Hot Science Cool Talks

UT Environmental Science Institute

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Design with Climate: Building for a Cooler Planet

Dr. Werner Lang

February 27, 2009

www.esi.utexas.edu

Design with Climate:
Building for a Cooler Planet

Dr. Werner Lang
Associate Professor of Architecture
The University of Texas at Austin

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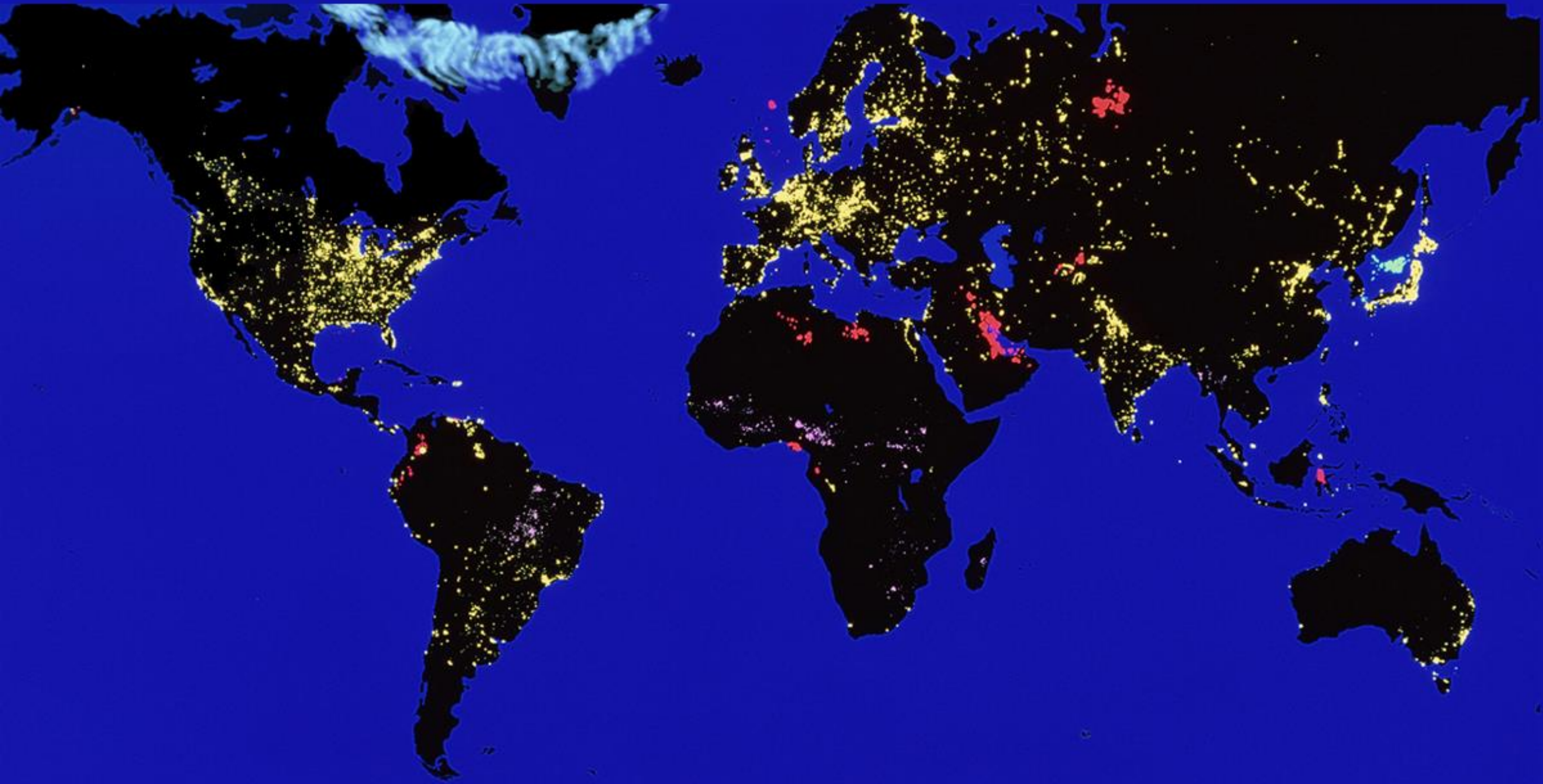
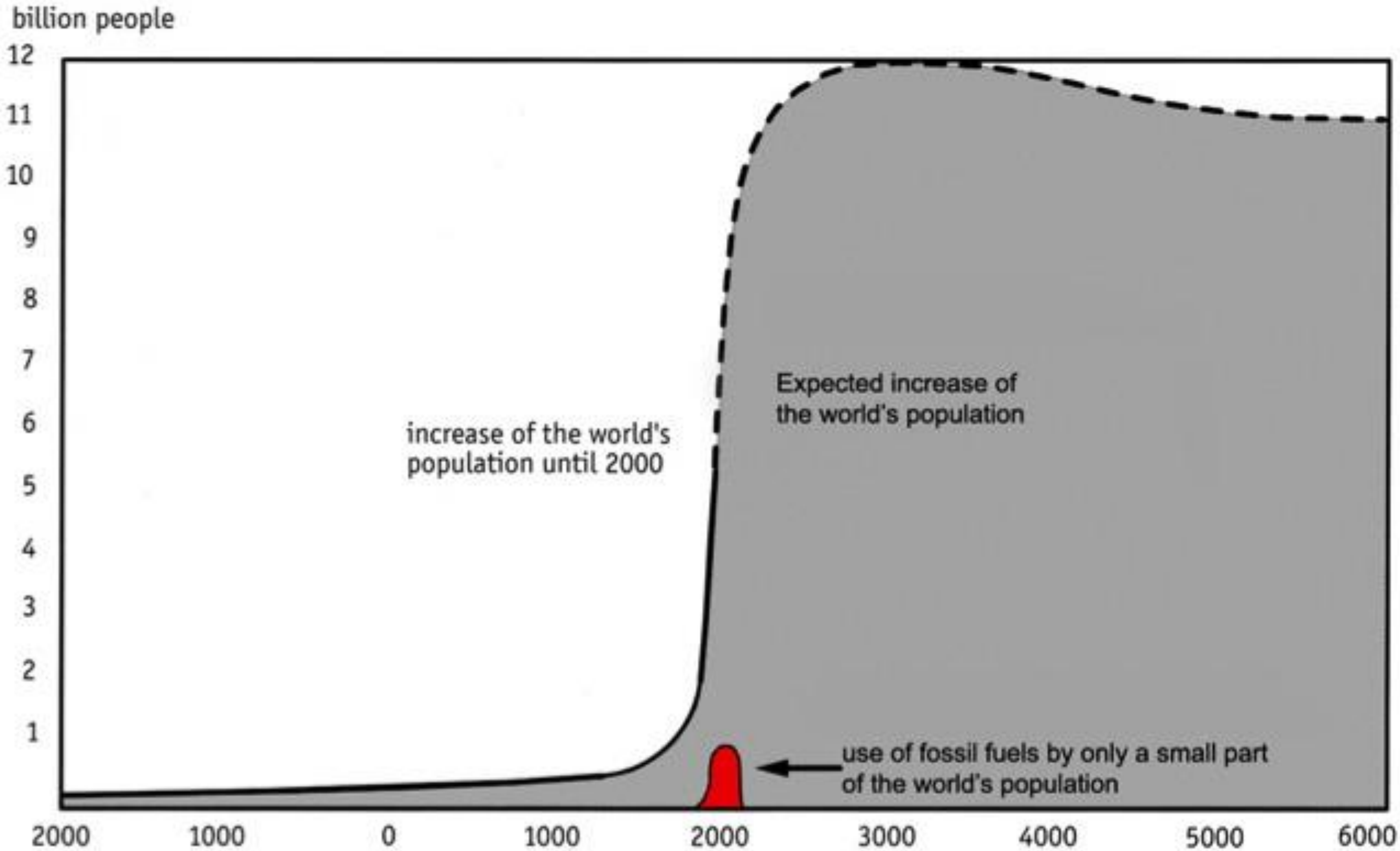
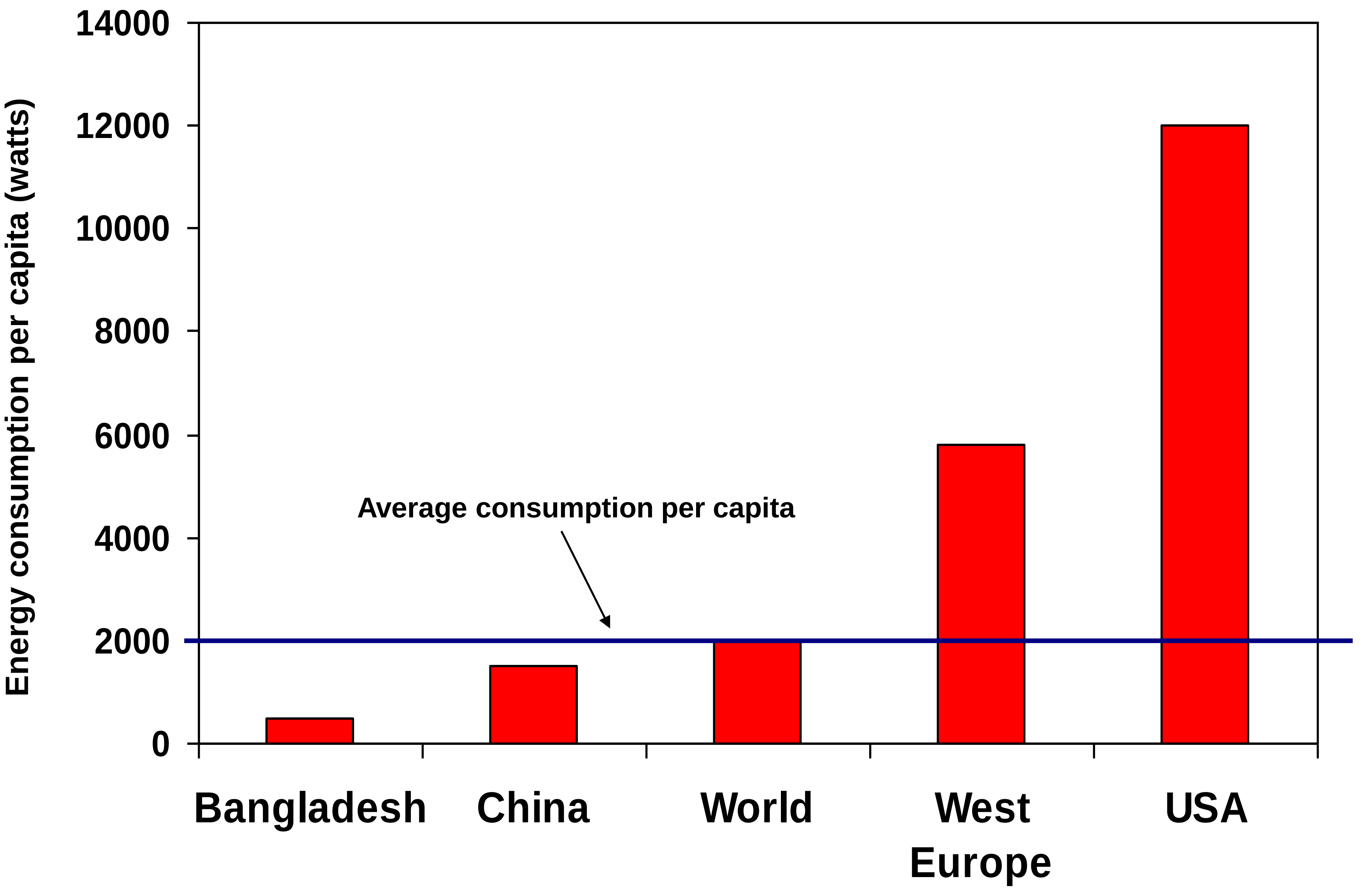
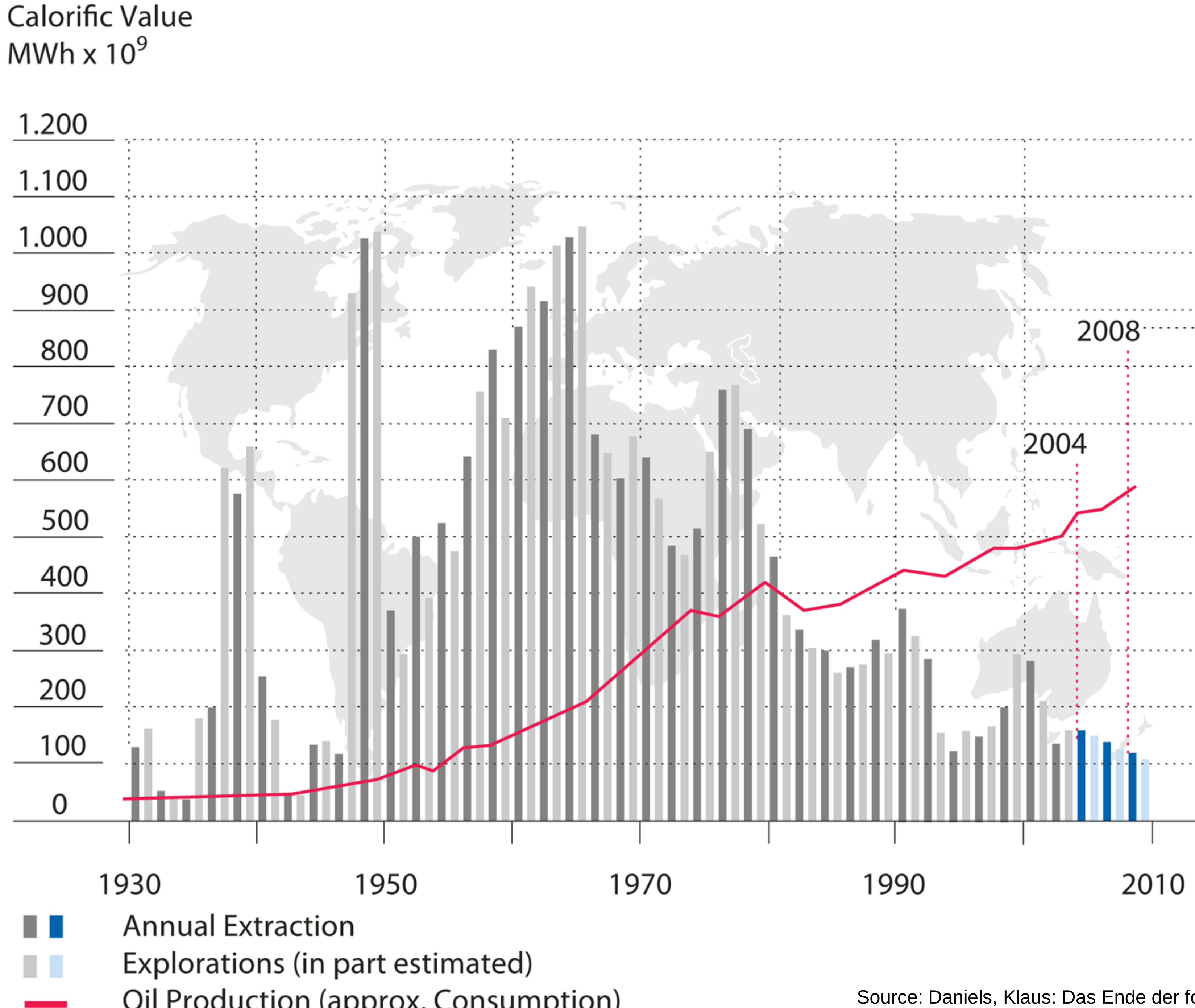
ESI · SECO State Energy Conservation Office · CSD Center for Sustainable Development · UTSOA



