

Sustainable Building Basic Concepts



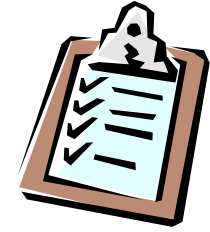
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Contents



- Sustainable development
- Green/sustainable building
- Why going green?
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- Design strategies
 - Urban and site design; Energy efficiency; Renewable energy; Building materials; water issues; Indoor environment; Integrated building design



What is



**Sustainable
Development?**

OUR COMMON FUTURE

THE WORLD COMMISSION
ON ENVIRONMENT
AND DEVELOPMENT

The Brundtland Report
defines
“Sustainable Development”



Full text of the report:

<http://www.un-documents.net/wced-ocf.htm>



Sustainable development

- The Brundtland Report (*Our Common Future*)
 - “...is development which meets the **needs of the present** without compromising the ability of **future generation** to meet their own needs.” – World Commission on Environment and Development.
- Two important concepts
 - Needs – maintain an acceptable life standard
 - Limits – within the carrying capacity of supporting ecosystems and resource base

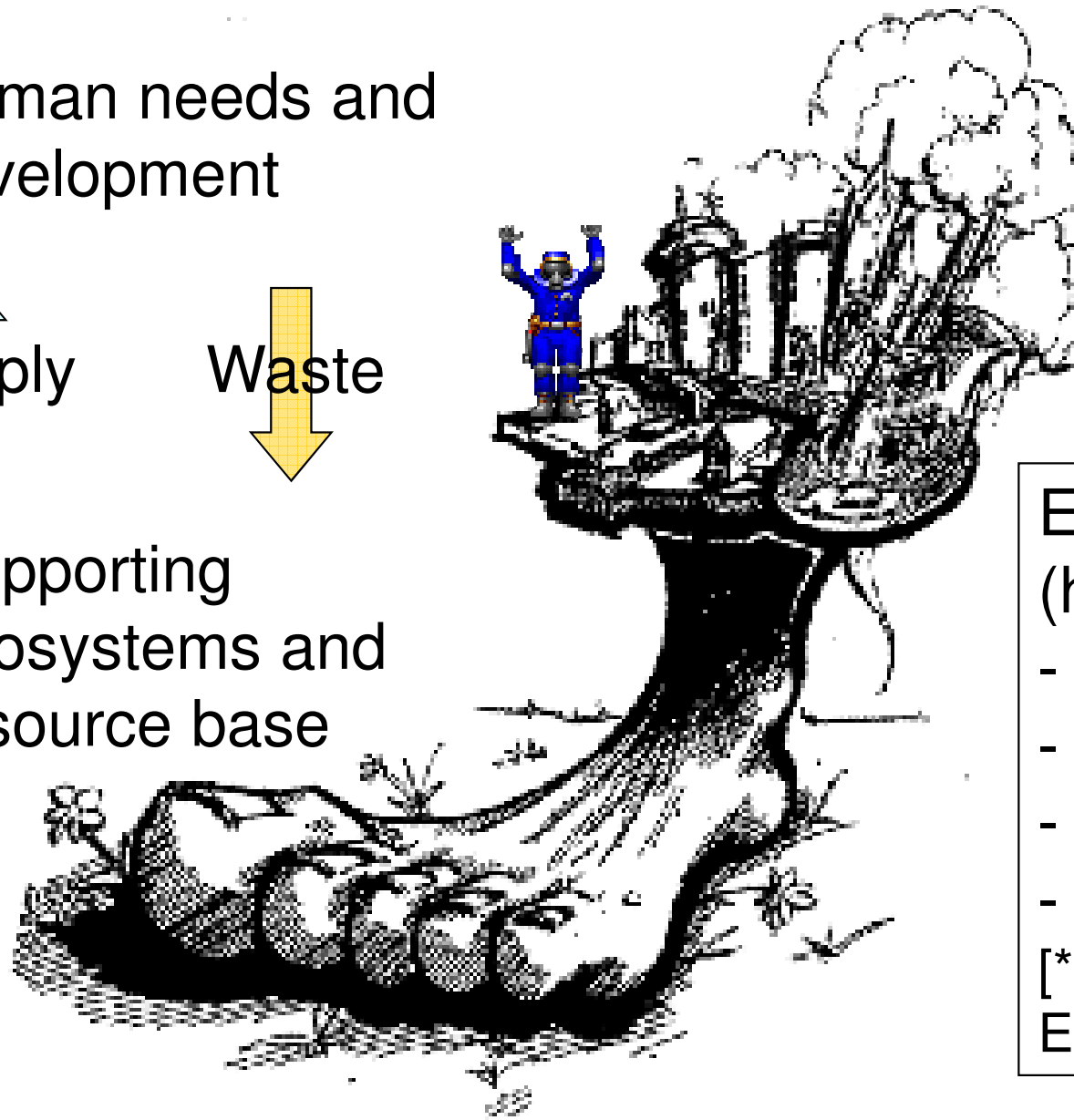
Carrying capacity and ecological footprint

Human needs and development

Supply

Waste

Supporting ecosystems and resource base



Ecological footprint (hectares/person) *:

- world average = 2.3
- USA = 10.3
- **Hong Kong = 6.0**
- China = 1.2

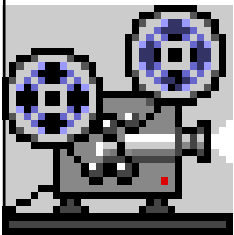
[* Source: Friends of the Earth (HK)]



Sustainable development



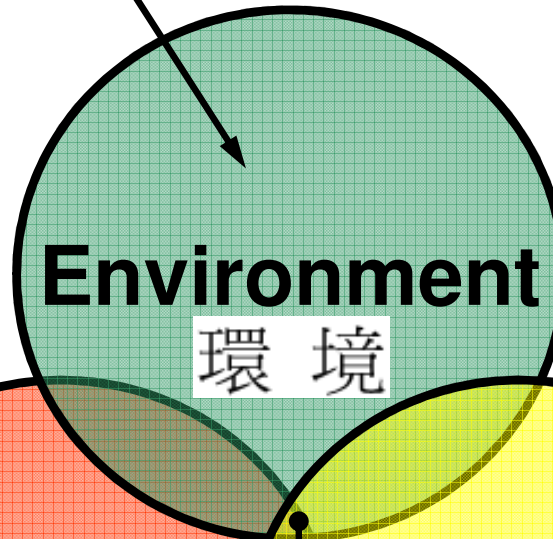
- Sustainability (可持續發展, 永續性)
 - The endurance of systems and processes
 - Improves the quality of human life while living within the carrying capacity of supporting eco-systems
- Video Presentation:
 - Sustainability explained through animation (2:00)
<http://youtu.be/B5NiTN0chj0>
 - What is Sustainability? (1:51)
<http://youtu.be/hH109q5kk0k>



Three dimensions of sustainability

Environmental Sustainability

Ecosystem integrity
Carrying capacity
Biodiversity



Environment

環境

Social Sustainability

Cultural Identity
Empowerment
Accessibility
Stability
Equity

Economic Sustainability

Growth
Development
Productivity
Trickle-down

Economy

經濟

Society

社會

Human Well Being





“What is
green
building?”



An example of green building in Hong Kong ?!

(A building in Pokfulam; photo taken by Dr Sam C M Hui)



Cologne

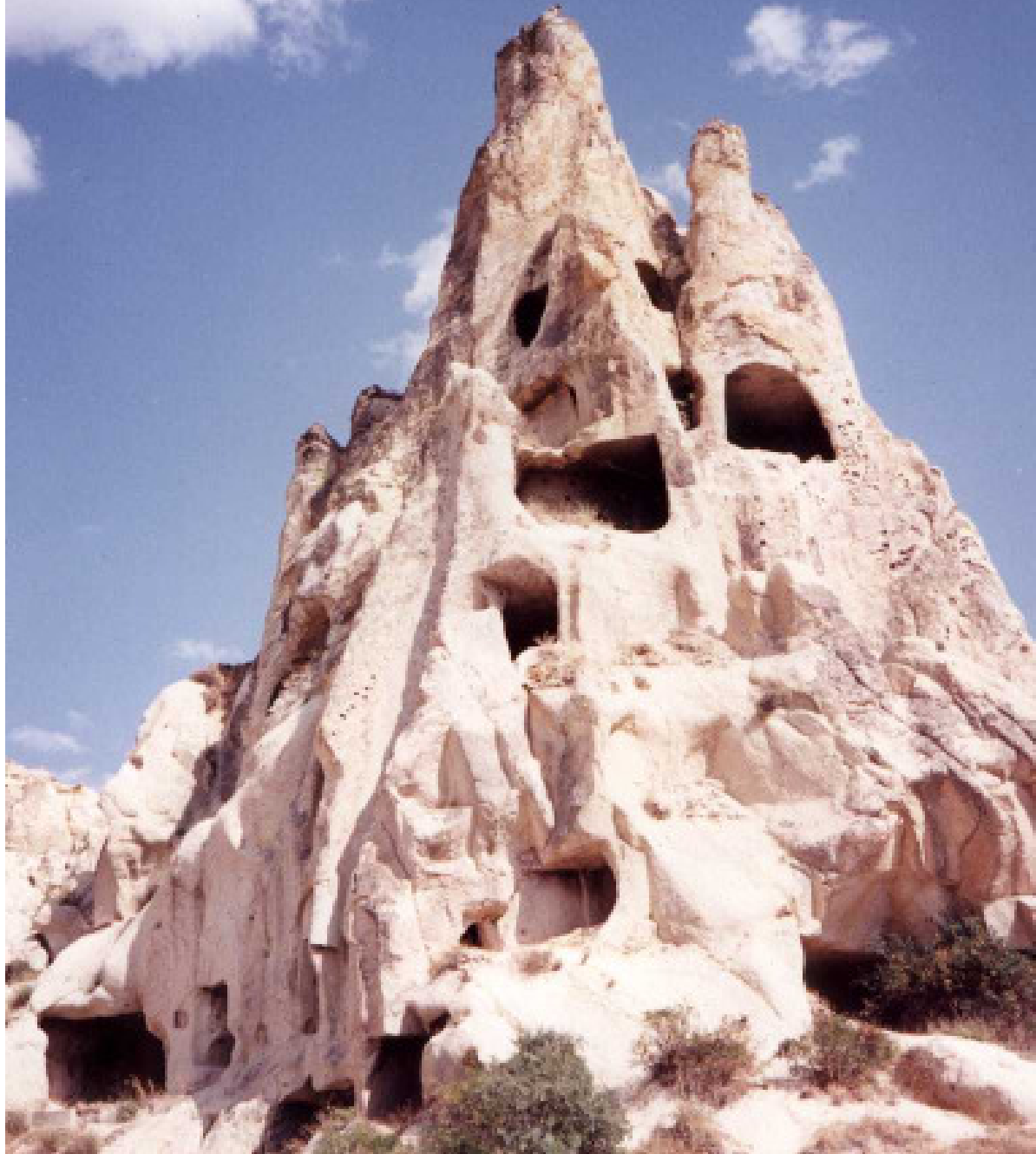
Building
+
Green

Toronto



Green building is NOT just adding a green outlook

Cave dwellings in Cappadocia, Turkey



(Photo taken during my travel to Turkey in 1992)

Sustainable Architecture

in ancient time
(cave dwellings)
(3500 years)

- cooperate with nature (climate, topography)
- durable and longlife are the trend



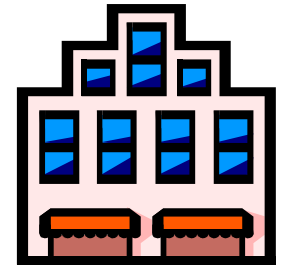
Photo credit: Renzo Piano Workshop Foundation

A modern example of
Sustainable Architecture:

Jean Marie Tjibaou
Cultural Center
(by Renzo Piano)

- Integration of
regional materials,
traditional construction
methods, contemporary
technology and
ecological design

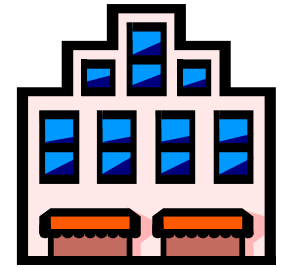
Green/sustainable building



- A loosely defined collection of land-use, building design, and construction strategies that reduces the **environmental impacts**
- The term “green” is extremely wide ranging, encompassing many viewpoints and open to broad interpretation
 - Debate around green building/architecture
 - Complexity of environmental issues



Green/sustainable building



- It involves a *holistic* approach to the design and operation of buildings. It considers:
 - *1) Economy and efficiency of resources*
 - *2) Life cycle design*
 - *3) Human well-being*
- Main objectives
 - Be environmentally friendly and responsible
 - Improve the quality of built environment

Cradle-to-Grave

Sustainable design requires life cycle thinking.



