Guest Lecture to HKU Department of Architecture
[ARCH 5303 - Sustainable Building Systems]
www.mech.hku.hk/bse/sbs/

Green Building Design Strategies (with case studies)

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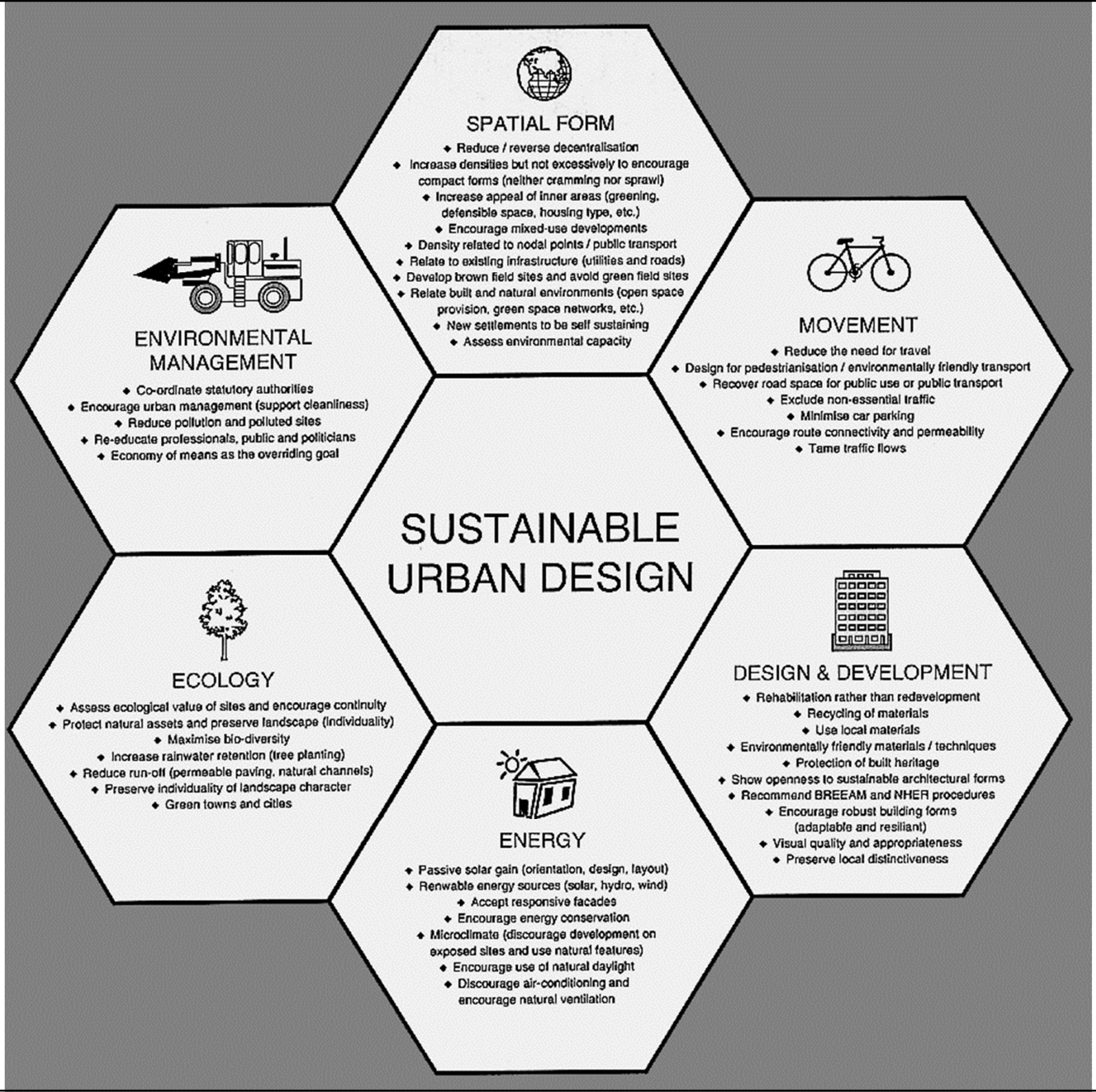
- Urban and site design
- Energy efficiency
- Renewable energy
- Building materials
- Water issues
- Indoor environment
- Integrated building design

