HKIE-BSD One Day BS Short Course 2013
"Sustainable Building Services Design and Case Studies"
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Essential Green Building Design Strategies

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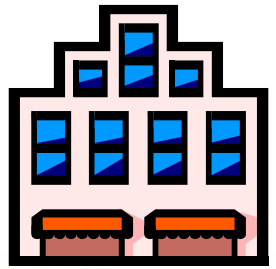
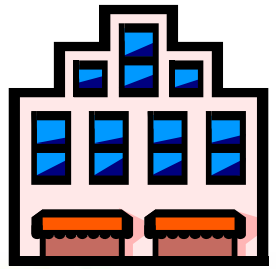
Green/sustainable building



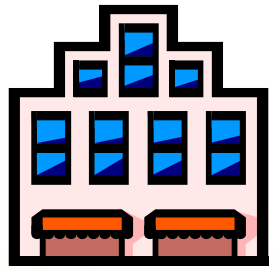
- Green buildings are
  - Energy and resource efficient
  - Non-wasteful and non-polluting
    - Sustainable design that helps minimise broad environmental impacts (e.g. ozone depletion)
  - Highly flexible and adaptable for long-term functionality (reduce renovation costs)
  - Easy to operate and maintain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

Green/sustainable building



- **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

Green/sustainable building

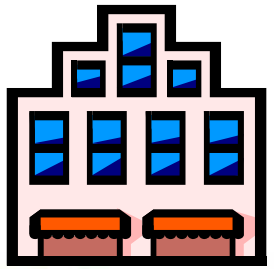


- **Sustainable Building** [HKGBC]
  - Provides a quality living amenity for its users and neighbours in terms of social, environmental and economic aspects while minimising negative environmental impact at the local, regional and global levels throughout its full life cycle

Examples of green building design features/issues

(Source: www.susdev.org.hk)

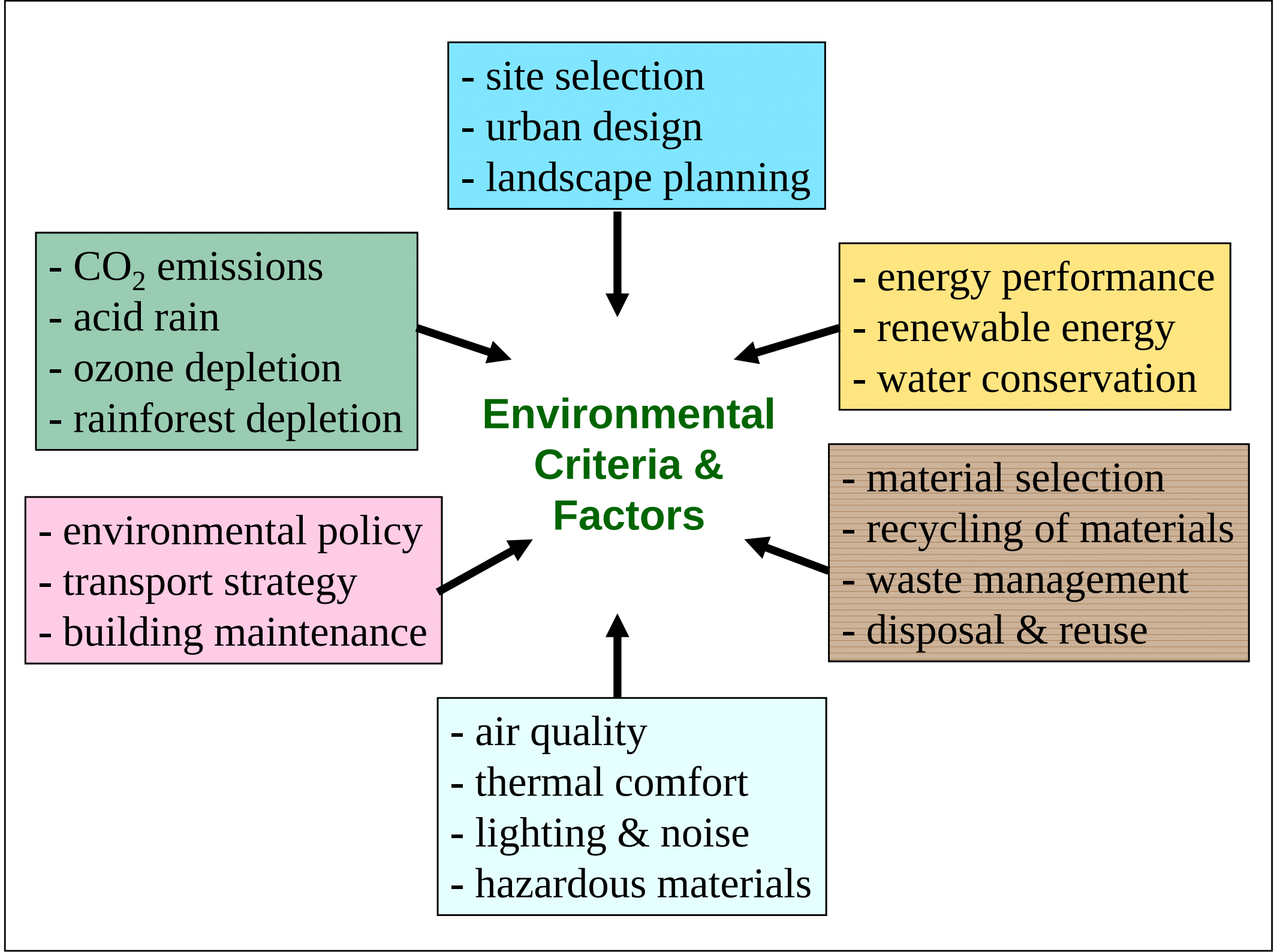
Green/sustainable building



- 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

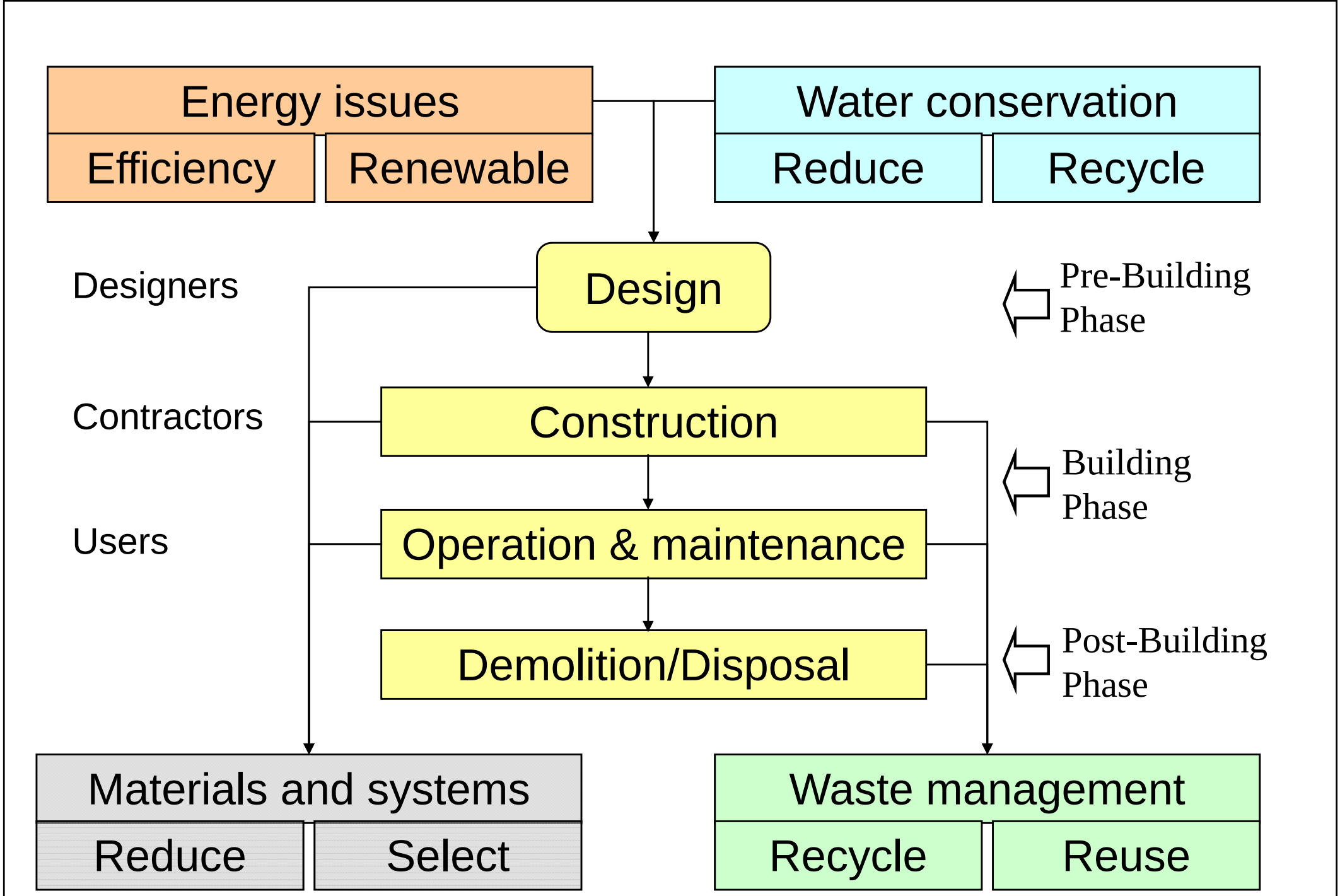
How to select and evaluate the criteria?

Source: www.moew.gov.ae

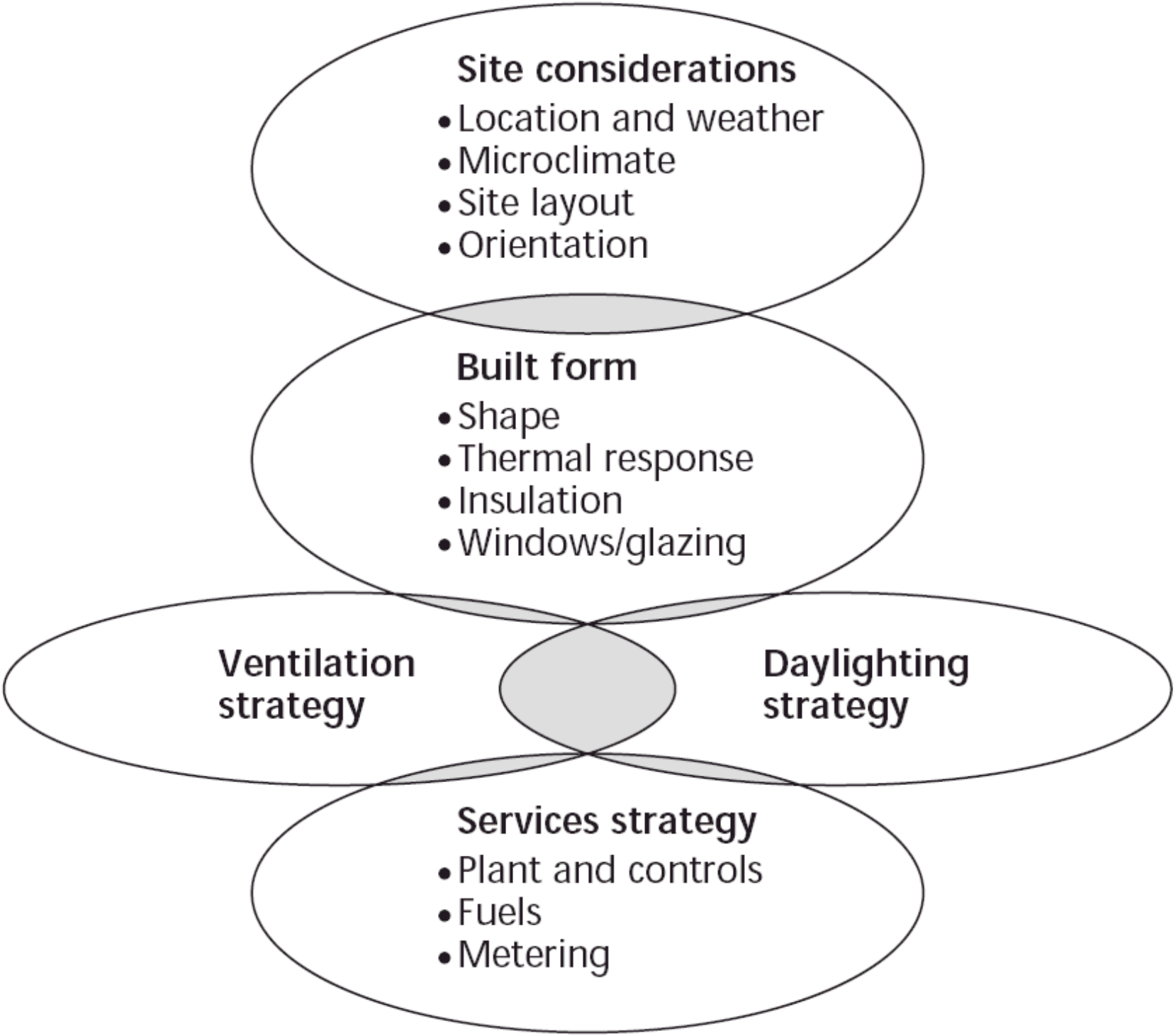

- site selection
- urban design
- landscape planning
- CO_2 emissions
- acid rain
- ozone depletion
- rainforest depletion
- energy performance
- renewable energy
- water conservation
Environmental Criteria & Factors
- environmental policy
- transport strategy
- building maintenance
- material selection
- recycling of materials
- waste management
- disposal & reuse
- air quality
- thermal comfort
- lighting & noise
- hazardous materials