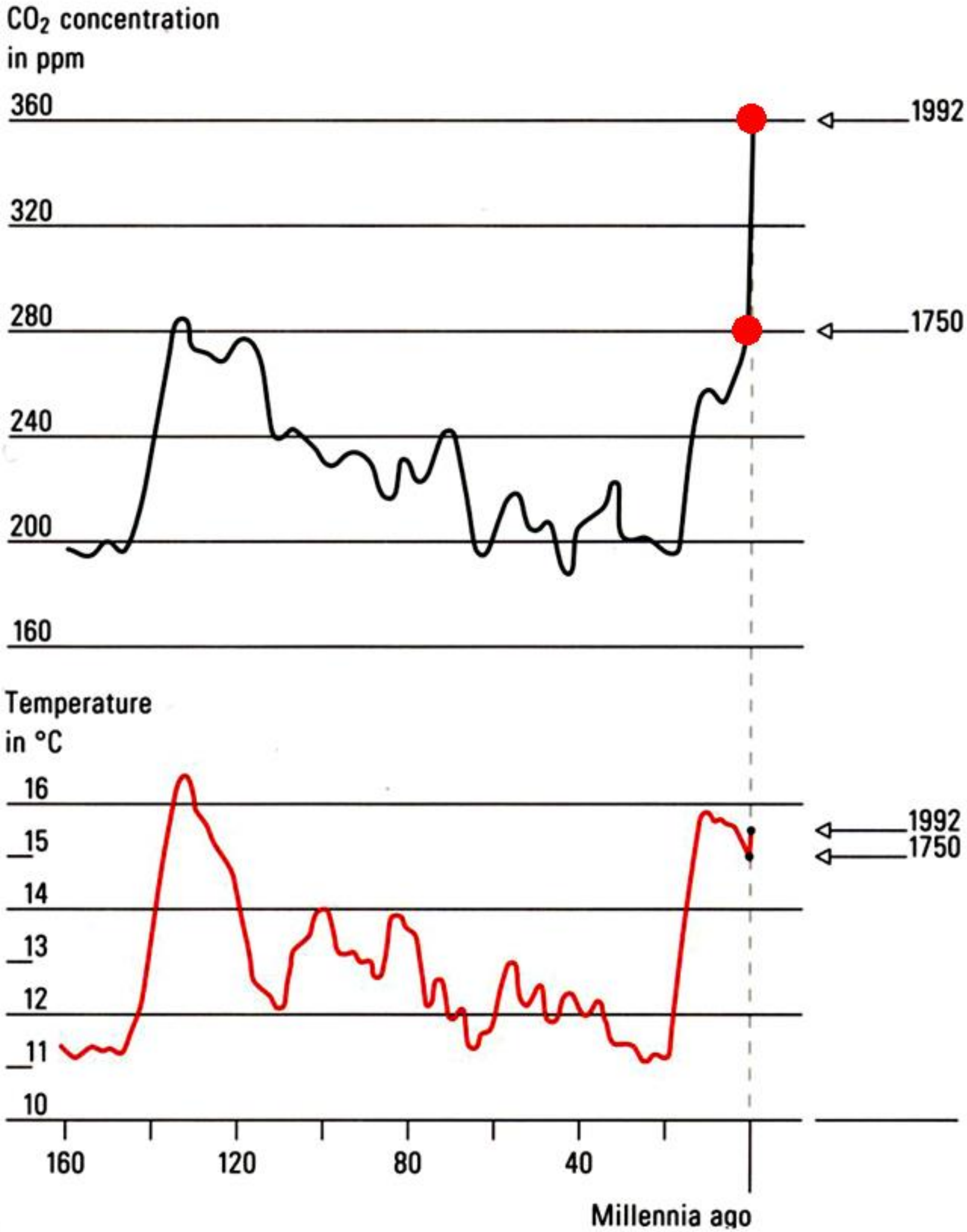

billion people
12
11
10
9
8
7
6
5
4
3
2
1
increase of the world's population until 2000
Expected increase of the world's population
use of fossil fuels by only a small part of the world's population
2000
1000
0
1000
2000
3000
4000
5000
6000



Source: Stulz, Roland. Die 2000-Watt-Gesellschaft.
In: archplus 184, October 2007, p. 40-41

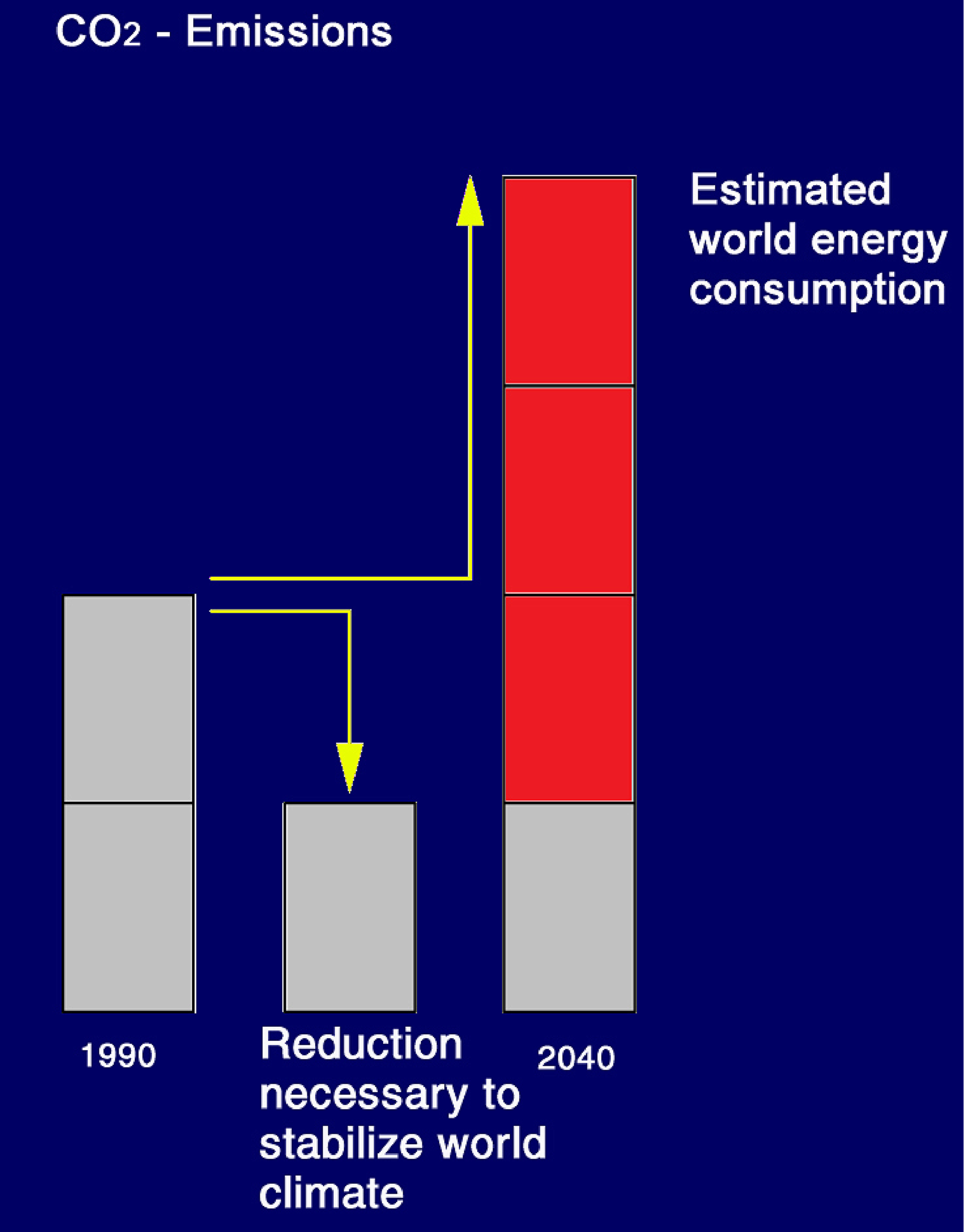


Source: Daniels, Klaus: Das Ende der fossilen Ära.
In: archplus 184, October 2007, p. 34-35

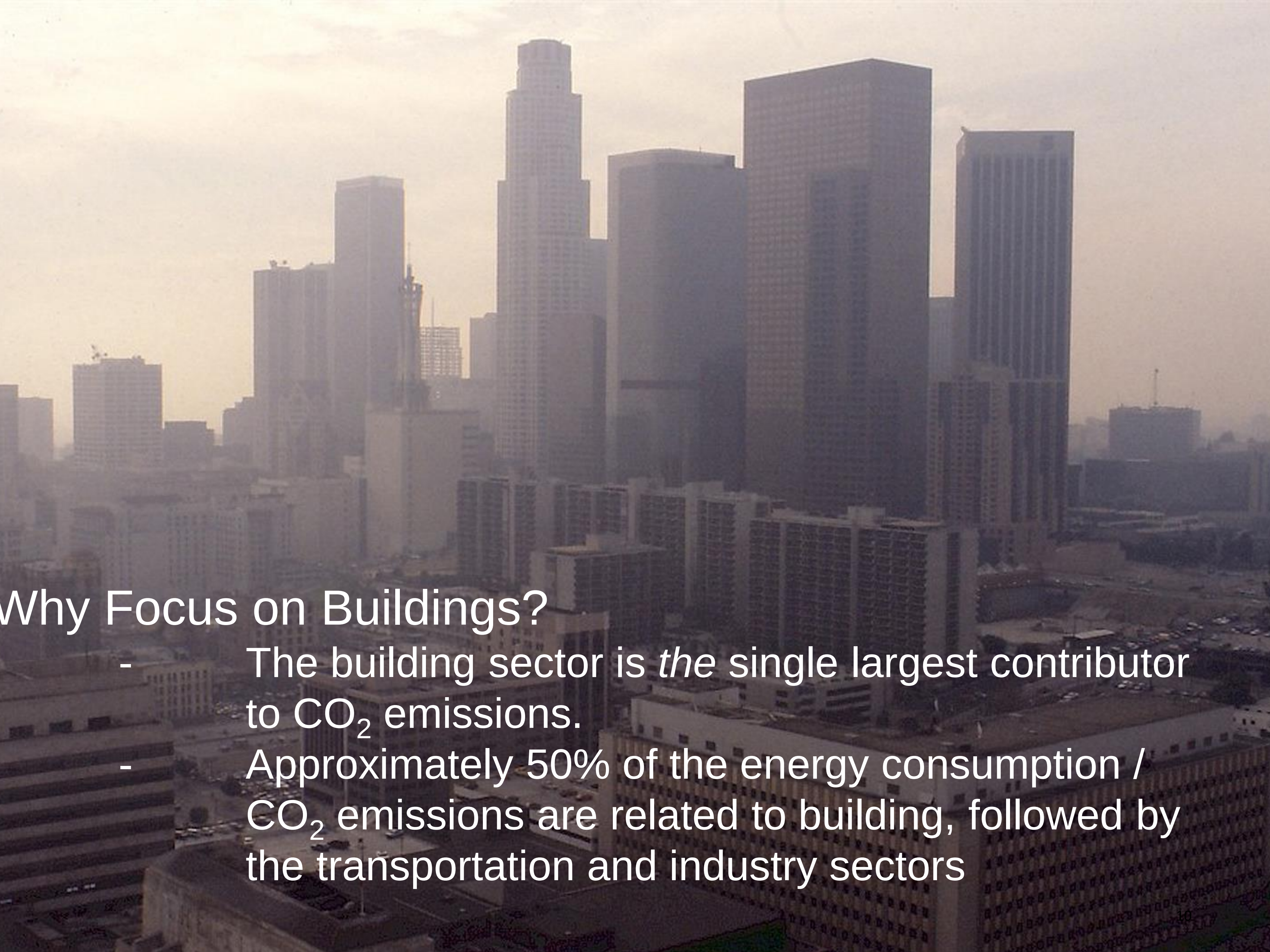


Relationship between CO2 concentration and global warming

Source: Daniels, Klaus. The Technology of Ecological Building, Basel: Birkhäuser, 1997. p. 22



