Building Energy, Water, and Land-use Our Common (Un-?) Future

Building as Power Plant/Invention Works

the Robert L Preger Intelligent Workplace

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Director, Center for Building Performance and Diagnostics
Carnegie Mellon University

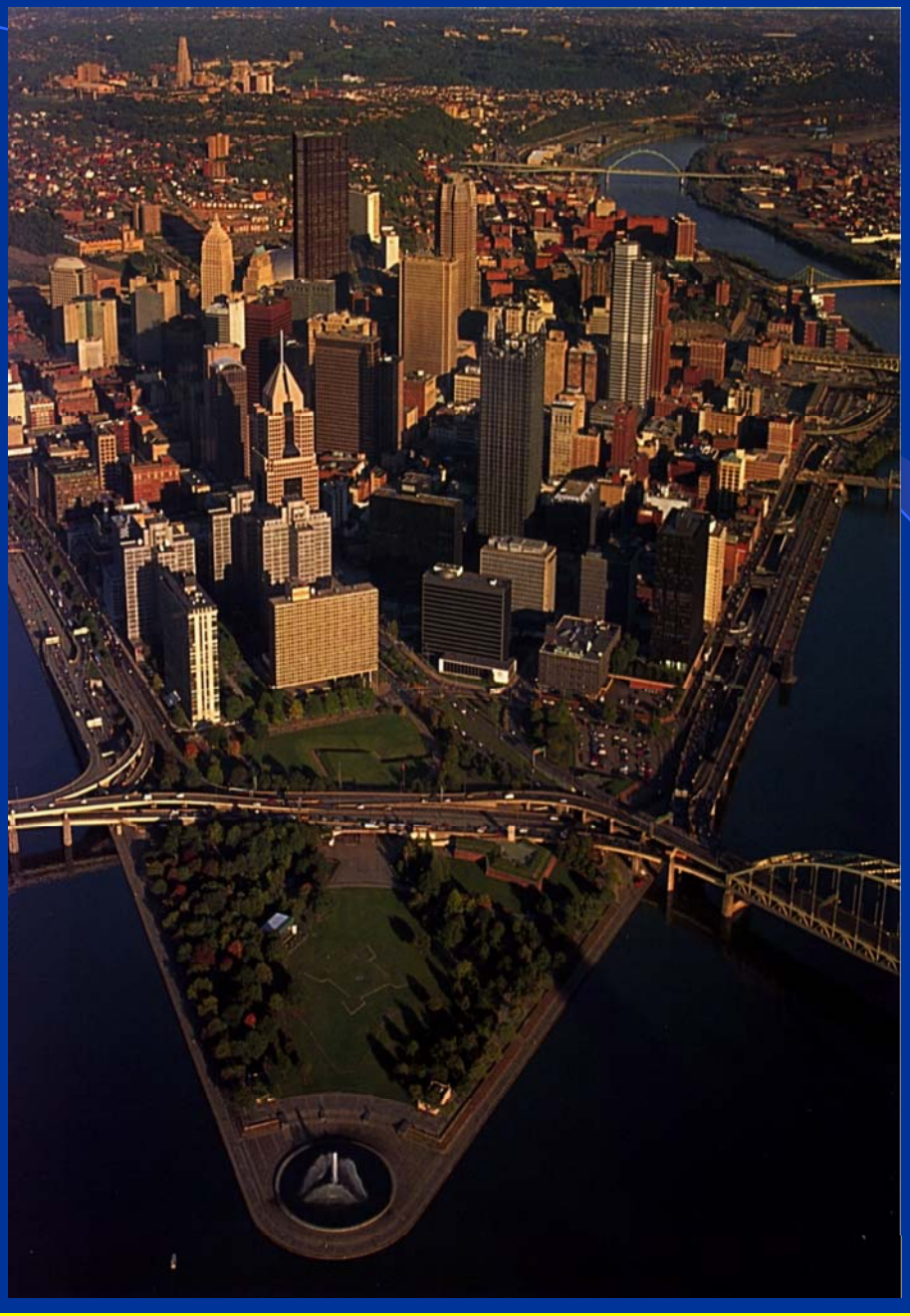
Meeting the Future: A Research Agenda for Sustainability
EPA Washington, DC, May 18-20, 2005

Basic Needs

- Nourishment
- Shelter/Habitat
- Health
- Freedom
- Mobility/Accessibility
- Community with Diversity
- Pursuit of Happiness/Opportunity

Time to move from object to continuum

the aesthetics of the processional



Source: Thomas Hylton

Land Use in Pennsylvania

Source: Thomas Hylton

Land Use in Pennsylvania

Source: Thomas Hylton

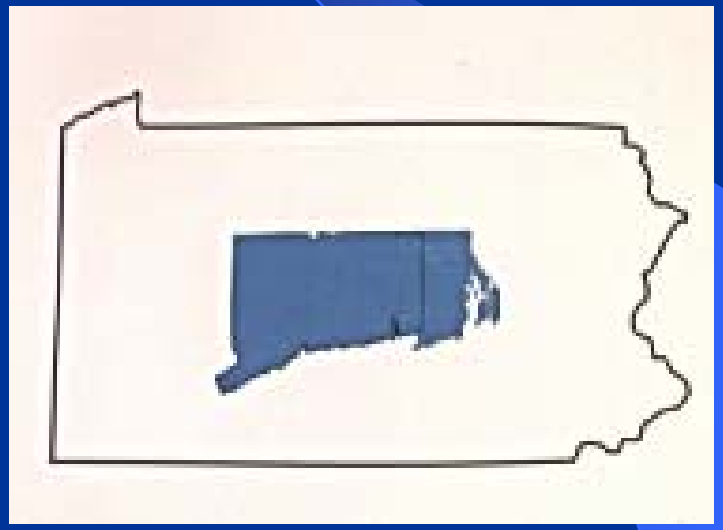
Cranberry

Land Use in Pennsylvania

Cities with Population Loss

Philadelphia	-23%
Pittsburgh	-45%
Scranton	-34%
Harrisburg	-41%
Reading	-33%
Johnstown	-55%
Erie	-16%

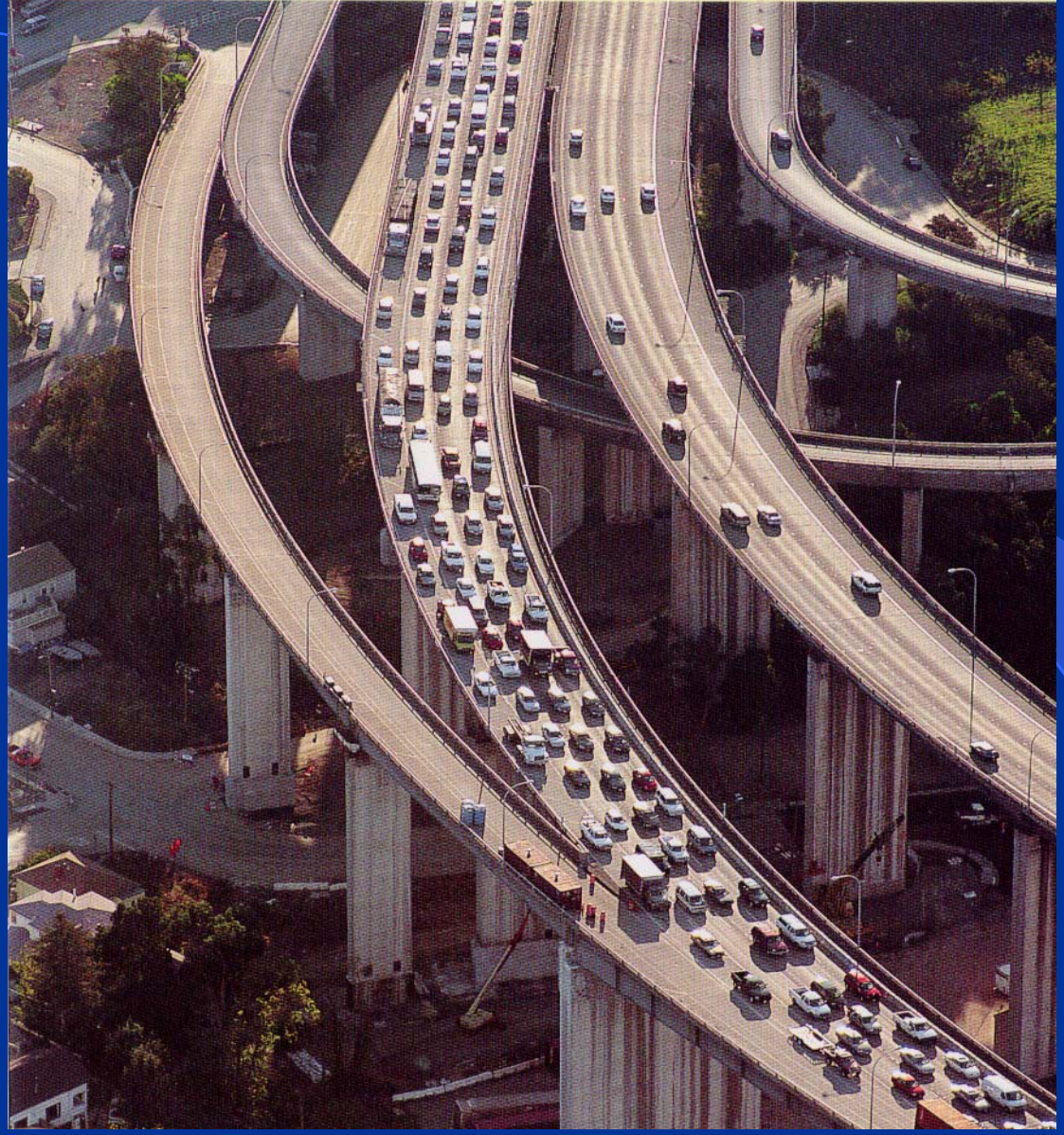
Source: Thomas Hylton



Pennsylvania has lost an area of farmland larger than the combined size of Connecticut and Rhode Island

Land Use in Pennsylvania

Source: Thomas Hahn

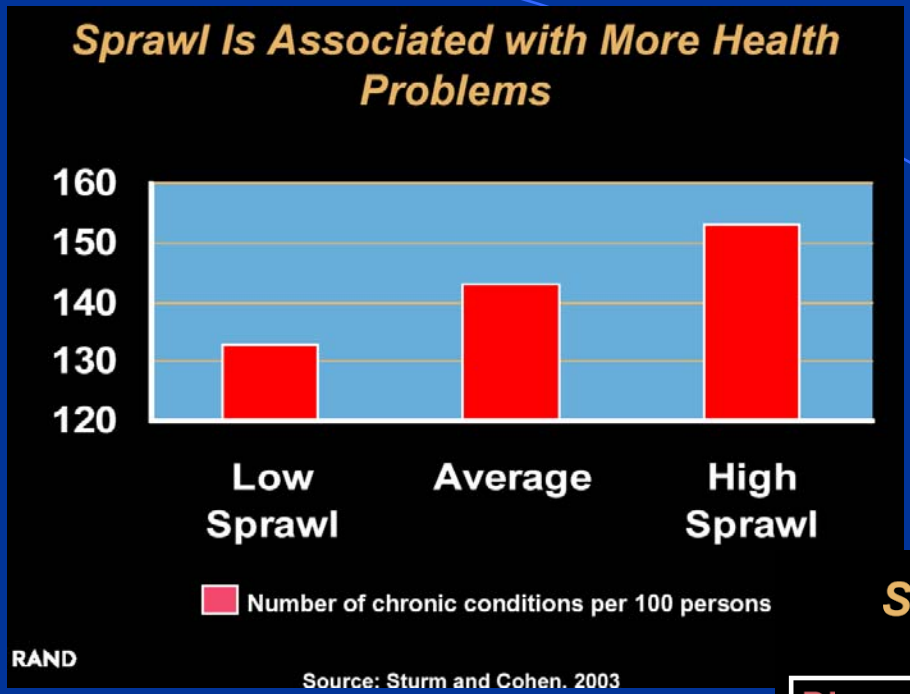


Dolores Hayden a Field Guide to Sprawl

www.pedbikeimages.org / Dan Burden

Which future?

Vehicle miles have risen by 80% from 1980 to 2000, while population rose only 21.5%, with both energy and health consequences.