Cradle-to-grave is the full Life Cycle Assessment from resource extraction ('cradle') to use phase and disposal phase ('grave').

- site selection
- urban design
- landscape planning

- CO₂ emissions
- acid rain
- ozone depletion
- rainforest depletion

- energy performance
- renewable energy
- water conservation

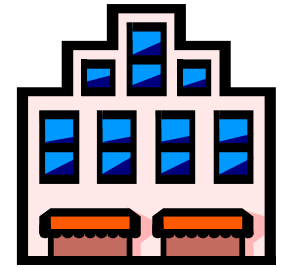
**Environmental
Criteria &
Factors**

- environmental policy
- transport strategy
- building maintenance

- material selection
- recycling of materials
- waste management
- disposal & reuse

- air quality
- thermal comfort
- lighting & noise
- hazardous materials

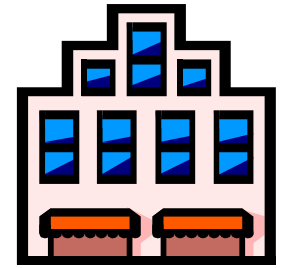
Green/sustainable building



- Green buildings are
 - Energy and resource efficient
 - Non-wasteful and non-polluting
 - Sustainable design that helps minimise broad environmental impacts (e.g. ozone depletion)
 - Highly flexible and adaptable for long-term functionality
 - Easy to operate and maintain (lower running costs)
 - Supportive of the productivity and well-being of the occupants



Green/sustainable building

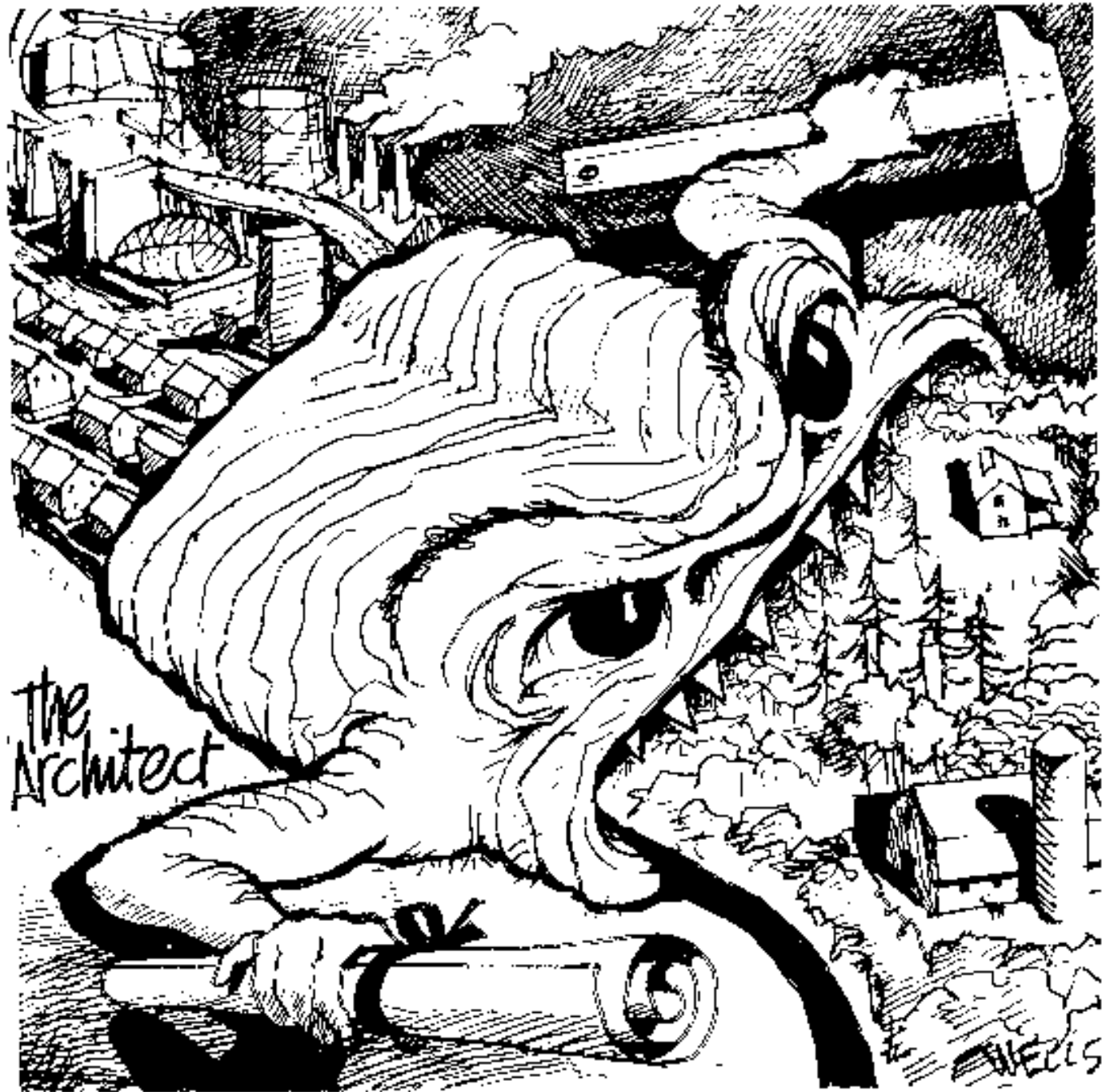


- **Definition of Sustainable Building** [by an OECD project]
 - Have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting
 - Apply practices which strive for integral quality (economic, social and environmental performance) in a very broad way

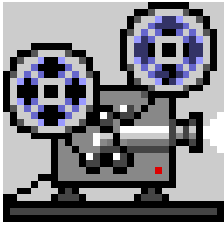
"It's not easy being green." -- Kermit the Frog, 1972.



Why going green?

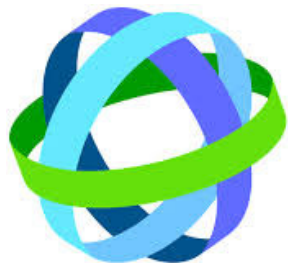
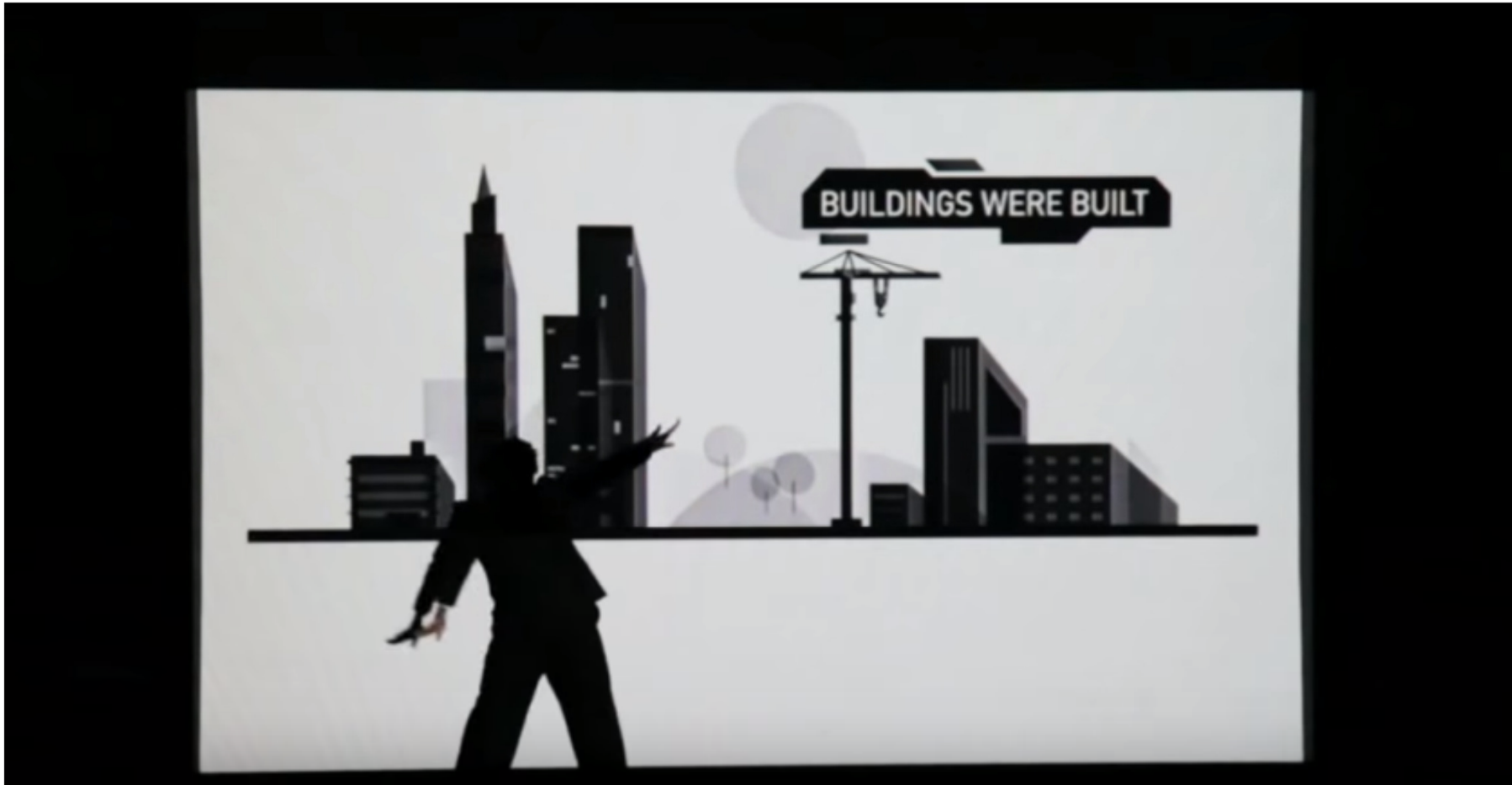


Drawing by the American architect Malcolm Wells



Green Building Evolution (3:47)

<http://www.youtube.com/watch?v=MroerBD69bA>

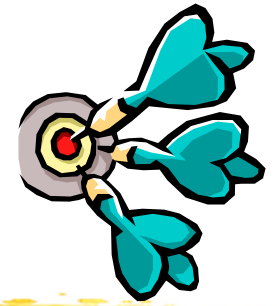


WORLD
GREEN
BUILDING
COUNCIL

www.worldgbc.org

The story of the evolution of the green building movement told through image and dance. At the opening of the WorldGBC Congress/GBCSA Convention in Cape Town in 2013.