Urban and site design

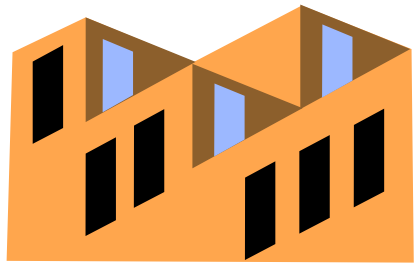
- Planning of development at different *scales*
  - Building, blocks, district, city/town, region
- Good urban design ensures economically viable places and spaces that are:
  - Resource efficient
  - Adaptable
  - Durable
  - Inclusive
  - Fit for purpose

Urban and site design

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

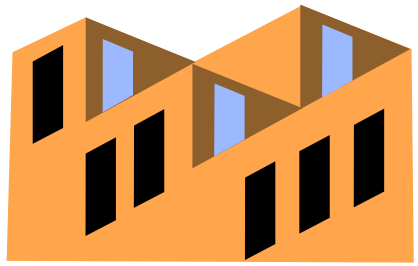

SUSTAINABLE URBAN DESIGN
SPATIAL FORM
◆ Reduce / reverse decentralisation
◆ Increase densities but not excessively to encourage compact forms (neither cramming nor sprawl)
◆ Increase appeal of inner areas (greening, defensible space, housing type, etc.)
◆ Encourage mixed-use developments
◆ Density related 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

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

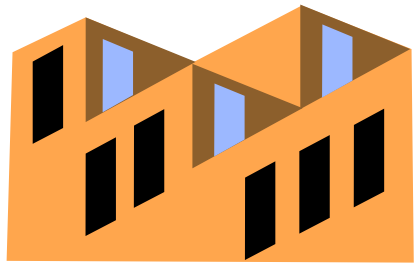
Urban and site design



- 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.]

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

Case study on urban and site design

- Hong Kong Science Park Virtual Tour (Phase 1 & 2) (3:11)
  - www.youtube.com/watch?v=ttYP85LlWTQ
- Case Studies on Sustainable Buildings
  - http://me.hku.hk/sbe/case_study/index/top.htm
  - Hong Kong Science Park
    - www.mech.hku.hk/sbe/case_study/case/hk/sc_pk/top.htm