Rand 2004 study, N=8686, 38 cities

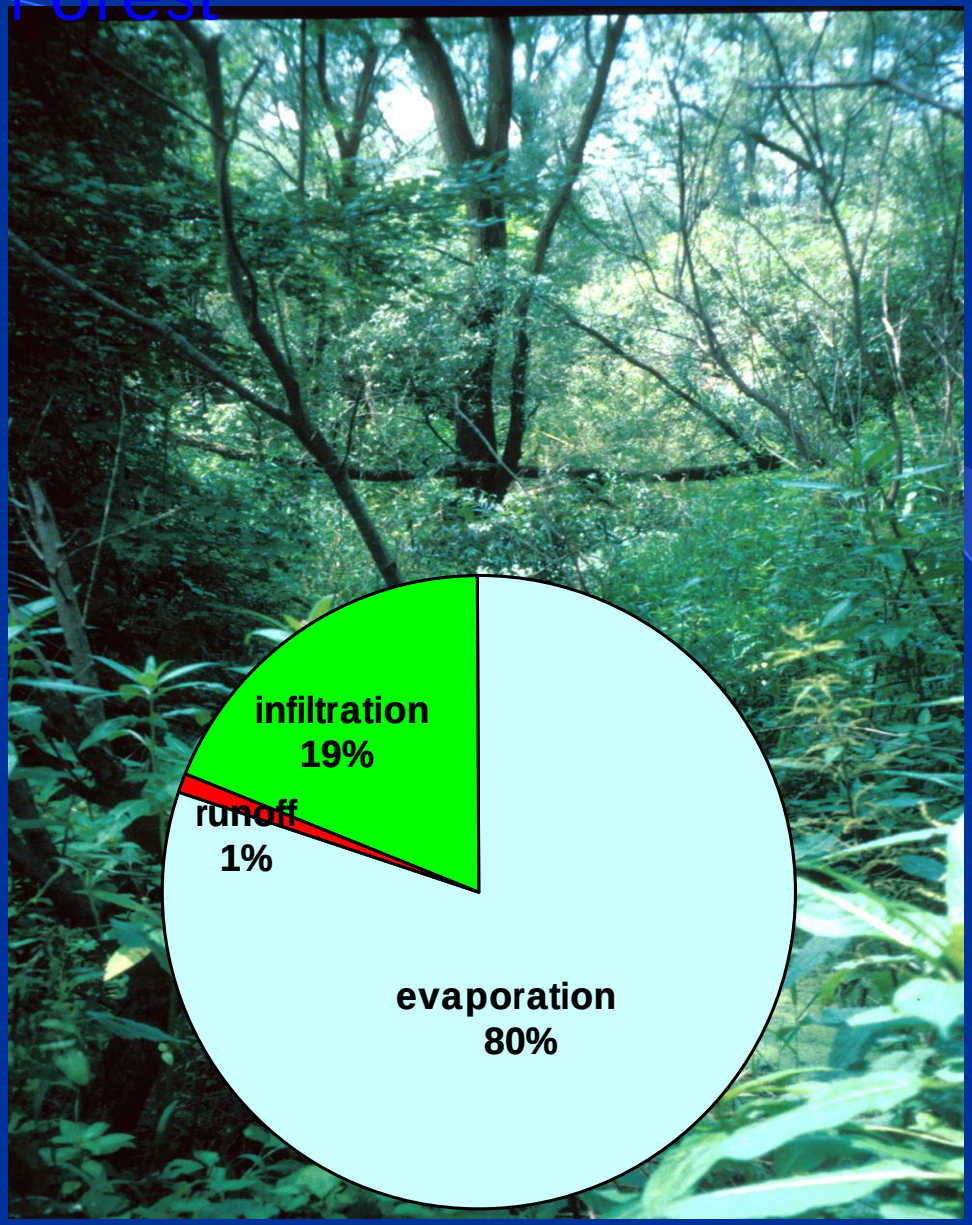
Certainly energy costs, but chronic health conditions and sprawl?

Sprawl Measures (Ewing et al, 2003)

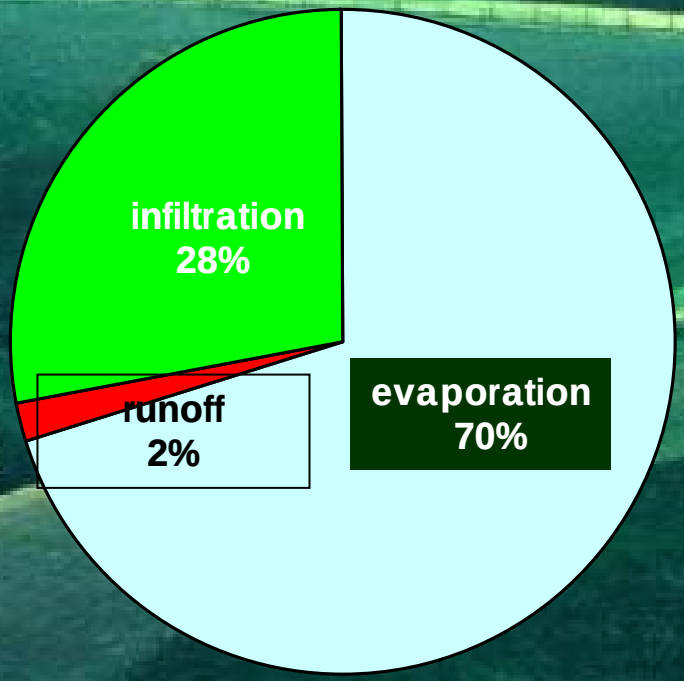
Dimension	Sample Metrics
Streets factor	• Average block length • Block size in square miles • % small blocks
Land use mix factor	• % population within 1 mile of shopping, schools, business • Job/resident balance
Concentration of people and jobs (Centers factor)	• Variation of density across census tracts • Density gradient • % of population less than 3 and % more than 10 miles from business center
Population density factor	• People per square mile • % in low density areas • % in high density areas • Average lot size

RAND January, 2004

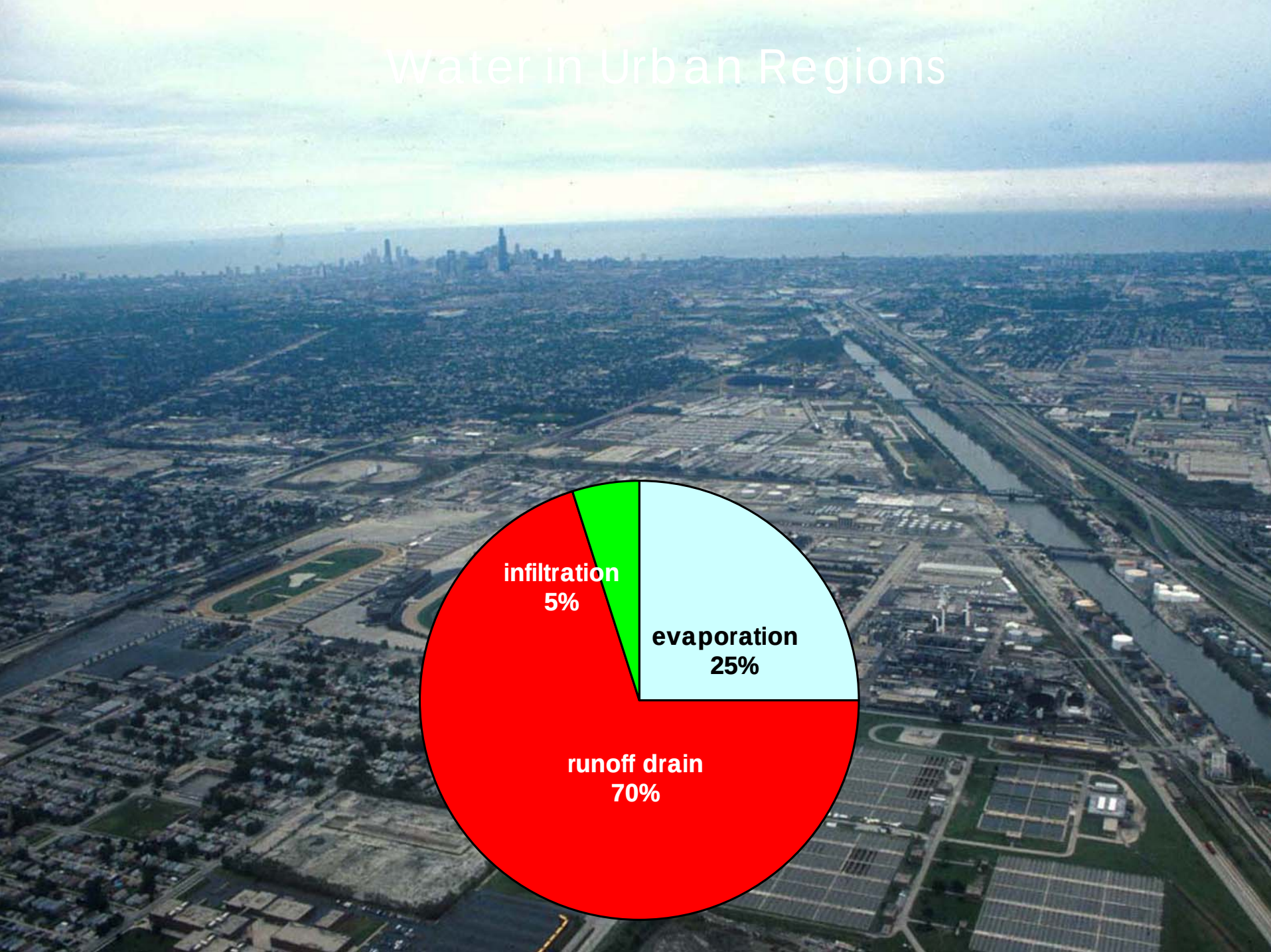
Water in the Forest



Water in Agricultural Landscape

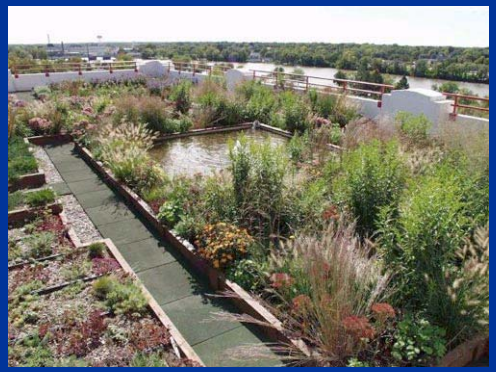


Water in Urban Regions



Sustainable design depends on the promotion of infrastructures to neighborhood amenities.

landscape for water management & environmental quality
landscape integral with mixed-mode transportation
district power and heating

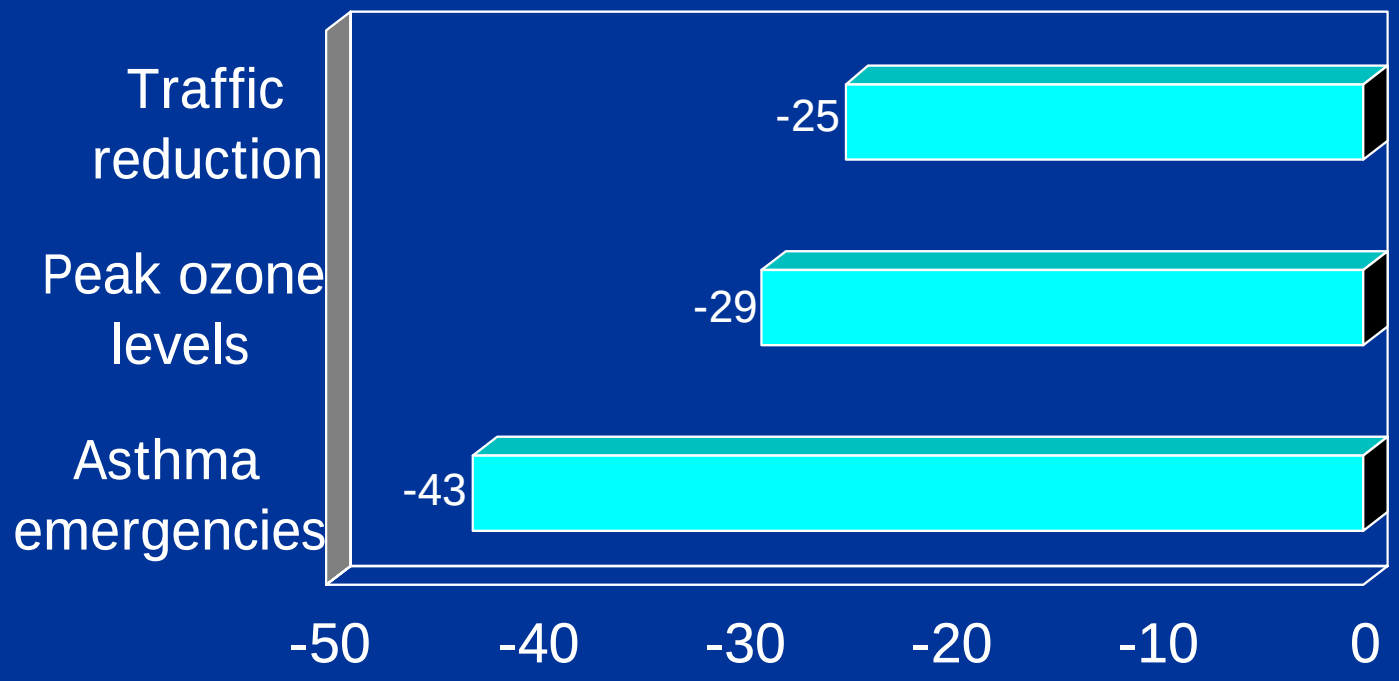


Cool Roofs and "Cool Community" developments reduce annual cooling loads by 10% and peak cooling by 5% with carbon sequestration, storm runoff management, and a 6-8% reduction in smog.

Milan on the Mon?