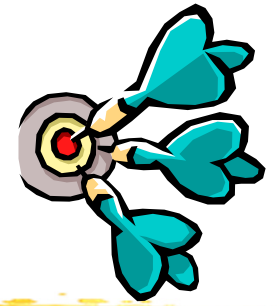
Why going green?



- Buildings consume significant resources
 - Consumption of energy & water
 - Use of building materials
 - Transport of materials & products
- Construction as the worst polluters
 - Operation on site and off site
 - Waste from construction/occupants
 - Pollutants from buildings



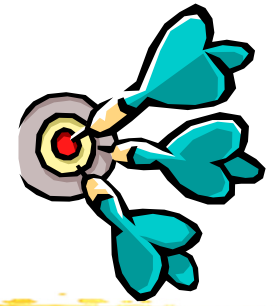
Why going green?



- Green buildings pay
 - Direct benefits (e.g. energy/cost savings)
 - Indirect benefits (e.g. healthier conditions)
 - Wider global benefits (e.g. reduced CO₂ emission)
- Life-cycle benefits
 - Total economic and environmental performance
 - Long-term “*sustainability*”



Why going **green**?



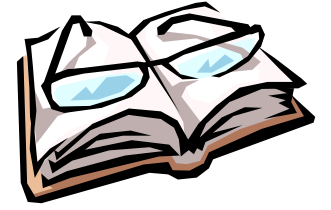
- Benefits of sustainable buildings:
 - They are designed to be cost effective
 - They boost employee productivity
 - They enhance health and well-being
 - They reduce liability
 - They create value for tenants
 - They increase property value
 - They benefit the community
 - They achieve more predictable results



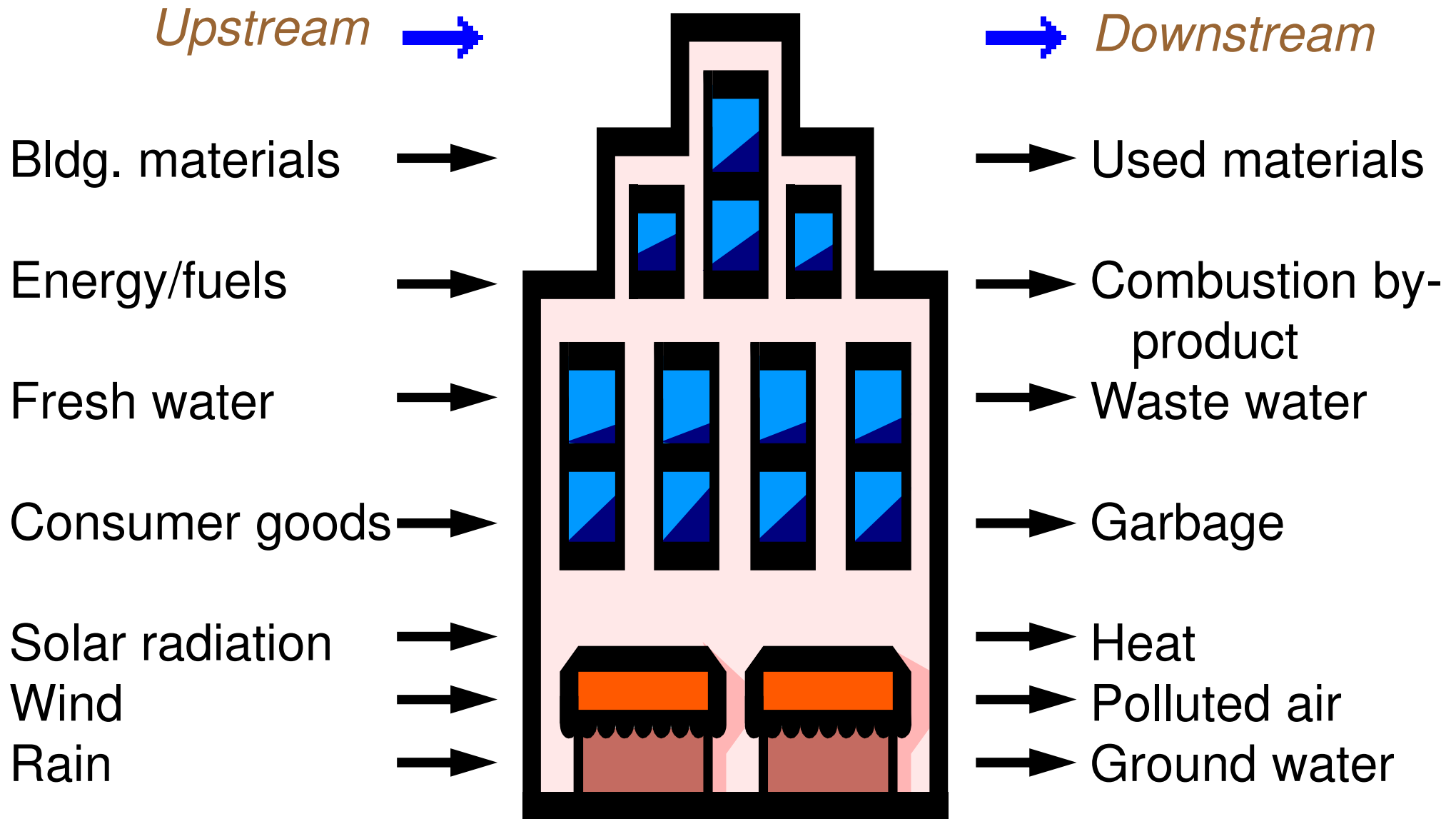


Basic Principles

Basic principles

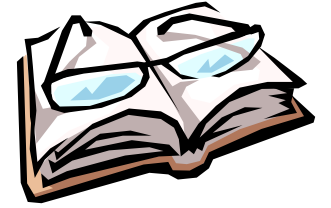


- Aims of green building design
 - Reduce energy in use
 - Minimise external pollution & environmental damage
 - Reduce embodied energy & resource depletion
 - Minimise internal pollution & damage to health
- Green design requires resolving many conflicting issues and requirements



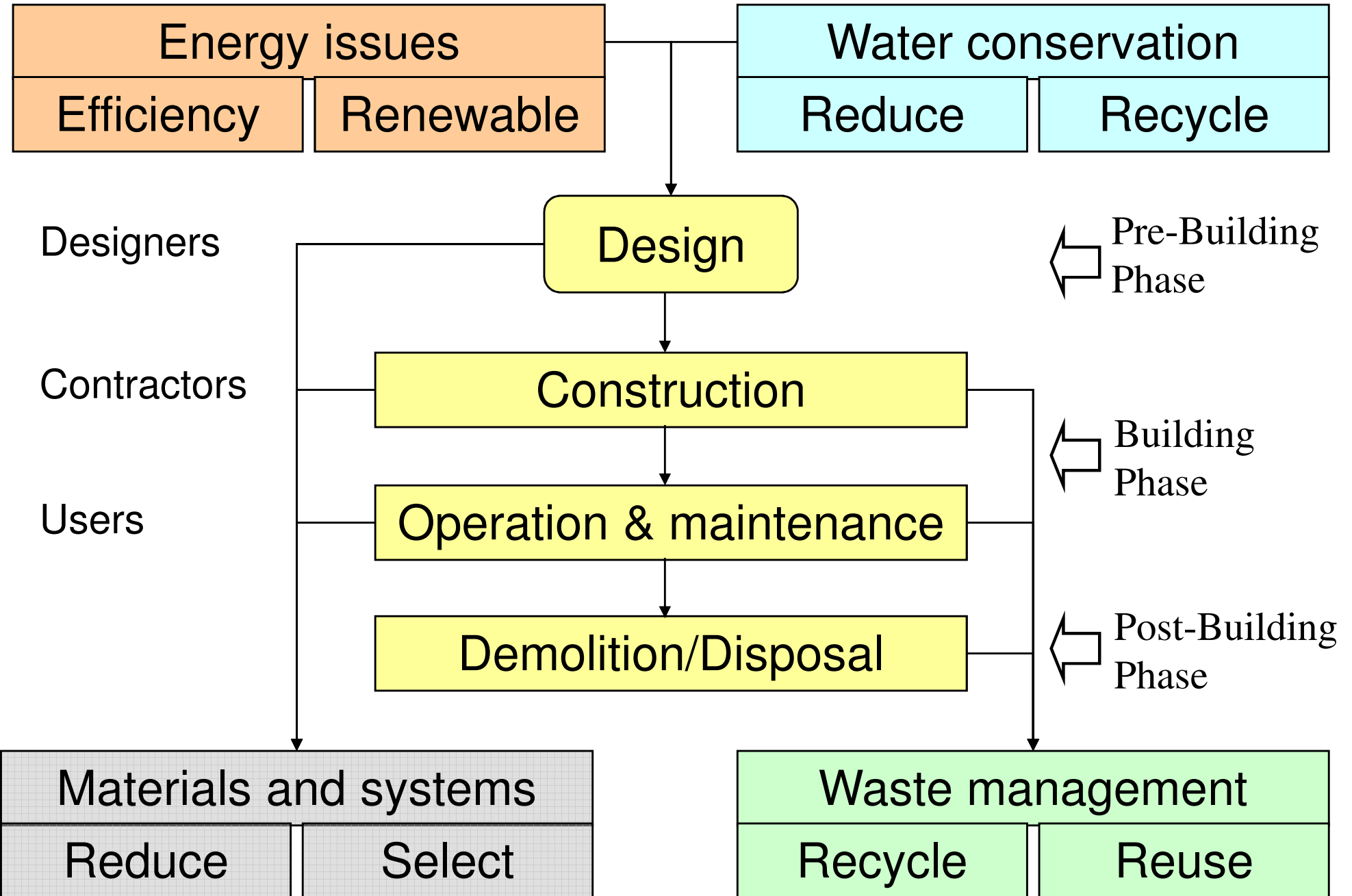
Resource and material flow in the building ecosystem

Basic principles

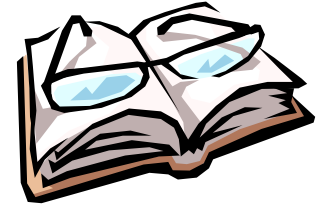


- Green building design involves
 - Holistic approach (whole systems thinking)
 - Each aspect is considered in relation to all others
 - Interdisciplinary efforts
 - Understanding & contribution from all involved
 - Understanding of building performance
 - Assessment & evaluation of performance
 - Caring for people
 - Well being of the occupants and users