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

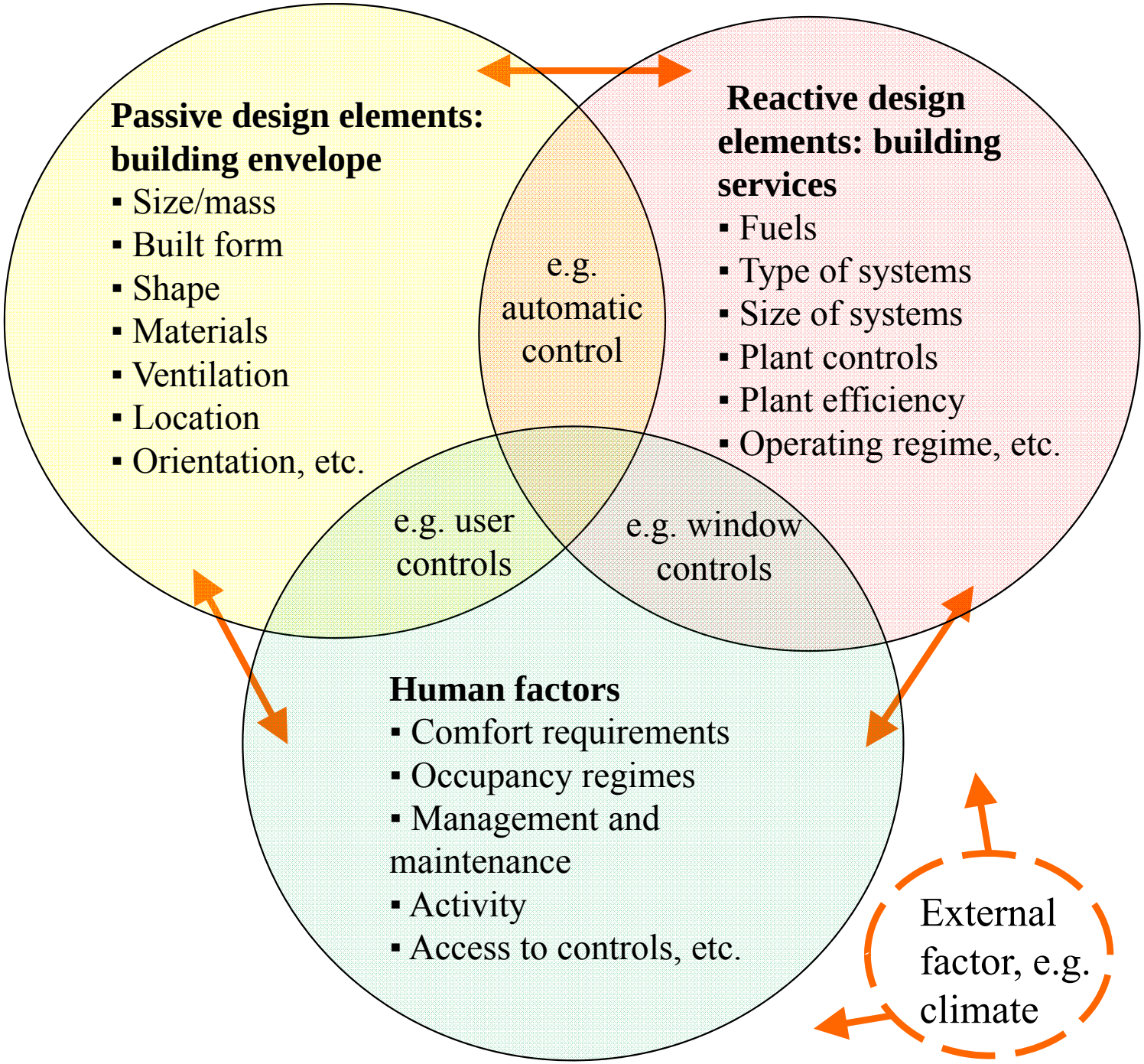
Integrated & total energy approach

Efficient systems

Good house-keeping

User education & awareness

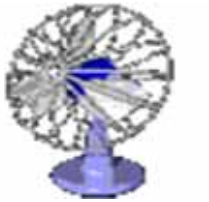
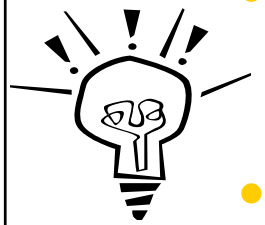
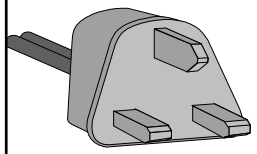
Efficient operation