Cradle-to-Grave

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



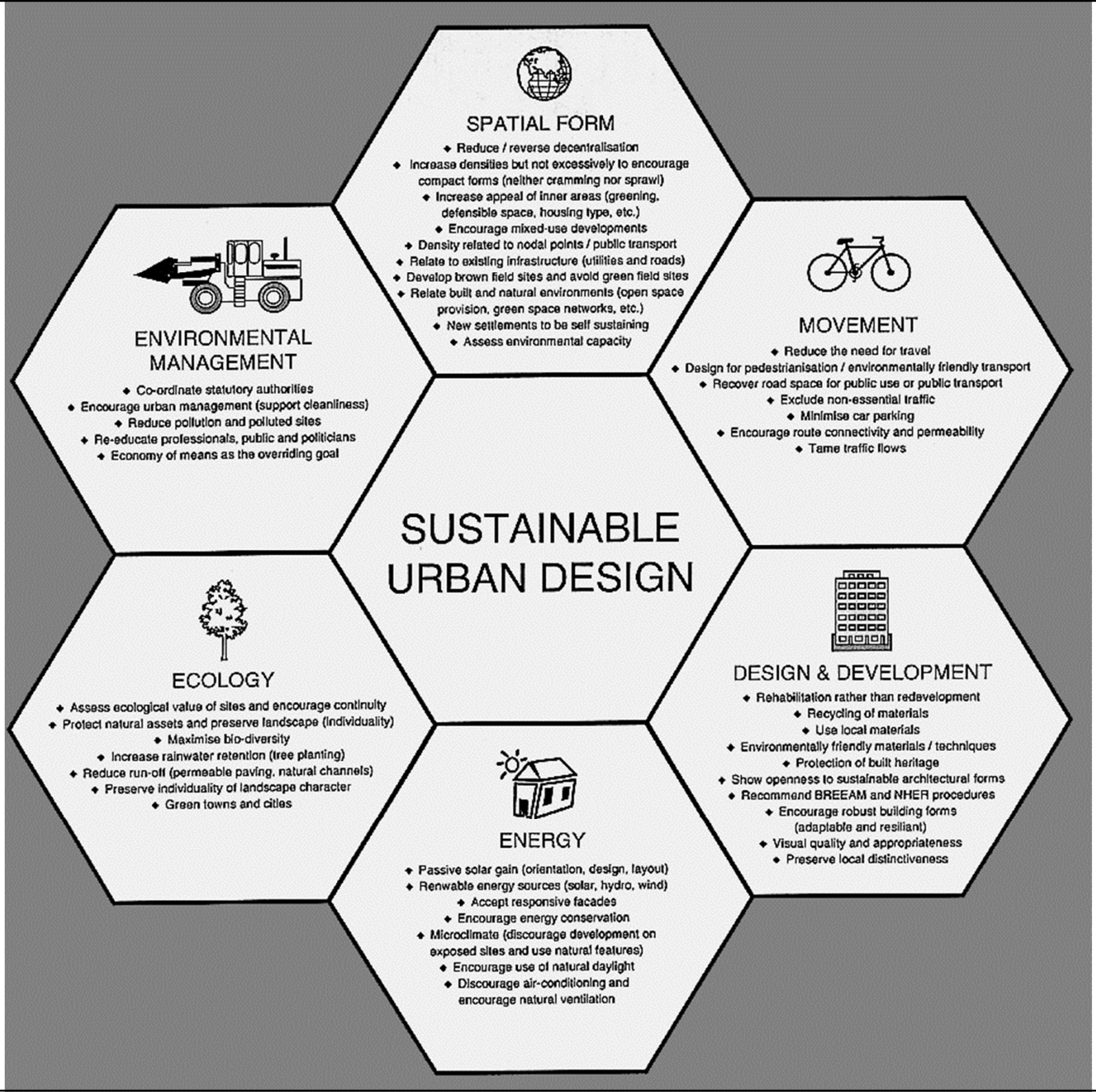
Building life cycle and sustainable construction



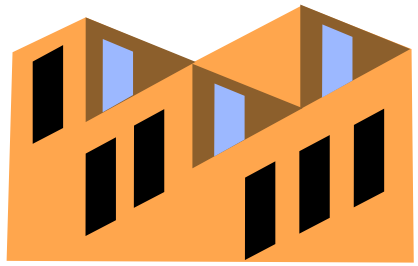
(Source: Energy Efficiency in Buildings: CIBSE Guide F)

Design strategies: Urban and site design

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

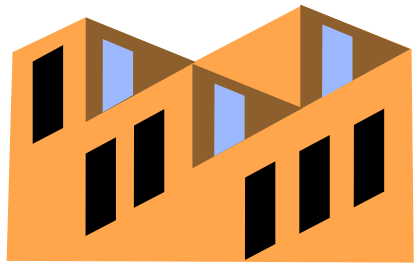

SUSTAINABLE URBAN DESIGN
SPATIAL FORM
◆ Reduce / reverse decentralisation
◆ Increase densities but not excessively to encourage compact forms (neither cramming nor sprawl)
◆ Increase appeal of inner areas (greening, defensible space, housing type, etc.)
◆ Encourage mixed-use developments
◆ Density related 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
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
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 resiliant)
◆ Visual quality and appropriateness
◆ Preserve local distinctiveness
ENERGY
◆ Passive solar gain (orientation, design, layout)
◆ Renwable 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
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
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

Design strategies: Urban and site design



- Basic principles
  - 1. Increase local self-sufficiency
  - 2. Concern for human needs (social+community)
  - 3. Develop energy-efficient movement networks
  - 4. The open space network (公共空間)
  - 5. Linear concentration
  - 6. An energy strategy
  - 7. Water strategy

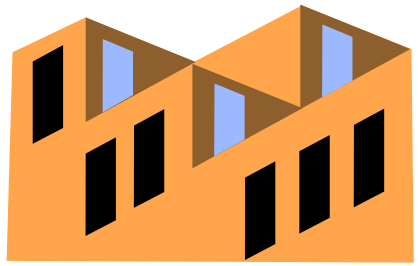
Design strategies: Urban and site design



- 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.]

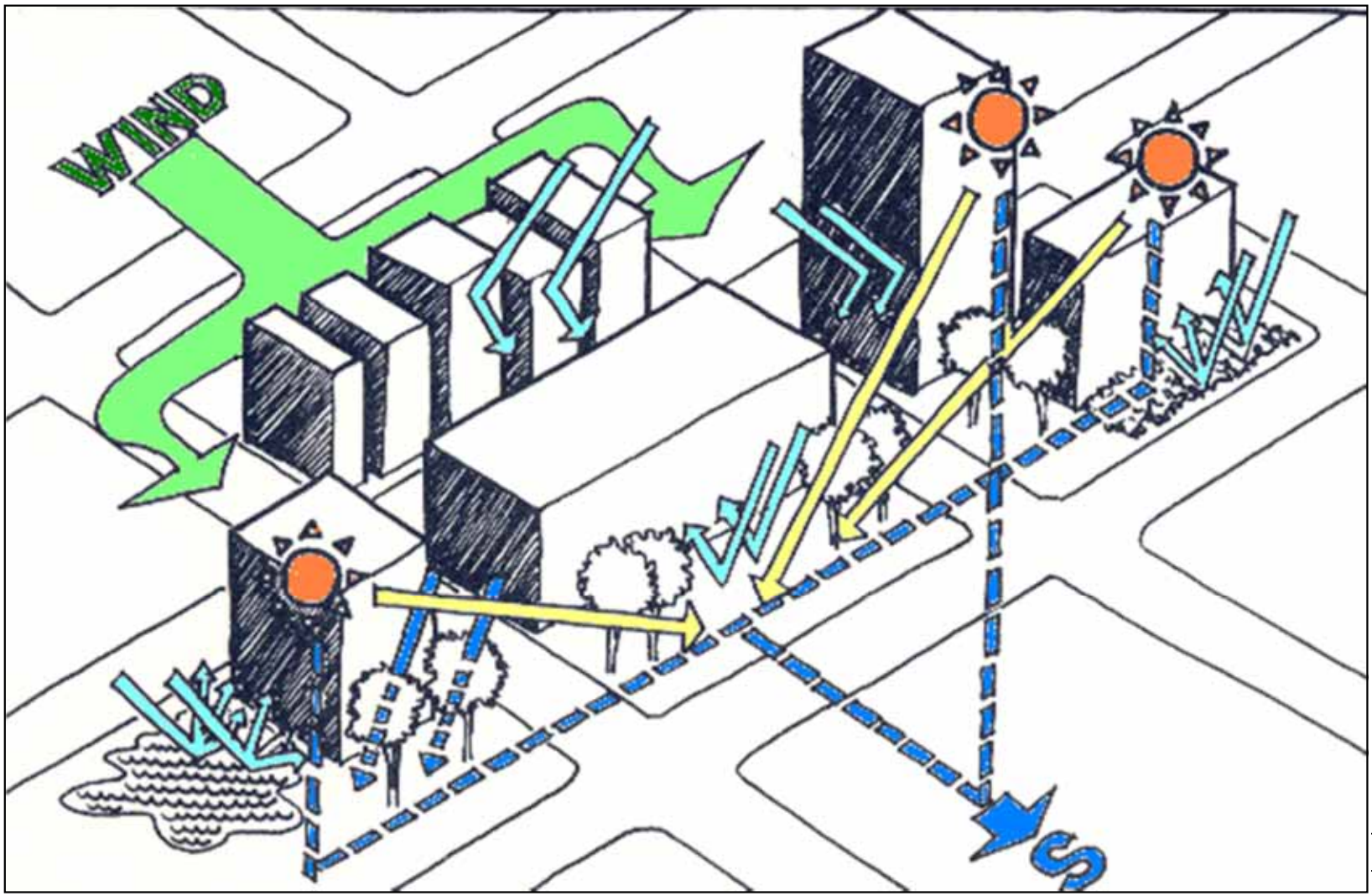
Design strategies: Urban and site design



- Design strategies
  - Integrate design with public transportation
    - Quite successful in Hong Kong
  - Promote mixed use development
    - Such as residential + commercial
  - Respect topographical contours (land forms)
  - Preserve local wildlife and vegetation
  - Make use of landscaping and planting (green space) to modify the local micro-climate