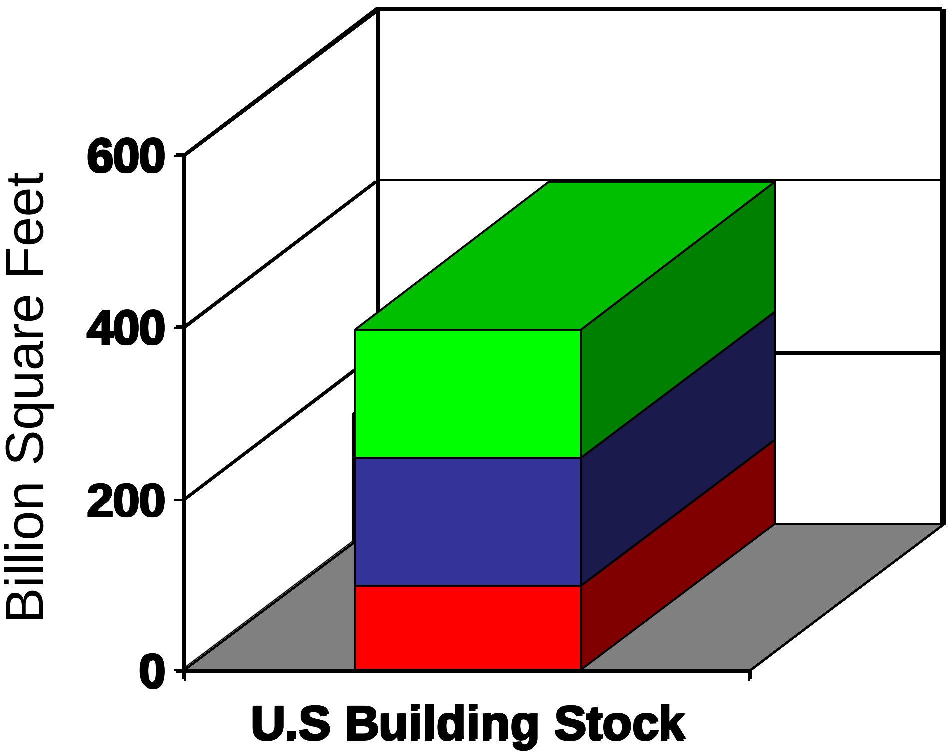
To stabilize the climate, we must use less energy.



Why Focus on Buildings?

- The building sector is *the* single largest contributor to CO_2 emissions.
- Approximately 50% of the energy consumption / CO_2 emissions are related to building, followed by the transportation and industry sectors

Why Focus on Buildings?



Over the next 30 years….

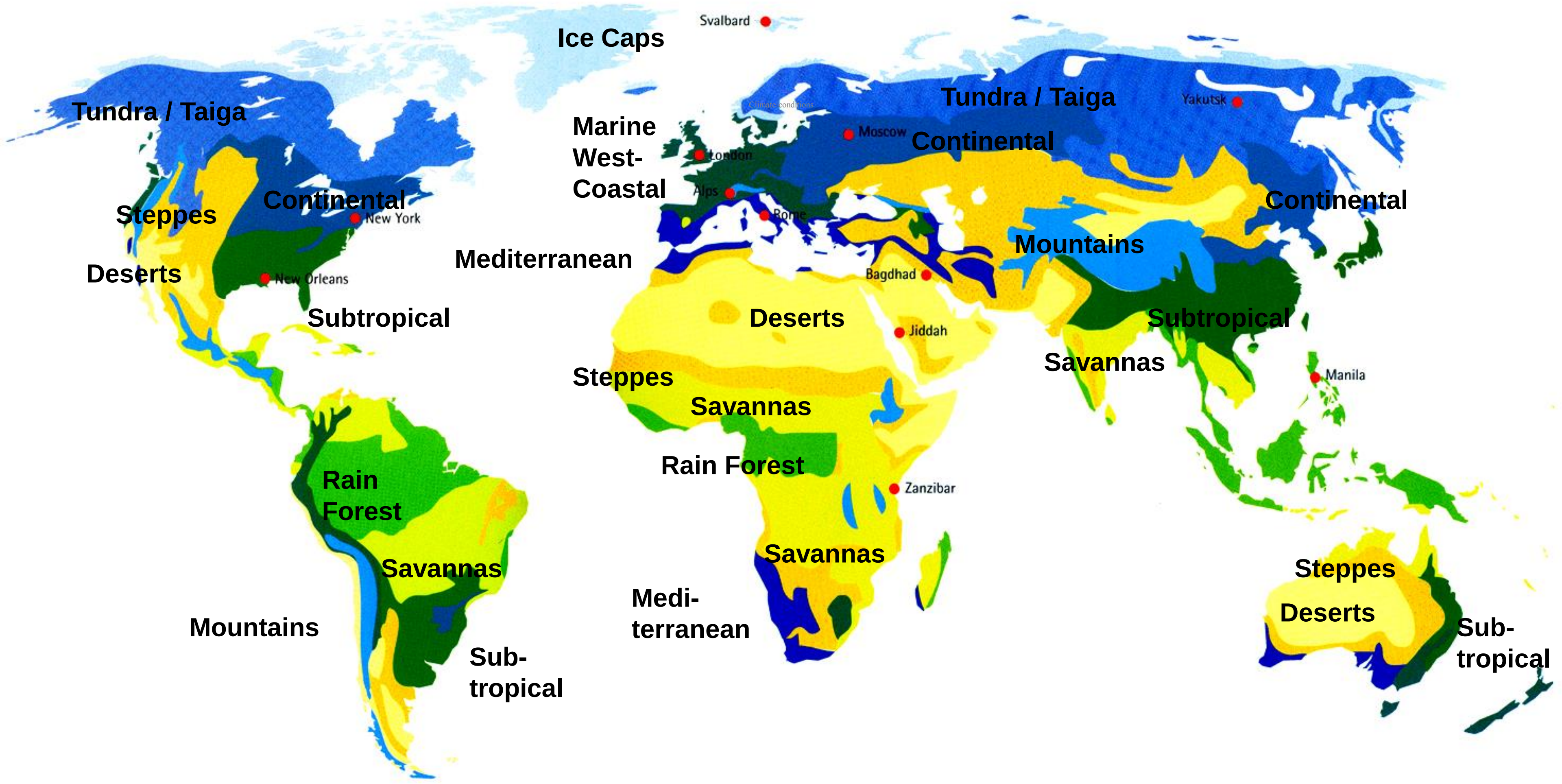
52 billion sf will be demolished….

150 billion sf will be remodeled…

150 billion sf will be new construction…

By 2035, almost 75% of our built environment will either be new or renovated.

What do we need to know for building the future?



Climate Conditions: The Earth‘s Comfort Zones


Ice Caps


Tundra / Taiga


Mountains/Continental


Marine West-Coastal


Mediterranean


Subtropical

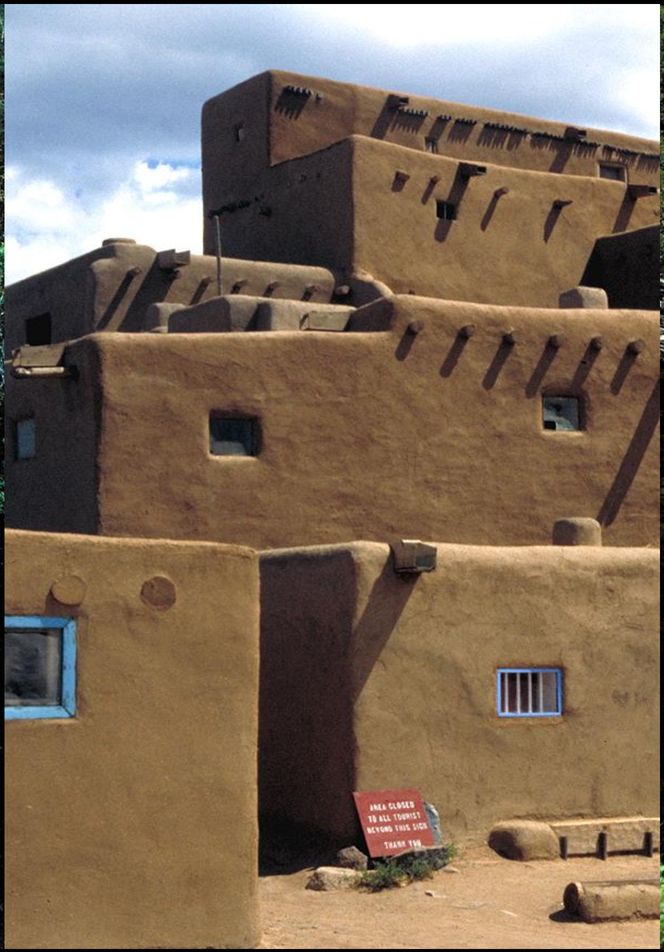

Rain Forest


Savannas/Steppes


Deserts

Tree House ‚Khaim‘, tribe of the ‚Korowai‘,
Western-New Guinea, 1996

Hot and humid all year



Taos Pueblo, New Mexico; USA

Hot and dry summers
Cold and dry winters

Farm Building in the Verzasca Valley, CH

Moderate/sunny summers
Cold and wet winters

Administration Building Budapest, Török Bank, 1906
Heinrich Böhm, Armin Hegedös

Building design related to local conditions

Administration Building Los Angeles, Two California Plaza, 1992, Arthur Erickson

Building design not related to local conditions

Challenges:

1. Reduce the energy demand

2. Enhance the comfort

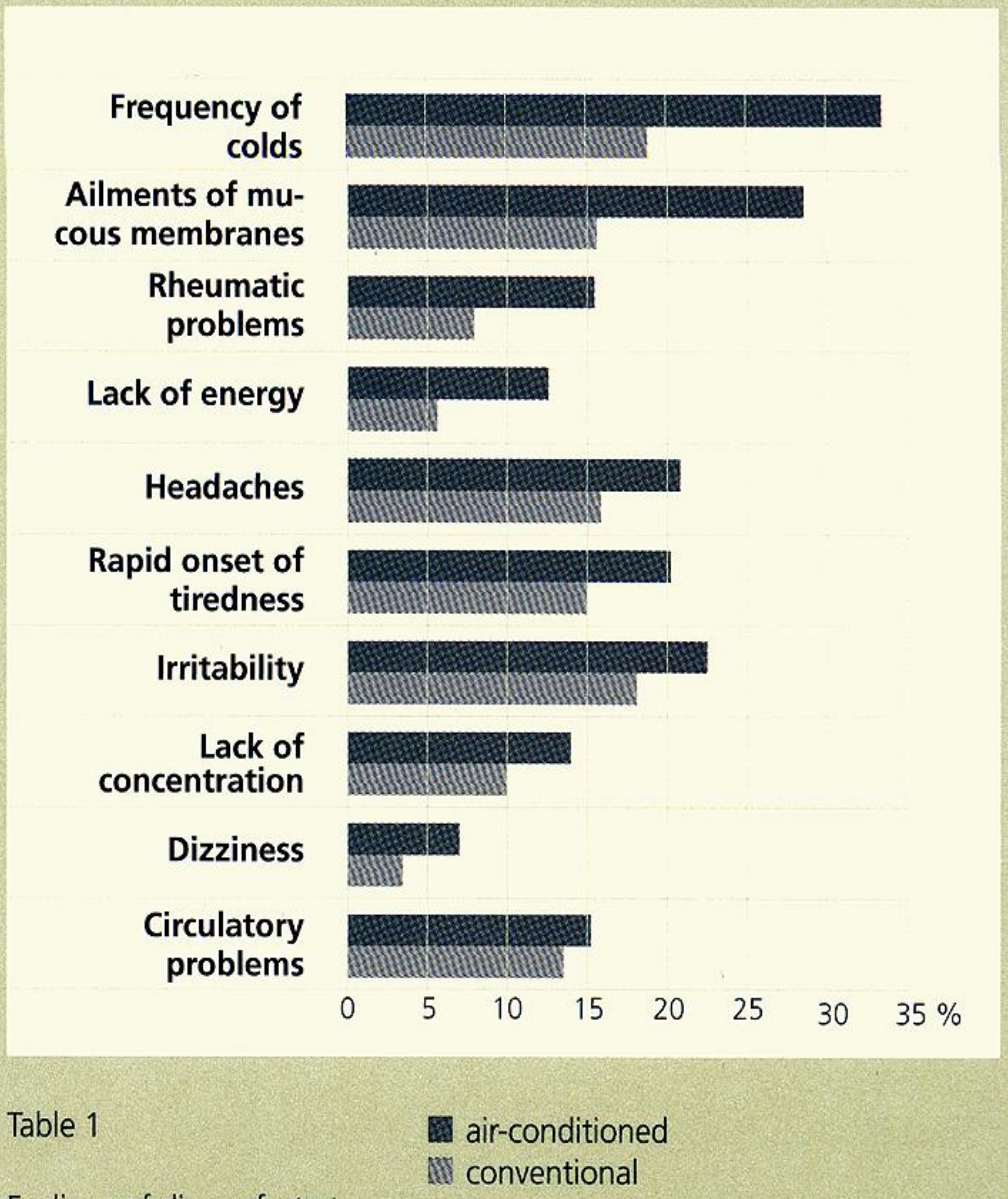


Table 1

Feelings of discomfort at conventional and air-conditioned workplaces

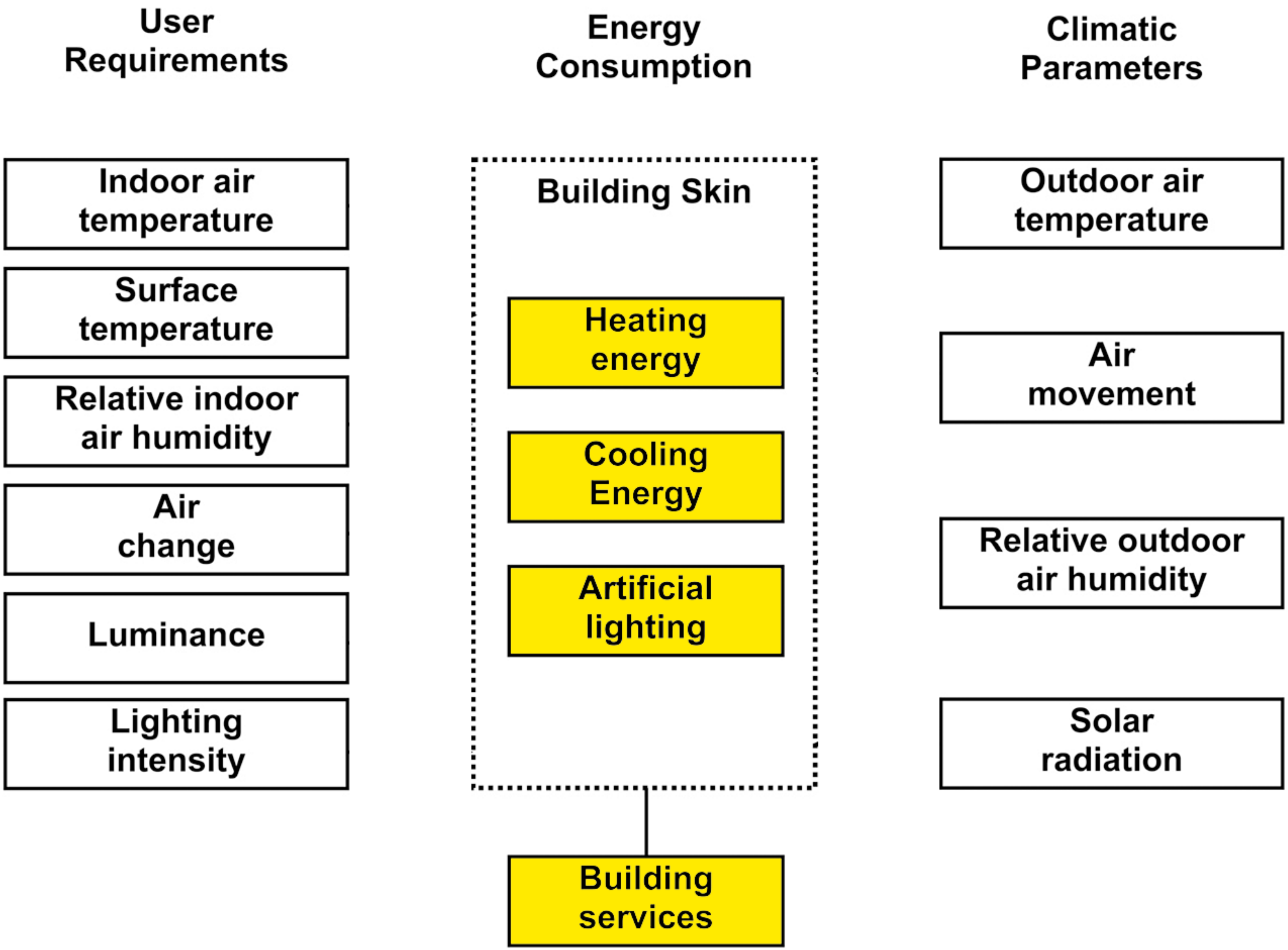
Source: Gartner: Double-Skin-Facades, 1998, p. 10.

Lessons learned from the past

Comfort:
Architecture is an answer to functional requirements of the user

Climatic conditions:
Architecture is derived from the outer conditions of the site

Energy:
Energy consumption is dependent on the performance of the building envelope

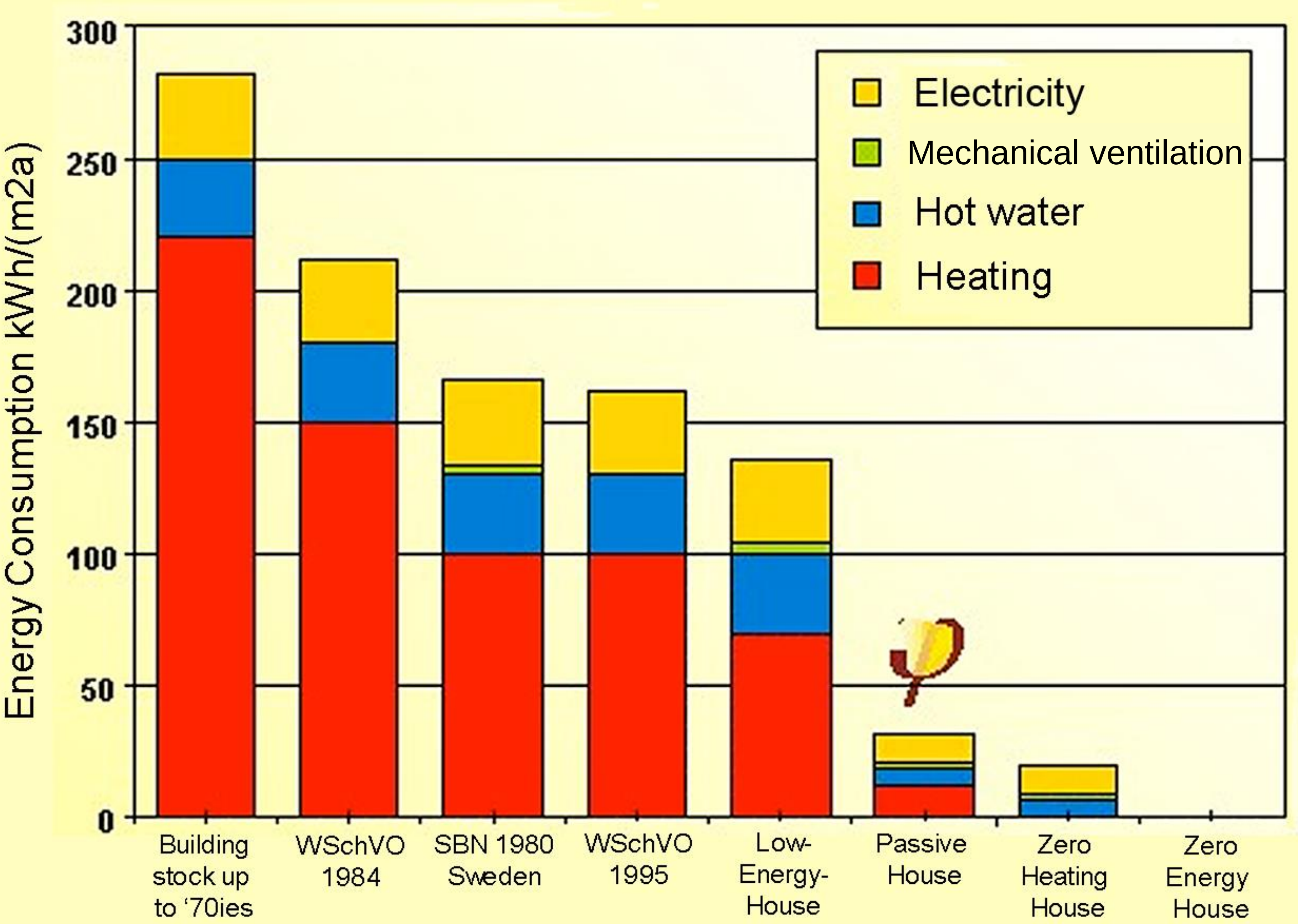

User Requirements
Energy Consumption
Climatic Parameters
Indoor air temperature
Surface temperature
Relative indoor air humidity
Air change
Luminance
Lighting intensity
Building Skin
Heating energy
Cooling Energy
Artificial lighting
Building services
Outdoor air temperature
Air movement
Relative outdoor air humidity
Solar radiation

What are the alternatives?

CO_2 emissions and use of fossil fuel must be reduced drastically:

Energy conservation:
-> Building design and construction

Use of renewable energies:
-> Building design and construction:



Source: http://www.passiv.de (02/03/2008)

Consumption of energy in building

Production Energy

How much energy will it take to build, maintain, and tear down/recycle this building?

Operating Energy

How much energy will it take to make people comfortable inside this building?

Induced Energy

How much energy will it take to use this building (drive there or supply it with goods)?


…and the demolition of our built environment.

Tjibaou Cultural Centre, Noumea, New Caledonia, 1998. Arch.: Renzo Piano Building Workshop

Source: Jodidio, Philip. Renzo Piano Building Workshop 1966 – 2005. Köln: Taschen 2005, p. 279

EXPO Pavilion Hanover, 2000
Arch.: Herzog +Partner
Source: Flagge, Herzog-Loible, Meseuer: Thomas Herzog: Architecture +Technology, München: Prestel 2001, p. 135

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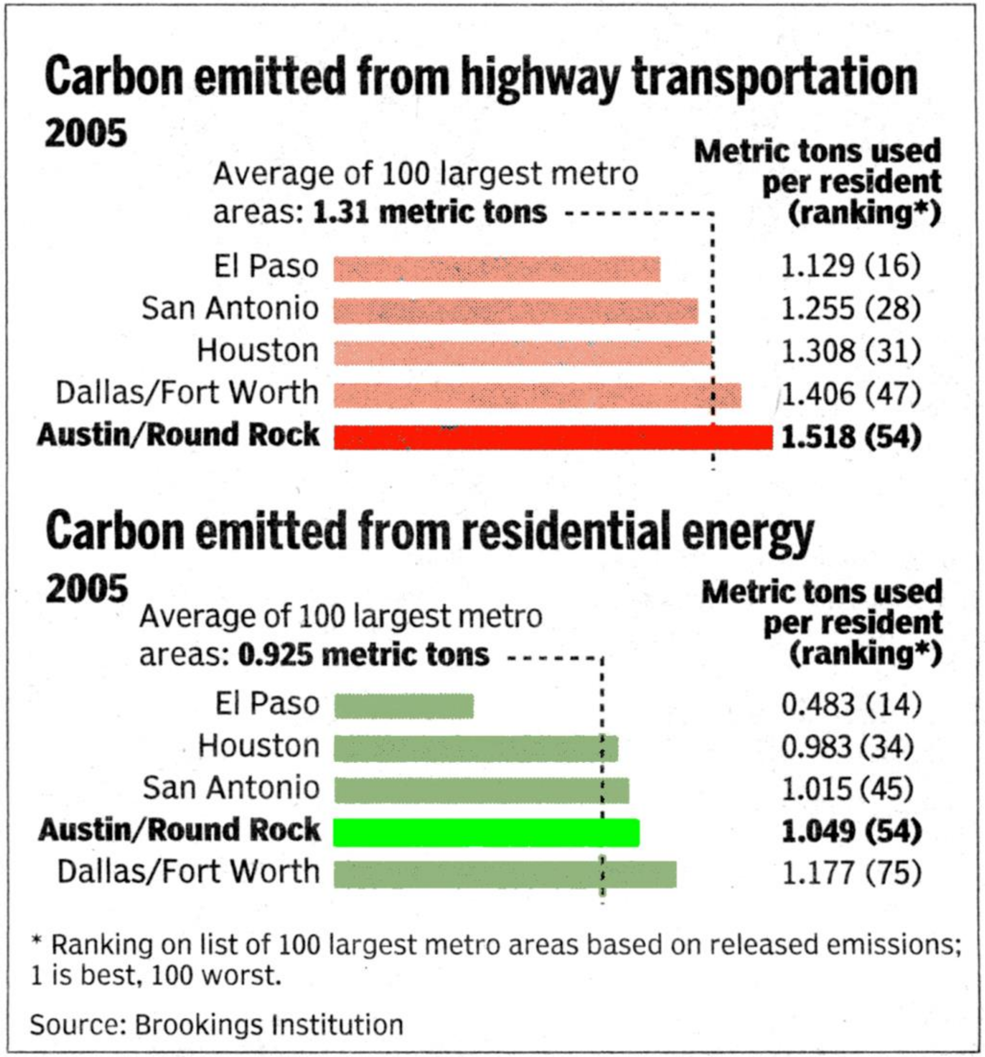


