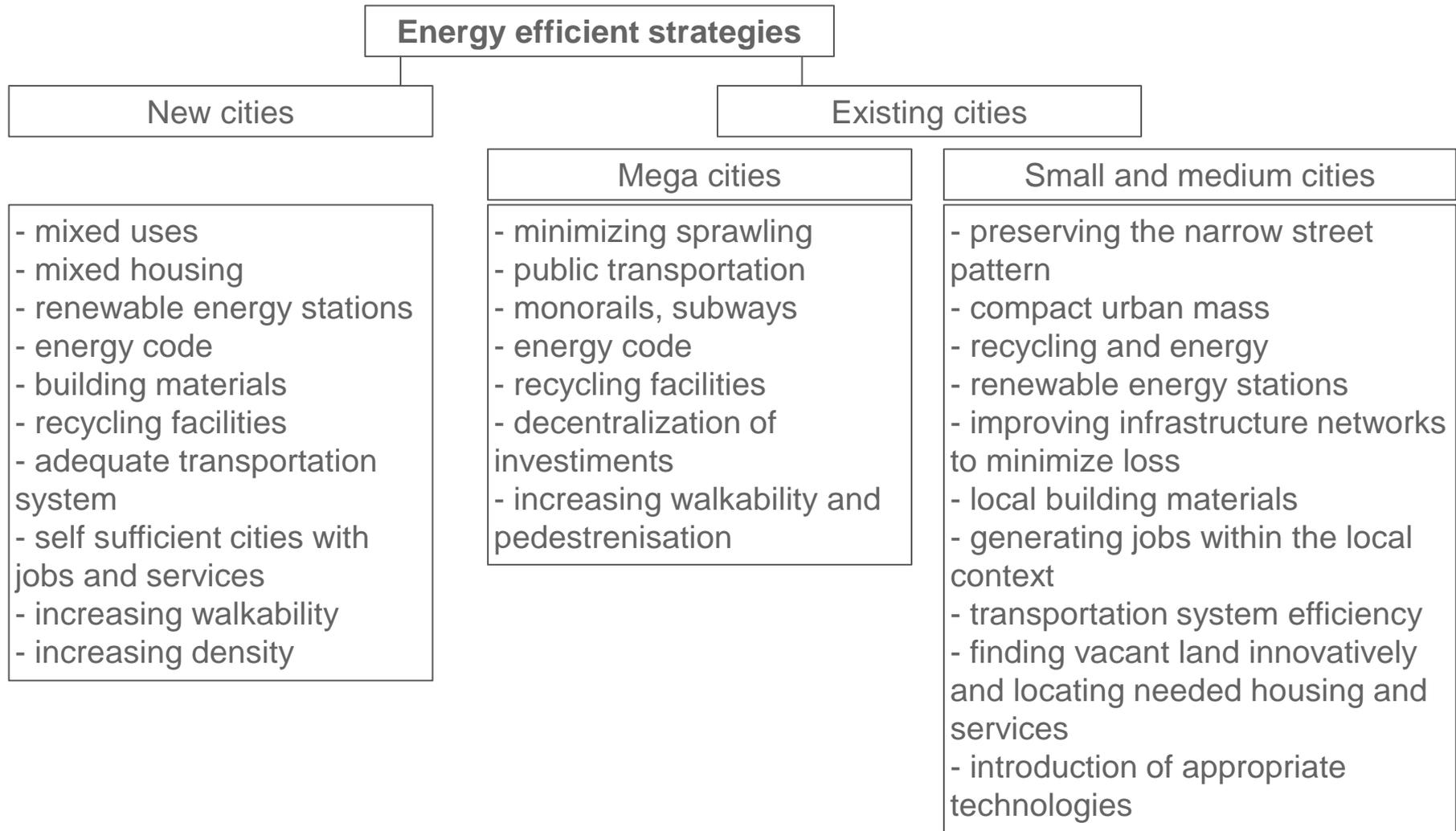
## Contributions to energy efficiency in buildings

- > Dimensions of the open spaces such as squares (air movements)
- > Distribution of green spaces and water features
- > Vegetation type



# ■ ■ Urban Planning

## ■ ■ Energy efficiency strategies in cities



# Urban Planning

## The Masdar City example



> Google Earth – location of Masdar City in UAE

# Urban Planning

## The Masdar City example



### > Energy concept of Master Plan based on vernacular principles:

> Optimally orienting the city grid and buildings to minimize solar heat gain on building walls and the street, while maximizing cooling nighttime breezes.

> During the day wind comes from North-west from the sea which is flat and warm (35°C), and thus heats up to 45-47°C and is very humid. This wind is blocked from the city by the way roads are arranged and by means of wind towers.