風
Wind

光
Light



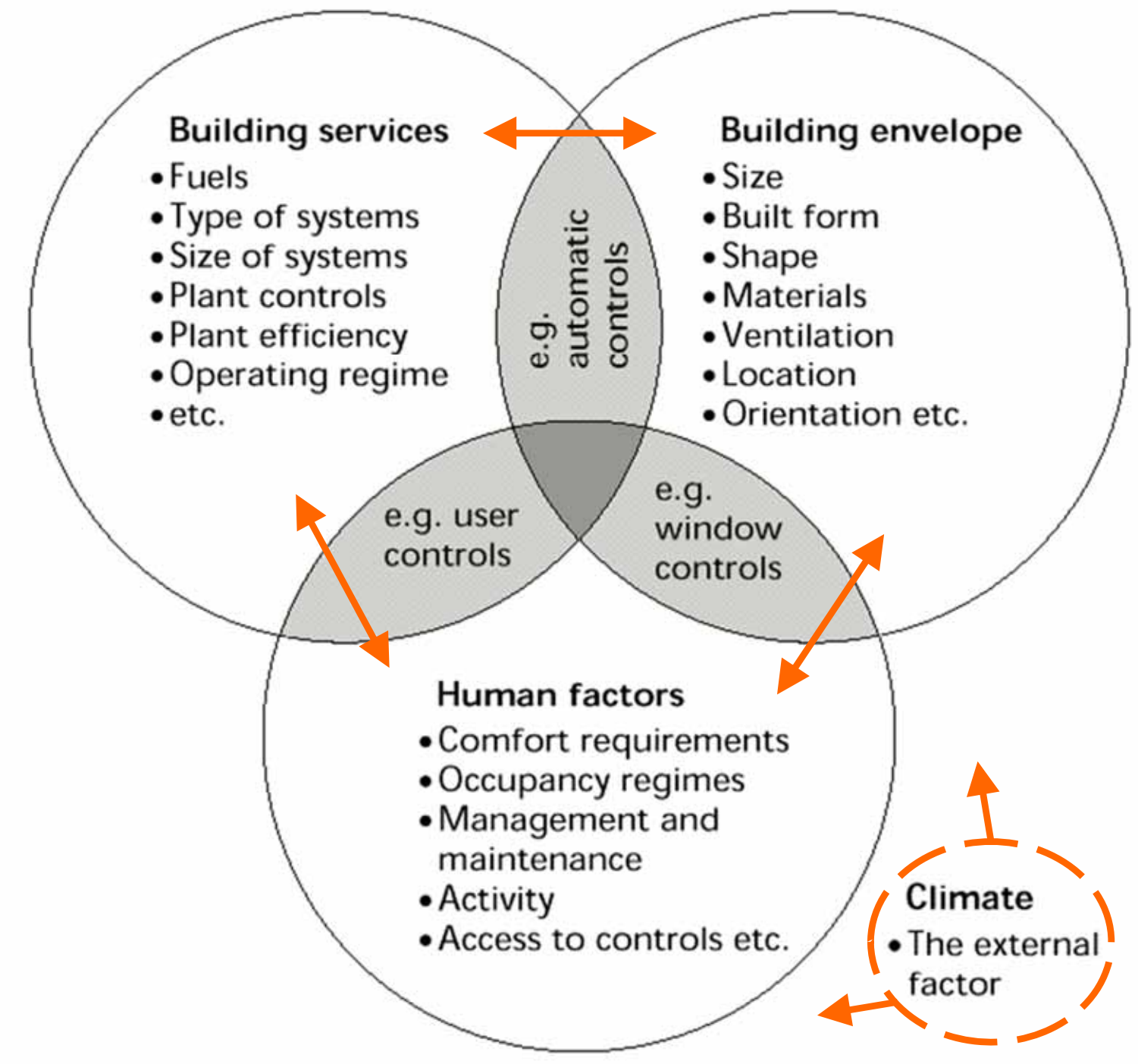
水
Water

物
Matter

Site analysis and understanding of the environmental factors is important

Design strategies: Energy efficiency

- Building energy efficiency codes
  - Building envelope, such as:
    - HK-OTTV standard
    - Overall thermal transfer value (OTTV)
  - Codes of Practice for building services systems
    - HVAC, lighting, electrical, lifts & escalators
  - Performance-based building energy code
- Become mandatory in 2011 in Hong Kong, under the Buildings Energy Efficiency Ordinance



Key factors influencing energy consumption

(Source: Energy Efficiency in Buildings: CIBSE Guide F)

Design strategies: 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
- Needs to study 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

Good design practices

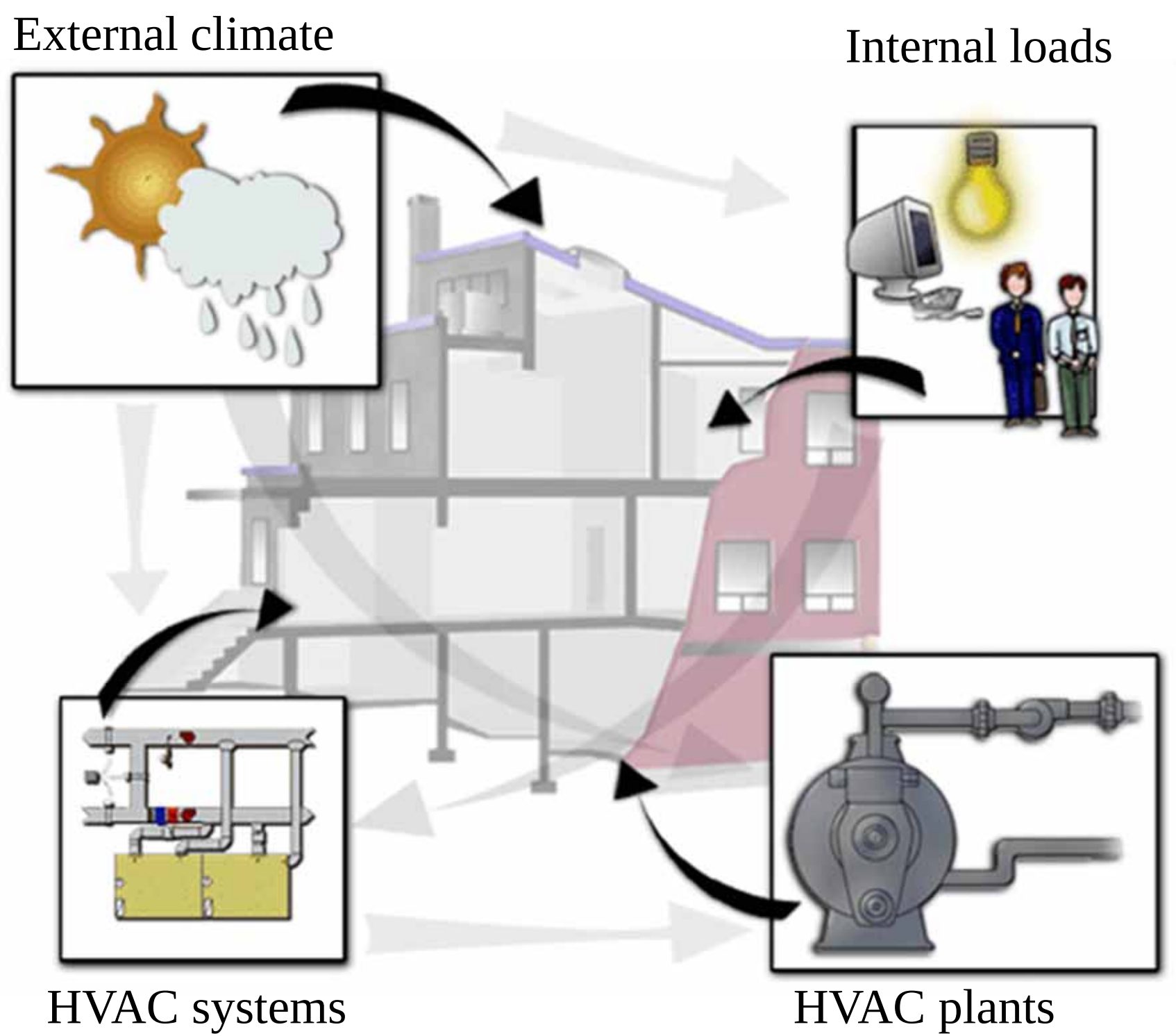
Integrated & total energy approach

Efficient systems

Good house-keeping

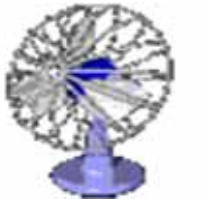
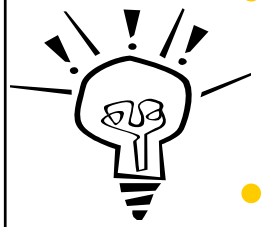
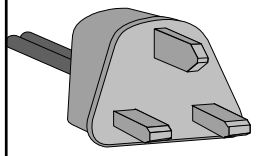
User education & awareness

Efficient operation

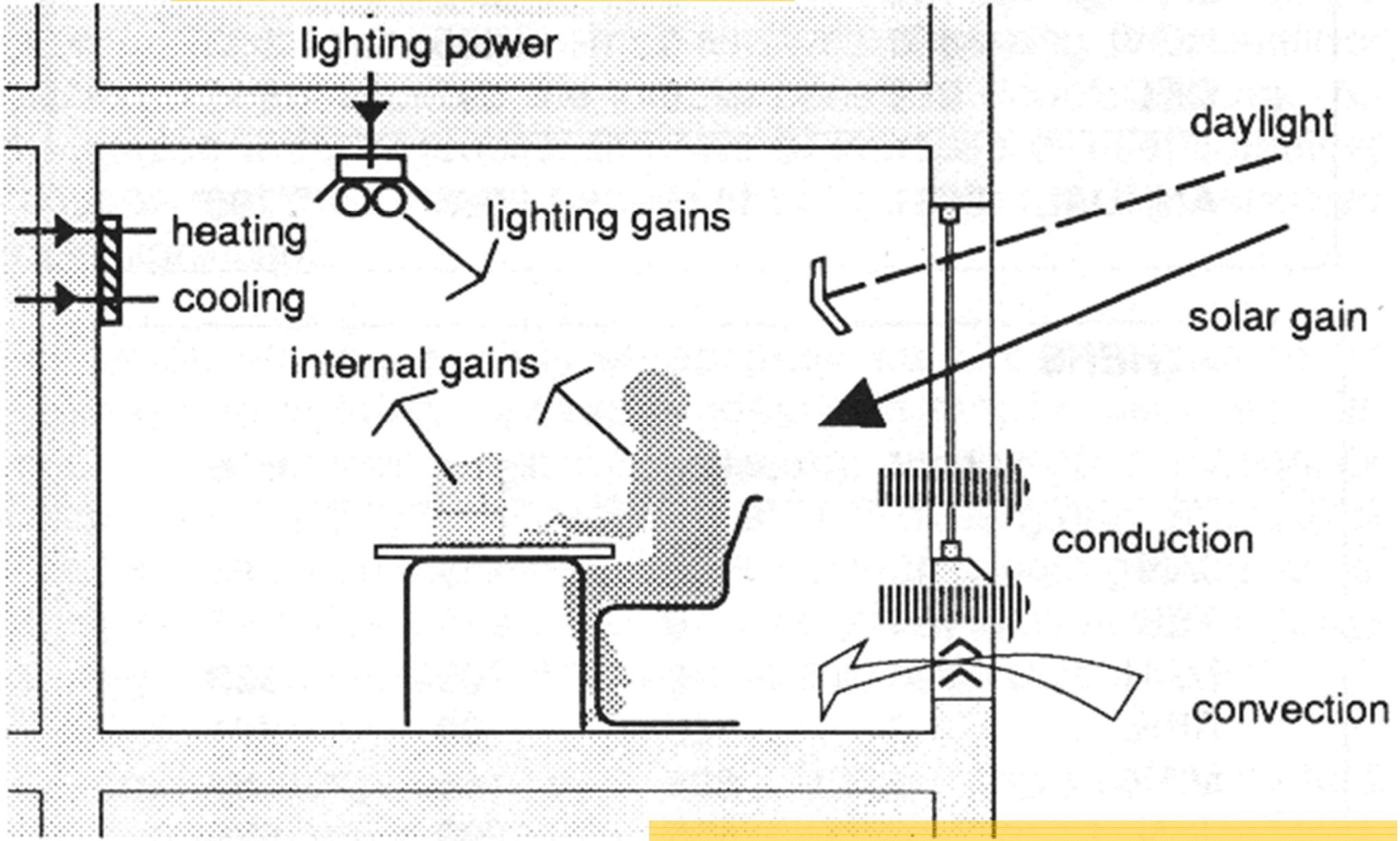


HVAC = heating, ventilation and air conditioning

Design strategies: 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)