Building life cycle and sustainable construction

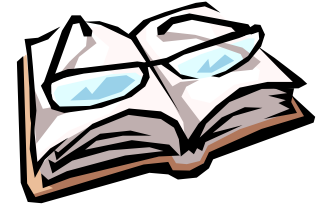


Basic principles

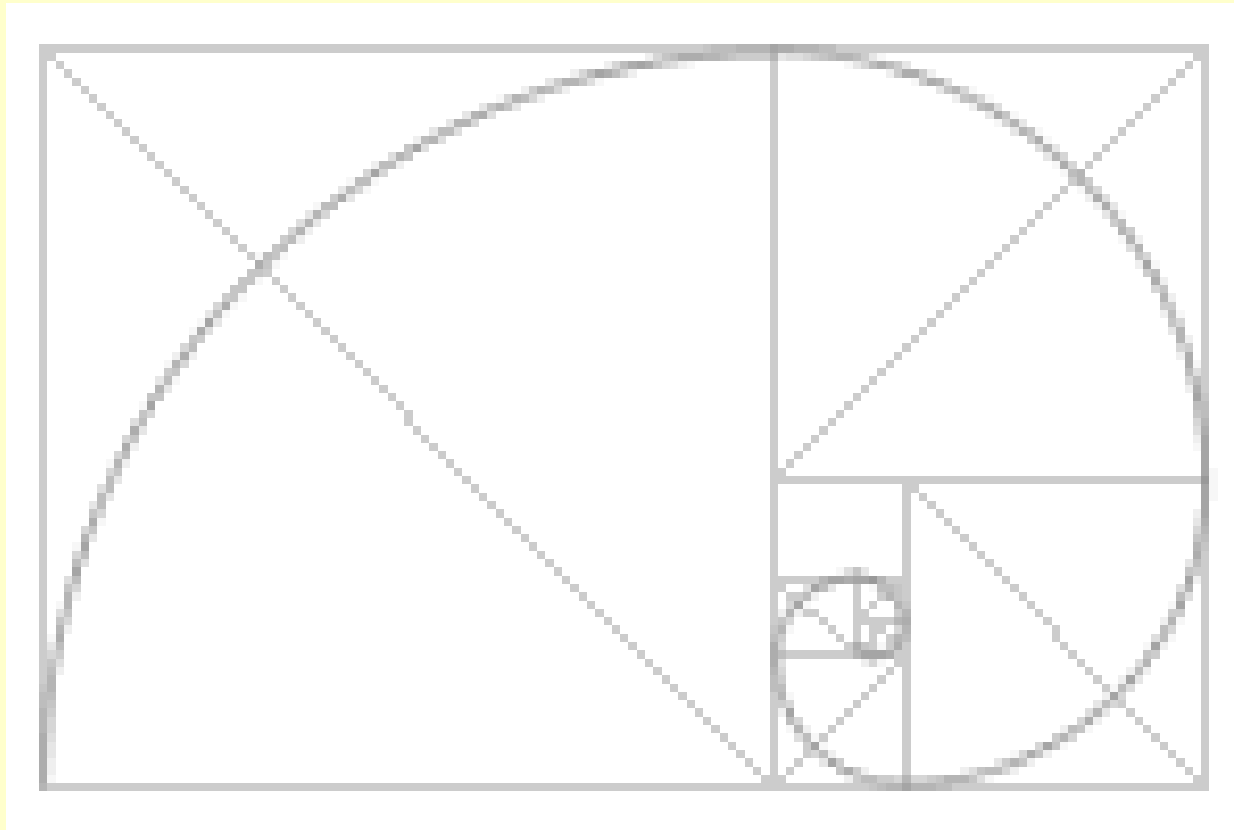


- Major concerns
 - Conserve non-renewable energy & scarce materials
 - Minimise life-cycle ecological impact
 - Use renewable energy and materials that are sustainably harvested
 - Protect & restore local air, water, soils, flora and fauna
 - Support pedestrians, bicycles and mass transit
 - Reduce human exposure to noxious materials

Basic principles

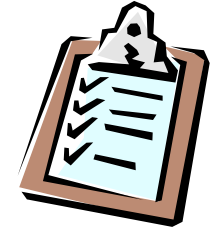


- Green strategies at different stages:
 - Inception (briefing, targets, site)
 - Design
 - Preliminary studies
 - Sketch studies
 - Pre-project
 - Basic project
 - Execution of project
 - Construction (tendering, supervision, acceptance)
 - Maintenance and Refurbishment



Design Strategies

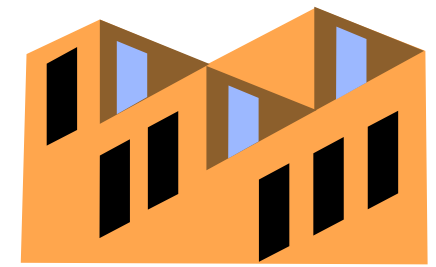
Design strategies



- Major aspects:
 - Urban and site design
 - Energy efficiency
 - Renewable energy
 - Building materials
 - Water issues
 - Indoor environment
 - Integrated building design



Urban and site design



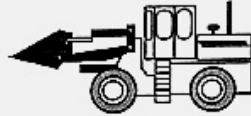
- Sustainable urban design should consider:
 - Spatial form
 - Movement
 - Design & development
 - Energy
 - Ecology
 - Environmental management
- Goal: to create livable cities





SPATIAL FORM

- ◆ Reduce / reverse decentralisation
- ◆ Increase densities but not excessively to encourage compact forms (neither cramming nor sprawl)
 - ◆ Increase appeal of inner areas (greening, defensible space, housing type, etc.)
 - ◆ Encourage mixed-use developments
- ◆ Density related to nodal points / public transport
- ◆ Relate to existing infrastructure (utilities and roads)
- ◆ Develop brown field sites and avoid green field sites
- ◆ Relate built and natural environments (open space provision, green space networks, etc.)
 - ◆ New settlements to be self sustaining
 - ◆ Assess environmental capacity



ENVIRONMENTAL MANAGEMENT

- ◆ Co-ordinate statutory authorities
- ◆ Encourage urban management (support cleanliness)
 - ◆ Reduce pollution and polluted sites
- ◆ Re-educate professionals, public and politicians
- ◆ Economy of means as the overriding goal



MOVEMENT

- ◆ Reduce the need for travel
- ◆ Design for pedestrianisation / environmentally friendly transport
 - ◆ Recover road space for public use or public transport
 - ◆ Exclude non-essential traffic
 - ◆ Minimise car parking
- ◆ Encourage route connectivity and permeability
 - ◆ Tame traffic flows

SUSTAINABLE URBAN DESIGN



ECOLOGY

- ◆ Assess ecological value of sites and encourage continuity
- ◆ Protect natural assets and preserve landscape (individuality)
 - ◆ Maximise bio-diversity
 - ◆ Increase rainwater retention (tree planting)
- ◆ Reduce run-off (permeable paving, natural channels)
 - ◆ Preserve individuality of landscape character
 - ◆ Green towns and cities



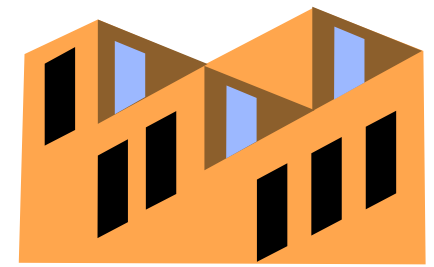
DESIGN & DEVELOPMENT

- ◆ Rehabilitation rather than redevelopment
 - ◆ Recycling of materials
 - ◆ Use local materials
- ◆ Environmentally friendly materials / techniques
 - ◆ Protection of built heritage
- ◆ Show openness to sustainable architectural forms
- ◆ Recommend BREEAM and NHER procedures
 - ◆ Encourage robust building forms (adaptable and resilient)
- ◆ Visual quality and appropriateness
 - ◆ Preserve local distinctiveness



ENERGY

- ◆ Passive solar gain (orientation, design, layout)
- ◆ Renewable energy sources (solar, hydro, wind)
 - ◆ Accept responsive facades
 - ◆ Encourage energy conservation
- ◆ Microclimate (discourage development on exposed sites and use natural features)
 - ◆ Encourage use of natural daylight
 - ◆ Discourage air-conditioning and encourage natural ventilation



Urban and site design

- Design issues:
 - Site selection (e.g. prefer brownfield site*)
 - Promote efficient movement network & transport
 - Control & reduce noise impacts
 - Optimise natural lighting & ventilation
 - Design for green space & landscape
 - Minimise disturbance to natural ecosystems
 - Enhance community values

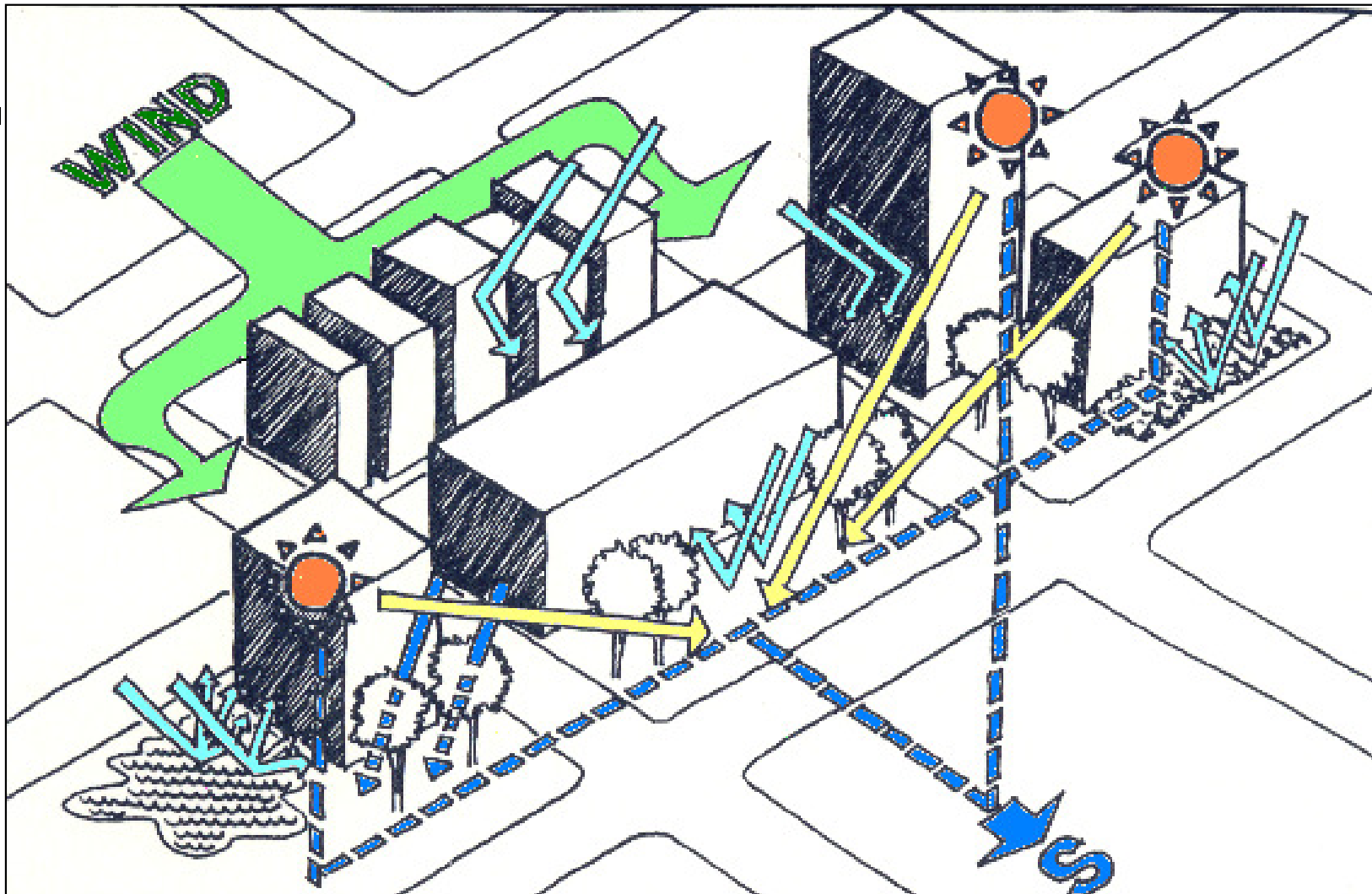
[* Brownfield sites are abandoned or underused industrial and commercial facilities available for re-use.]