Mary Coppinger AMERICAN-STATESMAN

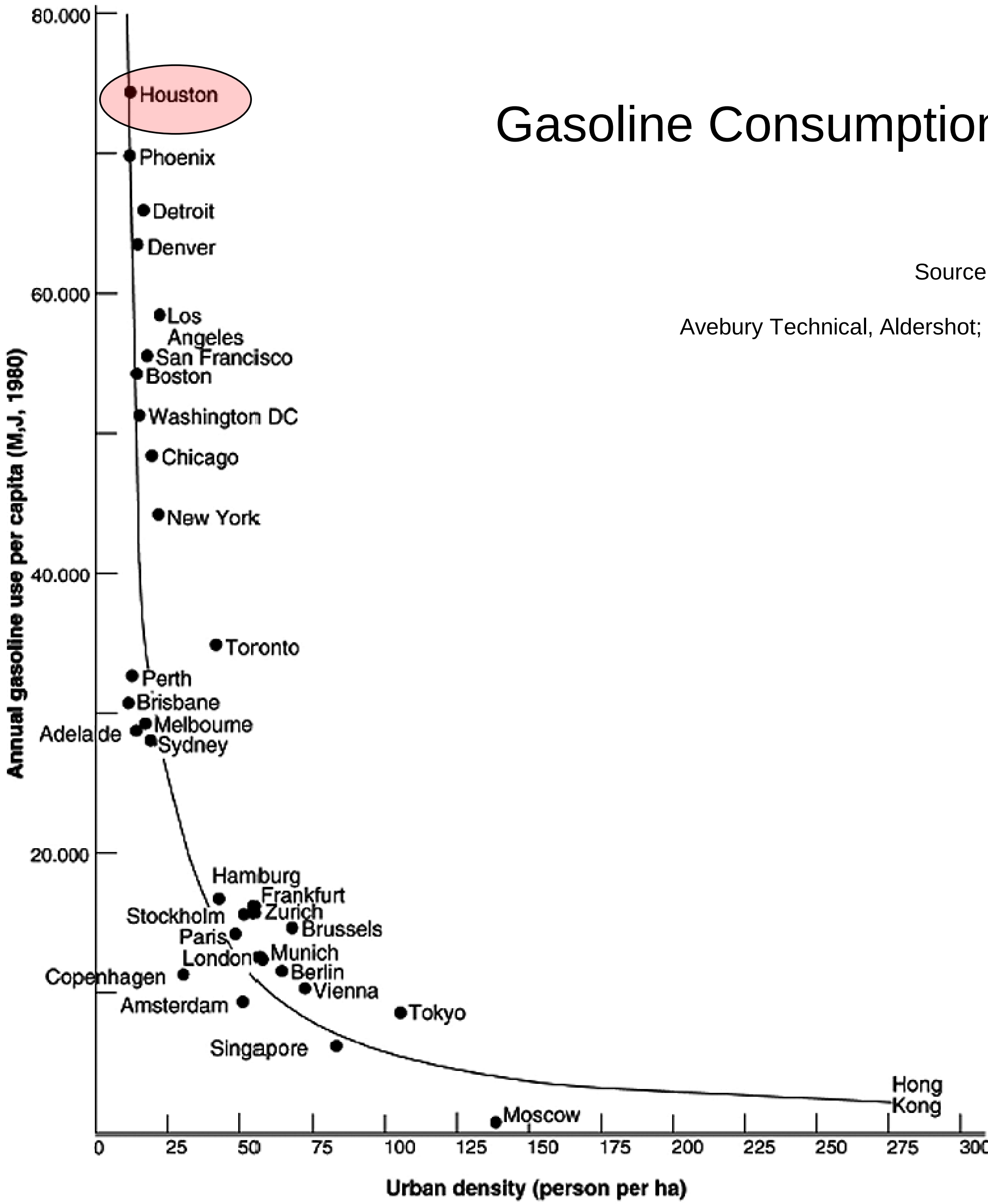
Austin American Statesman May 29, 2008

Induced energy consumption in Austin: 1.5 metric tons/year

Residential energy consumption in Austin: 1.0 metric tons/year

Gasoline Consumption per Capita is related to Urban Density

Source: Newman, Peter; Kenworthy, Jeffrey: Cities and Automobile Dependence: A Sourcebook. Avebury Technical, Aldershot; Brookfield; Hong Kong; Singapore; Sydney 1992



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What are the technological options?

Reduction of energy demand for heating

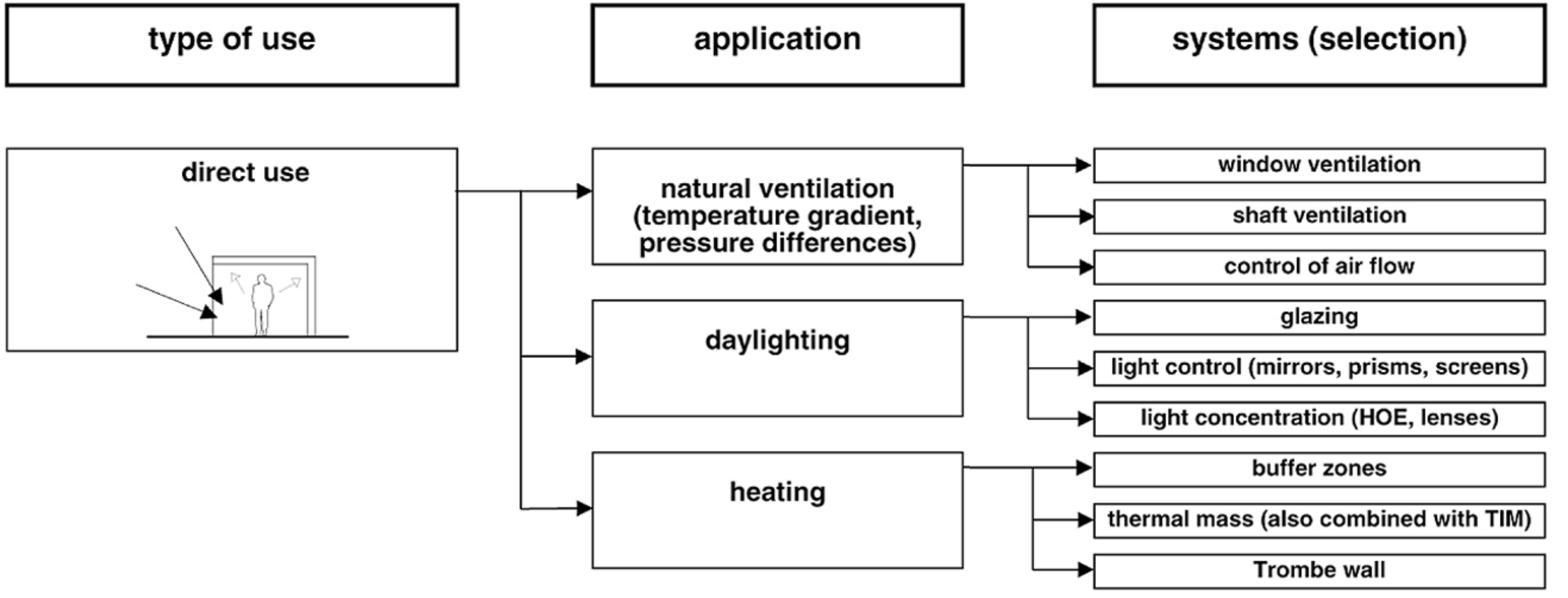
- minimization of energy losses of the building envelope
- maximization of energy gains: direct use of solar energy (passive use)
- maximization of energy gains: indirect use of solar energy (active use)

Reduction of energy demand for cooling

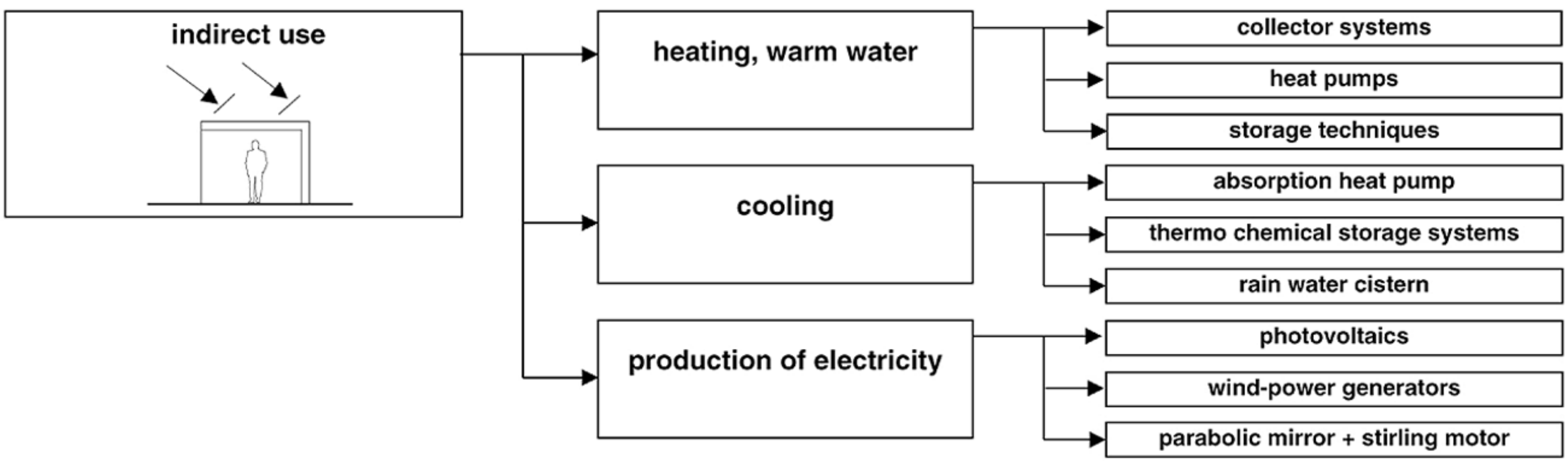
- minimization of energy losses of the building envelope
- minimization of direct energy gains: shading and sun protection, ventilation
- maximization of indirect gains: thermal collectors and photovoltaic collectors
- maximization of heat losses in hot season during the night

Reduction of energy demand for artificial lighting

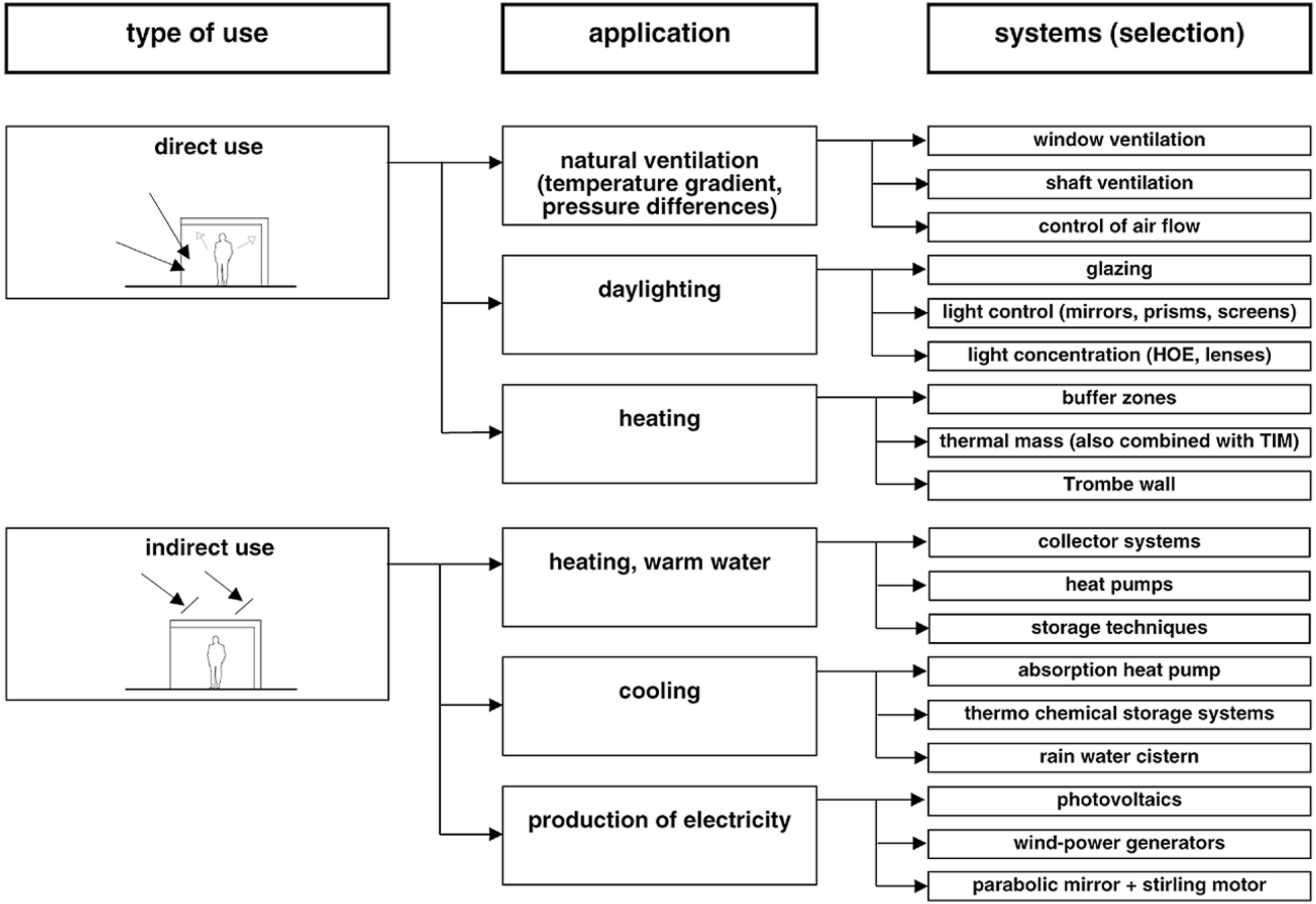
- maximization of energy gains: direct use of solar energy (passive use) for optimized daylight in buildings