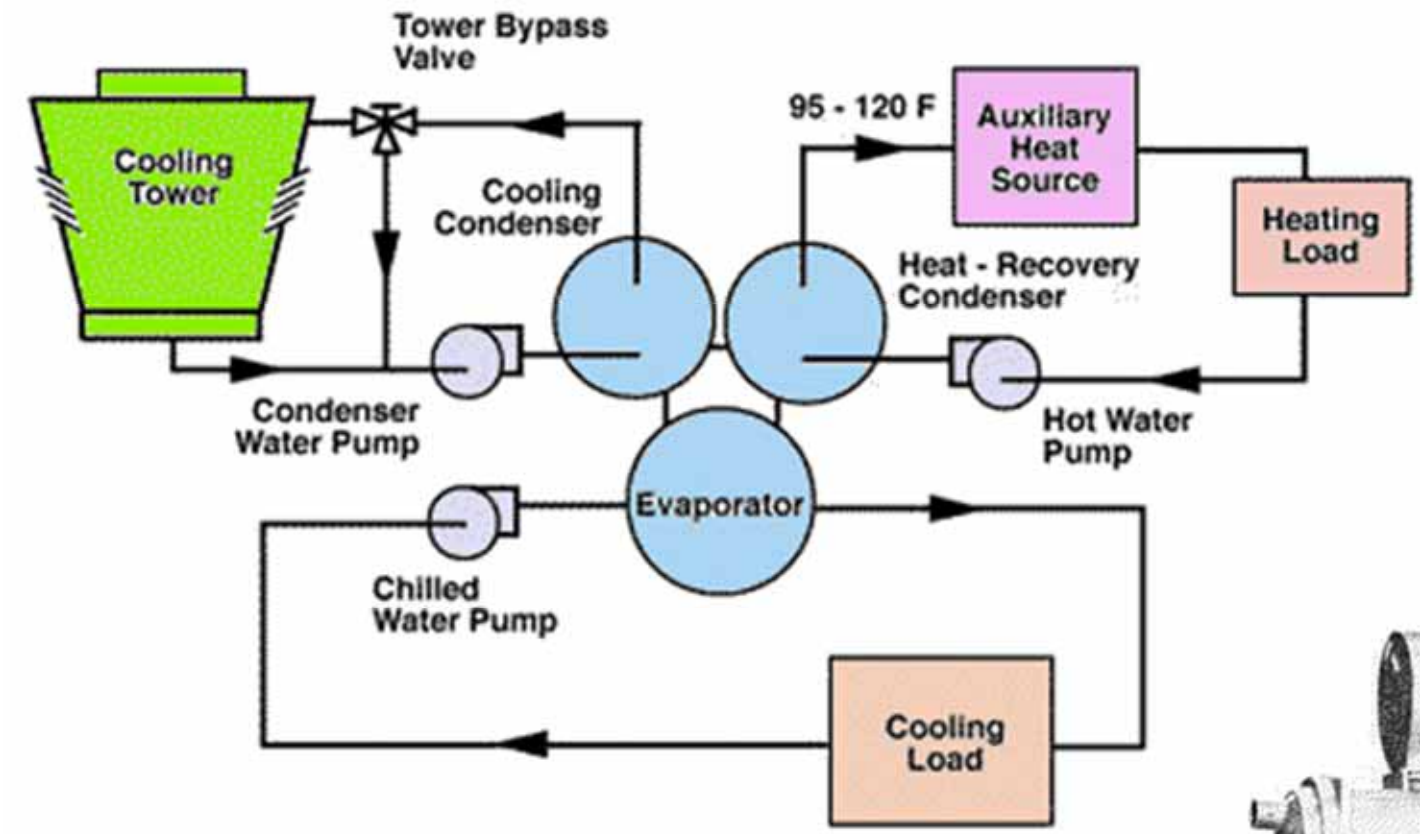
Strategy: reduce thermal loads



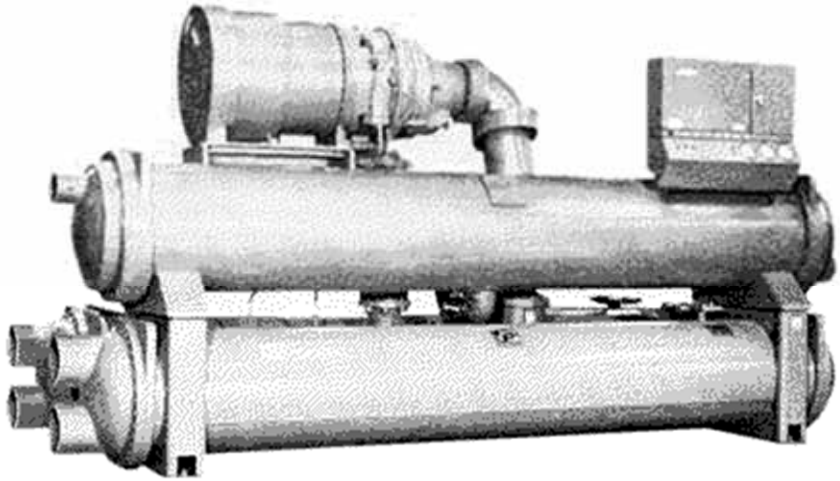
Strategy: optimise building envelope

Thermal energy balance in a building space

Strategy: use of heat recovery



Produce hot water or heating

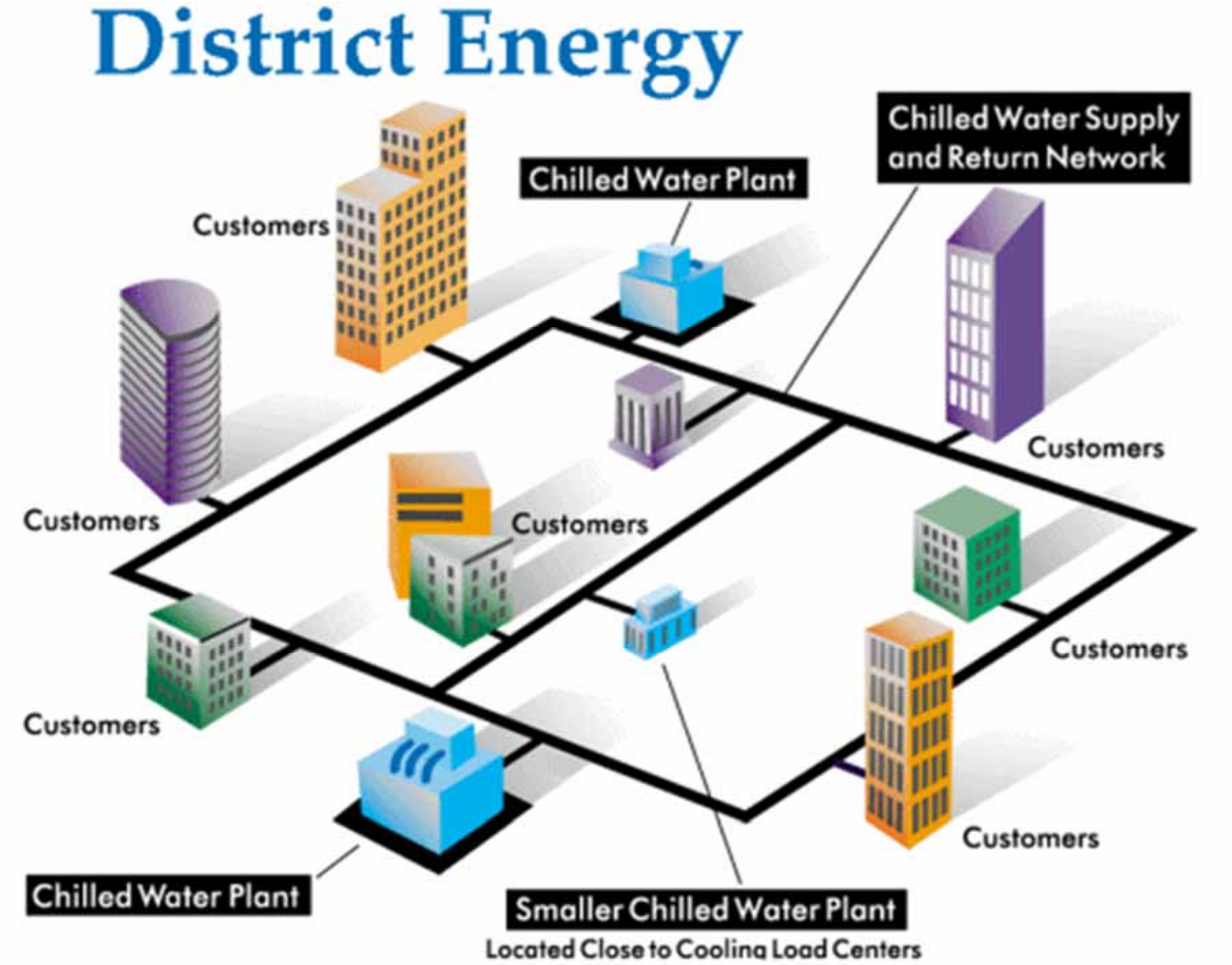


Double bundle heat recovery chiller

Waste heat recovery - double bundle heat recovery chiller

District cooling system (DCS)

Strategy: total energy approach



(Source: www.entergy-thermal.com/district_energy)

Design strategies: Renewable energy

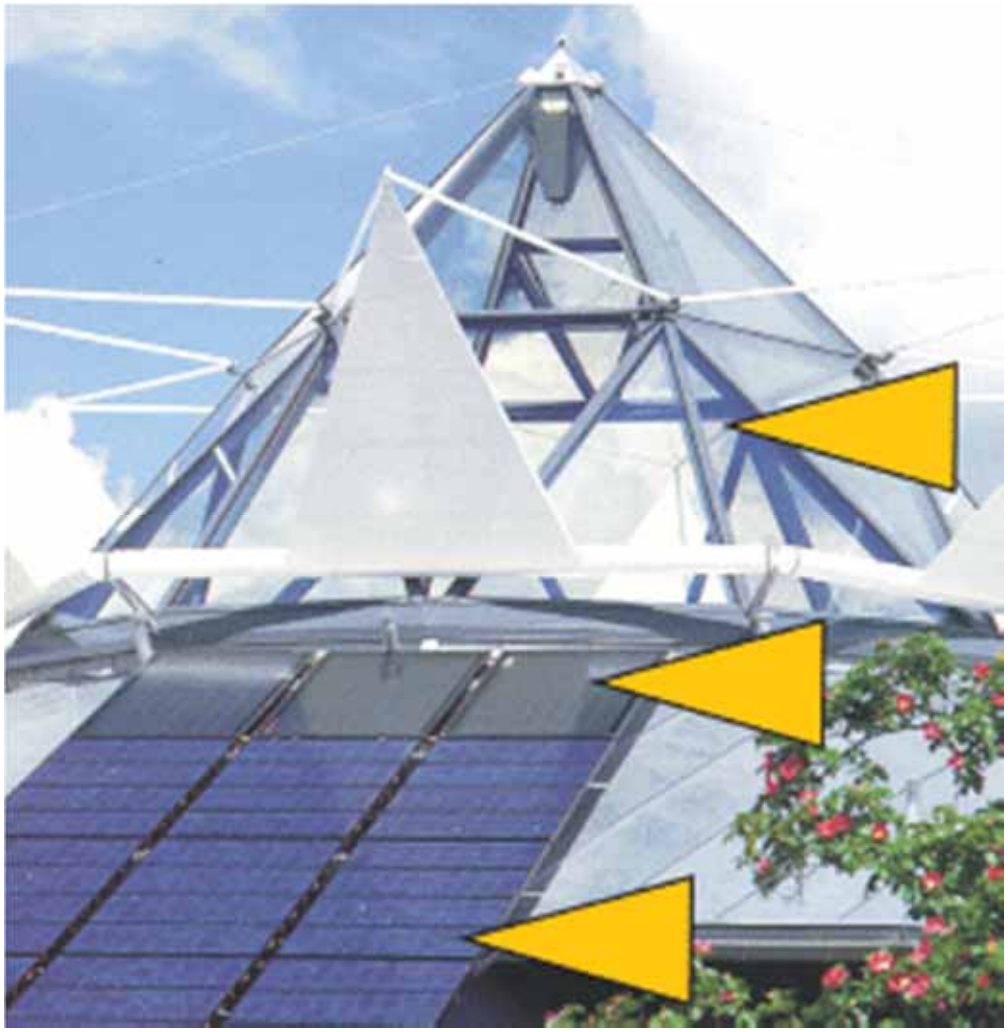
- Energy that occurs naturally and repeatedly on earth and can be harnessed for human benefit, e.g. solar, wind and biomass
- Common applications
  - Solar hot water
  - Solar photovoltaic
  - Wind energy
  - Geothermal
  - Small hydros

Solar PV systems in Hong Kong Science Park

Design strategies: 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)

因地制宜，多能互补。



Passive solar (e.g. skylight)

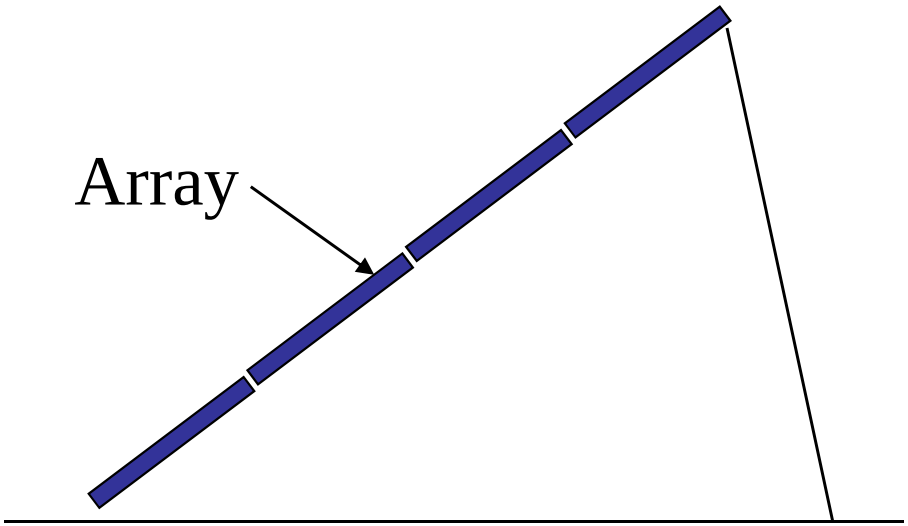
Active solar (solar hot water)