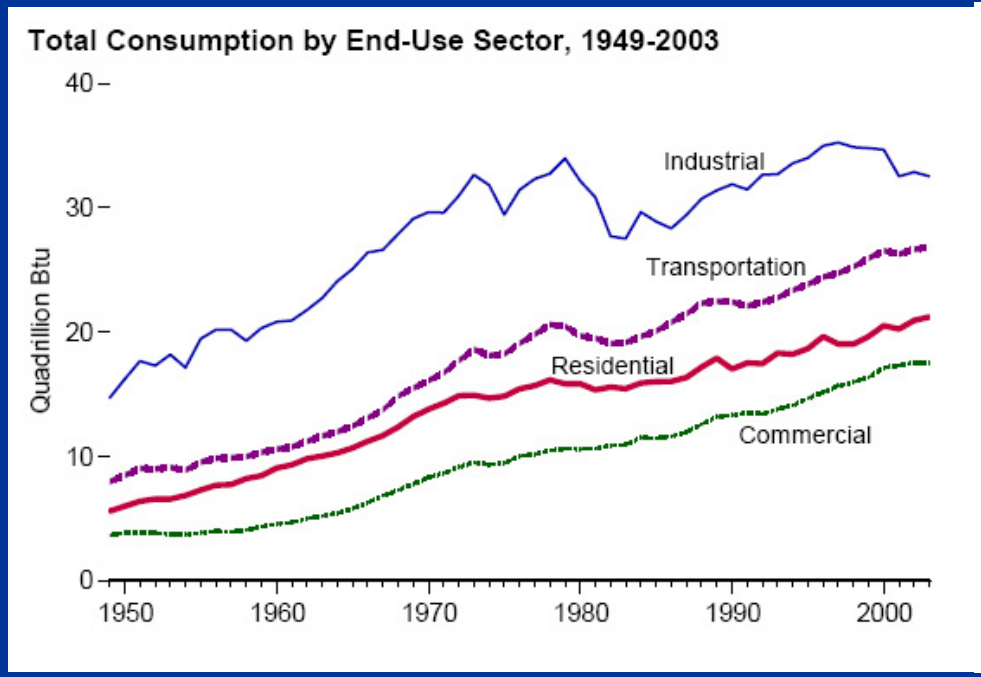
Addressing our transportation weaknesses can become major enterprise opportunities…

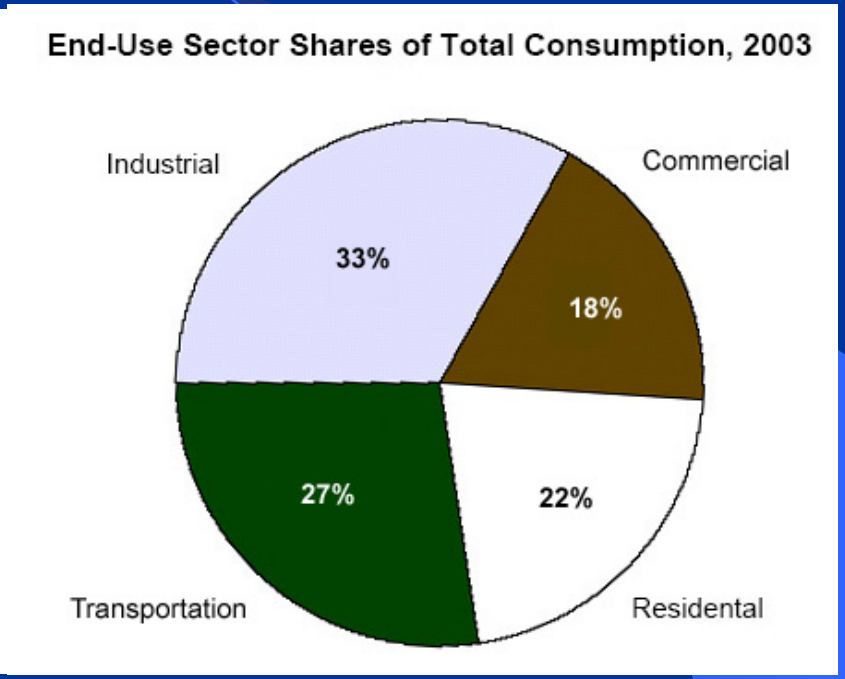
During the 1996 Olympics in Atlanta, city officials reduced vehicle traffic by 22.5% and asthmas related emergencies decreased 41.6%



Source: Friedman et al., 2001 (CDC/*JAMA*)

U.S. Energy Consumption by End-Use Sector



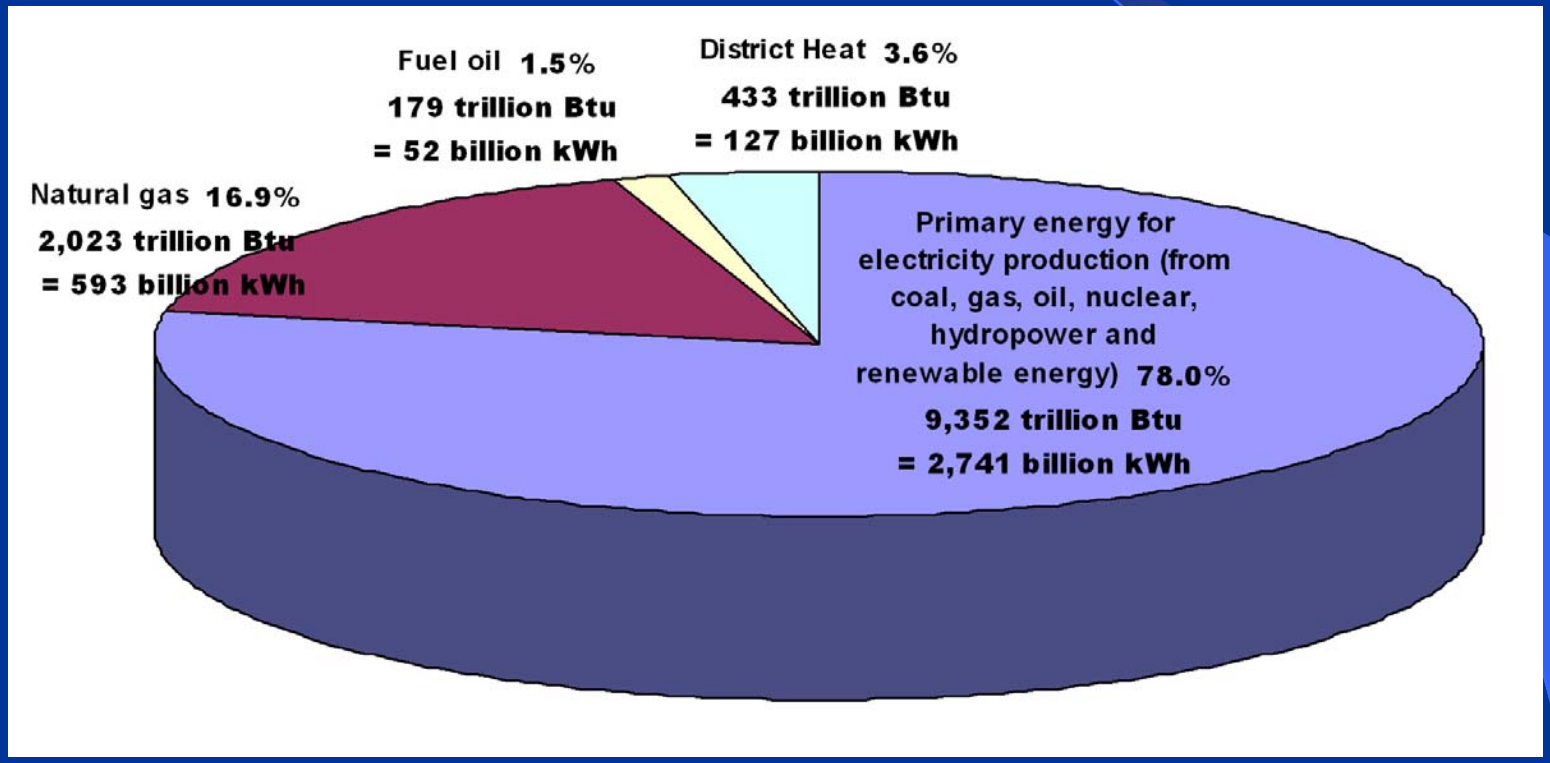


Source: EIA Annual Energy Review 2003

Annual Energy Consumption by U.S. Commercial Buildings

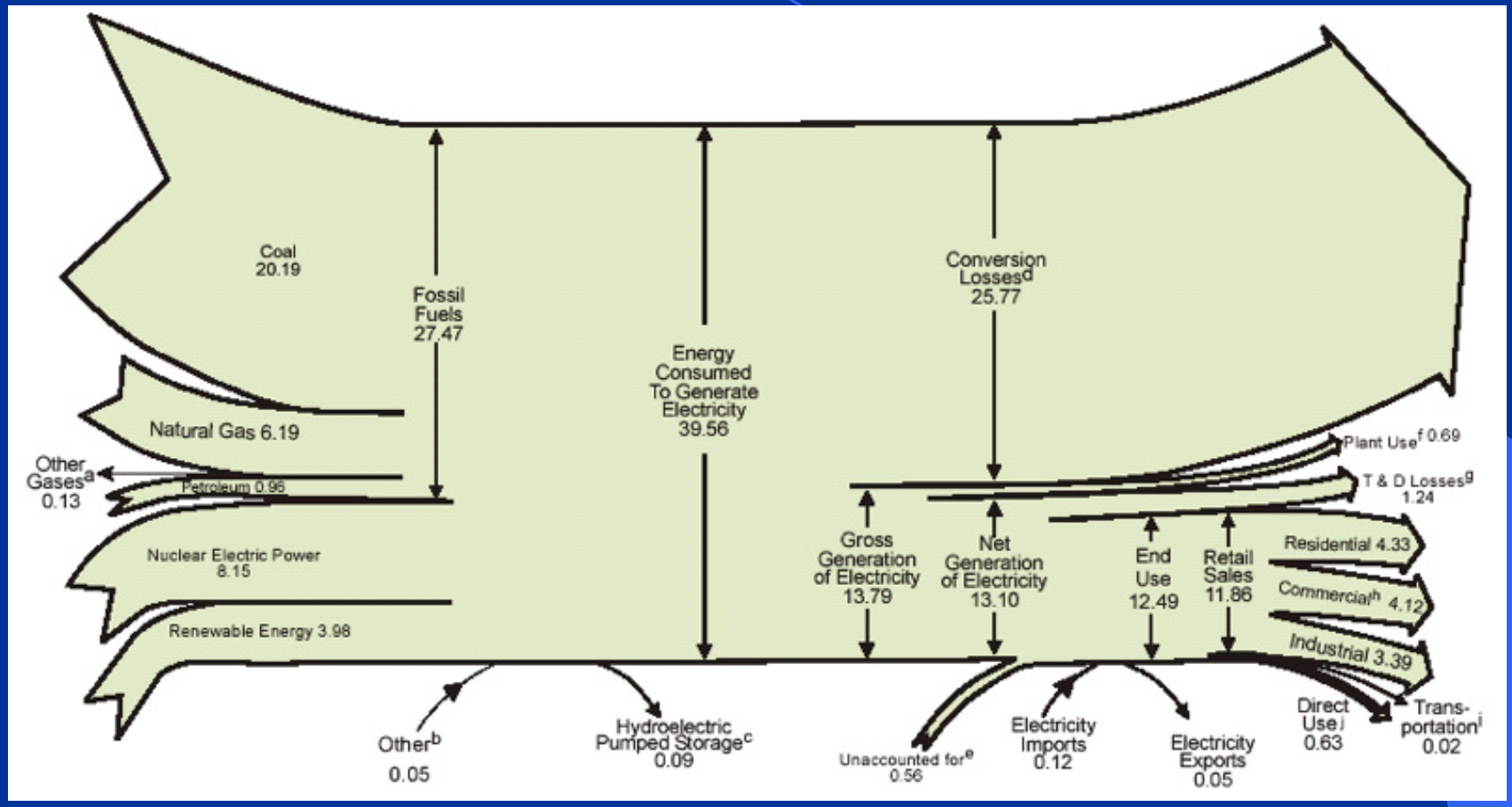
Total: 11,987 trillion Btu/yr

= 3.51 trillion kWh/yr



Data source: EIA 1999 Commercial Buildings Energy Consumption Survey. (Conversion: 3,412 Btu = 1 kWh)