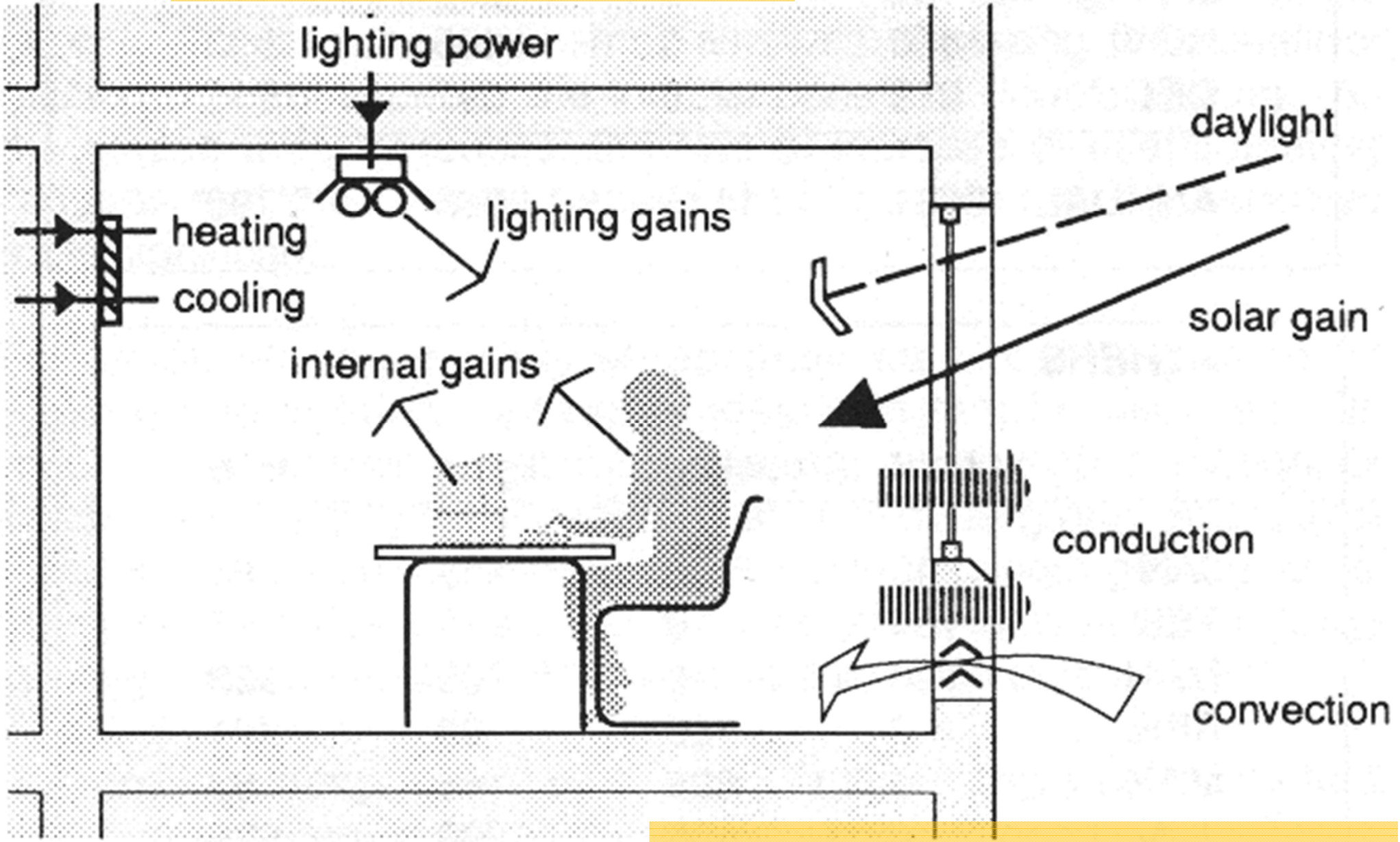
Key factors influencing energy consumption

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

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)