Use of solar energy in building



Use of solar energy in building

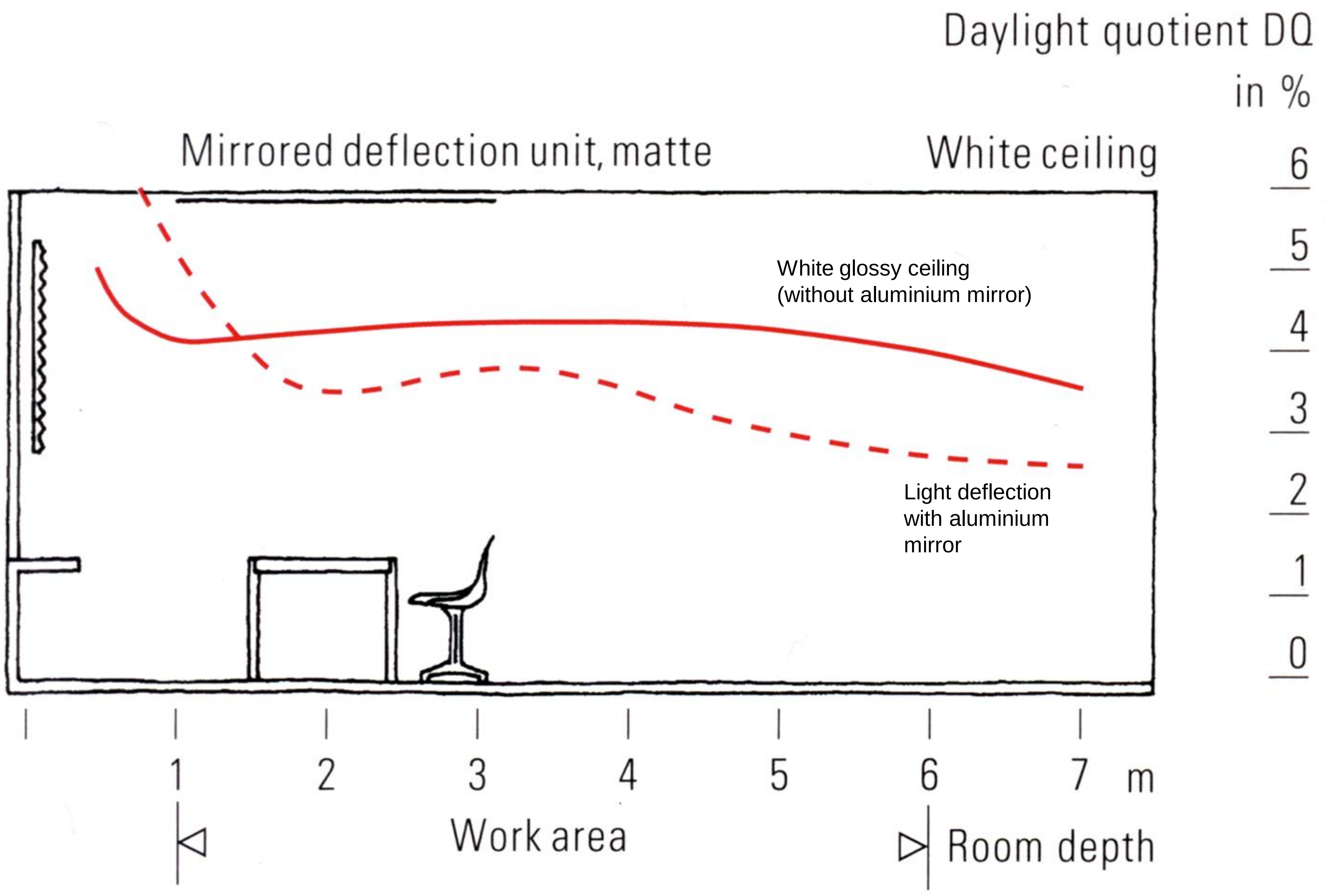


Use of solar energy in building

ect/passive use of solar energy: Adaptable facade / use of daylight

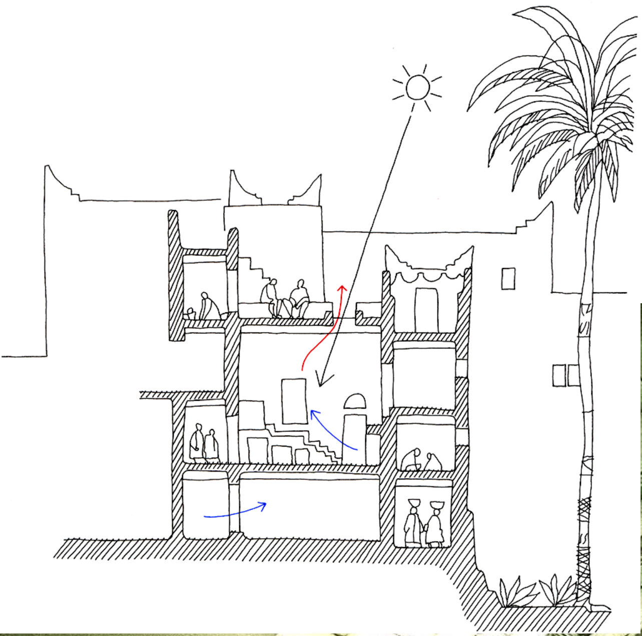
layered facade at the ‚Procuratie Vecchie‘, Venice, 1532.


Direct/passive use of solar energy: Adaptable facade/Use of daylight
Redirection of daylight with deflecting prisms



Direct/passive use of solar energy:

Prismatic deflectors for optimised light distribution



- Controlled daylighting
- Activation of thermal mass for temperature control
- Use of stack effect for natural ventilation
- Night-time radiation cooling and ventilation

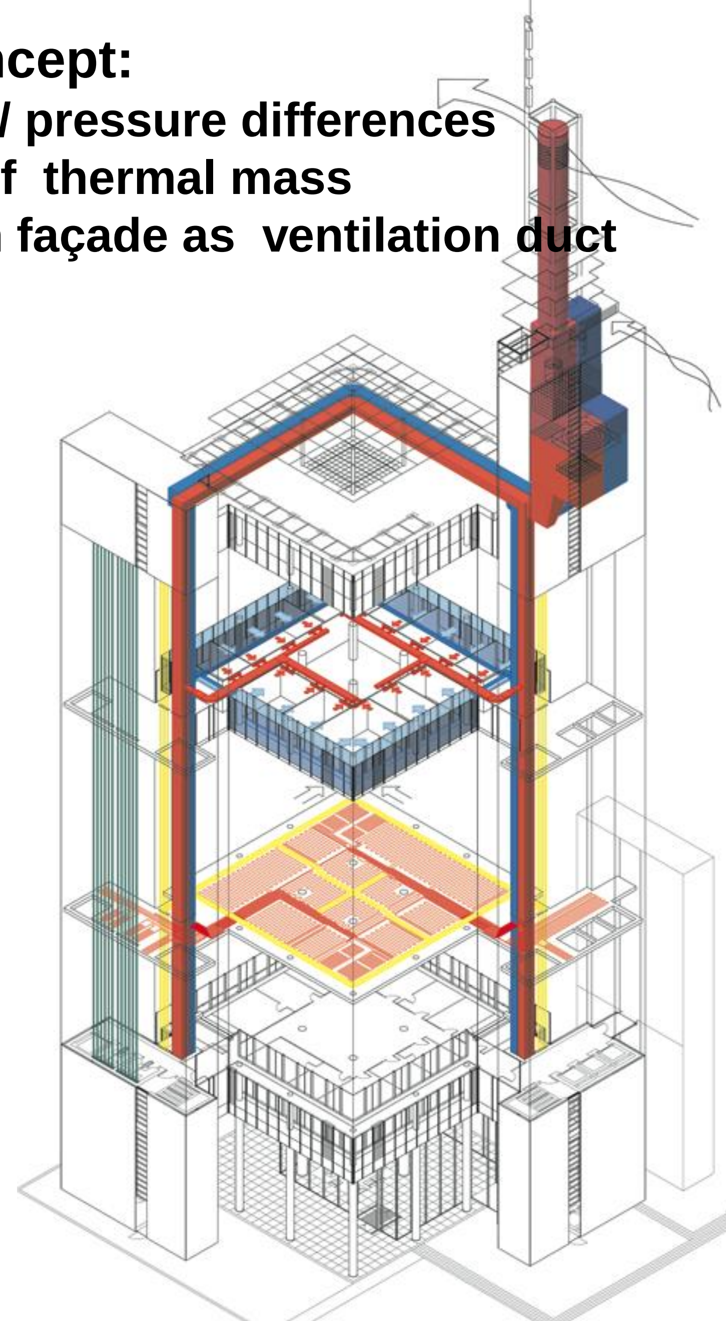
Private House in Ghadames, Libya

Direct/passive use of solar energy

Deutsche Messe AG Headquarters, Hanover. Herzog+Partner 1999

Climate concept:

- **stack effect/ pressure differences**
- **activation of thermal mass**
- **double-skin façade as ventilation duct**



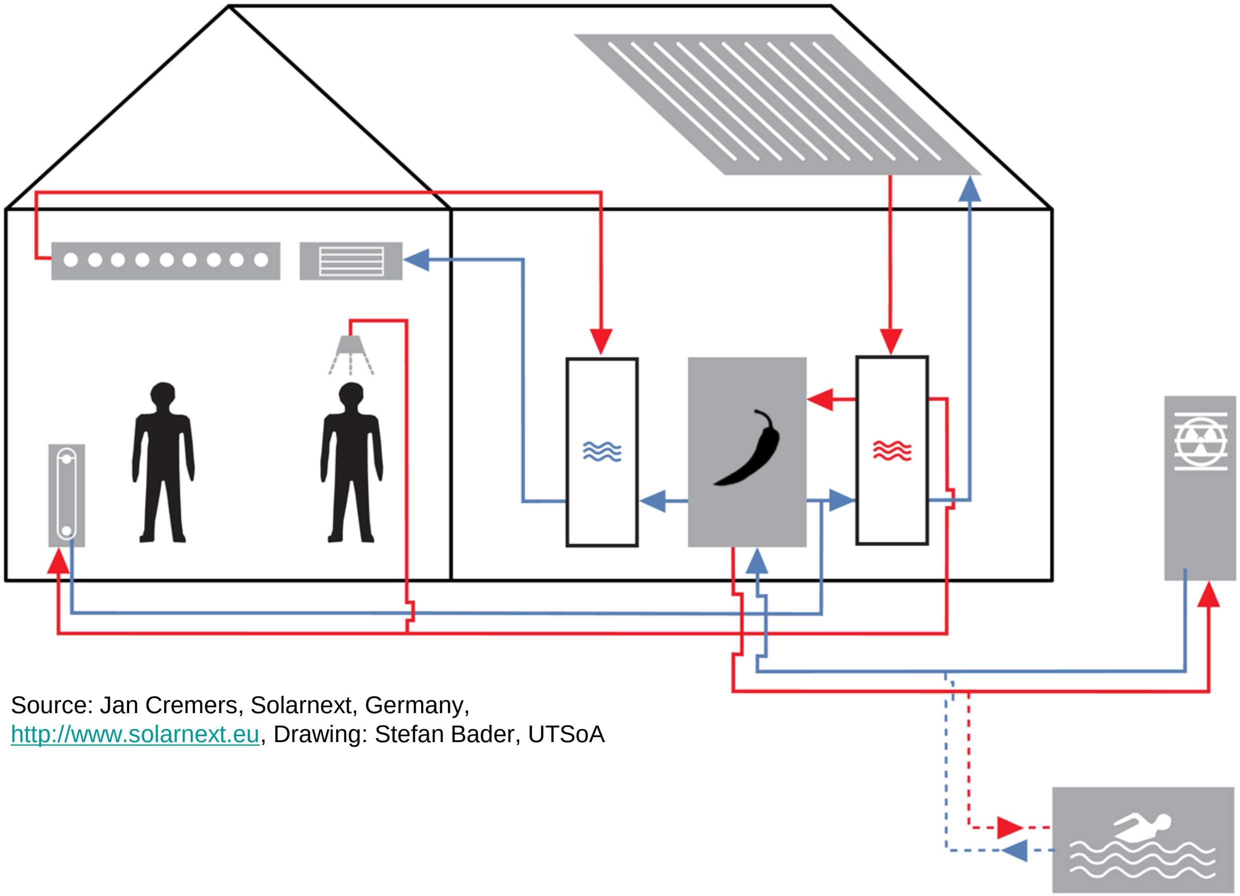
Source: Herzog, Krippner, Lang. Façade Construction Manual. Basel: Birkhauser 2004. p. 25