Photovoltaics

Integration of solar energy systems in buildings

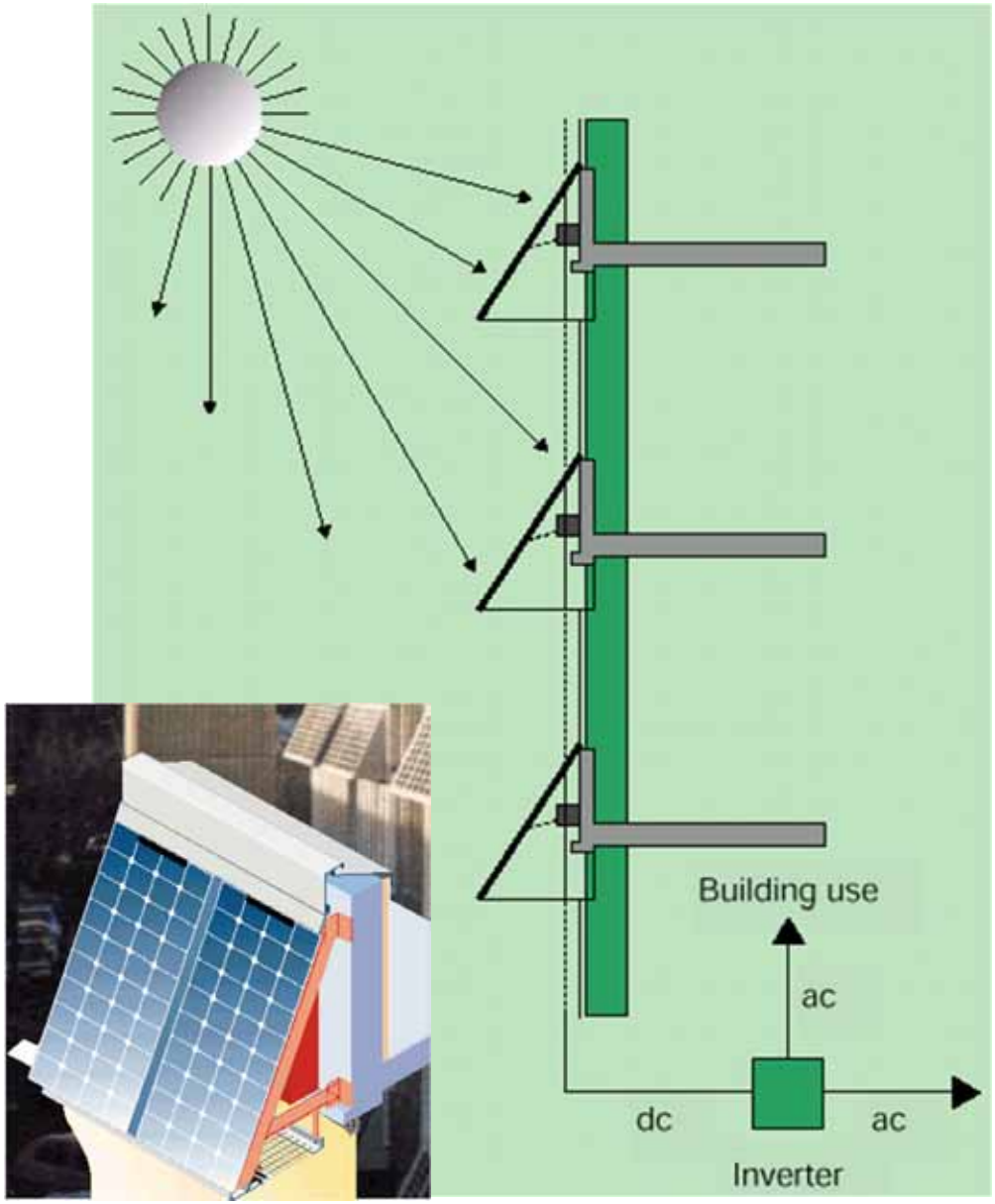
Evacuated-tube solar hot water system in a hotel in Lhsa, Tibet
(photo taken by Dr Sam C M Hui)

* Locate array in an unshaded area facing the equator



Tilt angle
= latitude (º) + 15º

(a) Roof (horizontal)



(b) Facades (vertical)

PV installations in buildings

Innovative ideas for building integrated renewable energy

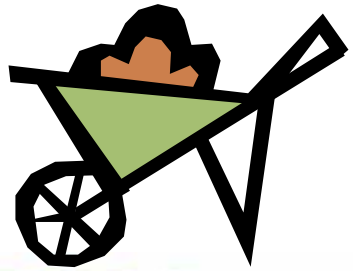
Dutch pavilion,
EXPO 2000 Hannover

Project Zed - London

Building integrated wind turbines (proposed WTC towers in Bahrain)

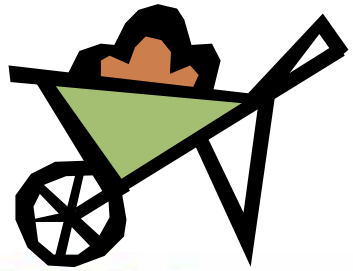
Pearl River Tower,
Guangzhou

Design strategies: Building materials



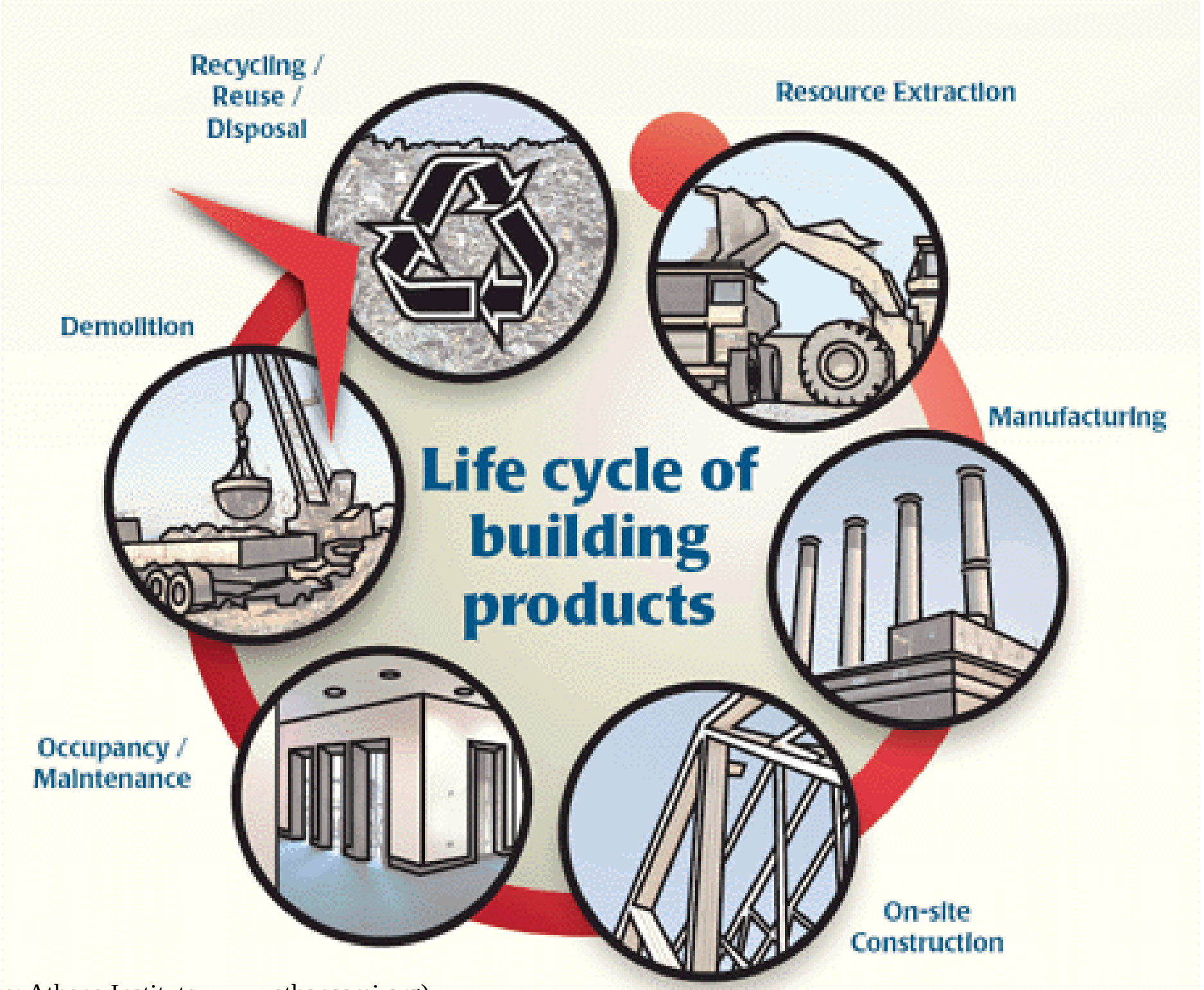
- Environmental impact of building materials
  - Through consumption of resources
  - Through production of resources (by-products, wastes, pollution, recyclables)
- Objectives
  - Make informed environmental choices about building materials and systems
  - Careful design & understanding about materials

Design strategies: 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]

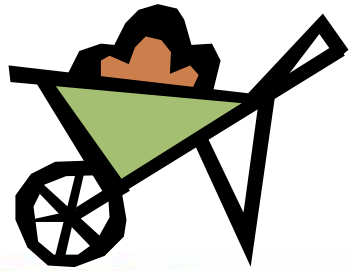


(Source: Athena Institute, www.athenasmi.org)

Estimated embodied energy of insulation materials

Material	Embodied energy (MJ/kg)	Mass per insulating unit (kg)	Embodied energy per insulating unit (MJ)
Cellulose	1.8	0.41	0.7
Fiberglass	28	0.17	5
Mineral wool	15	0.34	5
EPS	75	0.18	13
Polysio	70	0.22	15

Design strategies: Building materials

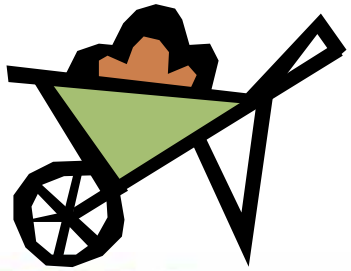


- Specify green materials & products
  - Made from environmentally attractive materials
    - Such as reclaimed, recycled or recyclable products
  - That reduce environmental impacts during construction, renovation, or demolition
  - That reduce environmental impacts of building operation
  - That contribute to a safe, healthy indoor environment
  - That are green because what isn’t there (e.g. CFC)

Green Features

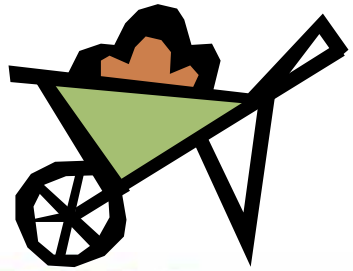
Manufacturing Process (MP)	Building Operations (BO)	Waste Mgmt. (WM)
Waste Reduction (**WR**)	Energy Efficiency (**EE**)	Biodegradable (**B**)
Pollution Prevention (**P2**)	Water Treatment & Conservation (**WTC**)	Recyclable (**R**)
Recycled (**RC**)	Nontoxic (**NT**)	Reusable (**RU**)
Embodied Energy Reduction (**EER**)	Renewable Energy Source (**RES**)	Others (**O**)
Natural Materials (**NM**)	Longer Life (**LL**)	

Design strategies: Building materials



- Material conservation
  - Adapt existing buildings to new uses
  - Material conserving design & construction
  - Size buildings & systems properly
  - Incorporate reclaimed or recycled materials
  - Use environment-friendly materials & products
  - Design for deconstruction (“close the loop”)
- Life cycle assessment (LCA) is often used to evaluate the environmental impact of building materials and products