風

Wind

光

Light



水

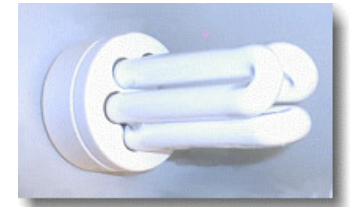
Water

物

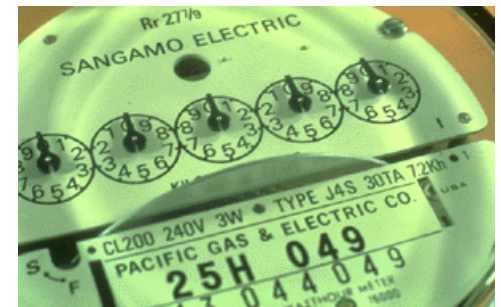
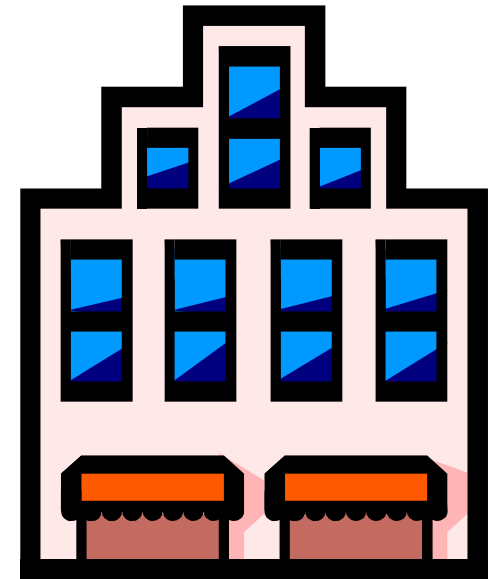
Matter

Site analysis and understanding of the environmental factors is important

Energy efficiency



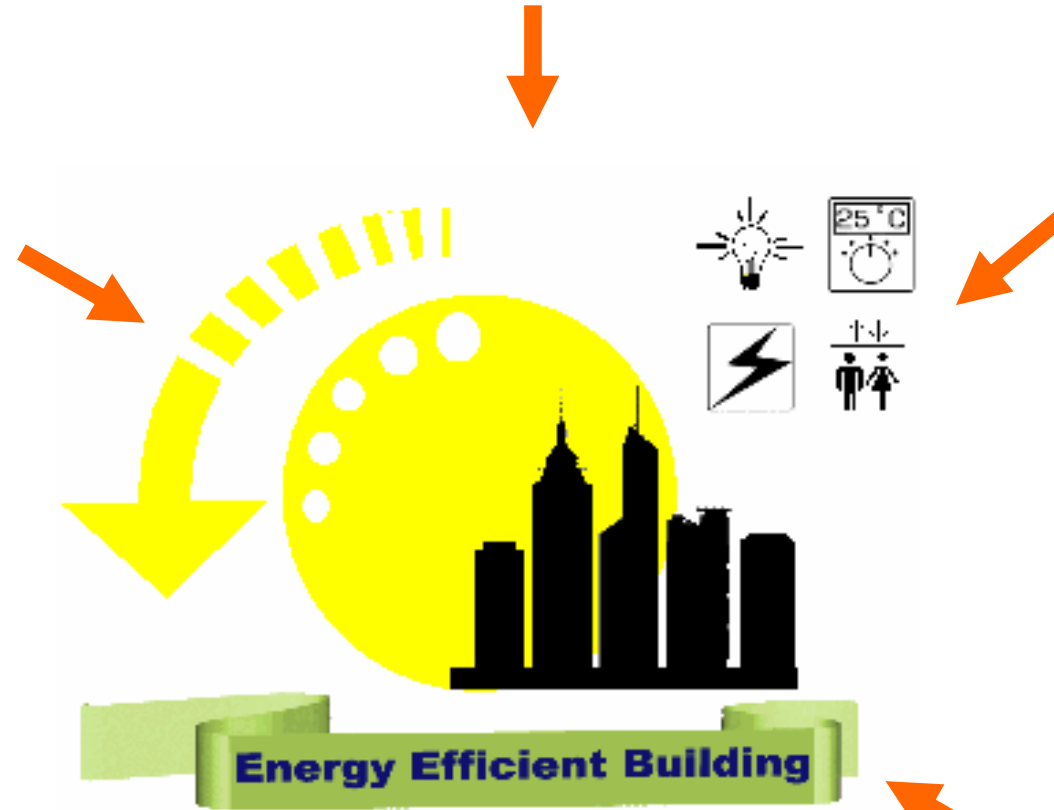
- For new buildings
 - Designing the building
 - Design strategy
 - Control strategies
 - Commissioning
- For existing buildings
 - Operating and upgrading the building
 - Building management
 - Refurbishment/renovation/retrofitting
 - Maintenance and monitoring



Good design practices

Integrated & total energy approach

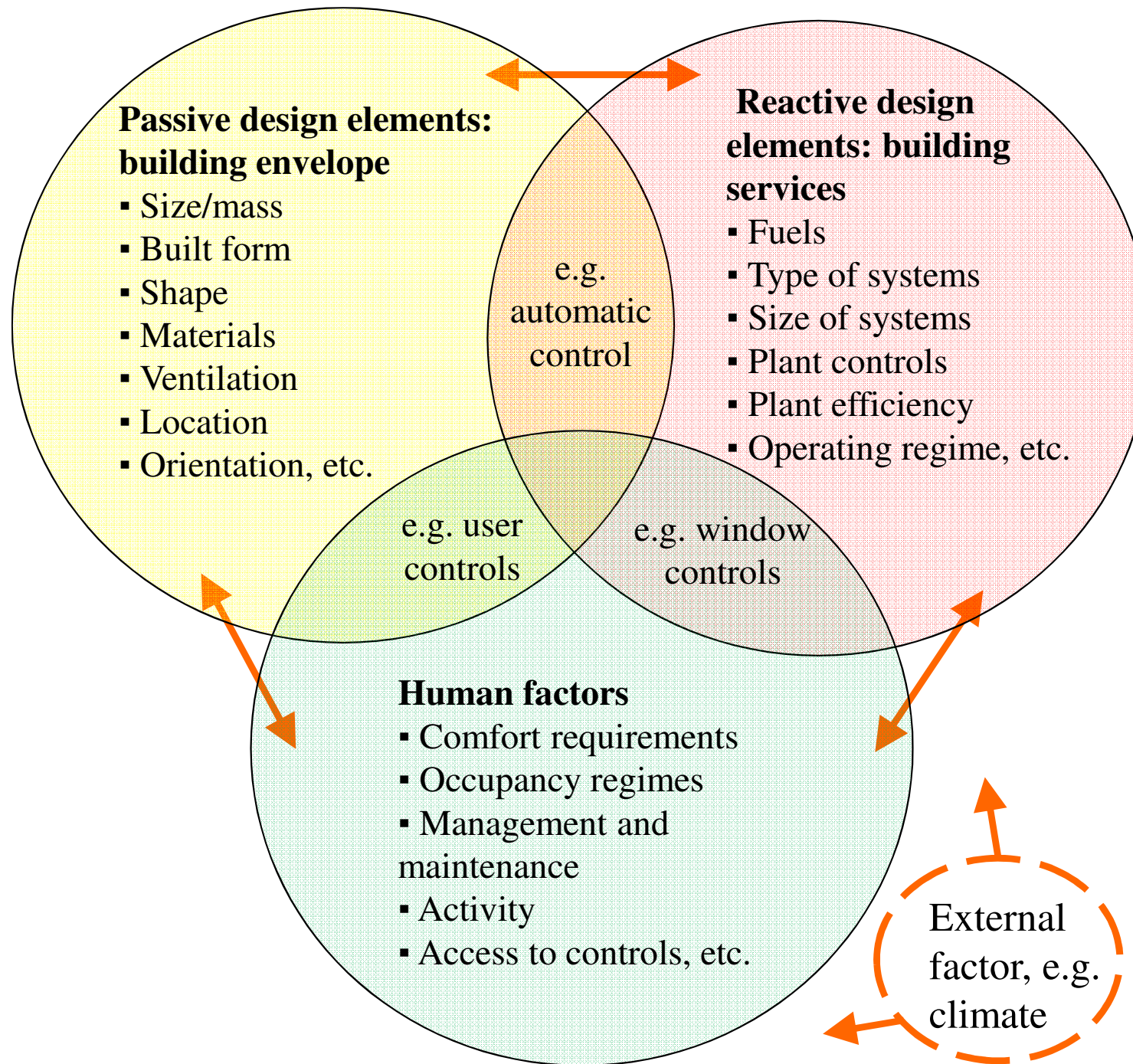
Efficient systems



Good house-keeping

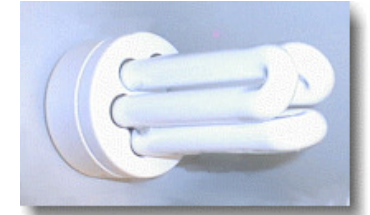
User education & awareness

Efficient operation



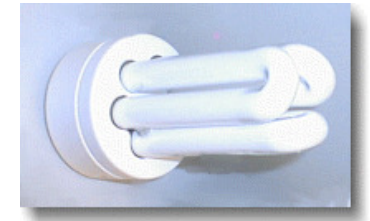
Key factors influencing energy consumption

(Adapted from Energy Efficiency in Buildings: CIBSE Guide F)



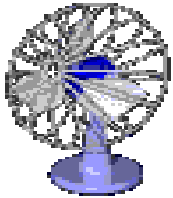
Energy efficiency

- Promote *passive design* and *natural ventilation*
 - e.g. bioclimatic buildings, passive cooling/heating
- Adopt energy efficient *building services systems*
 - Lighting, air-conditioning, electrical, lifts
- Study and optimise *thermal & energy performance*
 - e.g. by computer simulation or energy audit
- Must also ensure *efficient operation and management* of the building
 - User education & awareness, good housekeeping

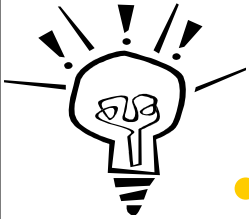


Energy efficiency

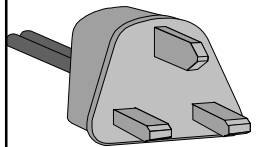
- Design strategies:



- Minimise thermal loads & energy requirements
 - e.g. by reducing heat gains from equipment



- Optimise window design & fabric thermal storage
 - Integrate architectural & engineering design



- Promote efficiency in building services systems
 - Use of heat recovery & free cooling methods