Direct/passive use of solar energy: Natural ventilation and night-time cooling

Private Home with Solar Thermal Application (around 1910), Pomona Valley, USA

Indirect/active use of solar energy: Hot-water collectors for heating

Source: Jan Cremers, Solarnext, Germany
http://www.solarnext.eu



Source: Jan Cremers, Solarnext, Germany, http://www.solarnext.eu, Drawing: Stefan Bader, UTSoA

Heat pipe/vacuum tube collector

SorTech ACS 15, Germany (15 kW)

Source: SorTech

Adsorption cooling unit

Indirect/active use of solar energy: Cooling and hot-water generation through solar cooling

Sources: SolarNext

Source: Jan Cremers, Solarnext, Germany, http://www.solarnext.eu,

H_2O/LiBr EAW Wegracal SE15
in Rimsting, Germany for Office Space Cooling and Heating

37 m²	Flat Plate and 34 m² Vacuum Tube Collectors & Oil Burner Back-up
2,000 l	Hot Water Storage and 1,000 l Cold Water Storage
15 kW	Cooling Capacity
35 kW	Wet Cooling Tower Capacity

chillii® Solar Cooling System at Office Building SolarNext, Rimsting, Germany (Refit)

SOLARNEXT

Indirect/active use of solar energy: Cooling and hot-water generation through solar cooling

Training Academy, Herne, Germany, 1999. Arch.: Jourda+Perraudin, Lyon with HHS, Kassel

Indirect/active use of solar energy: Building-Integrated Photovoltaics

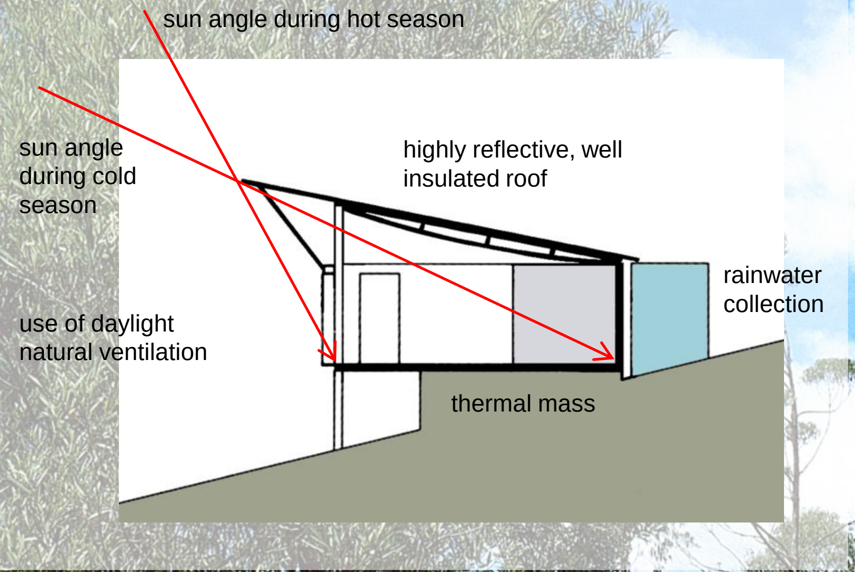
Case Study 1

Simpson-Lee House
Mount Wilson, New South Wales, Australia,1994

Glen Murcutt, Sydney

Simpson-Lee House, Australia,1994. Glen Murcutt, Sydney

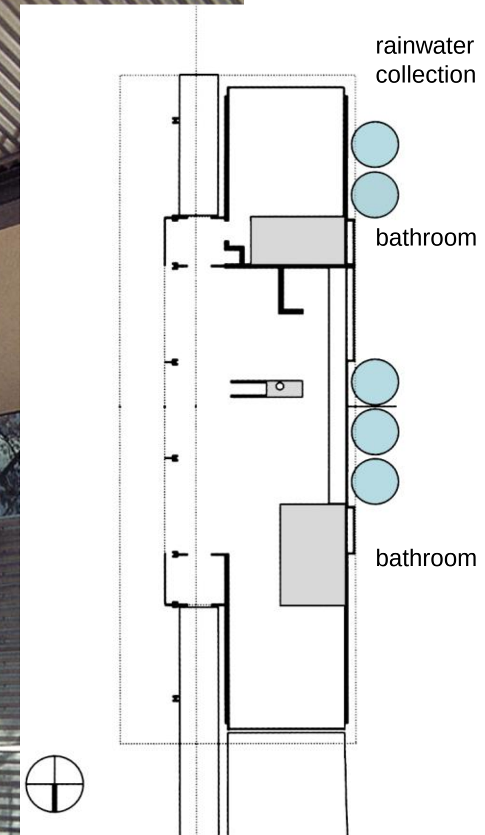
Shading of the interior and immediate outdoor area / rainwater collection
Highly reflective roof surface



Glenn Murcutt. Buildings and Projects 1962–2003,
Thames & Hudson, New York, 2003, p. 63, 209.

Main aspects of the design:

- Layout/floor plan related to topography
- Shading of the interior and immediate outdoor area during hot season
- Highly reflective roof, well insulated
- Direct/passive use of solar energy during cold season
- Cross ventilation for night-time cooling, especially during hot season
- ‚Activated‘ thermal mass for temperature control
- Well insulated envelope for energy conservation
- Rainwater collection



Simpson-Lee House, Australia,1994. Glen Murcutt, Sydney

Shading of the interior and immediate outdoor area/
Zoning of the floor plan/cross ventilation /well insulated envelope

Simpson-Lee House, Australia,1994.
Glen Murcutt, Sydney

Facade during hot season with external shading

Glenn Murcutt. Buildings and Projects 1962 – 2003.
Thames & Hudson, New York, 2003, p. 212.

Facade open during moderate condition

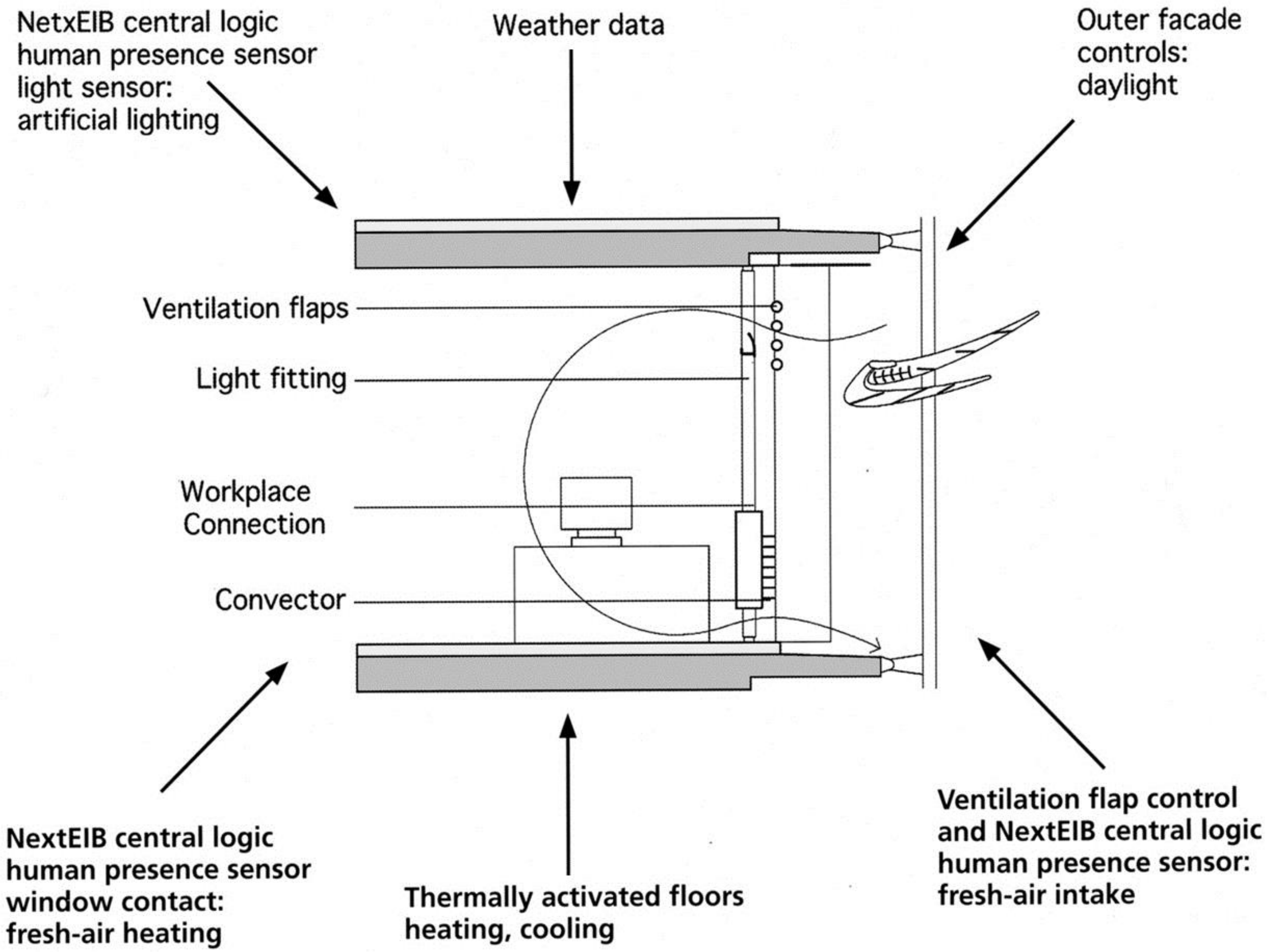
Case Study 2

Administration Building in Wiesbaden/Germany

Herzog + Partner, Munich

Administration Building, Wiesbaden, 2003. Herzog + Partner

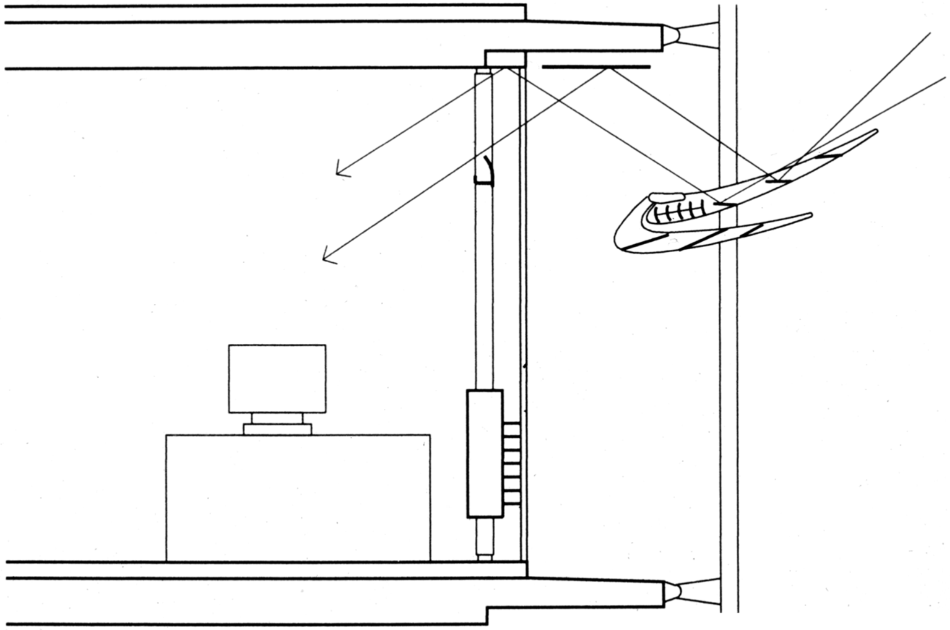
Integrated approach towards design and operation of buildings



Main aspects of the design:

- **Building construction with activated thermal mass as temperature control element**
- **Human presence sensor: controlled lighting and ventilation**
- **Daylight control for comfort and energy conservation**
- **Energy consumption ¼ of comparable office buildings (96 kWh/m2a for heating, cooling, electricity)**