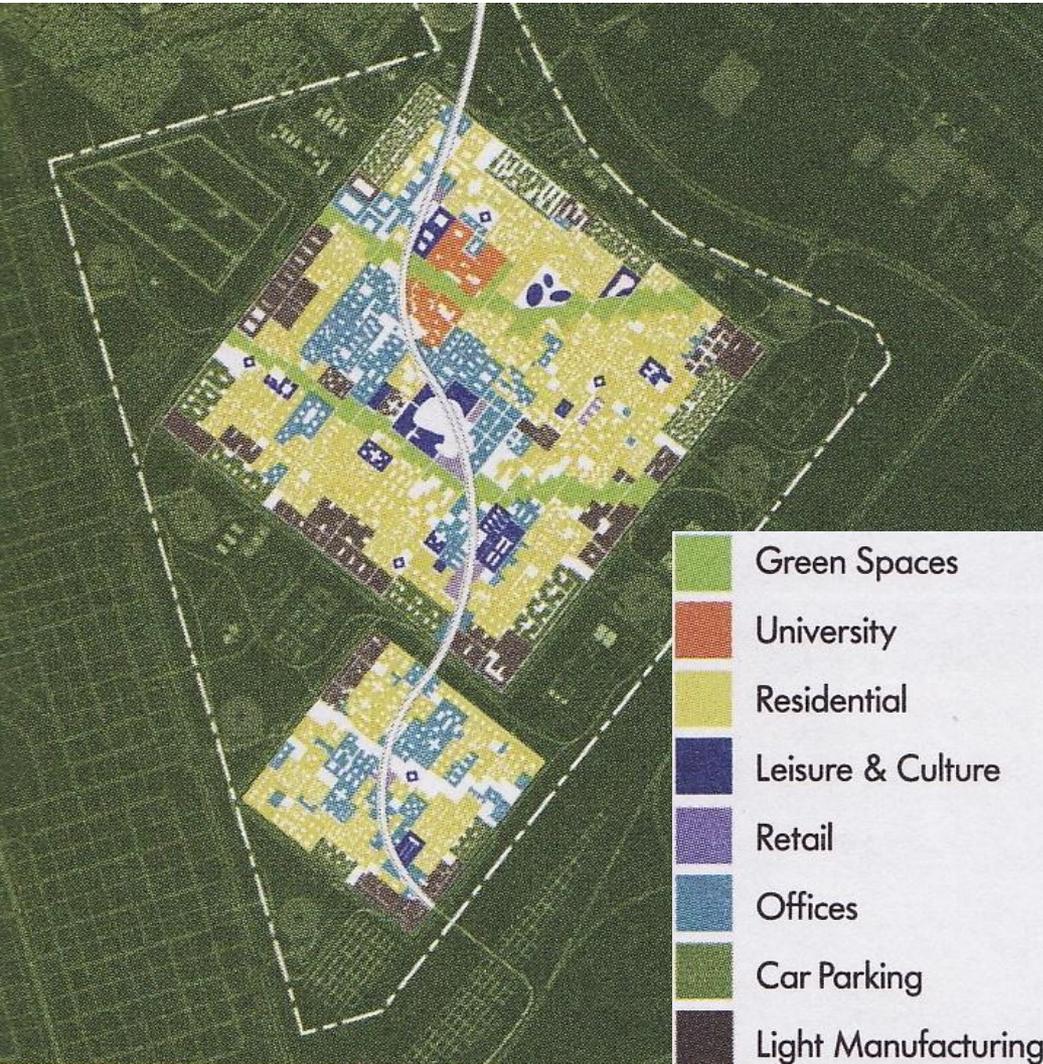
> The city is densely built which means that buildings shade each other and the streets, as well.

> Green courtyards provide daylight for the buildings.

Source: Post-Oil City (engl.) The History of the City's Future  
 ISBN 978-3-931435-18-9 <http://www.archplus.net/home/post-oil-city/>

# Urban Planning

## The Masdar City example



> Masdar has an integrated nature: all aspects of city life are integrated and all in close proximity, for convenience and to minimize use of transportation.

> The transport system of Masdar City is based on electric cars because emissions from fossil fuels contribute to the heat island effect.