Electricity Efficiency



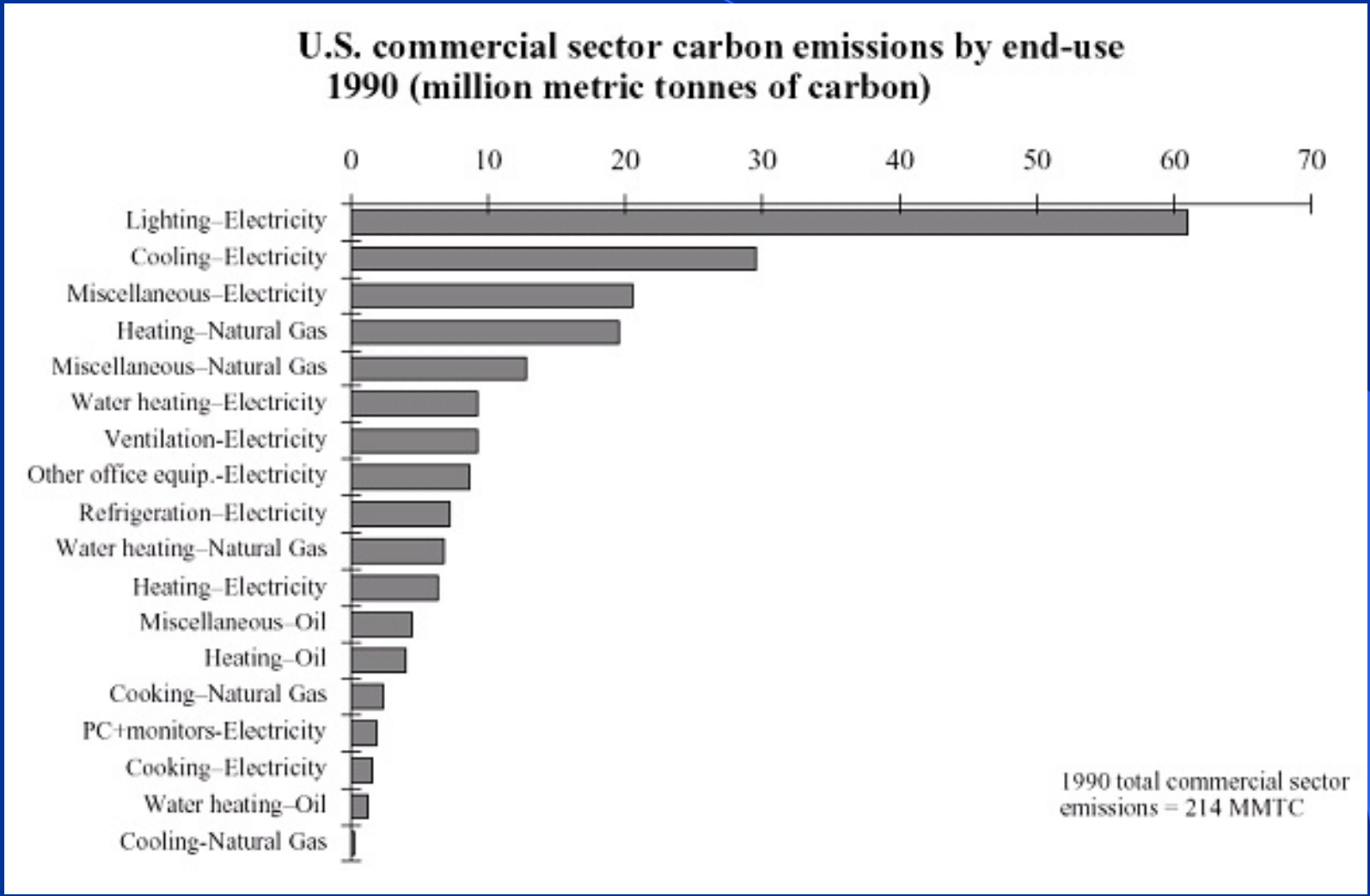
2002 Electricity Flow, in Quadrillion Btu (10^{15} Btu) (Conversion: 1 quadrillion Btu = 293 billion kWh)

Total energy consumed to generate electricity in 2002 is 39.56 quadrillion Btu = 11.59 trillion kWh

Source: EIA, Annual Energy Review 2002, Diagram 5.

Dolores Hayden A Field Guide to Sprawl

U.S. Commercial Sector Carbon Emissions

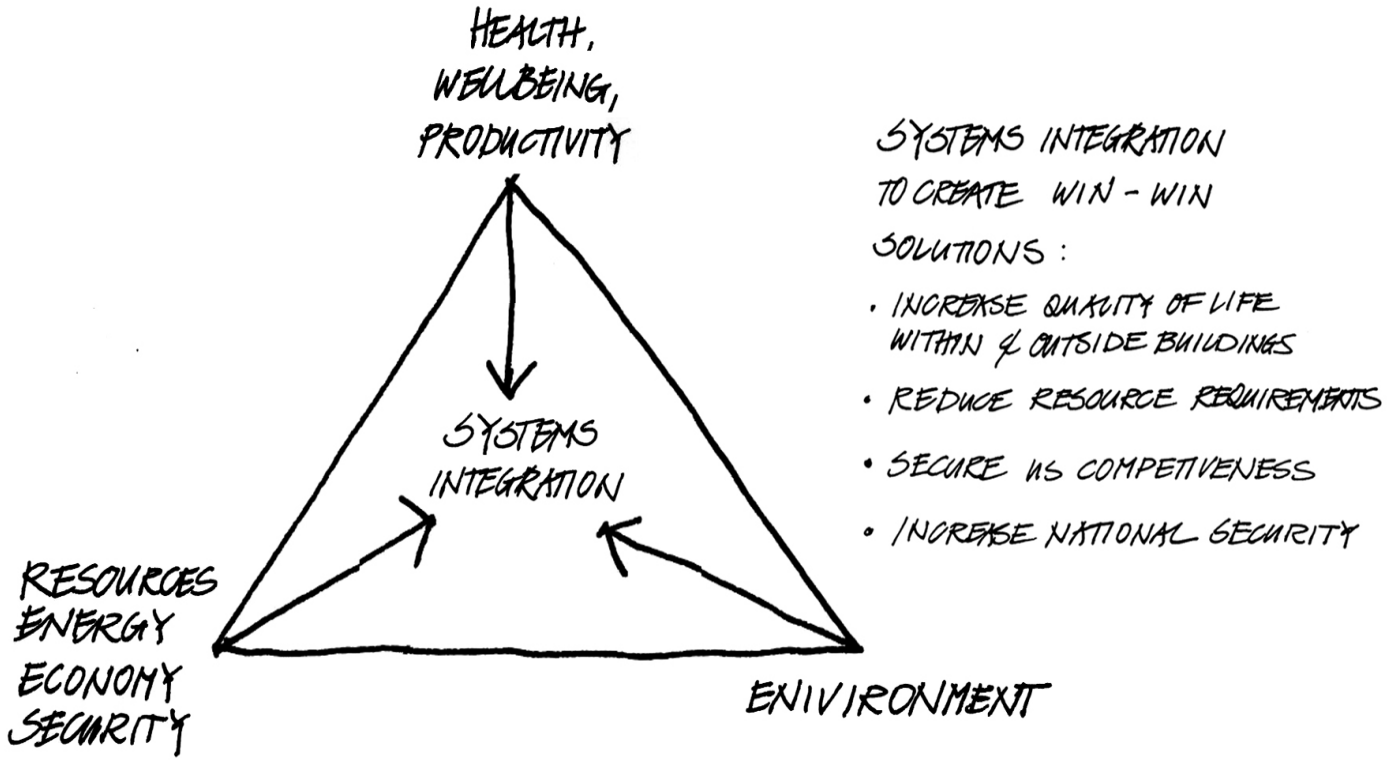


The Role of Universities

- In the US there are about 4000 colleges with almost 16 million students
- Combined annual expenditures exceed US $ 275 billion, which is 2,8% of GDP, this is greater than the GDP of all but 25 nations
- In the near absence of long term US National policy, institutions of higher learning should lead the country by example
- Beginning collaboration between Texas A&M, Carnegie Mellon University, ISR, SNC, & UMD
- Sponsored by Congressmen Doyle, Hall, Barton, Mollohan, Hoyer, Gibbons and Senator Reid

First Passive/Active Solar House in an Inner-City Neighborhood, 1976

Neighborhood Wide Redevelopment an Inner-City, 1980-82



SYSTEMS INTEGRATION TO CREATE WIN - WIN SOLUTIONS :

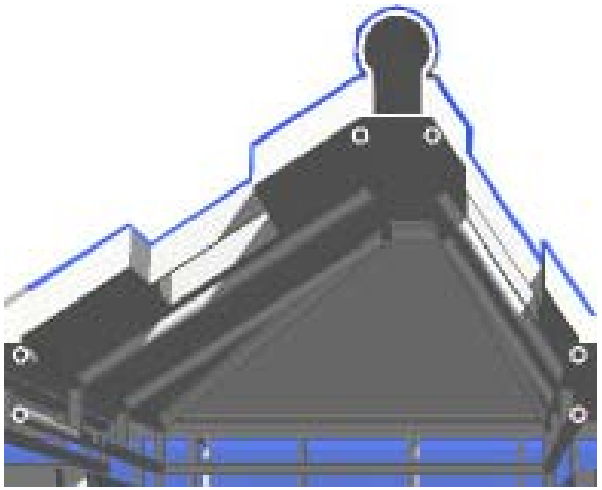
- INCREASE QUALITY OF LIFE WITHIN & OUTSIDE BUILDINGS
- REDUCE RESOURCE REQUIREMENTS
- SECURE US COMPETIVENESS
- INCREASE NATIONAL SECURITY

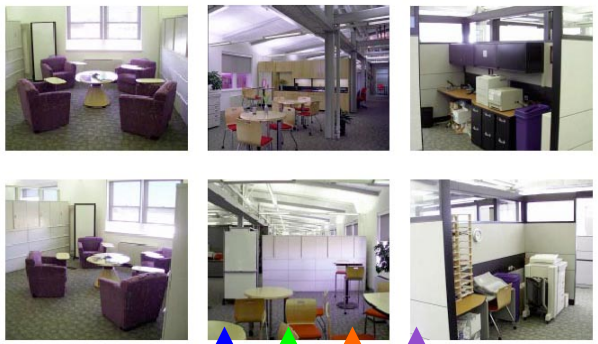
The Intelligent Workplace as an enabling instrument for

- Individual Comfort and Productivity
- Organizational Flexibility
- Technological Adaptability
- Energy and Environmental Effectiveness

Energy Services

- Security
- Reliability
- Quality
- Effectiveness



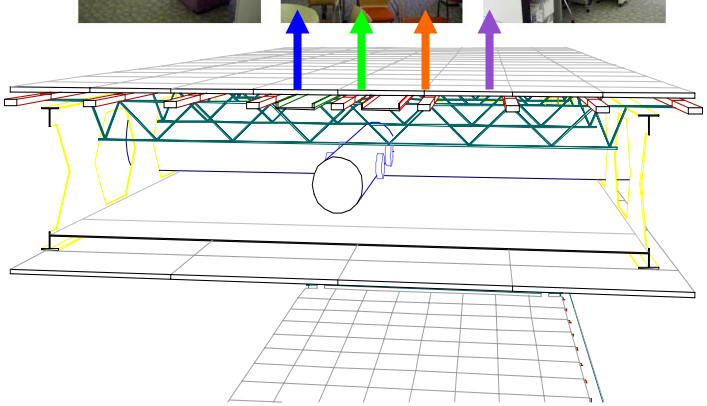


THEATER

Stage set

- Flexibility

Distributed Energy Generation and Supply

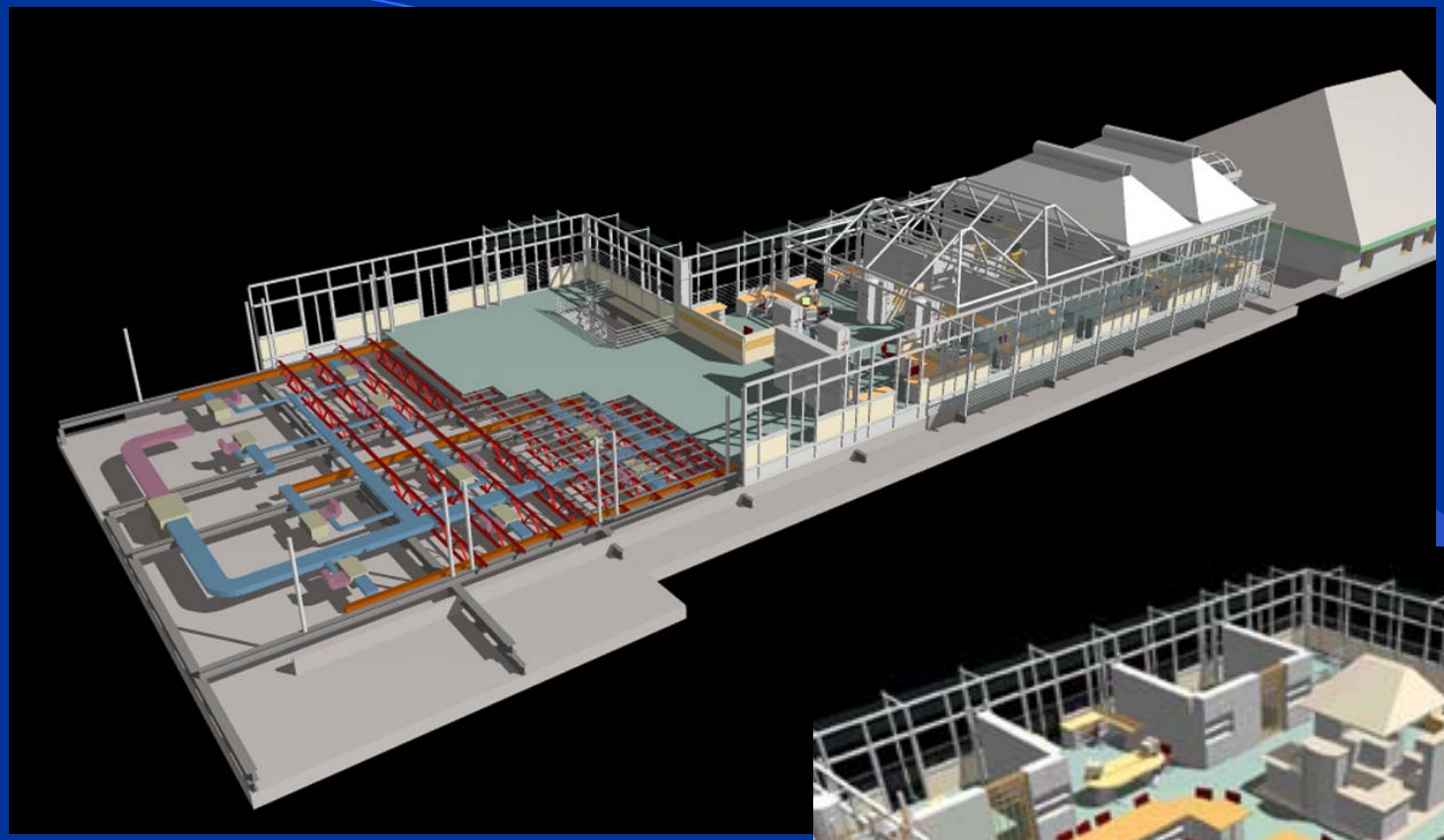


PLATFORM

Air/ Water Heating/Cooling

PVD

- (power, voice, data, video)