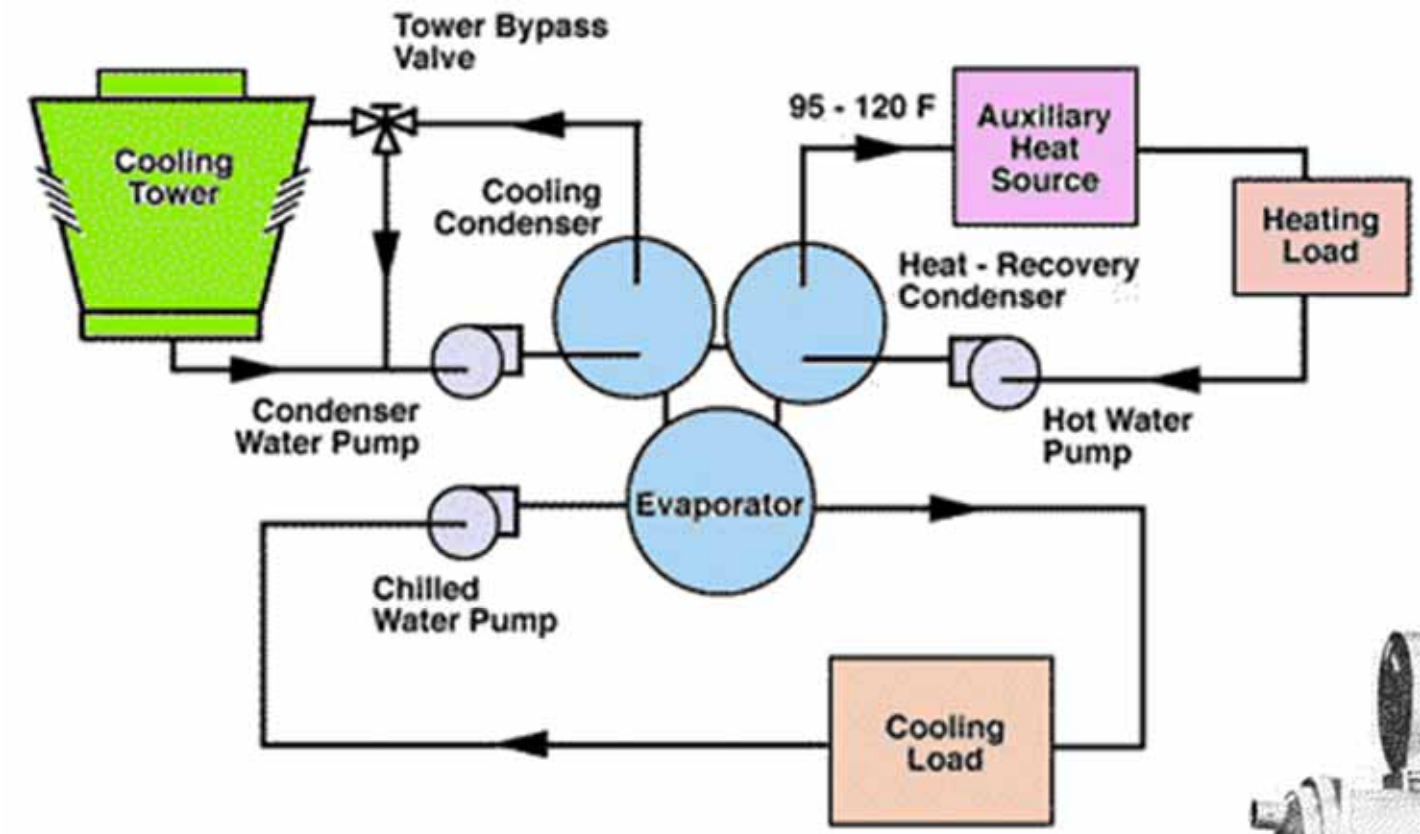
Strategy: reduce thermal loads

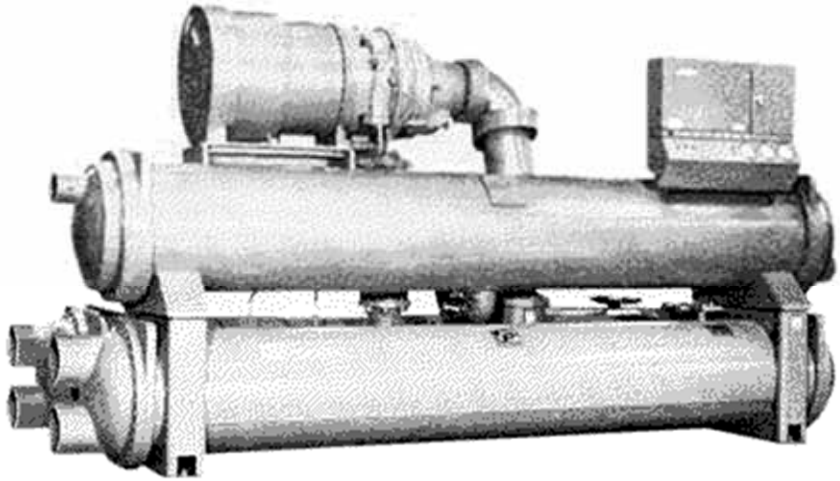


Strategy: optimise building envelope

Thermal energy balance in a building space

Strategy: use of heat recovery





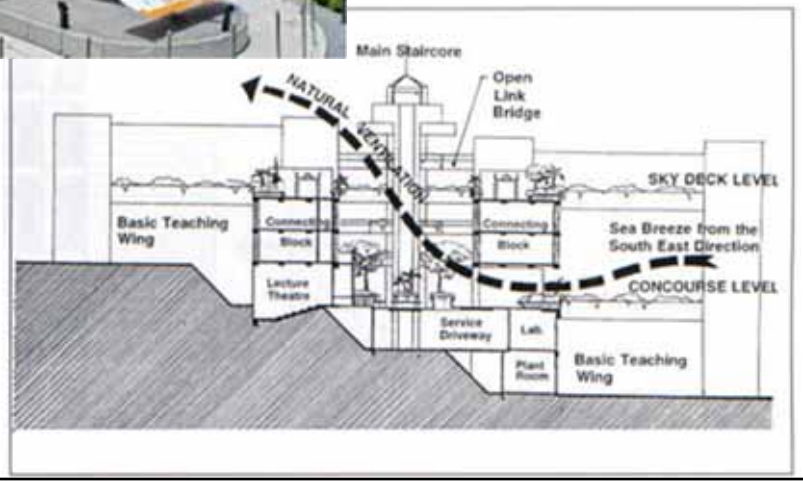
Double bundle heat recovery chiller

Produce hot water or heating

Waste heat recovery - double bundle heat recovery chiller

Case studies on energy efficiency

- Case Studies on Sustainable Buildings
  - http://me.hku.hk/sbe/case_study/index/top.htm
  - Hong Kong Techinical College (Tsing Yi) [now IVE Tsing Yi]
    - www.mech.hku.hk/sbe/case_study/case/hk/hktc/
  - Information & Communication Centre, Matsushita Electric Industrial Co., Japan (i.e. Panasonic)
    - www.mech.hku.hk/sbe/case_study/case/jap/Matsushita/