Integrated approach towards design and operation of buildings

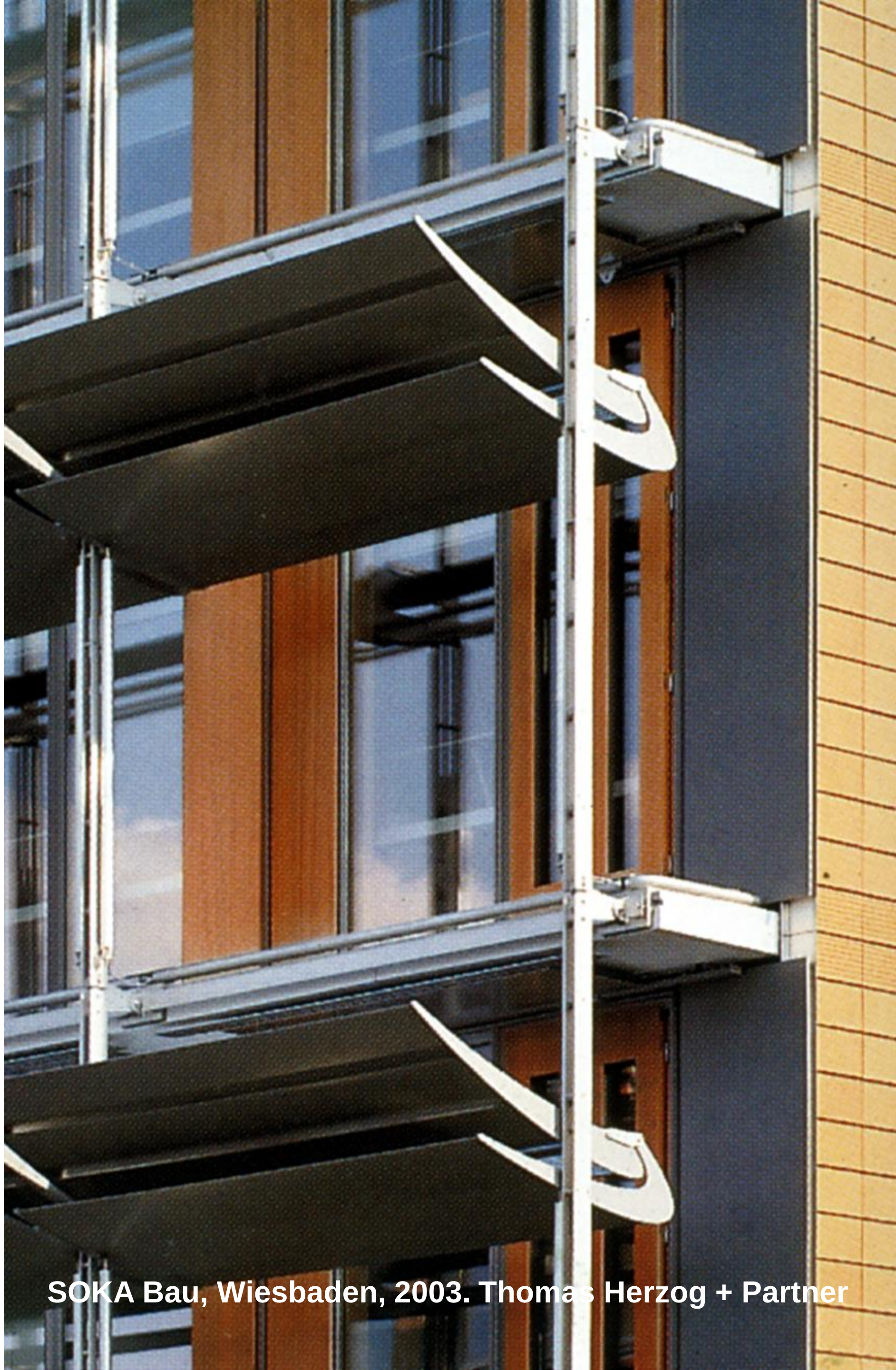


South facade:

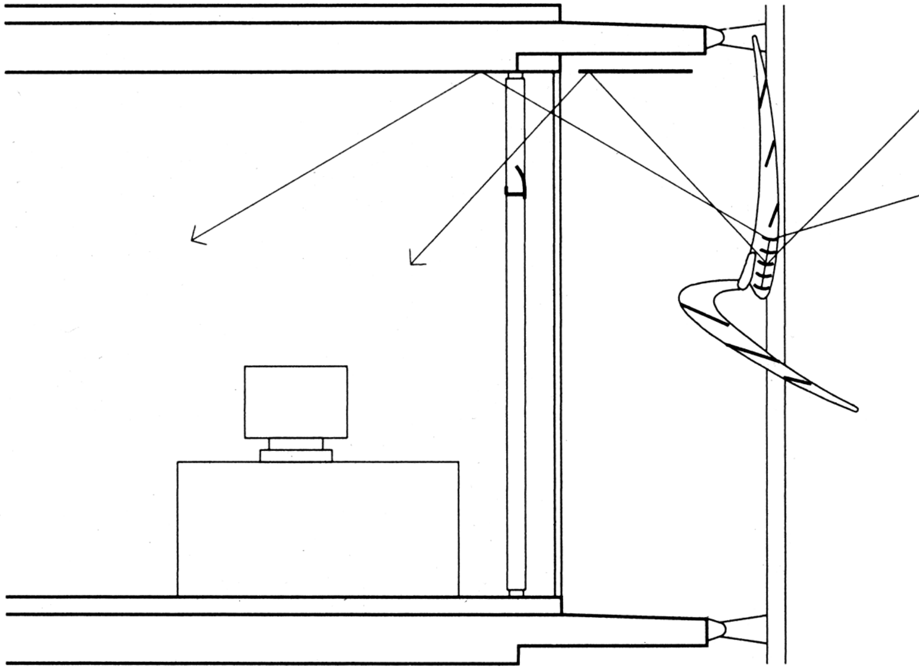
Use of diffuse daylight:

Daylight deflection when sky is overcast

Integrated approach towards design and operation of buildings



SOKA Bau, Wiesbaden, 2003. Thomas Herzog + Partner

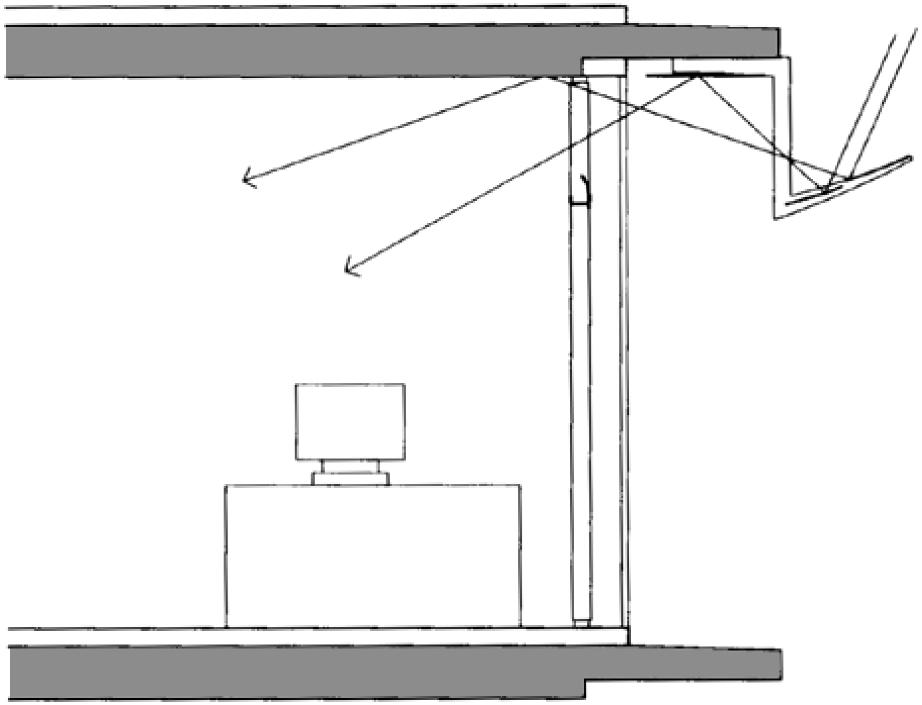


South facade:

Use of direct daylight:

Shading and daylight deflection when sun is shining

Integrated approach towards design and operation of buildings



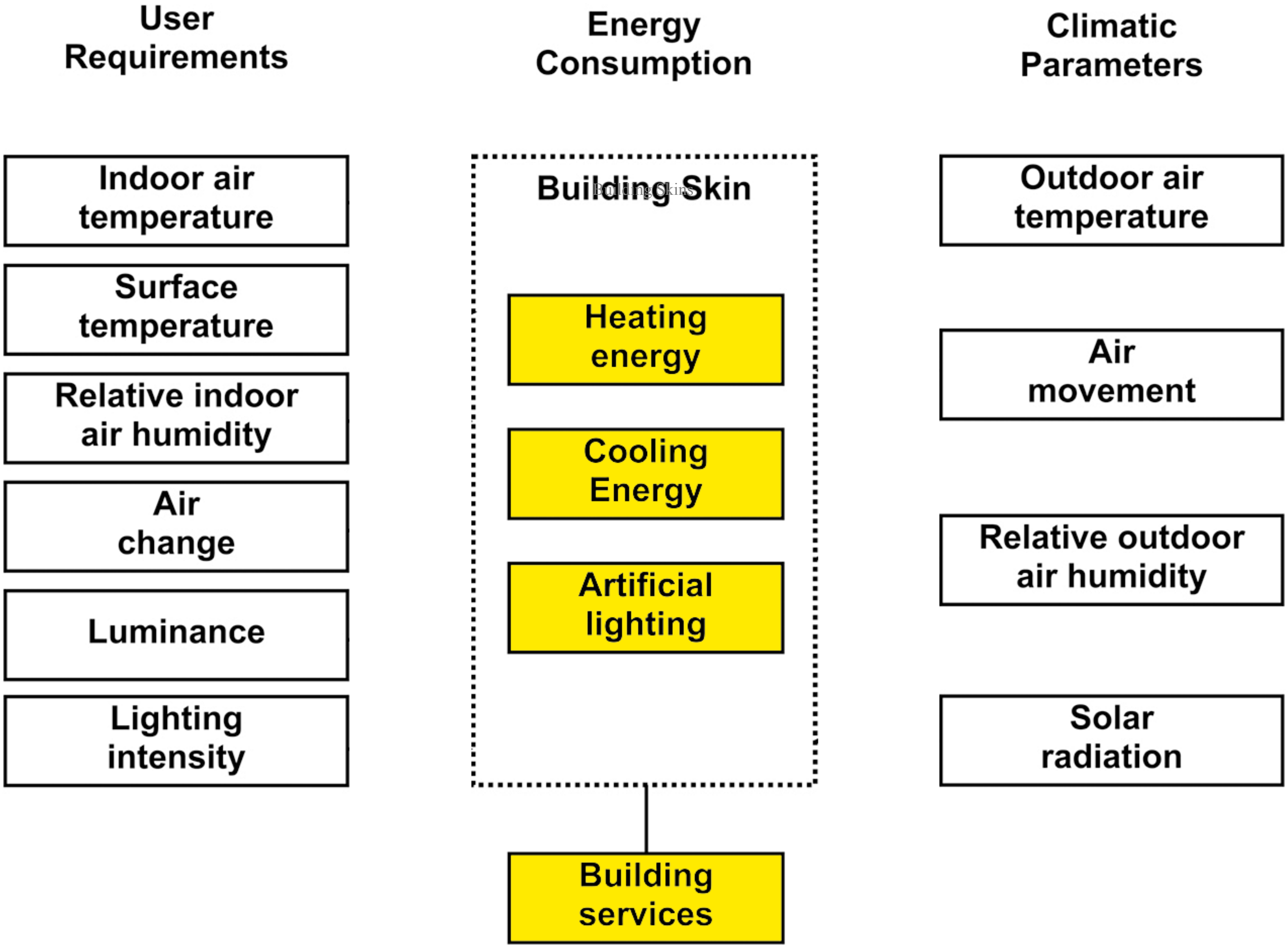
North facade:

Use of diffuse daylight:

Daylight deflection when sky is overcast

Integrated approach towards design and operation of buildings

Where do we go from here?



Research in the field of the ‘ Building Skin‘ as the decisive system with regard to physical properties and thermal performance of buildings

Experimental research in the field of:

- Shading systems
- Daylighting systems
- Glare control systems
- Ventilation systems
- Cooling systems
- Building integrated photovoltaics
- Activated thermal mass
- Integrated building services

Thermal Lab at UTSoA (view from south-east)


Where do we go from here?
Touch the Earth lightly

Resources

American Institute of Architects
Committee on the Environment (COTE)

Mission: "… promote the role of the architect as a leader in preserving and protecting the planet and its living systems."

2008 Top Ten Green Projects Awards

www.aia.org/cote
www.usgbc.org
www.architecture2030.org

City of Austin / Austin Energy

City of Austin/Austin Energy

Programs

- Austin Energy Green Building
- GreenChoice™ Renewable Energy
- Power Saver™ Program
- Volunteers
- Power Partner Thermostats
- Refrigerator Recycling
- Free Home Improvements
- ENERGY STAR® CFLs

Loans

- Home Performance with ENERGY STAR®
- Solar

Rebates

- Home Performance with ENERGY STAR®
- Air Conditioning
- Solar Photovoltaics
- Solar Water Heaters
- Pool Pump and Motor

Tools and Tips

- Participating Companies
- Energy Efficiency Tips
- How to Read your Meter
- Online Energy Audit—Home Energy Analysis
- Green Building Workshop
- Energy Efficient Apartment Search
- ENERGY STAR® Appliance Dealers
- Speakers on Energy Topics

www.austinenergy.com/

Literature

Lang, Werner: The functional, energetic and structural aspects of the building skin. In: Building Skins, Birkhäuser 2006

Herzog, Krippner, Lang:
Façade Construction Manual, Birkhäuser, 2004

Hausladen, de Saldanha, Liedl, Sager:
Climate Design, Birkhäuser, 2004

Herzog, Thomas (Ed.): SOKA Bau, Prestel, 2006

Dr. Werner Lang

Dr. Lang joined the UT School of Architecture Faculty in 2008, where he is currently teaching building construction, sustainable design and the use of renewable energies in architecture. His focus in research ison the energy performance of buildings and the relationship between the environment and architectural design.

Dr. Lang is member of the Center for Sustainable Development at the UT School of Architecture. He is a practicing and licensed architect and one of three managing directors of Lang Hugger Rampp GmbH Architect