The Intelligent Workplace, CMU

Project Room

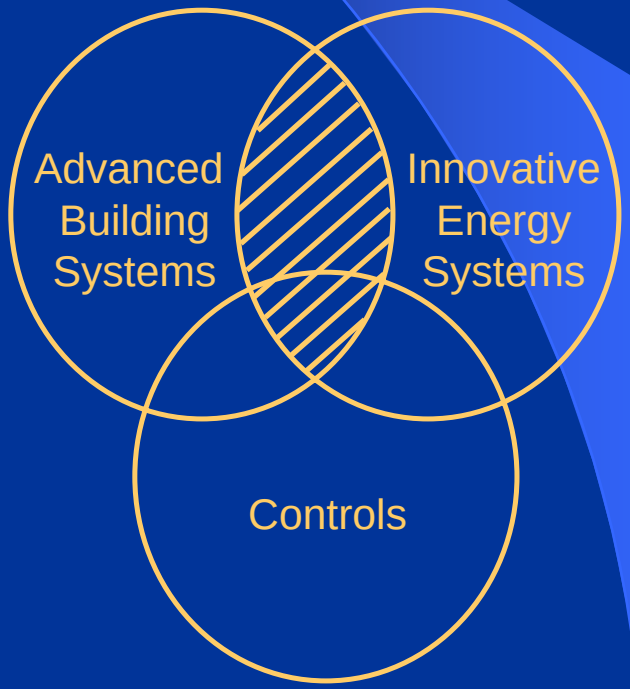
Conference Room (pre "service pub")

"Service Pub" :
equipment, ergonomics, places to pause and sit, interactive tools

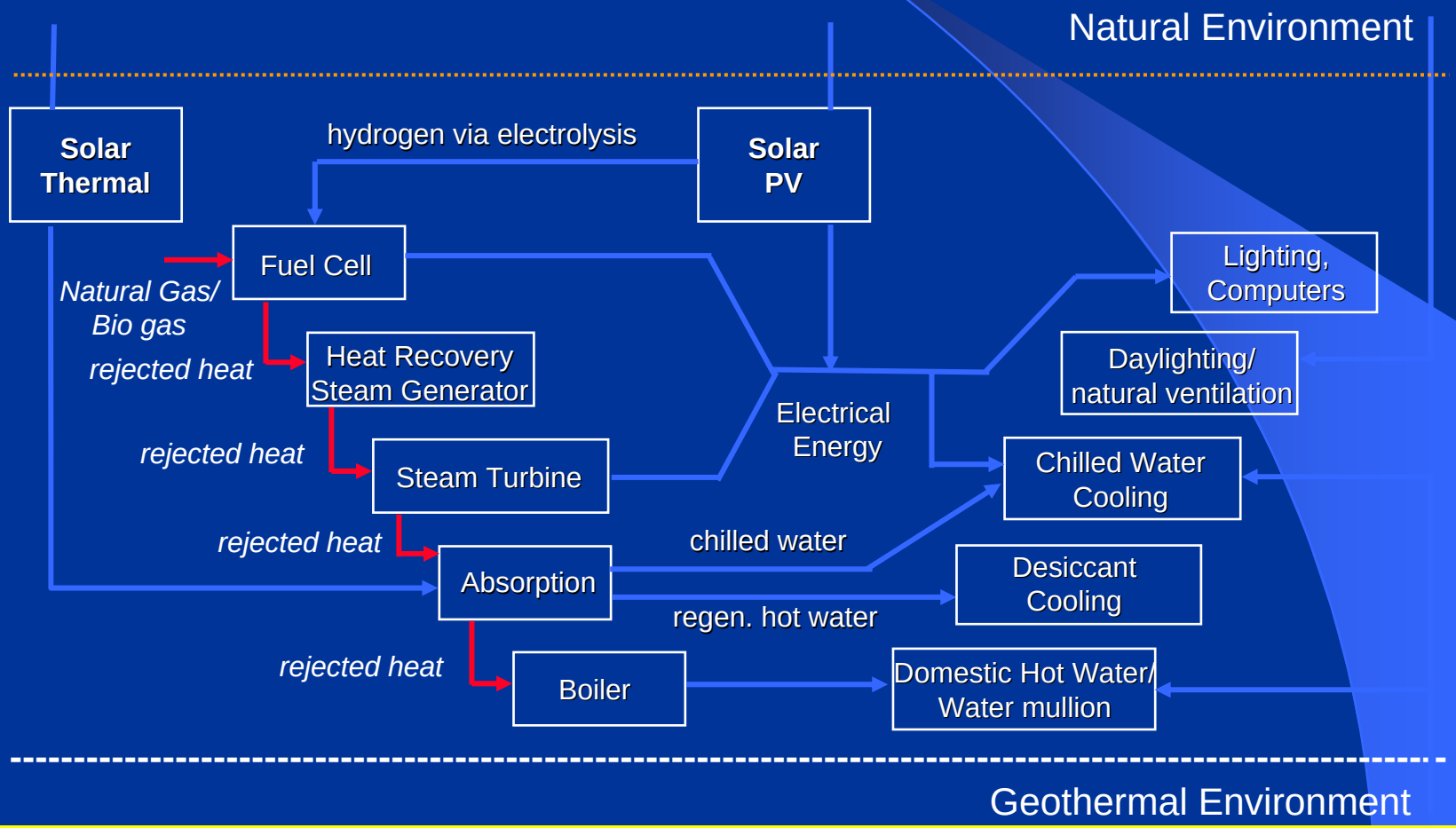
Buildings Can be Net Exporters of Energy

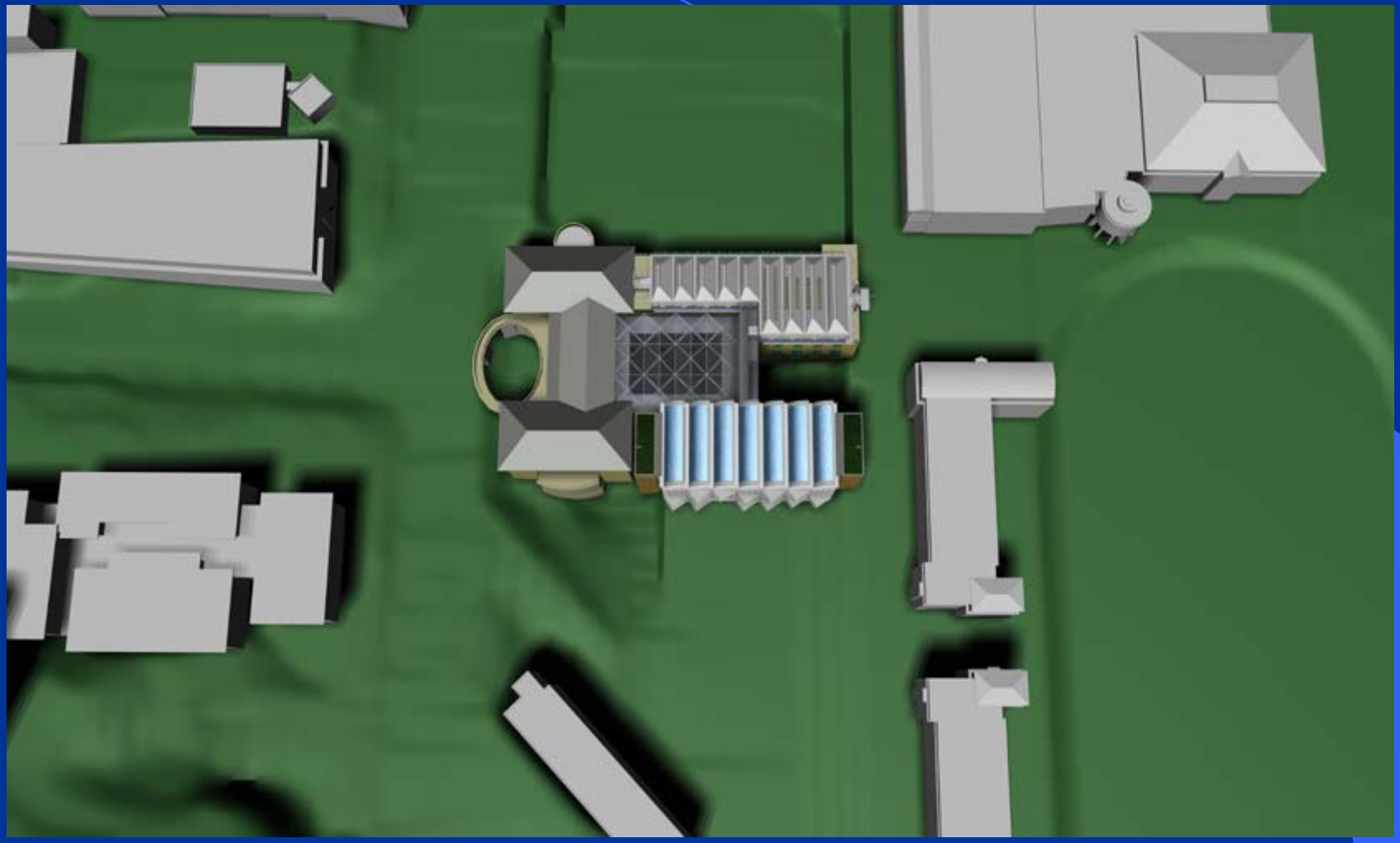
Systems Integration for:

- First, life cycle, environmental cost reduction
- Increased energy effectiveness
- Improved performance for user comfort
- Reliable and effective control technology
- Reliable energy supply
- Increased Return on Investment