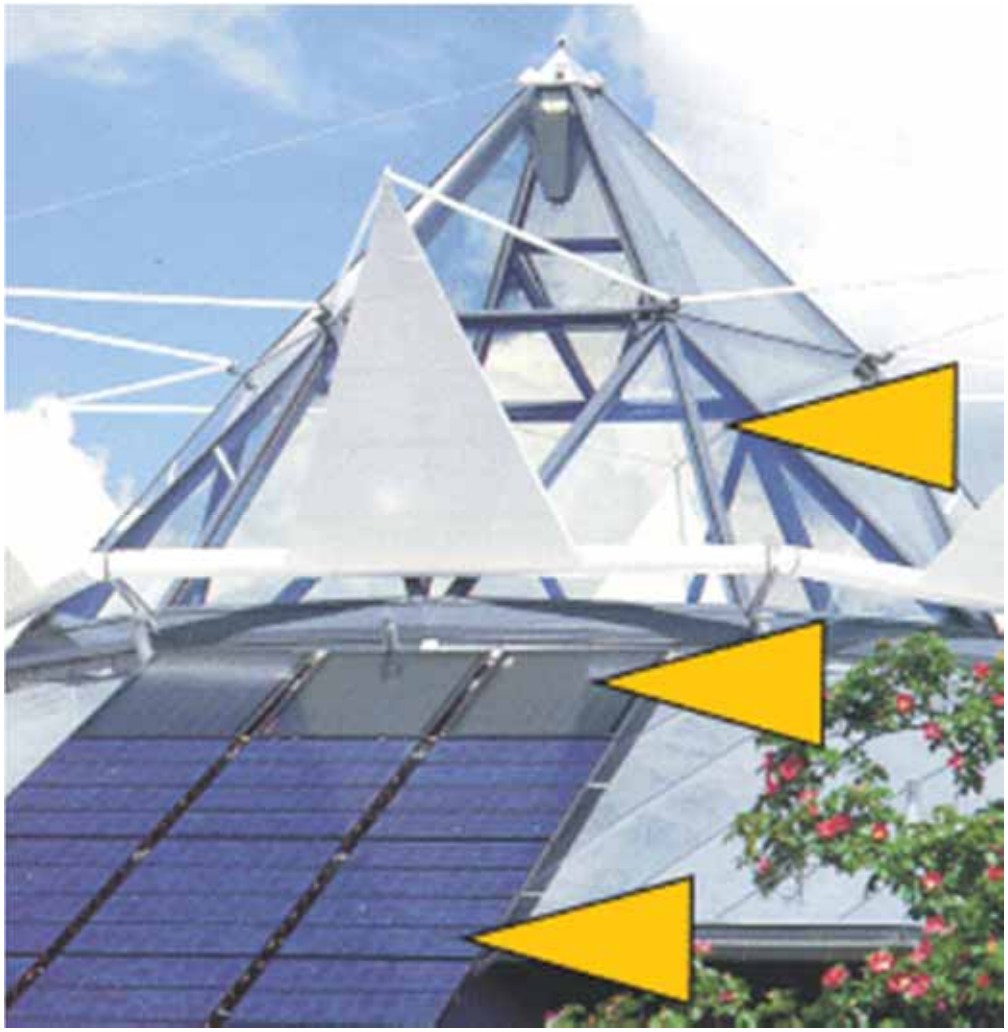
Renewable energy

- 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)

因地制宜，多能互补。



Passive solar (e.g. skylight)

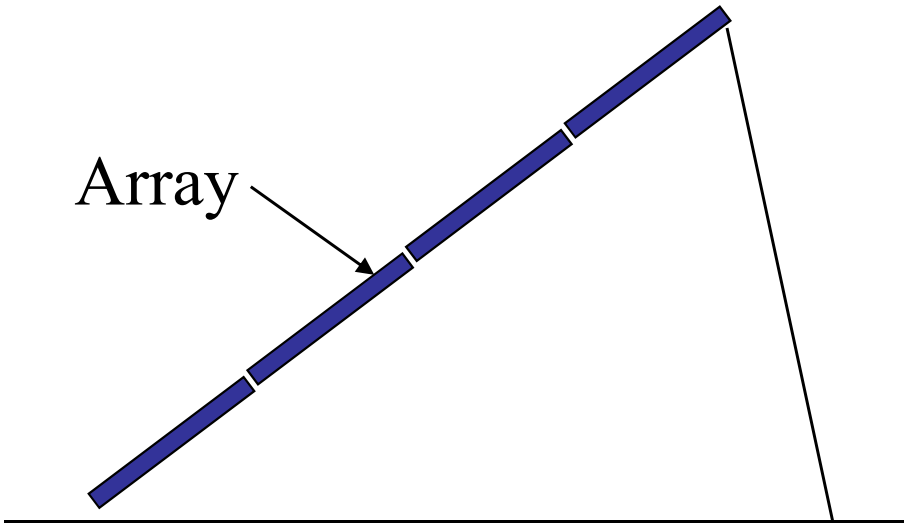
Active solar (solar hot water)