Design strategies: Building materials

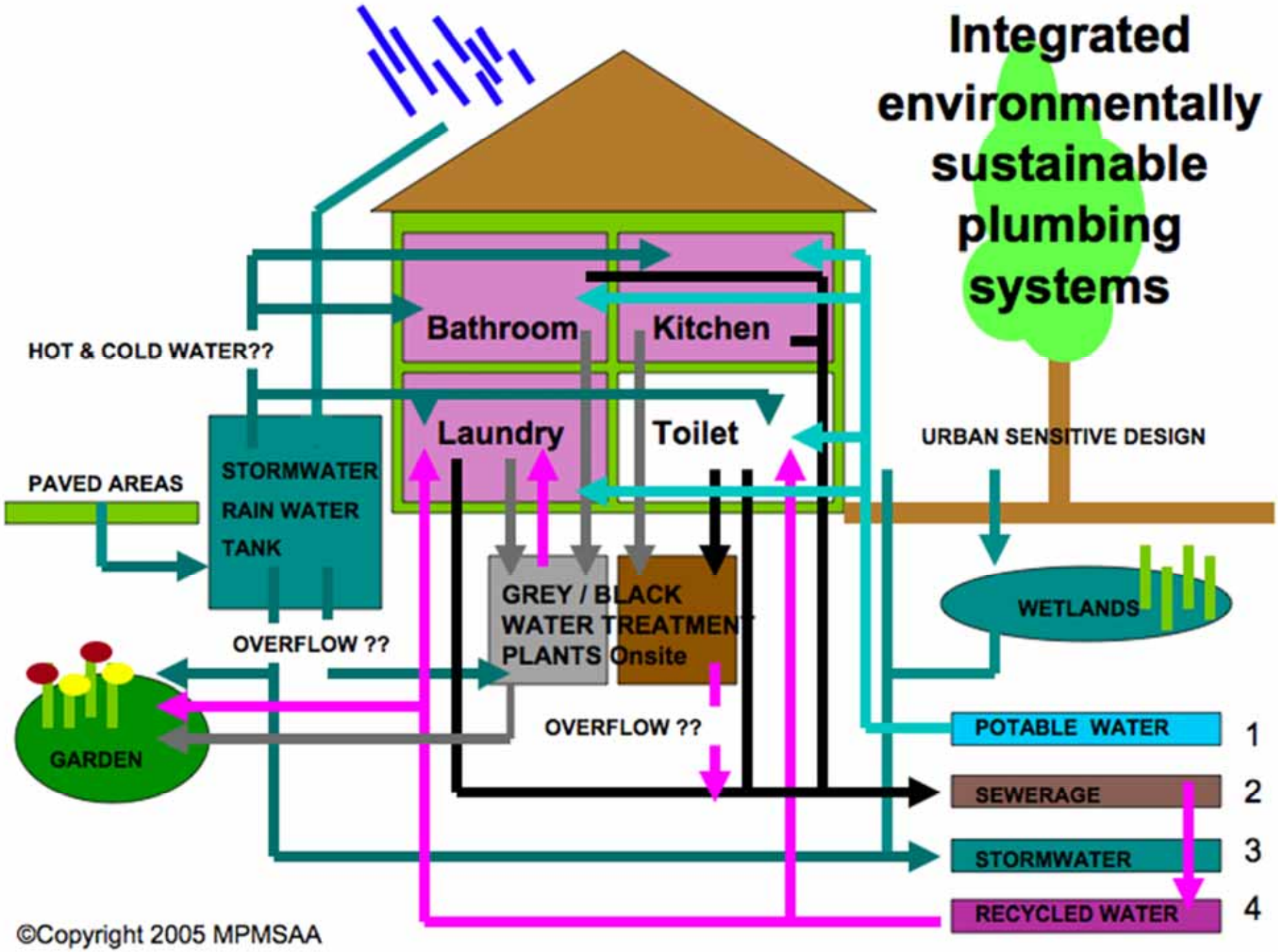


- Waste management strategies
  - Waste prevention & reduction
  - Construction and demolition recycling
  - Architectural reuse
  - Design for material recovery
- Important factors
  - On-site collection & storage space
    - In HK, the space is very limited
  - Sorting & separation (paper, glass, plastic, metal)

Design strategies: Water issues

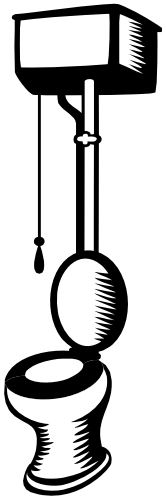
- Stormwater or watershed protection
  - Control rainwater runoff, flooding and erosion
    - Preservation of soils and drainage ways
    - Porous paving materials
    - Drainage of concentrated runoff
  - Avoid pollution and soil disturbance

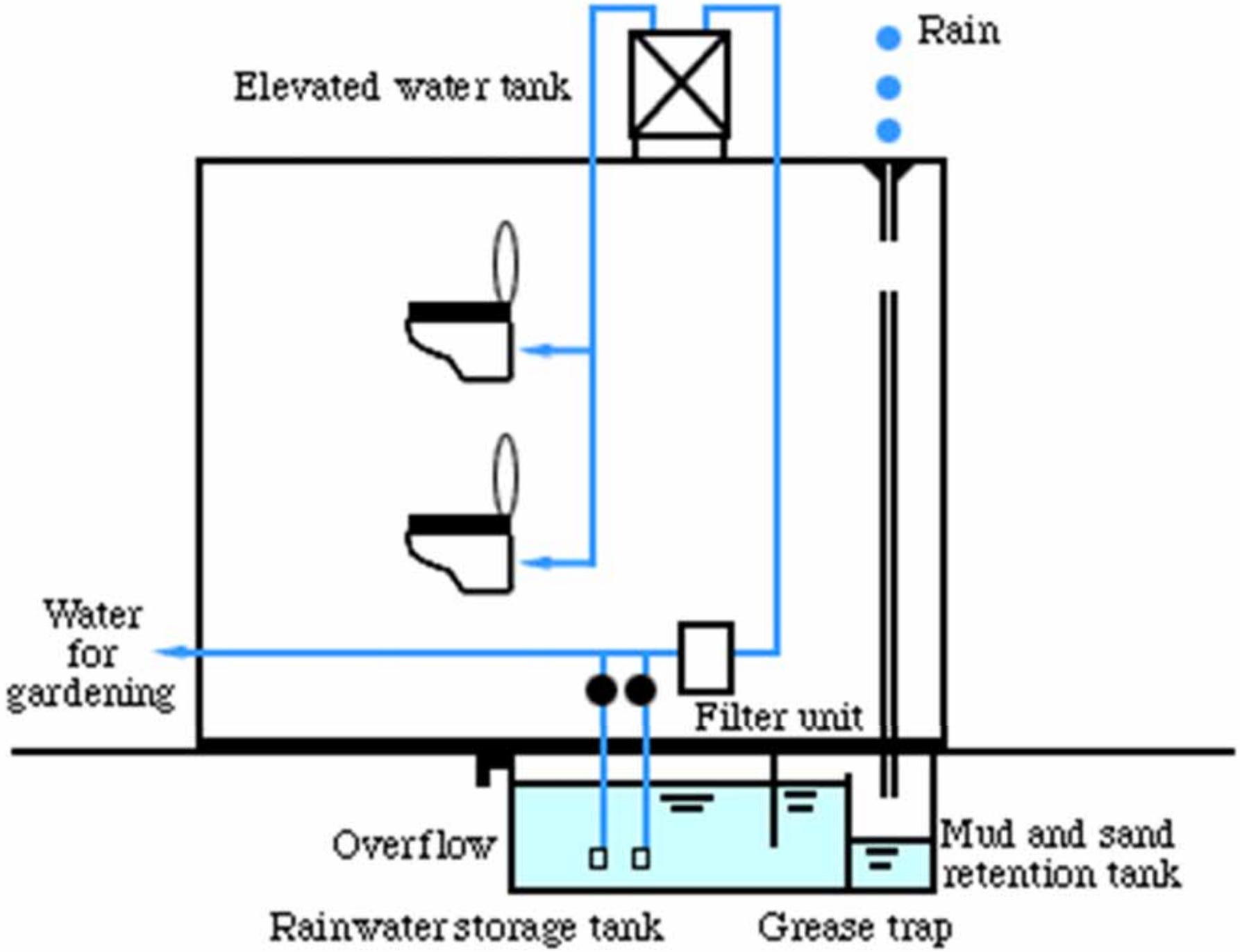
- Water efficiency and conservation
  - Saving of water and money: water-use charge, sewage treatment costs, energy use, chemical use


Integrated environmentally sustainable plumbing systems
Bathroom
Kitchen
Laundry
Toilet
HOT & COLD WATER??
PAVED AREAS
STORMWATER RAIN WATER TANK
OVERFLOW ??
GREY / BLACK WATER TREATMENT PLANTS Onsite
OVERFLOW ??
GARDEN
URBAN SENSITIVE DESIGN
WETLANDS
POTABLE WATER
1
SEWERAGE
2
STORMWATER
3
RECYCLED WATER
4
©Copyright 2005 MPMSAA

Design strategies: Water issues

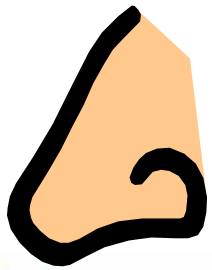
- Design strategy for water efficiency
  - Reduce water consumption
    - Low-flush toilets & showerheads
    - Leak detection & prevention
  - Correct use of appliances (e.g. washing machine)
  - Reuse and recycle water onsite
    - Rainwater collection & recycling
    - Greywater recycling (e.g. for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





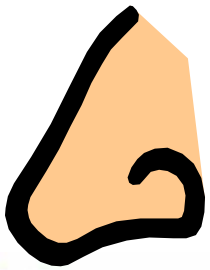
Rainwater recycling system

Design strategies: 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

Design strategies: Indoor environment

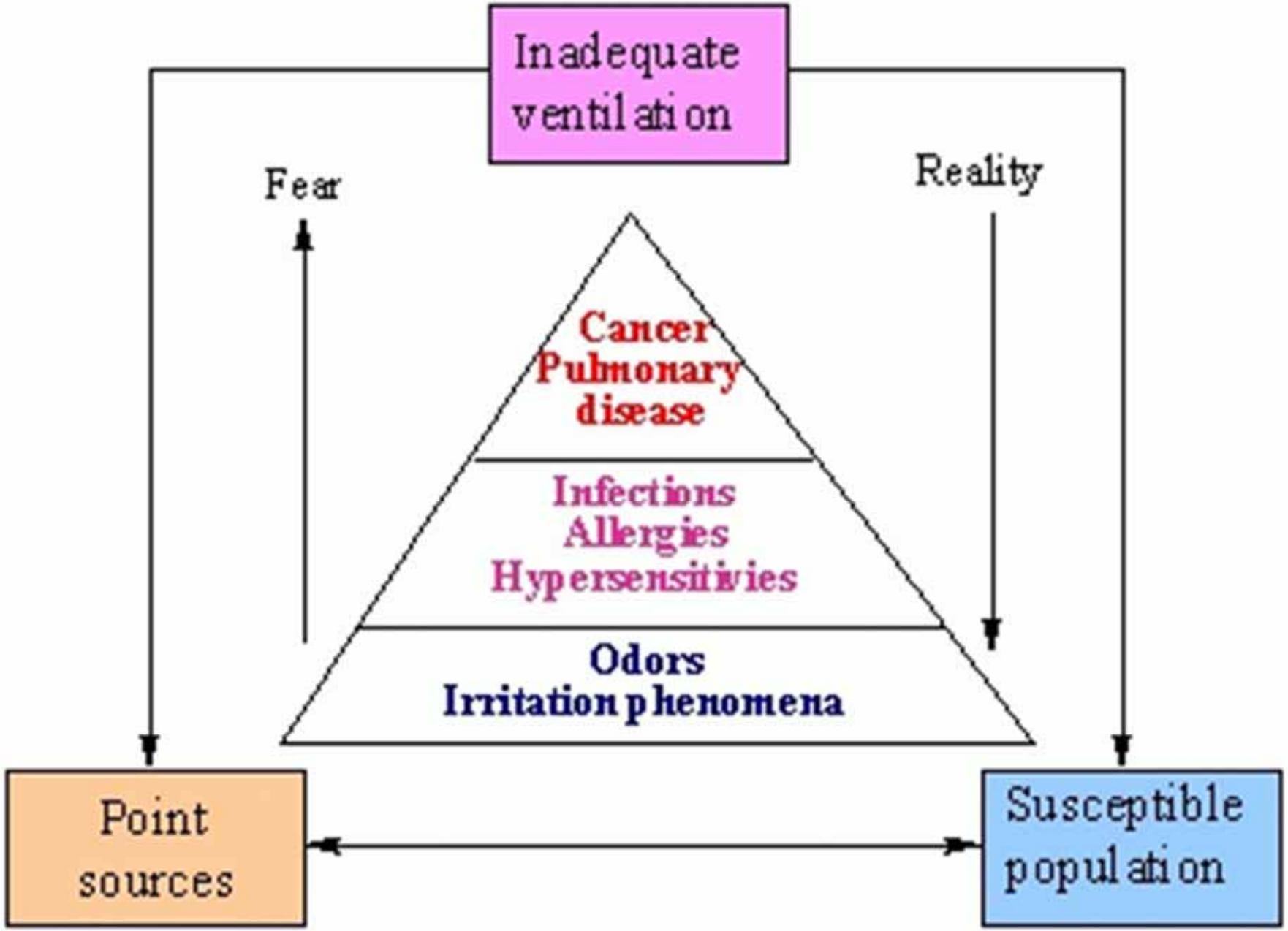


- Indoor air quality (IAQ)
  - People spend most of their time indoors
  - Pollutants may build up in an enclosed space
  - Effects on health and productivity