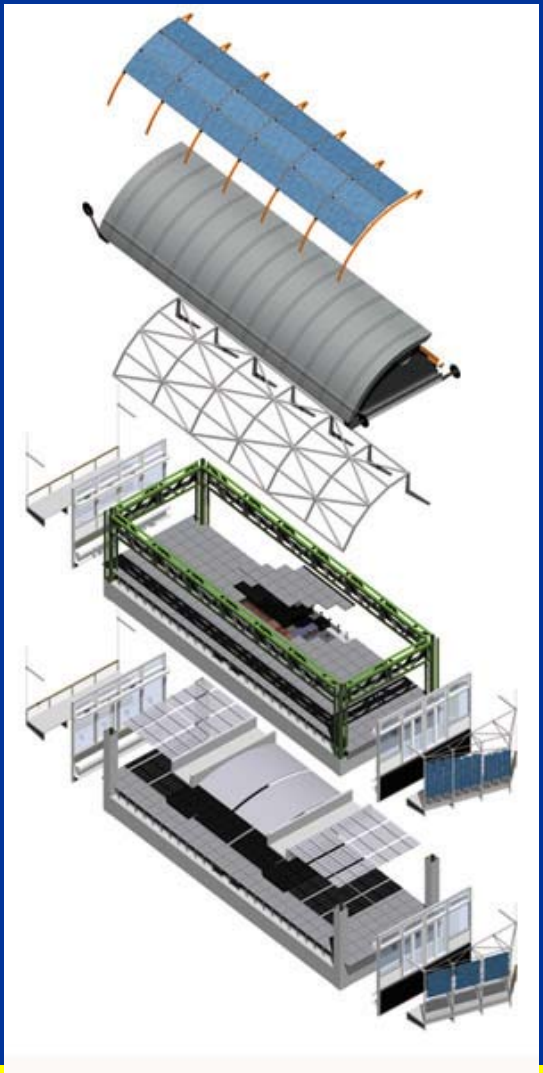


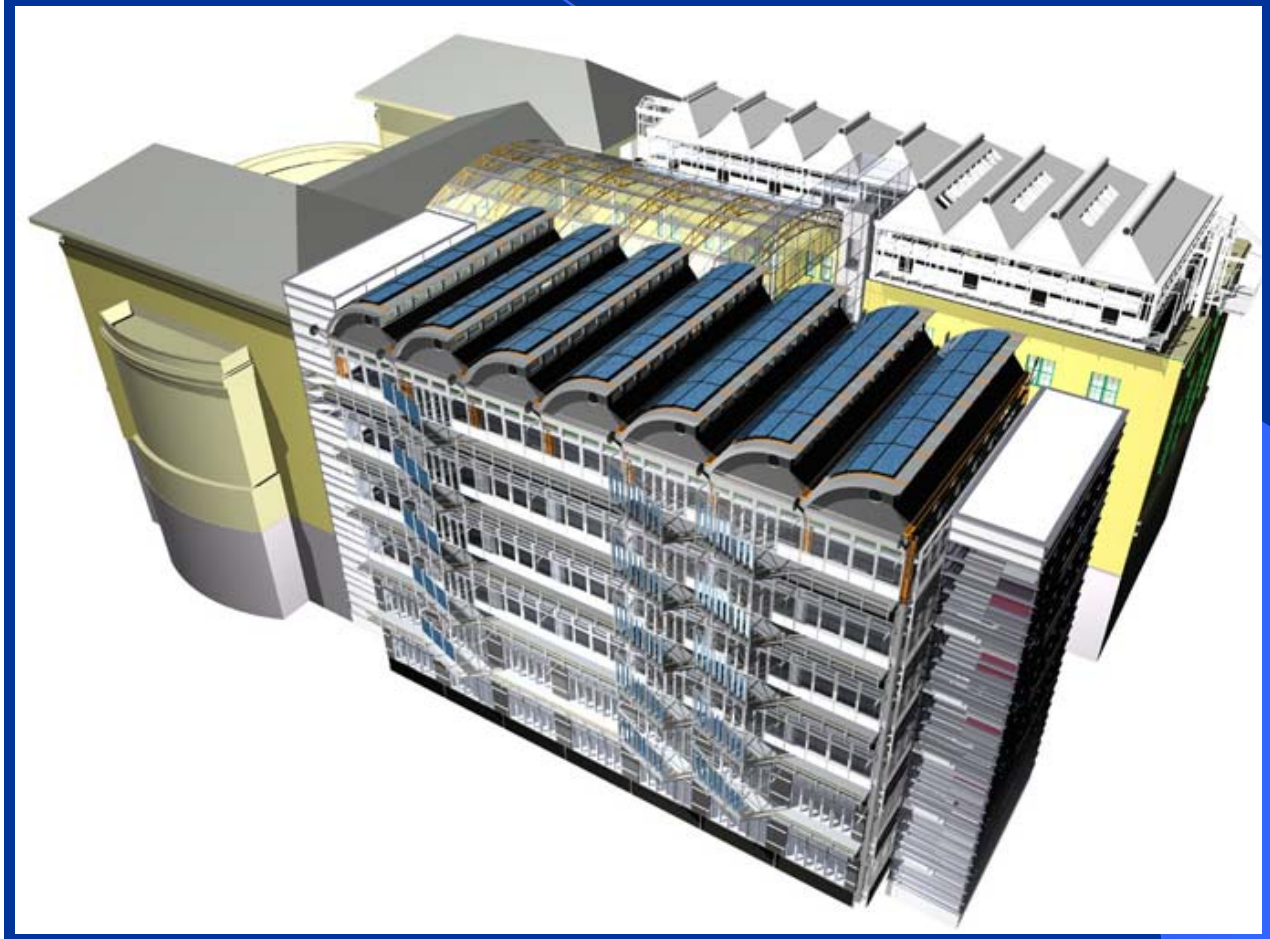
Innovative Energy Systems
Ascending-Descending Strategy



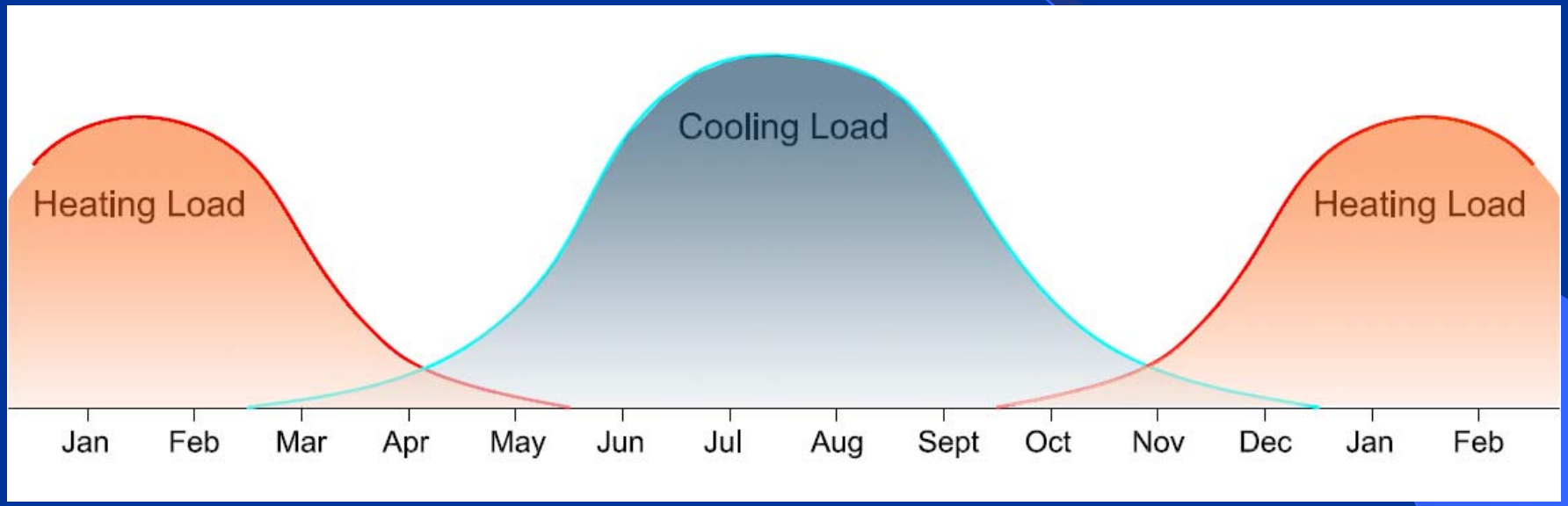


Building As Power Plant (BAPP)



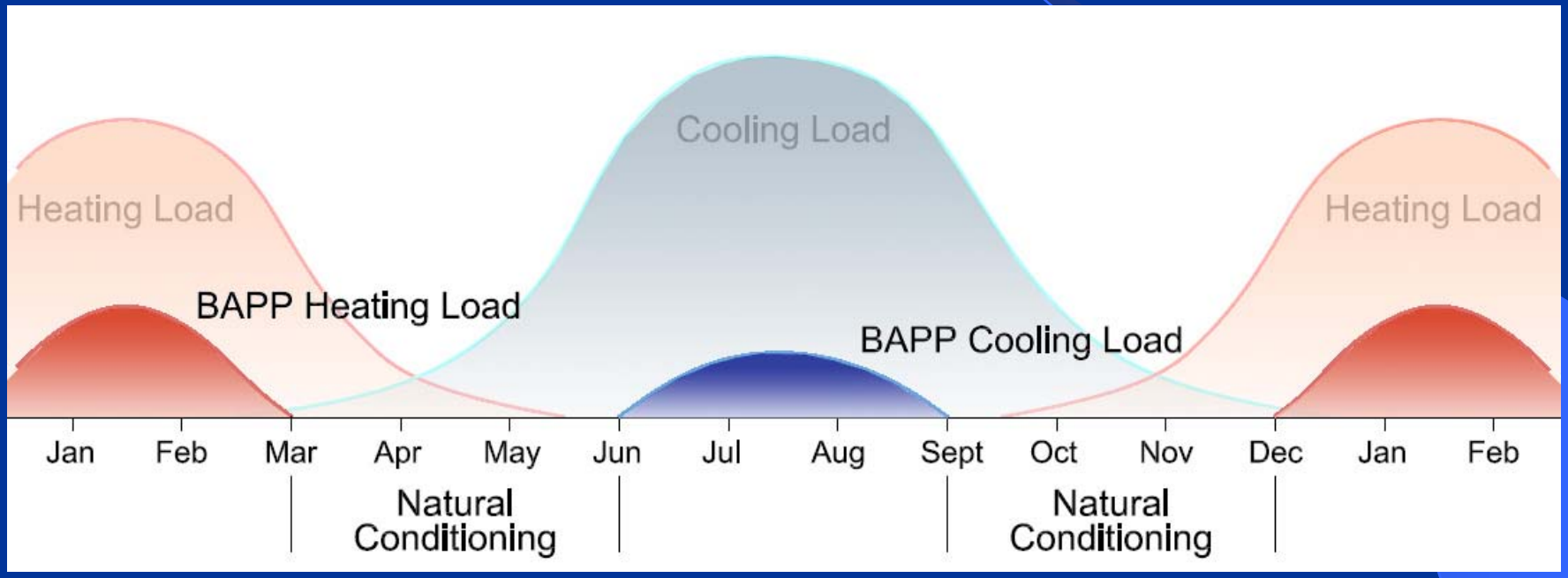


Annual Load Profile of Typical Office Buildings



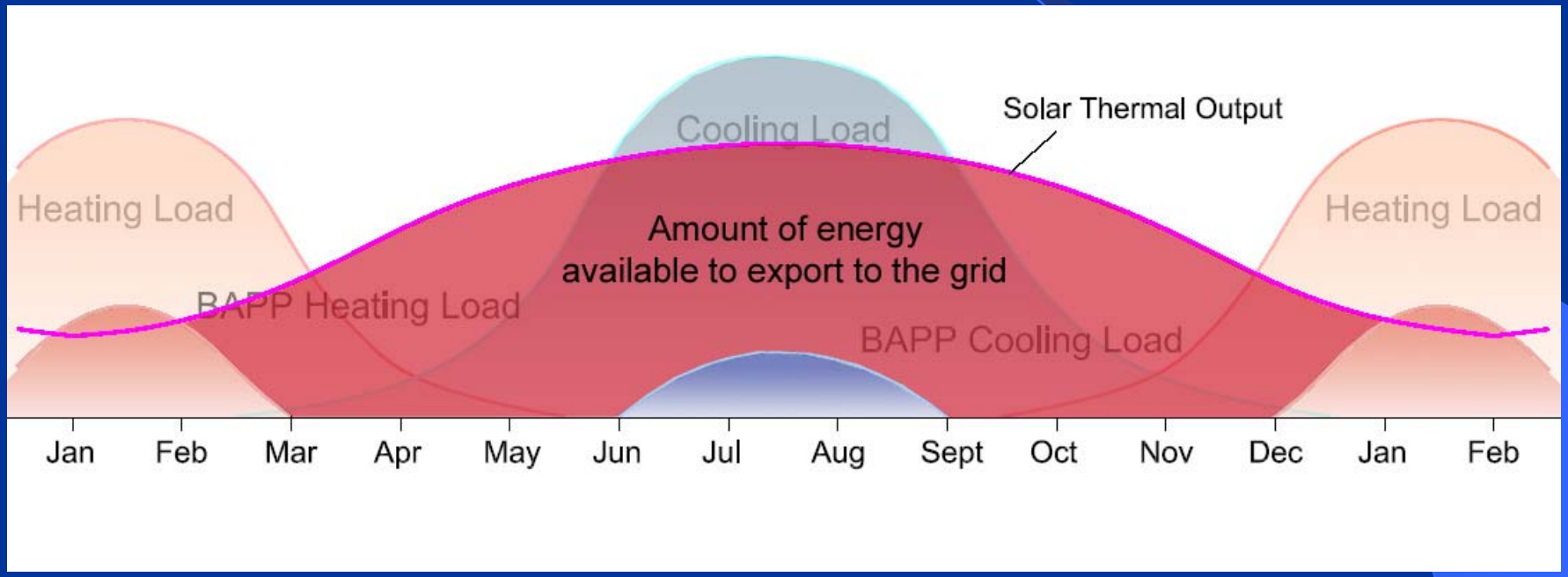
Typical Office Buildings Annual Heating/Cooling Load Profile