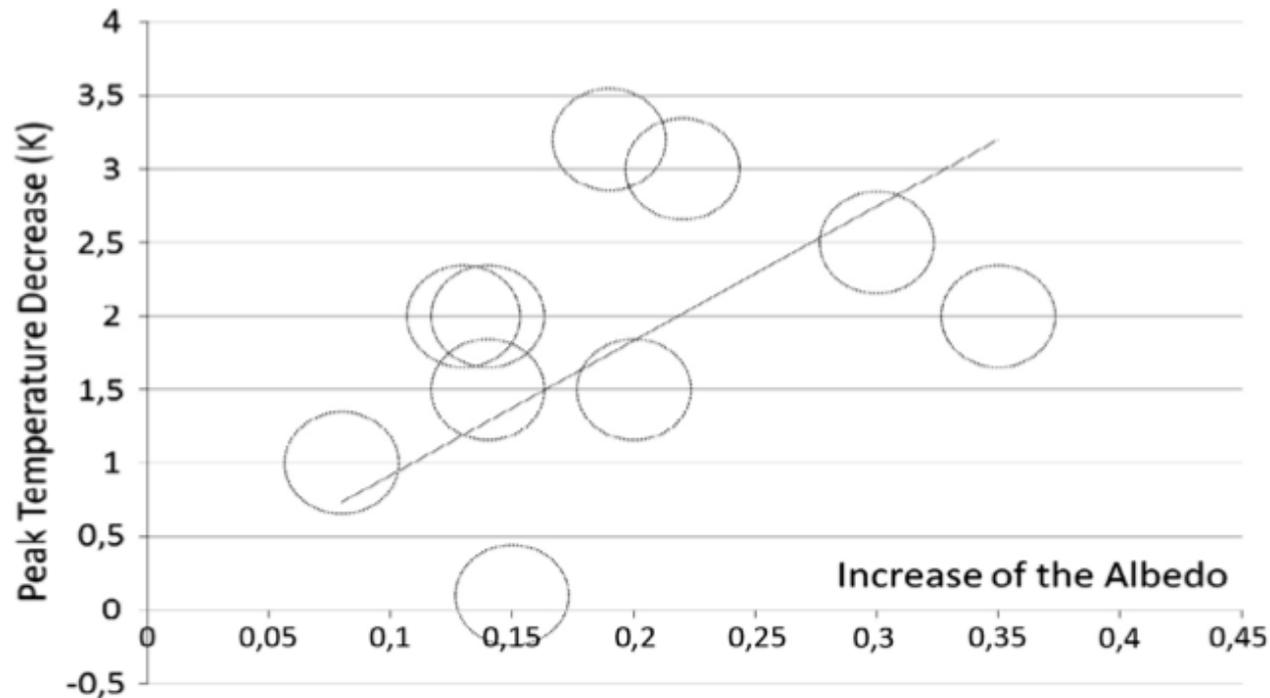
> There is a car parking at the city border where people change to the electric transport system.

> Masdar is pedestrian focused - narrow, shaded streets, and pleasant shaded walkways and other paths that encourage walking. The integrated nature of the city means it's not far to walk to many destinations.

# Urban Planning

## Increase of albedo and decrease of temperature

> Correlation between the possible albedo change and the corresponding decrease of the peak ambient temperature in urban areas.



Source: Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments M. Santamouris. Group Building Environmental Research, Physics Department, University of Athens, Athens, Greece. Solar Energy 103 (2014) 682–703

# Urban Planning

## Measures during various planning stages and cooling effects

	Type of cooling effect	Reduce / manage heat storage	More evaporation	More transpiration	More shading	More reflection	More cool air generation	More ventilation	Increase Sky-View-Factor	Additional benefits
Planning stage	Measures									
Zoning plan	Urban farming (large areas)	x	x	x			x		x	Local food supply
	Parks (large areas)	x	x	x			x		x	Recreation
	Control of wind flows							x		Air pollution control
Layout plan	Compactness of building geometry (reduction of wall surface)	x								Efficient material use
	Orientation of buildings	x								
	Overhangs				x					
	Building height and density				x					Efficient material use
	Layout to making use of beneficial wind flows							x		Air pollution control
	Green and shaded courtyards	x	x	x	x					Provide daylight
	Trees (with closed crowns) in the streets and courtyards	x	x	x	x					Air purification (e.g. particles)
	Cover with plants and grass	x	x	x						
	Materials with high albedo						x			
Cool paving and paving with low soil sealing degree	x	x	x							



## Urban Planning

### ENVI-met tool for the simulation of surface-plant-air interactions

> ENVI-met is a three-dimensional non-hydrostatic model for the simulation of surface-plant-air interactions not only for but especially inside urban environments. It is designed for microscale with a typical horizontal resolution from 0.5 to 10 m and a typical time frame of 24 to 48 hours with a time step of 10 sec at maximum. This resolution allows to analyze small-scale interactions between individual buildings, surfaces and plants. <http://www.envi-met.com/>

> The model calculation includes:

- > Shortwave and longwave radiation fluxes with respect to shading, reflection and re-radiation from building systems and the vegetation
- > Transpiration, evaporation and sensible heat flux from the vegetation into the air including full simulation of all plant physical parameters (e.g. photosynthesis rate)
- > Surface and wall temperature for each grid point and wall
- > Water- and heat exchange inside the soil system
- > Calculation of biometeorological parameters like Mean Radiant Temperature or Fanger's Predicted Mean Vote (PMV) -Value
- > Dispersion of inert gases and particles including sedimentation of particles at leafs and surfaces
- > Buildings, vegetation, soils/ surfaces and pollutant sources can be placed inside the model area. Besides of natural and artificial surfaces, the model is also able to handle water bodies.

***Thank you for your attention!***

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