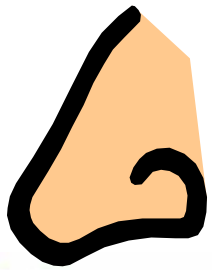
- Control methods
  - Assess materials to avoid health hazards
    - Such as volatile organic compounds (VOC)
  - Ensure good ventilation & building management

Understanding Indoor Air Quality Problems

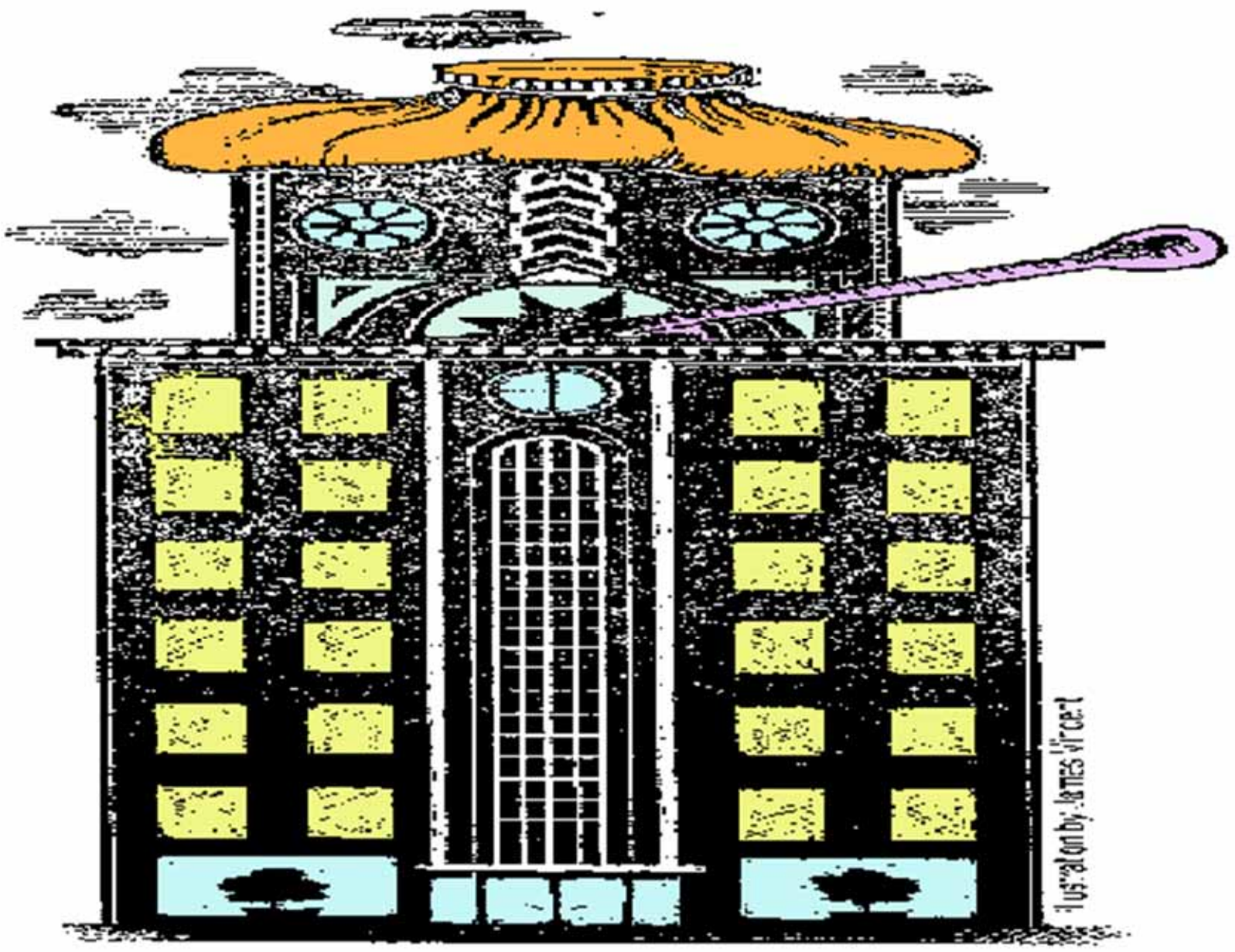
(Brooks & Davis, 1992)



Design strategies: Indoor environment

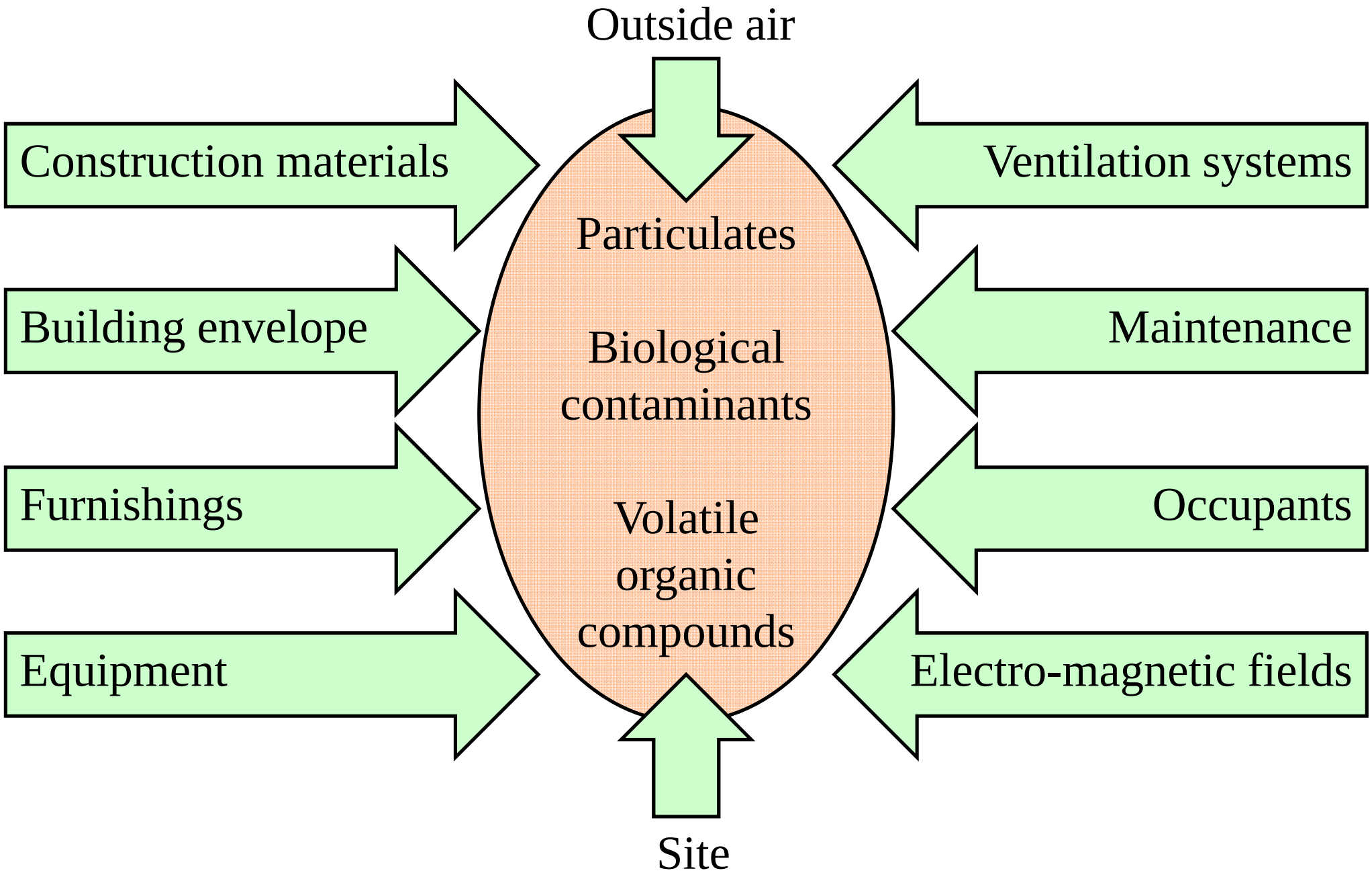


- IAQ problems
  - Not simple, and is constantly changing interaction of complex factors including:
    - Source of pollutants or odours
    - Maintenance and operation of ventilating systems
    - Moisture and humidity
    - Occupant perceptions and susceptibilities (e.g. elderly)
    - Other psychological factors
  - May cause dissatisfaction and complaints, but cannot determine the reasons [Sick Building]



Avoid “sick building syndromes” by maintaining good indoor air quality

Major factors contributing to indoor air quality (IAQ)



(Source: PTI, 1996. *Sustainable Building Technical Manual*)

Four principles of indoor air quality design

1. Source Control

+

2. Ventilation Control

+

3. Occupant Activity Control

+

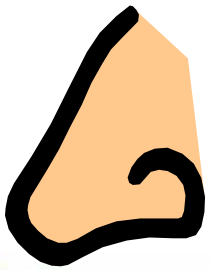
4. Building Maintenance

=

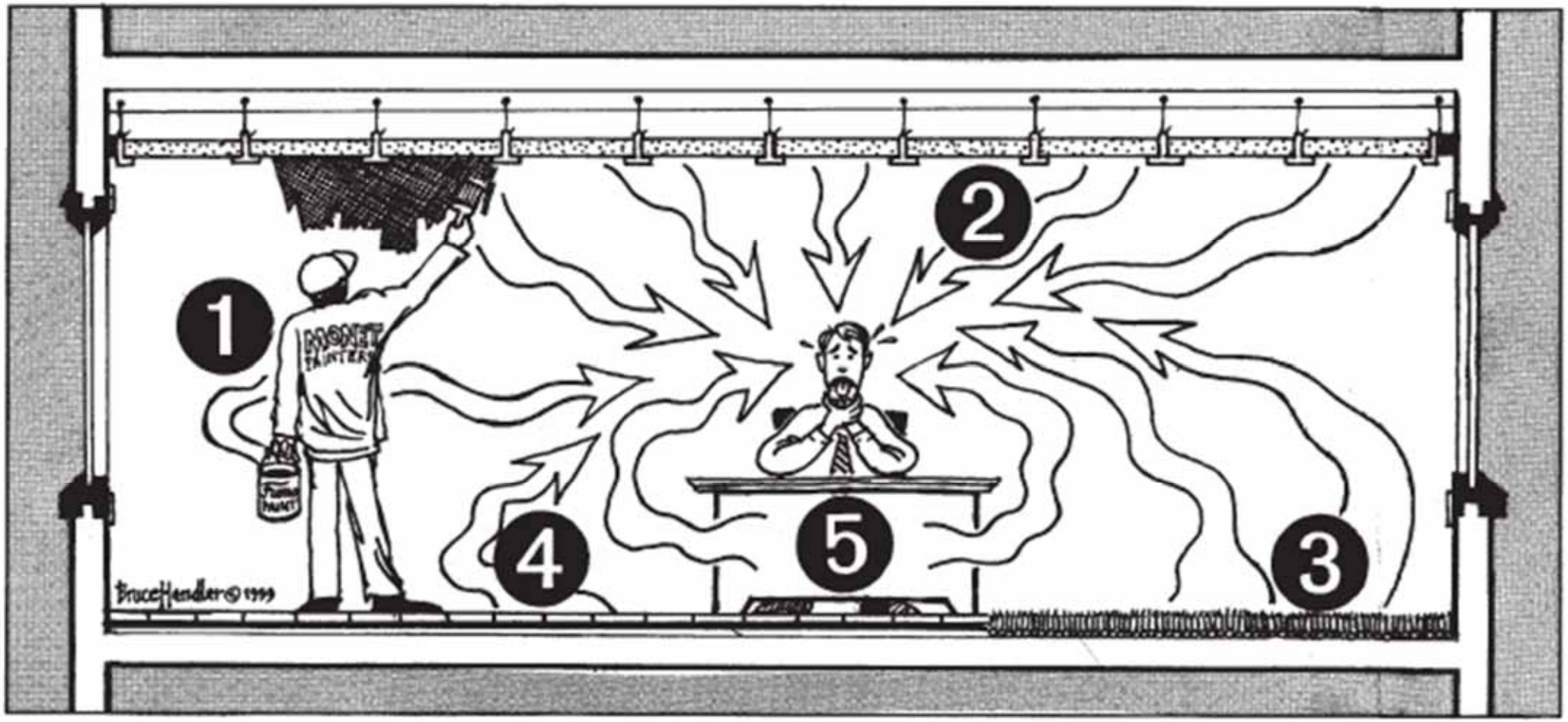
Total Indoor Air Quality

(Source: PTI, 1996. *Sustainable Building Technical Manual*)