Annual Load Profile of BAPP



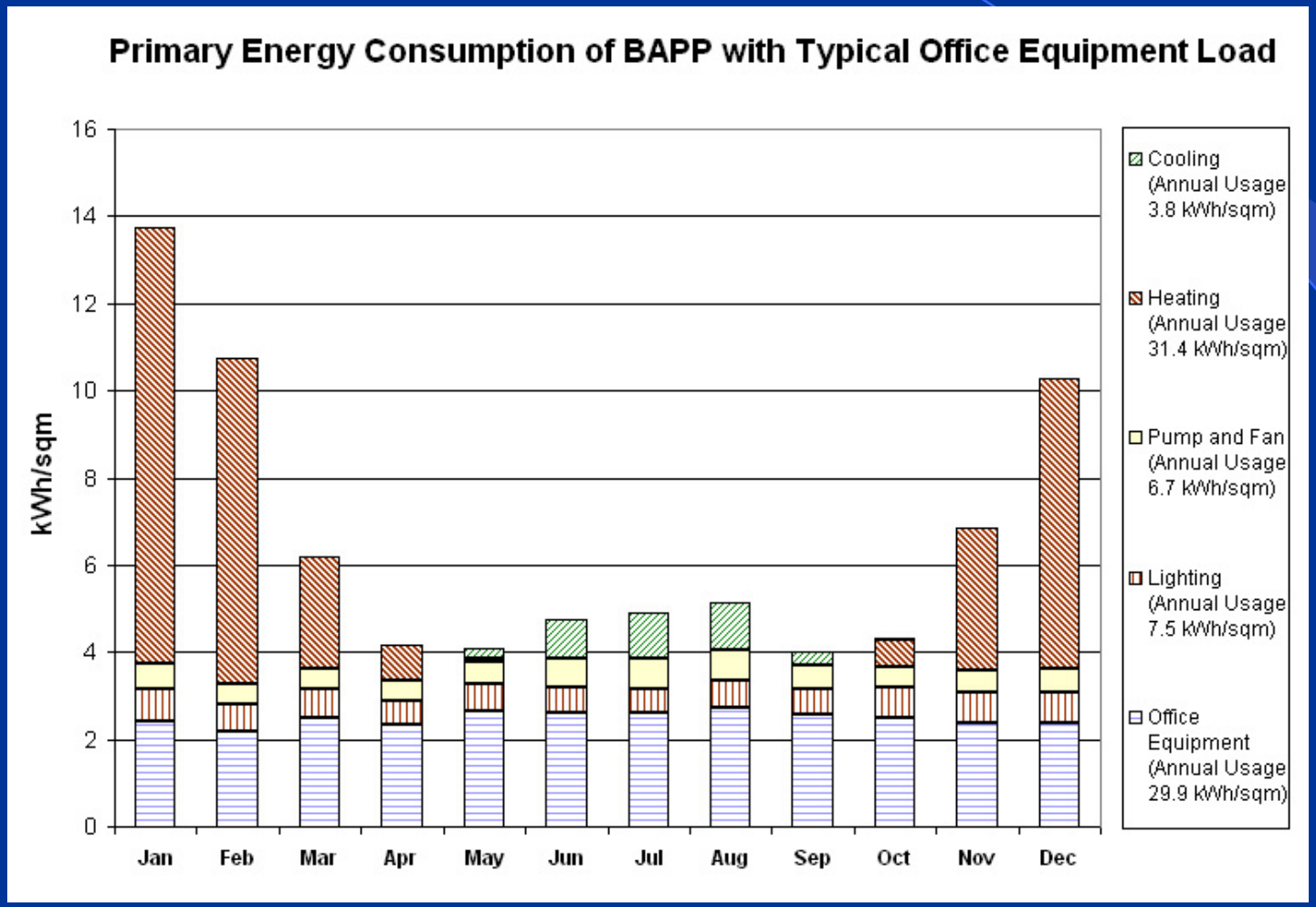
BAPP Annual Heating/Cooling Load Profile

Annual Load Profile of BAPP

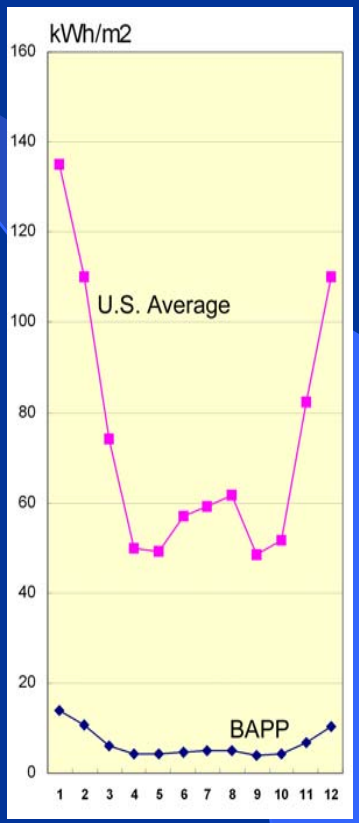


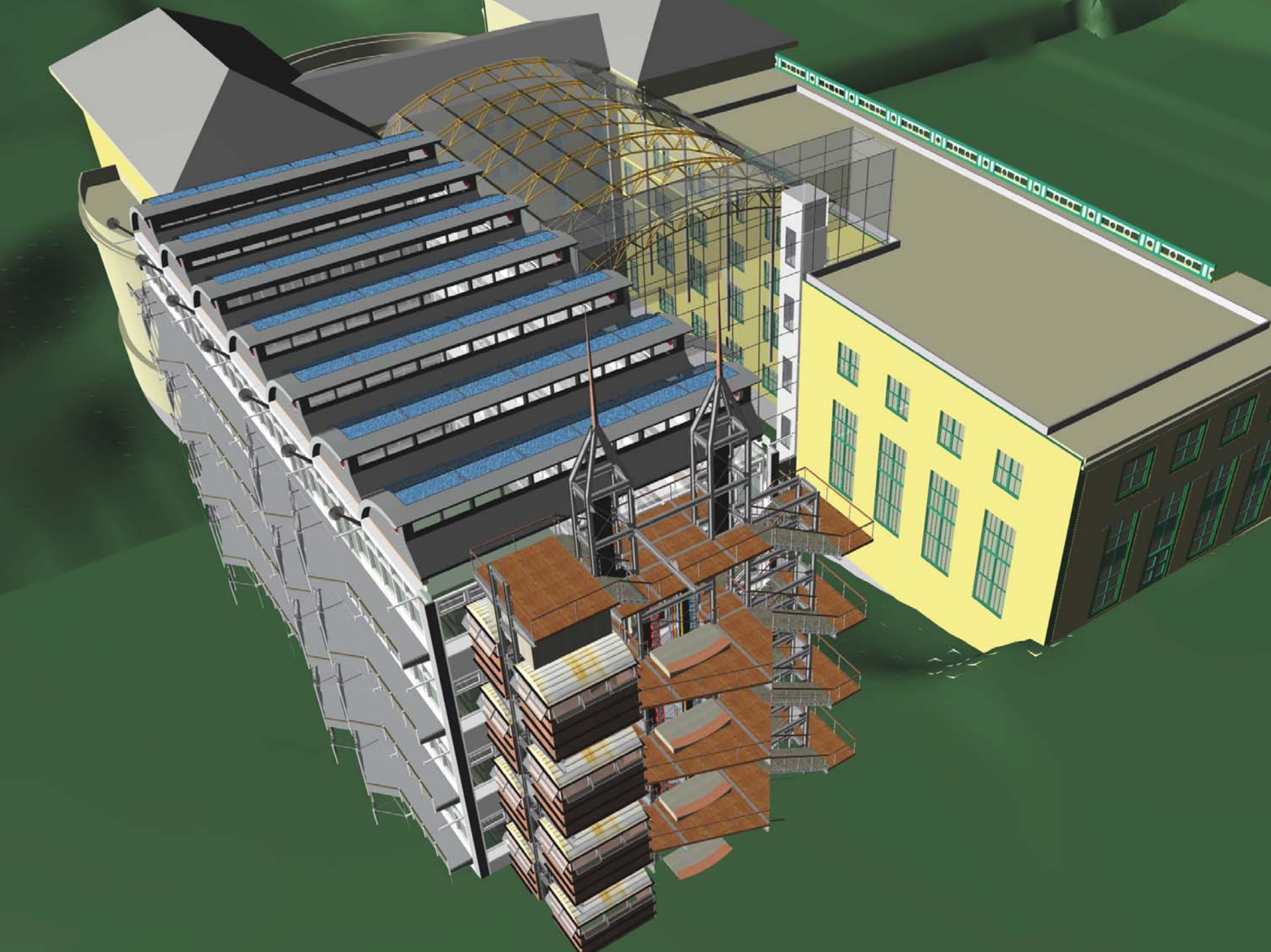
BAPP Annual Heating/Cooling Load Profile – Energy exported to the grid

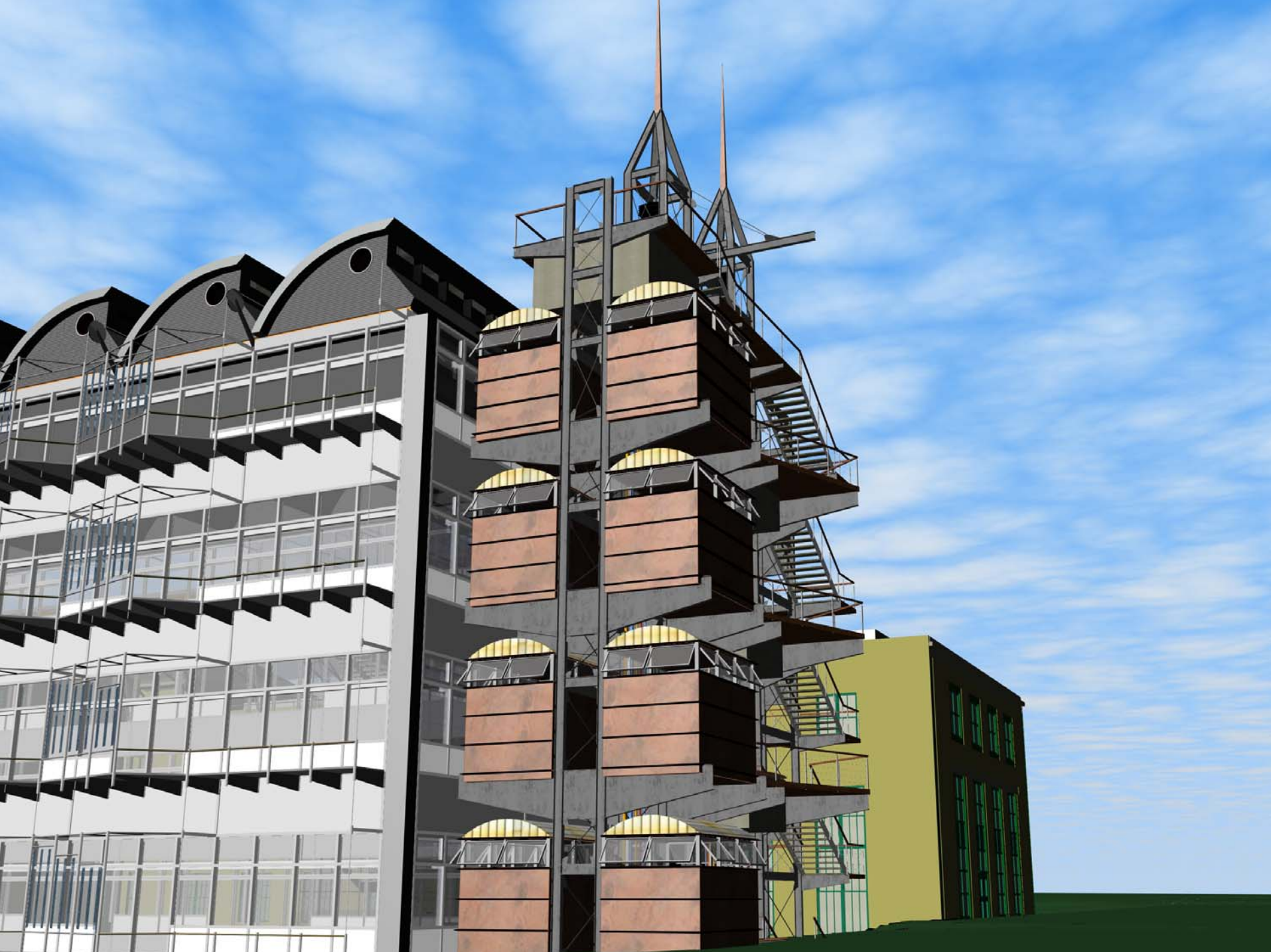
BAPP Primary Energy Consumption – More Details