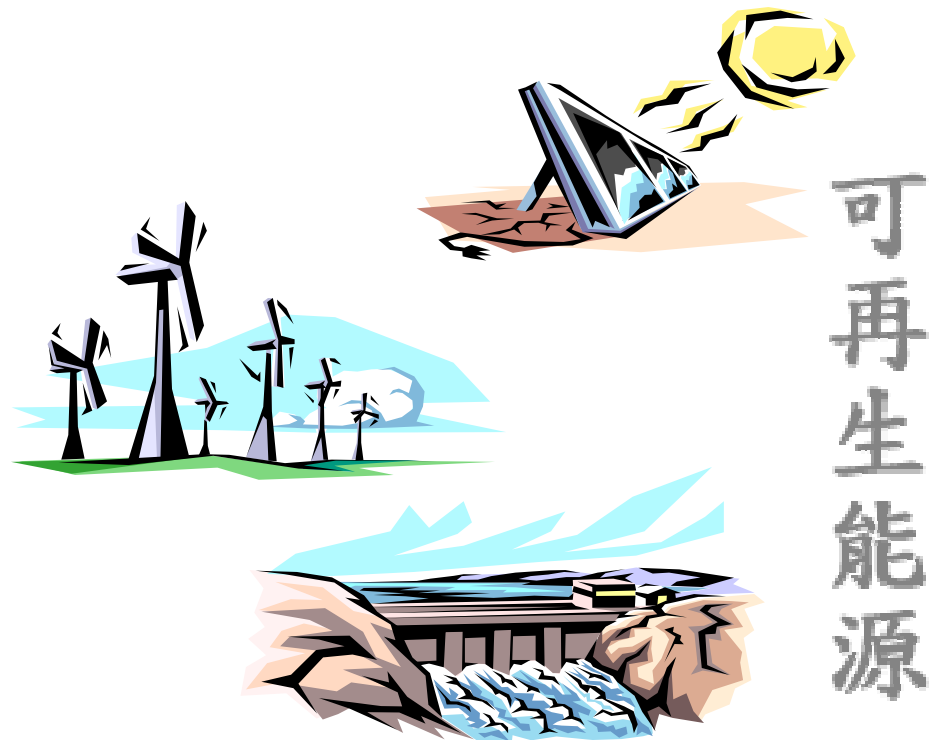
- Energy efficient lighting design & control
- High-efficiency mechanical & electrical systems

• Adopt total energy approach (e.g. district cooling, combined heat & power)



Renewable energy

- Energy that occurs naturally and repeatedly on earth and can be harnessed for human benefit, e.g. solar, wind and biomass
- Common applications
 - Solar hot water
 - Solar photovoltaic
 - Wind energy
 - Geothermal
 - Small hydros



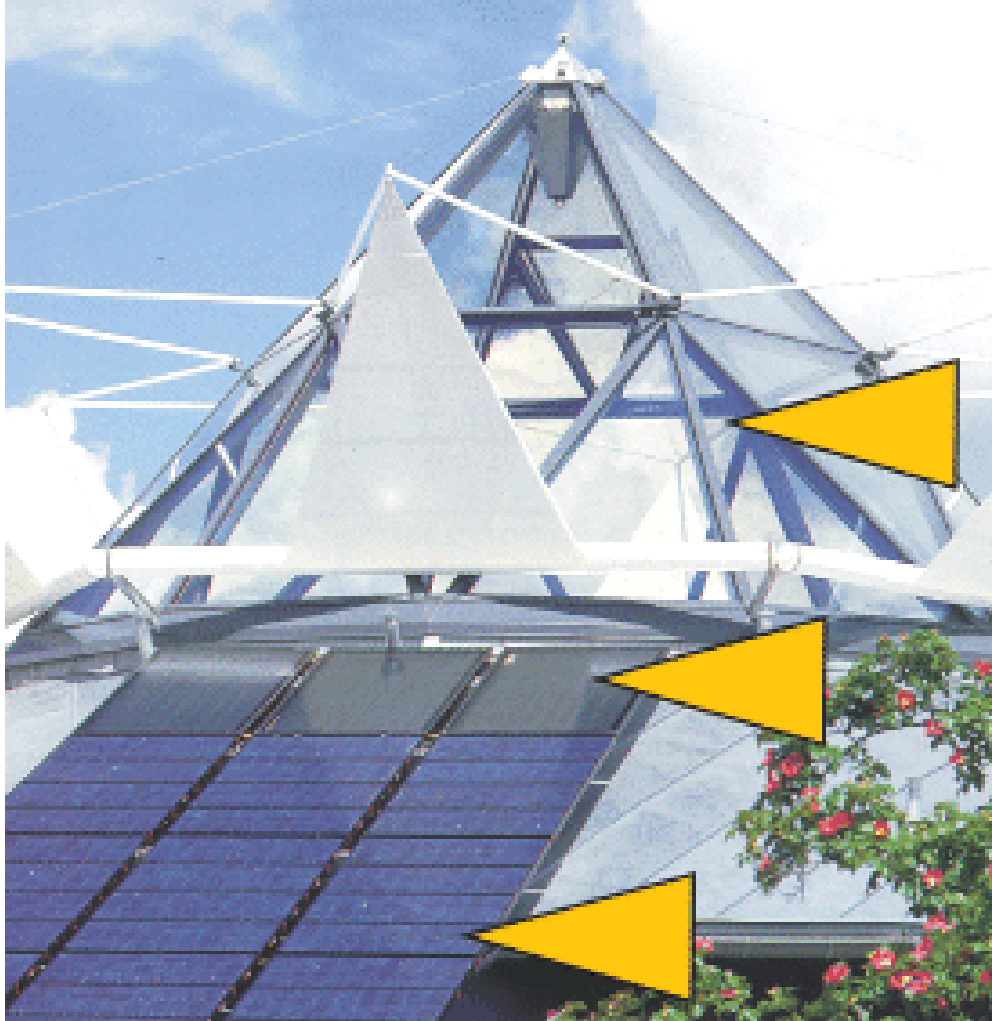
Renewable energy



- Renewables for buildings
 - Solar energy
 - Passive (low energy architecture)
 - Active (solar thermal)
 - Photovoltaics
 - Other renewables
 - Wind (using buildings to harvest wind energy)
 - Geothermal (e.g. hot springs)
 - Small hydros (e.g. water wheels)
 - Hybrid systems (e.g. PV + wind + diesel)

多 因
能 地
互 制
补 宜
。

Integration of solar energy systems in buildings



Passive solar (e.g. skylight)

Active solar (solar hot water)

Photovoltaics

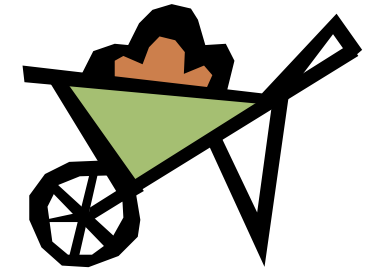
Innovative ideas for building integrated renewable energy



Dutch pavilion,
EXPO 2000 Hannover

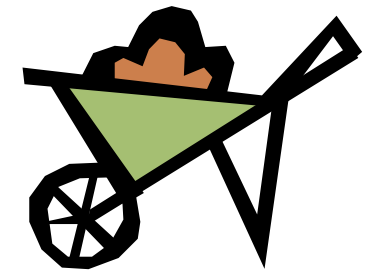


Project Zed - London



Building materials

- Environmental impact of building materials
 - Through consumption of resources
 - Through production of resources (by-products, wastes, pollution, recyclables)
- Objectives
 - Make informed environmental choices about building materials and systems
 - Careful design & understanding about materials

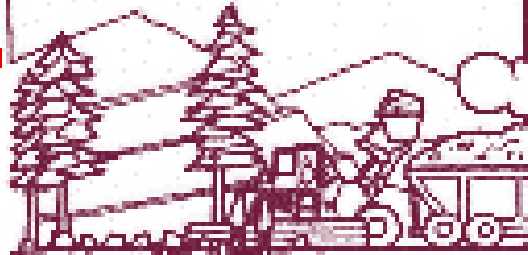


Building materials

- What makes a product **green**?
 - Measured by their environmental impact
 - Life cycle of a sustainable material
 - Using local, durable materials
- Embodied energy*
 - ‘Lifetime’ energy requirement of a material
 - Energy input required to quarry, transport and manufacture the material, plus the energy used in the construction process

[* http://en.wikipedia.org/wiki/Embodied_energy]

Resource Extraction



Manufacturing

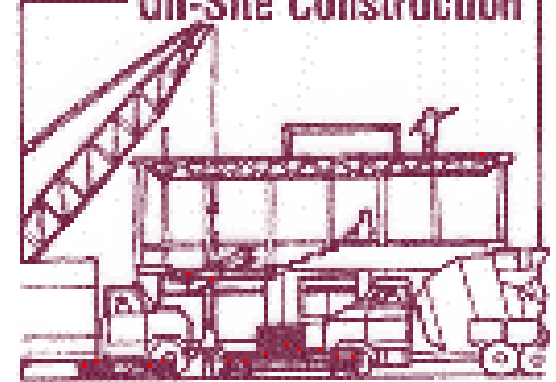


Recycling/Reuse/Disposal

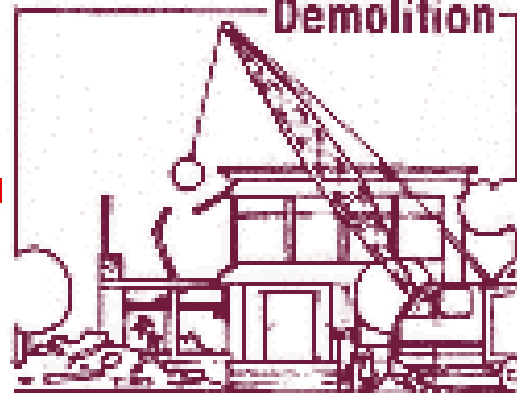


Life Cycle of Building Products

On-Site Construction



Demolition



Occupancy/Maintenance



Green Features

**Manufacturing
Process (MP)**

**Building
Operations (BO)**

**Waste
Mgmt. (WM)**

Waste
Reduction (**WR**)

Pollution
Prevention (**P2**)

Recycled (**RC**)

Embodied Energy
Reduction (**EER**)

Natural
Materials (**NM**)

Energy
Efficiency (**EE**)

Water Treatment &
Conservation (**WTC**)

Nontoxic (**NT**)

Renewable Energy
Source (**RES**)

Longer Life
(**LL**)

Biodegradable
(**B**)

Recyclable
(**R**)

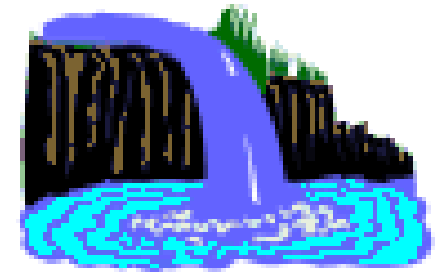
Reusable (**RU**)

Others (**O**)