Design strategies: Indoor environment



- Source control
  - Site
  - Construction materials
  - Equipment
  - Building contents
  - Human activity
  - Light & noise
  - Furnishings
  - HVAC Systems

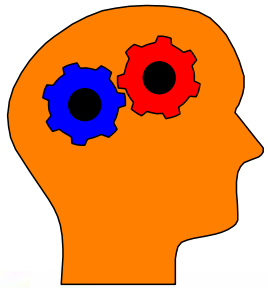


Sources of offgassing in building materials:
1) paints, 2) ceiling tiles, 3) carpeting, 4) VCT floor tiles
5) manufactured wood products

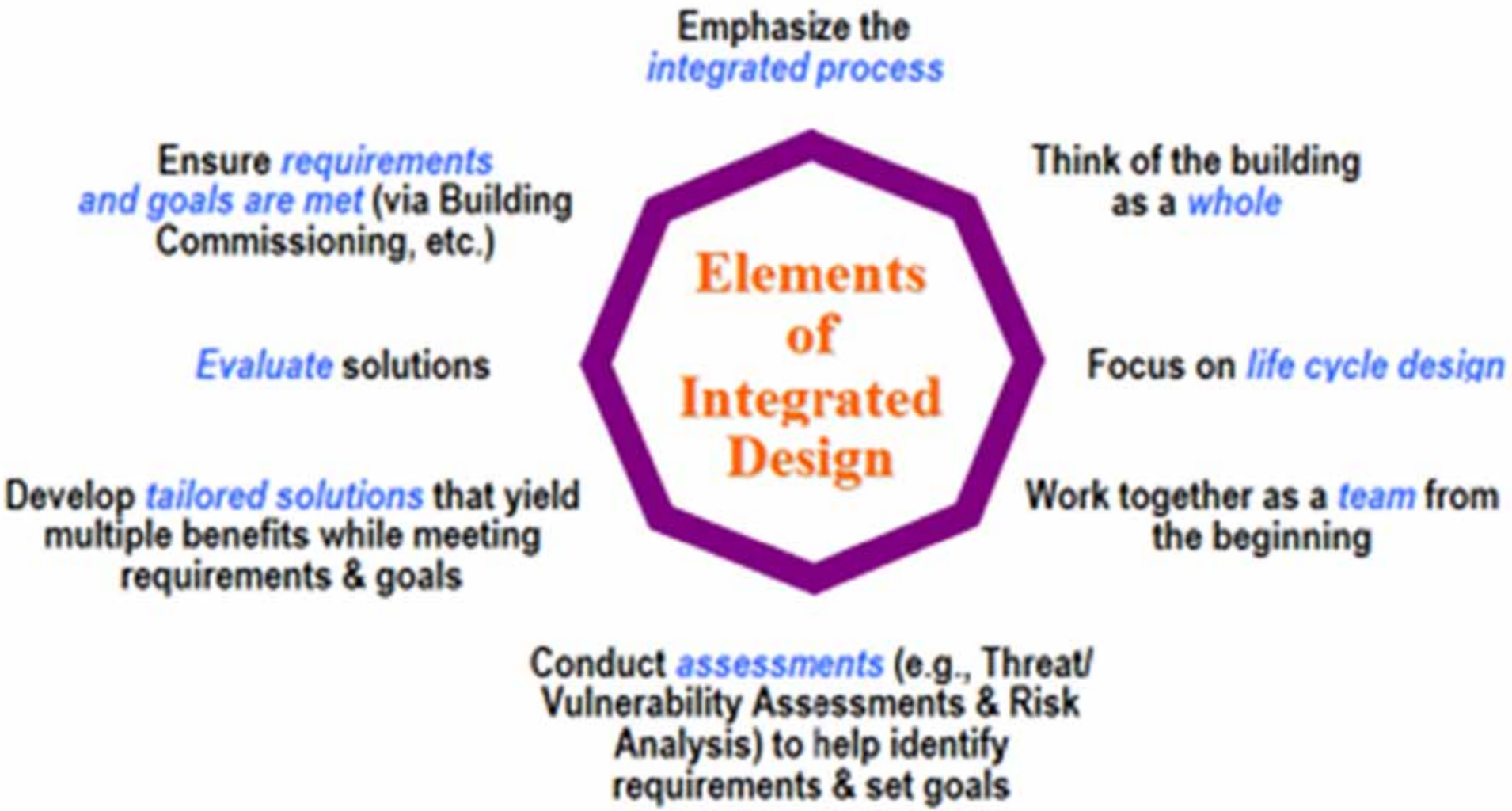
Design strategies: Indoor environment

- Ventilation control
  - Air intake location
  - Air exhaust location
  - Air filtration
  - Fibrous insulation
  - Ventilation rates
  - Temperature, humidity
  - Control systems, exhaust systems
  - Building commissioning

Design strategies: Integrated building design

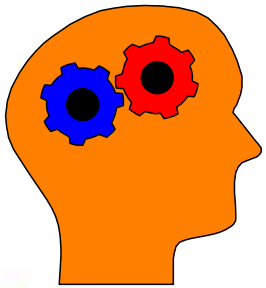


- WBDG - The Whole Building Design Guide
  - www.wbdg.org
- Two components of whole building design:
  - Integrated design approach
  - Integrated team process
- A holistic design philosophy
  - Holism + Interconnectedness + Synergy
  - "*The whole is greater than the sum of its parts*"



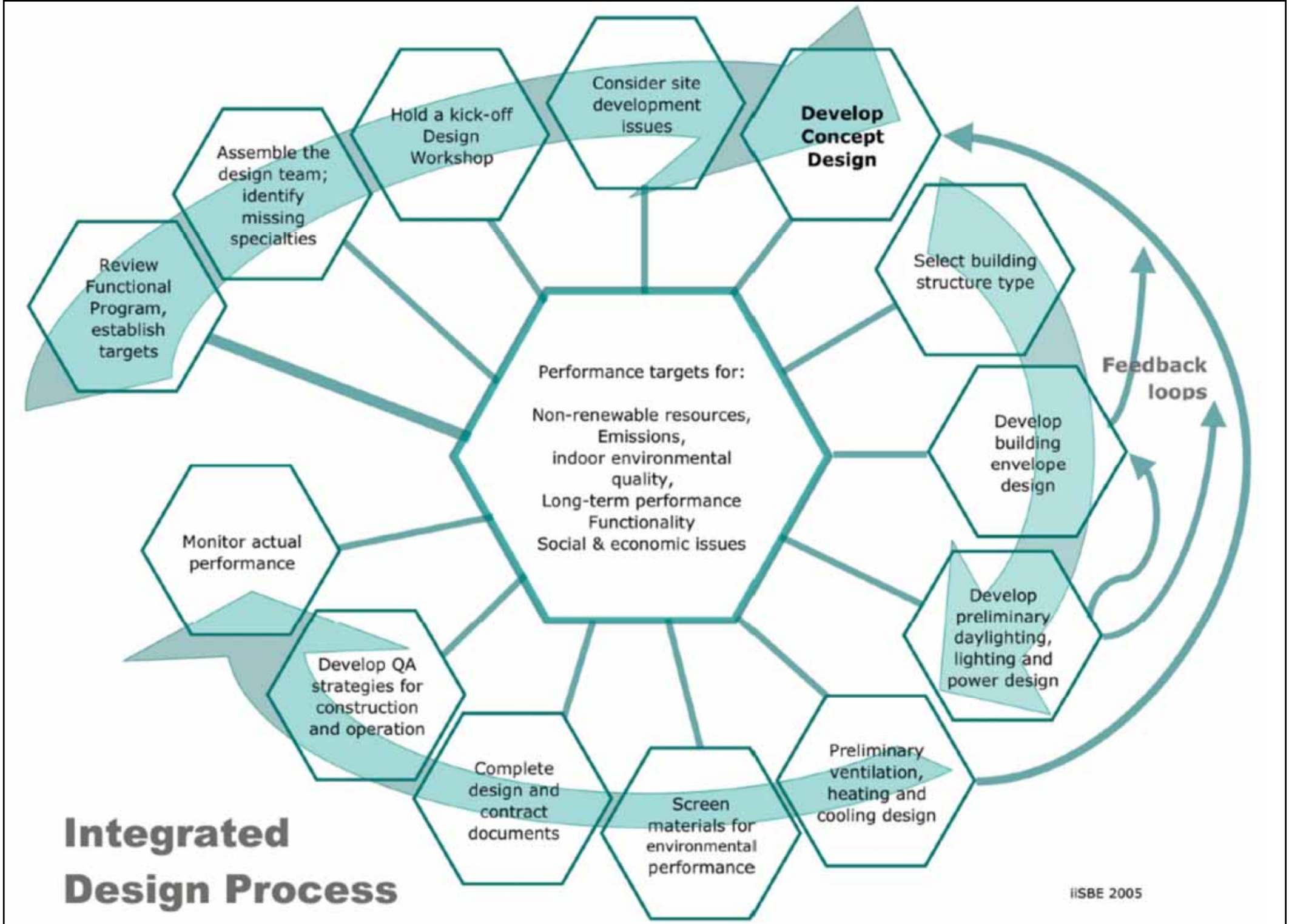
(Source: www.wbdg.org)

Design strategies: Integrated building design



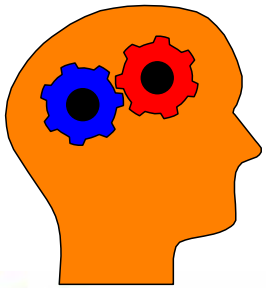
- Typical integrated design process
  - Preparation
  - Design development
  - Contract documents
  - Construction phase
  - Commissioning
  - Post-occupancy evaluation

- Usually more efforts in preparation and pre-design phases



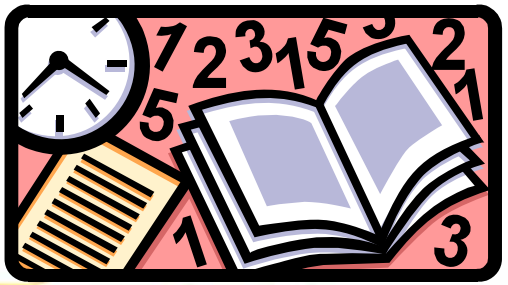
(Source: International Initiative for a Sustainable Built Environment (iiSBE), www.iisbe.org)

Design strategies: Integrated building design



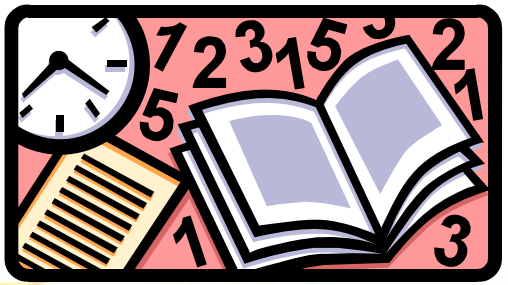
- Integrated, multidisciplinary project team
  - Owner's representative
  - Architect
  - Building Services Engineer
  - Civil/Structural Engineer
  - Construction Manager
  - Landscape Architect
  - Specialized Consultants

Further Reading



- Sustainable Building Systems
  - http://www.mech.hku.hk/bse/sbs/
- HK Green Building Technology Net
  - http://gbtech.emsd.gov.hk
- Whole Building Design Guide (WBDG)
  - http://www.wbdg.org
- Sustainable Building Technical Manual
  - http://smartcommunities.ncat.org/pdf/sbt.pdf

Further Reading



- ASHRAE, 2010. *ASHRAE Greenguide: the Design, Construction, and Operation of Sustainable Buildings*, 3rd ed., Elsevier/Butterworth-Heinemann, Amsterdam and Boston.
- ASHRAE Standard 189.1: Design of High-Performance Green Buildings
  - www.ashrae.org/greenstandard

THANK YOU 多谢 !!

(More information: www.mech.hku.hk/bse/bee-sbd/)