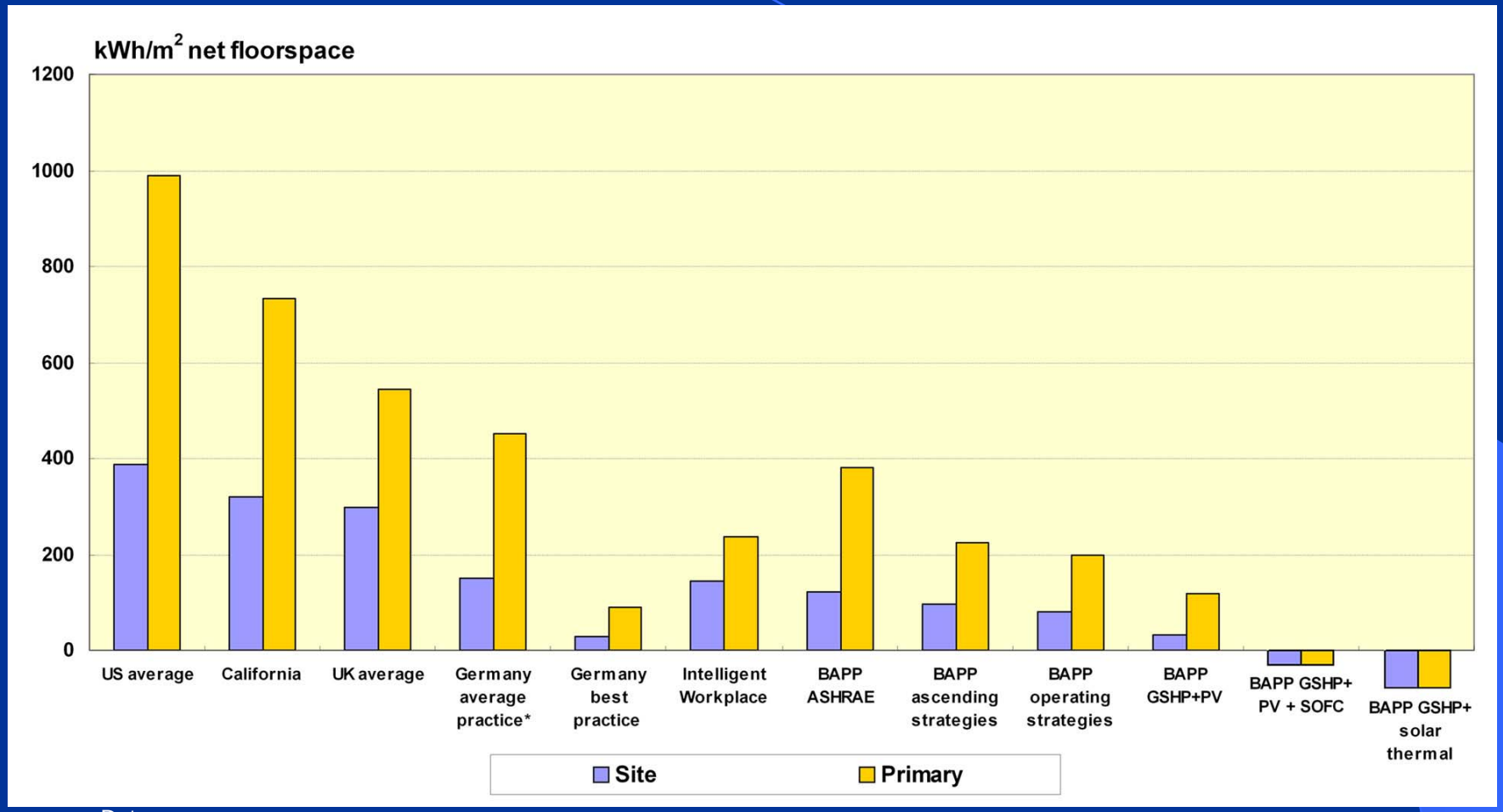
Comparison of Primary Energy Consumption between BAPP and US average







Annual Site/Primary Energy Consumption in Office Buildings

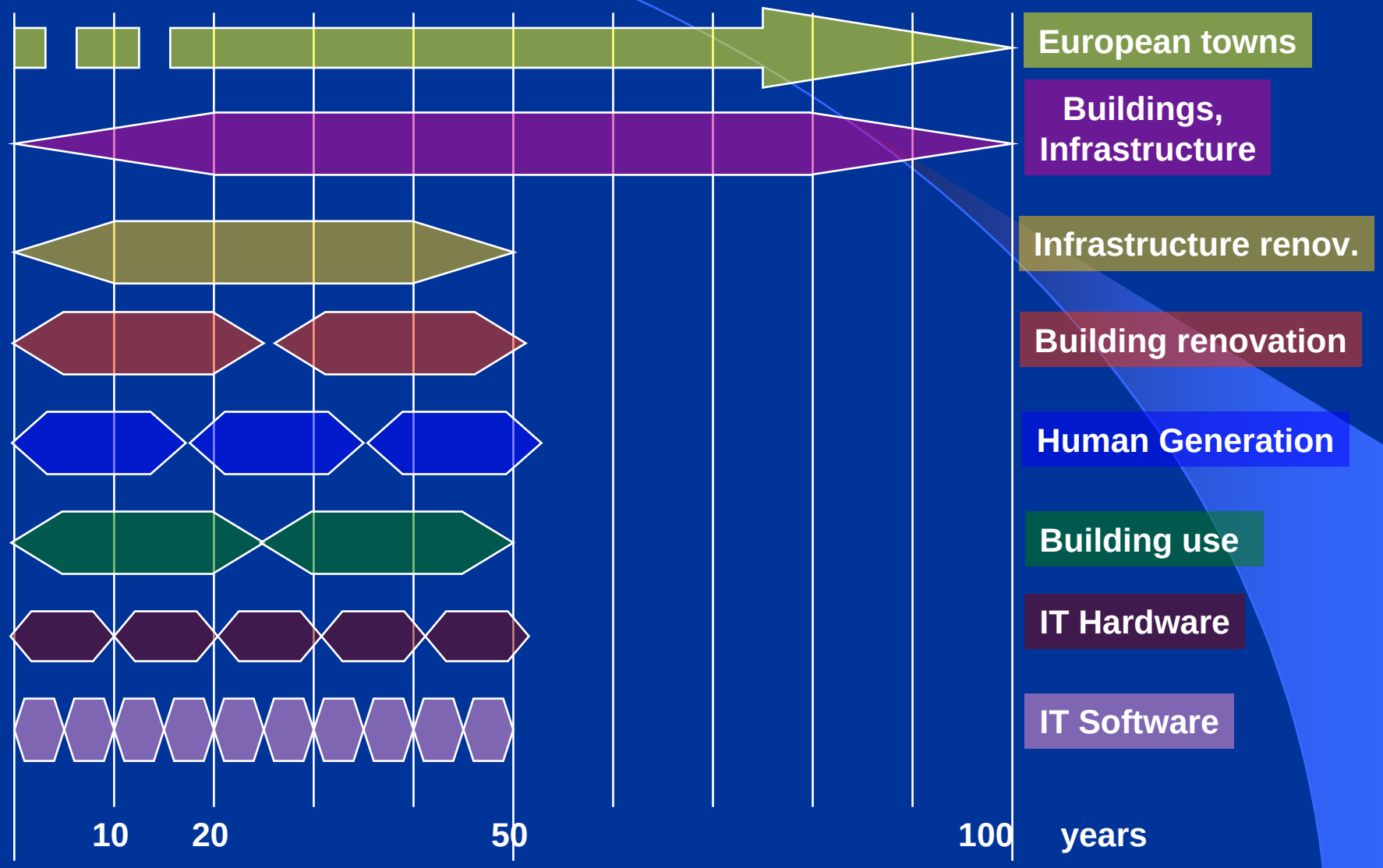


Data source:

EIA, Commercial Building Energy Consumption Survey 1995; PG&E, Commercial Building Survey Report 1999; UK National Statistics

* Germany average practice is calculated based on the energy consumption measurements of 15 German office buildings built between 1990 and 2002 (with primary energy consumption ranging from 180kWh/m² to 1,000kWh/m²).

Generational transformation in the Built Environment



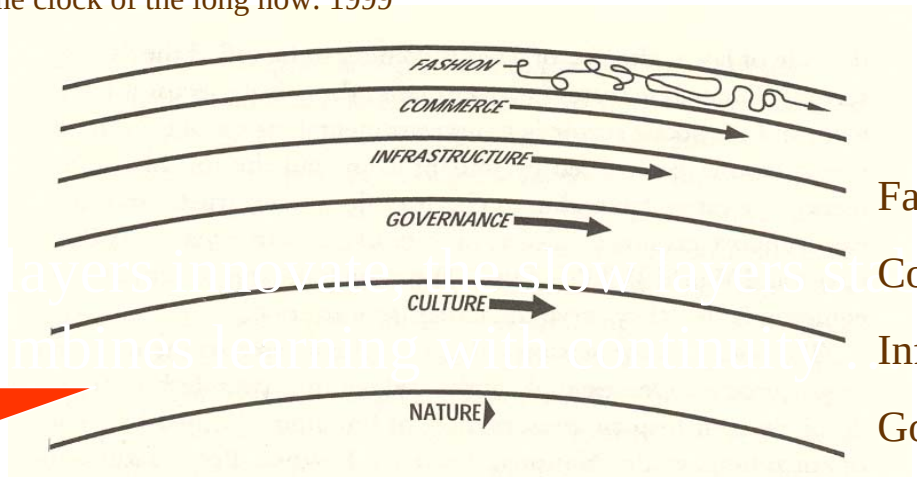
After :N. Kohler 2003

The Order of Civilisation

The fast layers innovate, the slow layers stabilise. The whole combines learning with continuity.

Stewart Brand – The clock of the long now. 1999

Invigorate



Fashion

Commerce

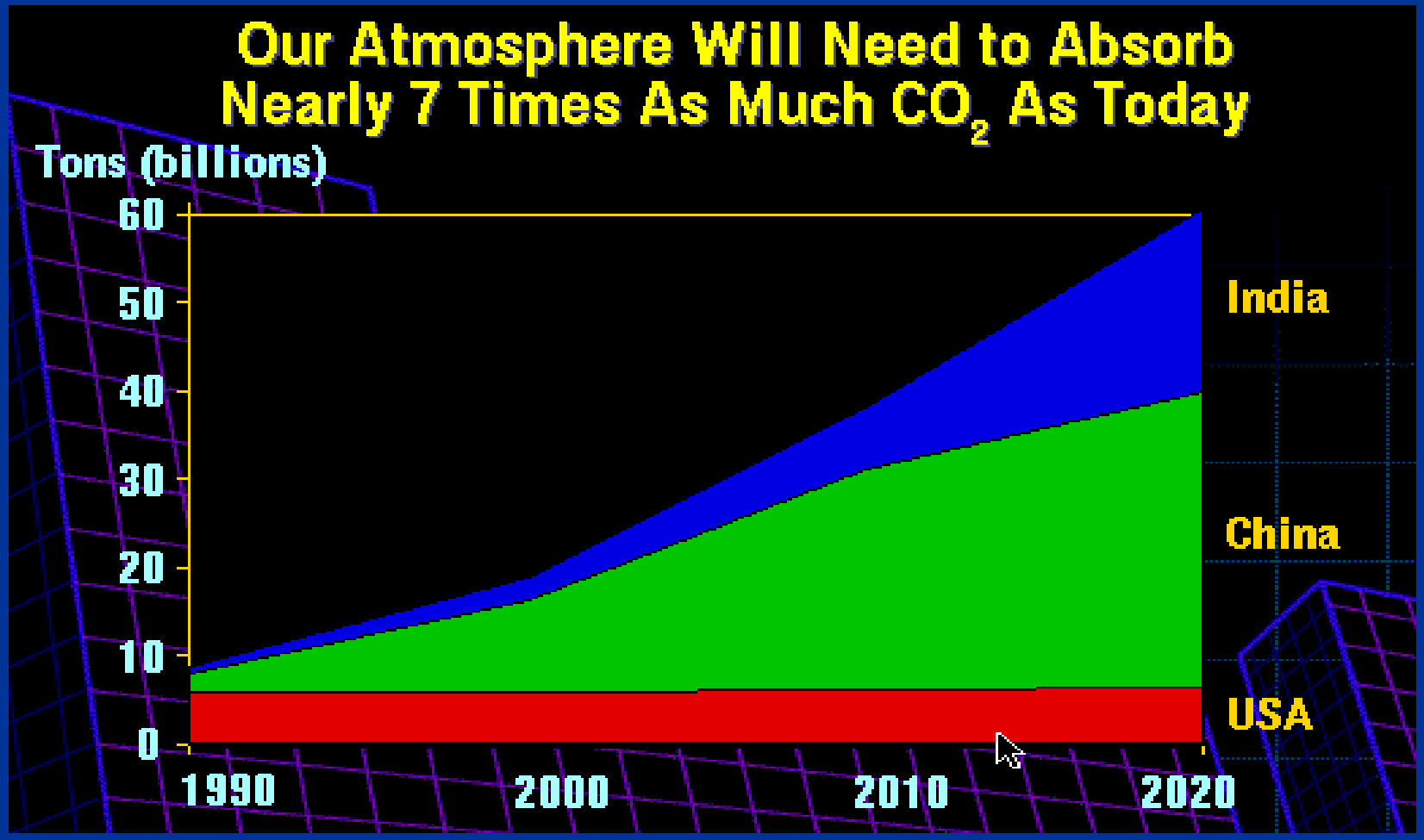
Infrastructure

Governance

Culture

Nature

Sustain


Our Atmosphere Will Need to Absorb
Nearly 7 Times As Much CO_2 As Today
Tons (billions)
60
50
40
30
20
10
0
1990
2000
2010
2020
India
China
USA

Two Planets meet in Space

- One has homo sapiens sapiens