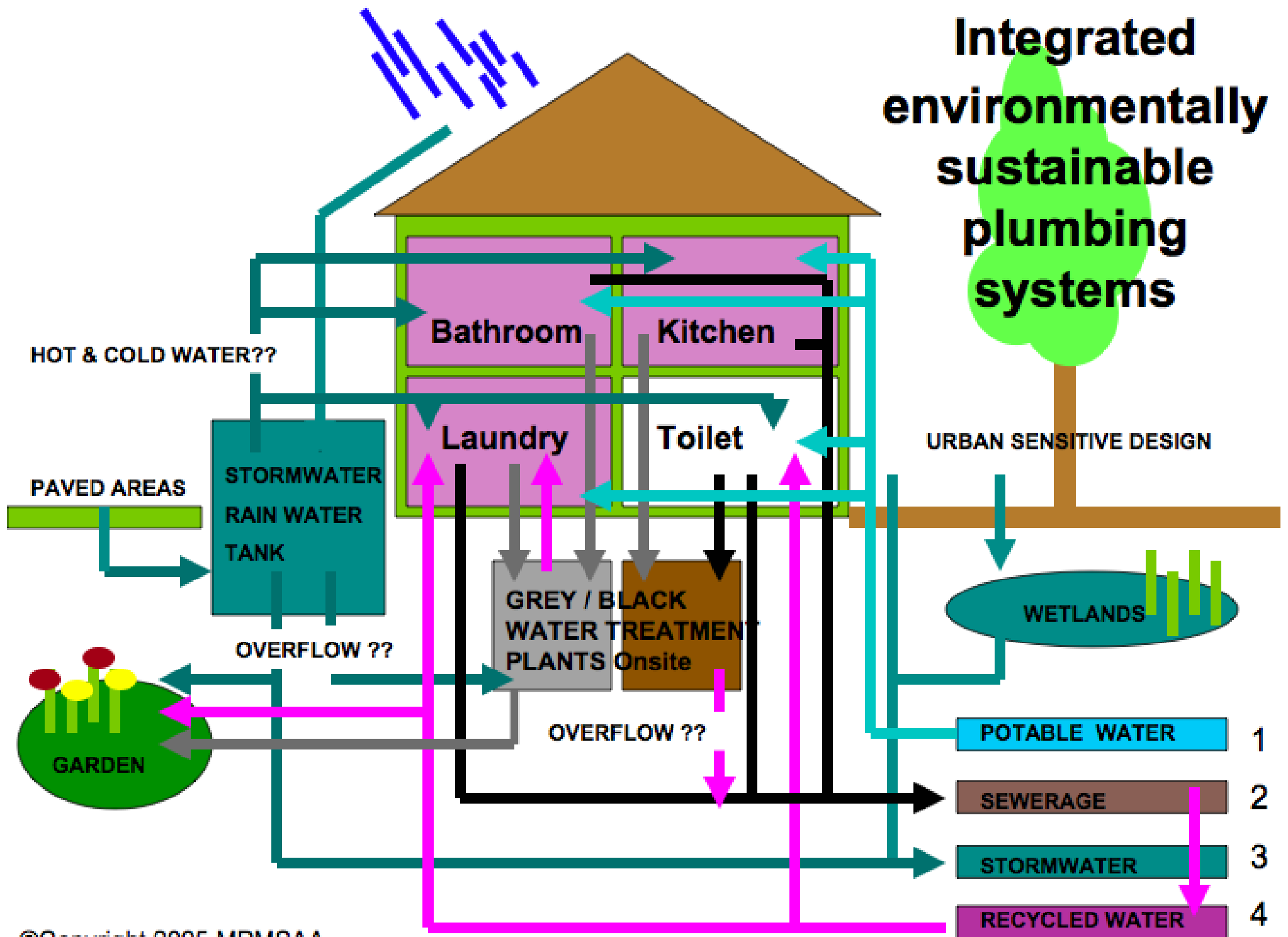
Water issues



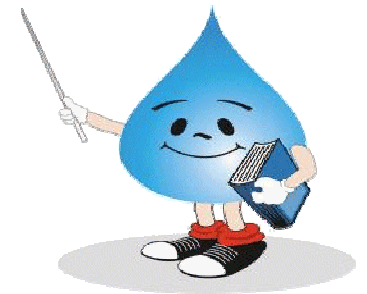
- Stormwater or watershed protection
 - Control rainwater runoff, flooding and erosion
 - Preservation of soils and drainage ways
 - Porous paving materials
 - Drainage of concentrated runoff
 - Avoid pollution and soil disturbance
- Water efficiency and conservation
 - Saving of water and money: water-use charge, sewage treatment costs, energy use, chemical use



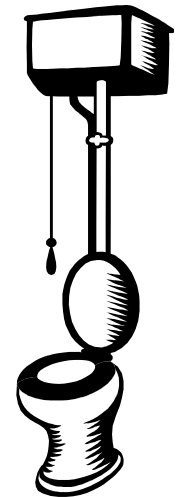
Integrated environmentally sustainable plumbing systems



Water issues

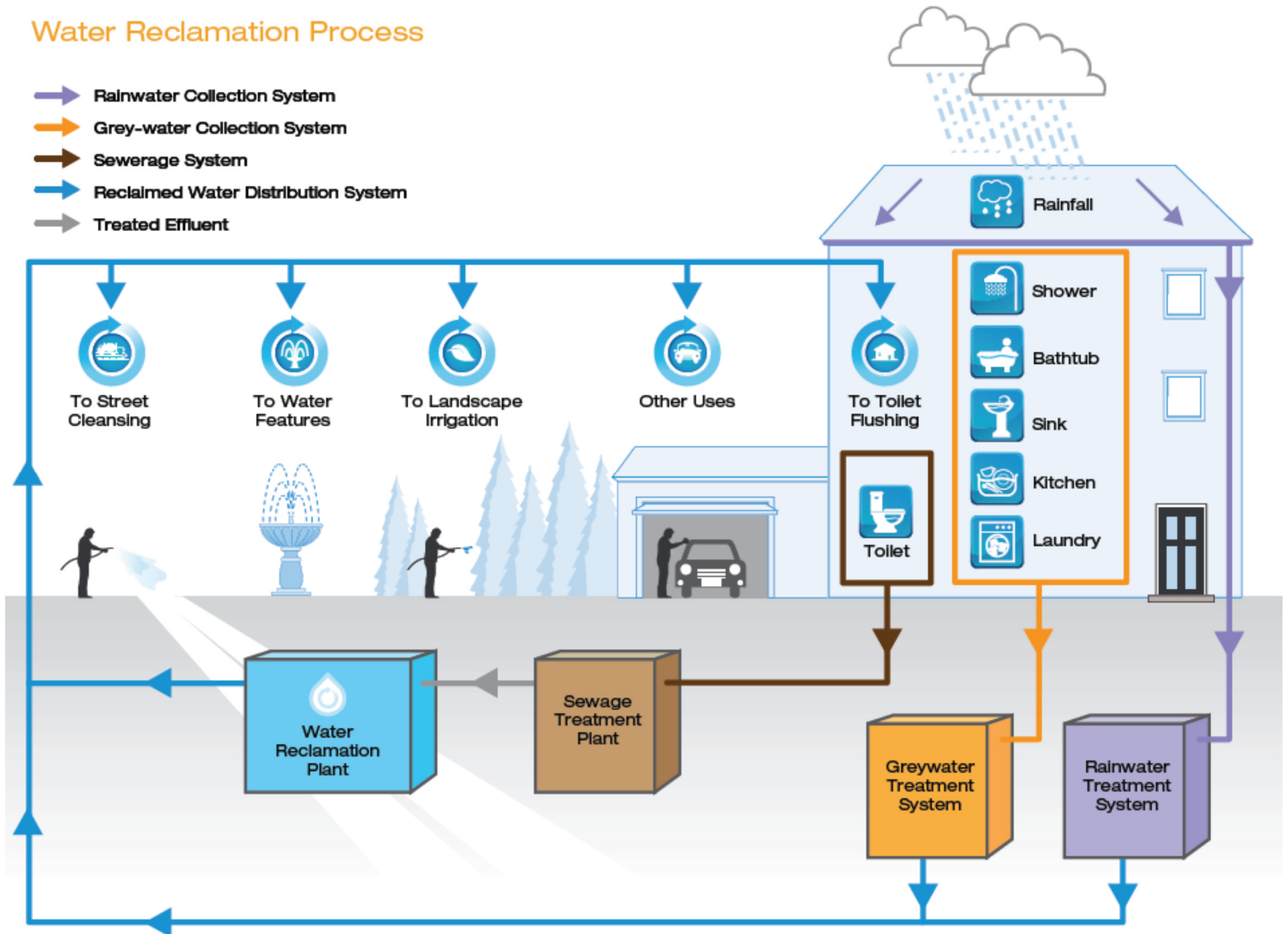


- Design strategy for water efficiency
 - Reduce water consumption
 - Low-flush toilets & showerheads
 - Leak detection & prevention
 - Correct use of appliances (e.g. washing machine)
 - Reuse and recycle water onsite
 - Rainwater collection & recycling
 - Greywater recycling (e.g. for irrigation)
 - No-/Low-water composting toilet



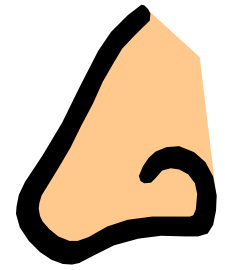
Water Reclamation Process

- ➔ Rainwater Collection System
- ➔ Grey-water Collection System
- ➔ Sewerage System
- ➔ Reclaimed Water Distribution System
- ➔ Treated Effluent



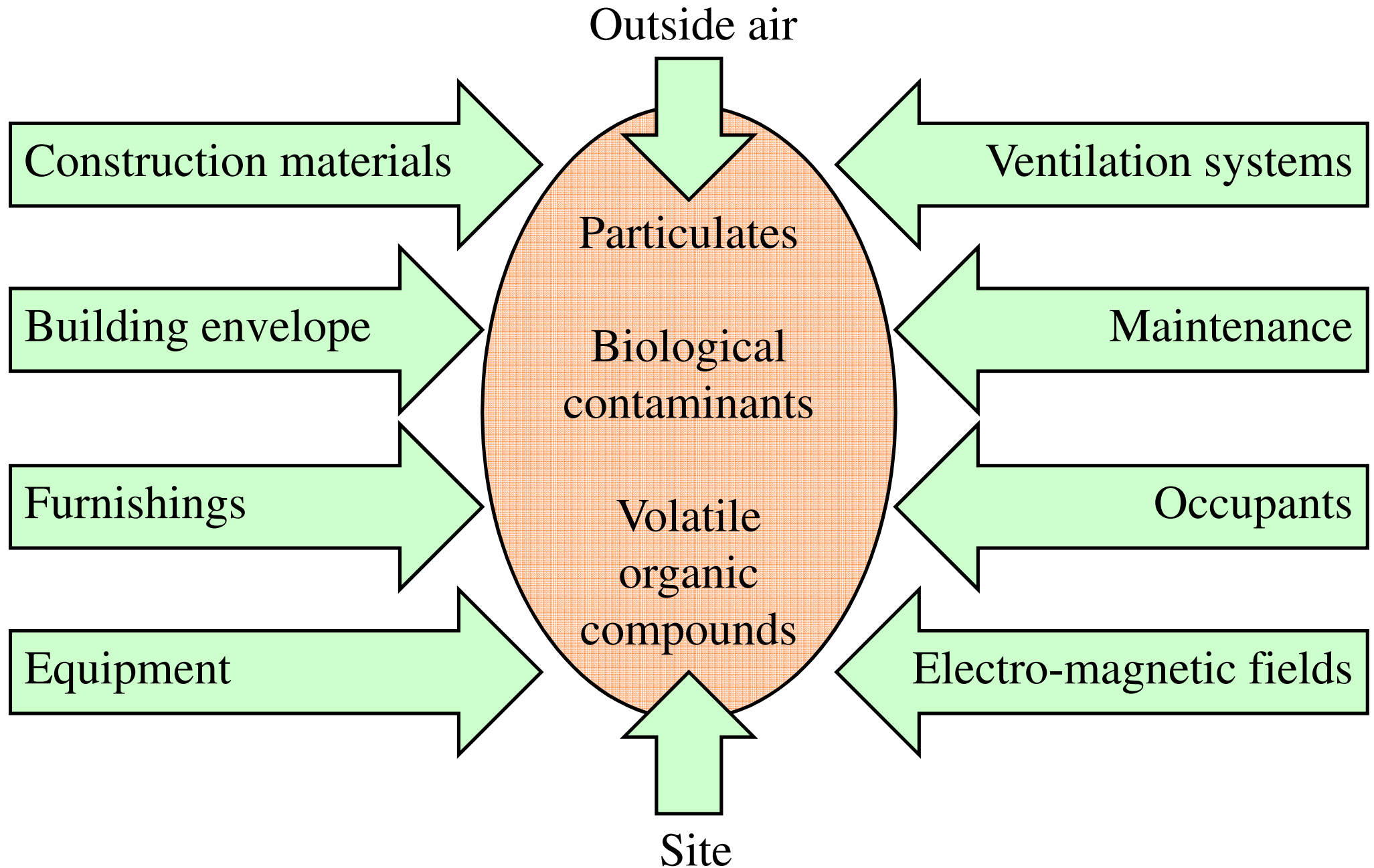
(Source: Water Supplies Department, www.wsd.gov.hk)

Indoor environment



- Indoor environmental quality (IEQ)
 - Indoor air quality
 - Ensure health & well-being
 - Visual quality
 - Provide daylight & comfortable conditions
 - Acoustic quality
 - Noise control
 - Controllability
 - Allow occupant control over thermal & visual

Major factors contributing to indoor air quality (IAQ)



Four principles of indoor air quality design

1. Source Control

+

2. Ventilation Control

+

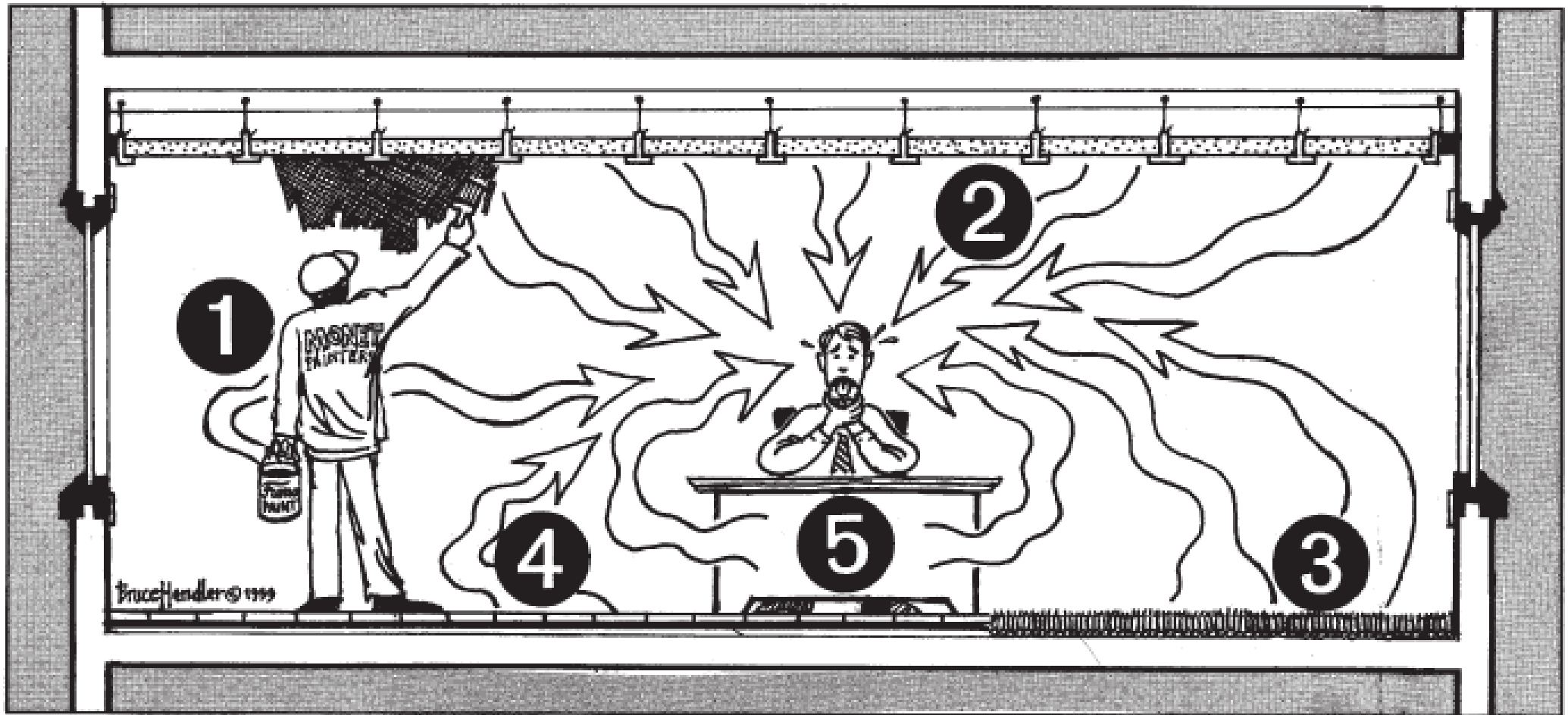
3. Occupant Activity Control

+

4. Building Maintenance

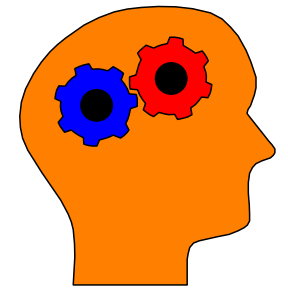
=

*Total
Indoor
Air
Quality*



Sources of offgassing in building materials:

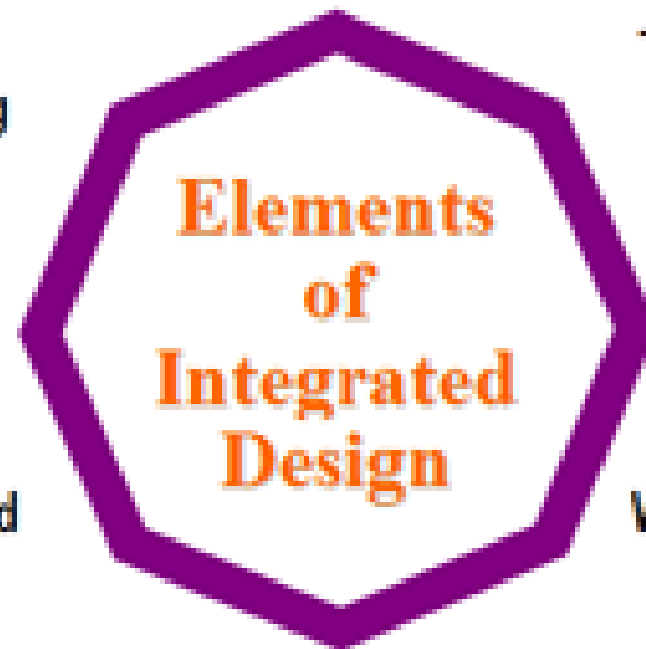
- 1) paints,
- 2) ceiling tiles,
- 3) carpeting,
- 4) VCT floor tiles
- 5) manufactured wood products



Integrated building design

- WBDG - The Whole Building Design Guide
 - http://www.wbdg.org/design/engage_process.php
- Two components of whole building design:
 - Integrated design approach
 - Integrated team process
- A holistic design philosophy
 - Holism + Interconnectedness + Synergy
 - *“The whole is greater than the sum of its parts”*





Emphasize the *integrated process*

Ensure *requirements and goals are met* (via Building Commissioning, etc.)

Think of the building as a *whole*

Evaluate solutions

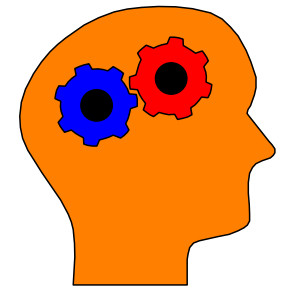
Focus on *life cycle design*

Develop *tailored solutions* that yield multiple benefits while meeting requirements & goals

Work together as a *team* from the beginning

Conduct *assessments* (e.g., Threat/Vulnerability Assessments & Risk Analysis) to help identify requirements & set goals

Integrated building design



- Typical integrated design process
 - Preparation
 - Design development
 - Contract documents
 - Construction phase
 - Commissioning
 - Post-occupancy evaluation
- Usually more efforts in preparation and pre-design phases



Further Reading



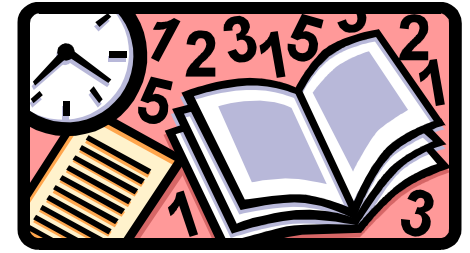
- Teaching Kit: Sustainable Design for Buildings (ArchSD)
 - <http://www.archsd.gov.hk/archsd/html/teachingkits/tk1/>
 - Sustainable planning
 - Sustainable building design
 - Green procurement
 - Green construction management
 - Sustainable maintenance



Further Reading

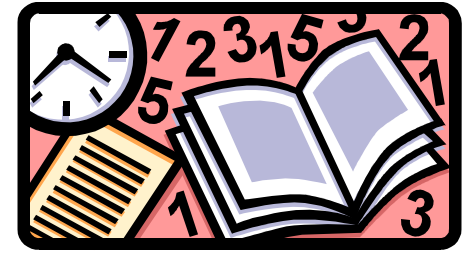


- Whole Building Design Guide (WBDG)
 - Sustainable, www.wbdg.org/design/sustainable.php
- Sustainable Building Technical Manual
 - www.smartcommunities.ncat.org/pdf/sbt.pdf
 - Chapter 5: Sustainable Site Design
 - Chapter 6: Water Issues
 - Chapter 13: Indoor Air Quality
- HK Green Building Technology Net
 - <http://gbtech.emsd.gov.hk>



References

- Recommended references:
 - ASHRAE, 2013. *ASHRAE Greenguide: the Design, Construction, and Operation of Sustainable Buildings*, 4th ed., Elsevier/Butterworth-Heinemann, Amsterdam and Boston. [720.47 A82 A] (2nd ed.: ebook)
 - European Commission, Directorate General XVII for Energy, 1999. *A Green Vitruvius: Principles and Practice of Sustainable Architectural Design*, James & James, London. [720.47 G79 E]



References

- Recommended references: (cont'd)
 - PTI, 1996. *Sustainable Building Technical Manual: Green Building Design, Construction and Operations*, Public Technology, Inc. (PTI), Washington, D.C. [721.0467 S964]
 - www.smartcommunities.ncat.org/pdf/sbt.pdf
 - Salat, S. (ed.), 2006. *The Sustainable Design Handbook: China: High Environmental Quality Cities and Buildings*, CSTB, Cedex, France. [720.470951 S96]