Photovoltaics

Integration of solar energy systems in buildings

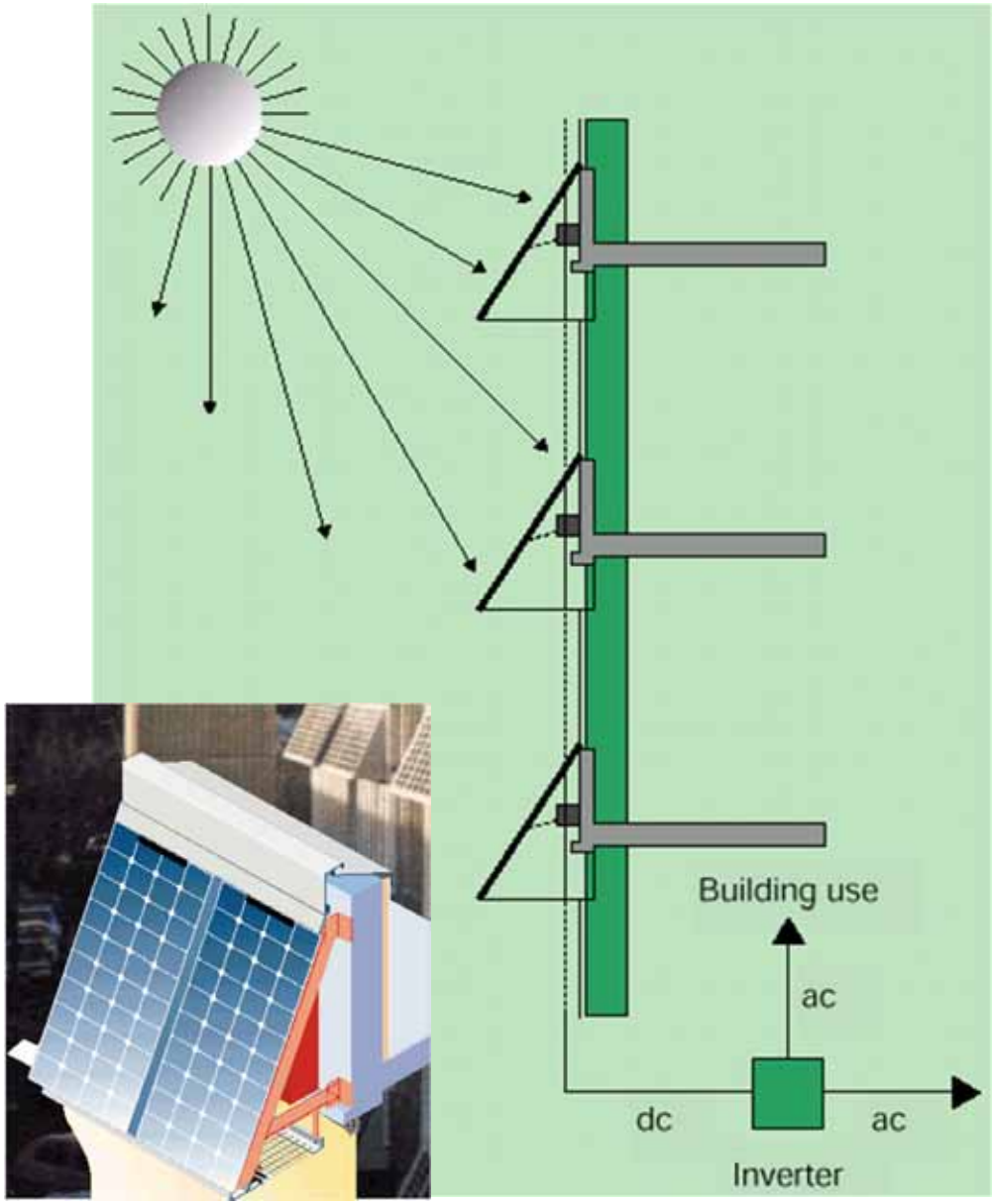
Evacuated-tube solar hot water system in a hotel in Lhsa, Tibet
(photo taken by Dr Sam C M Hui)

* Locate array in an unshaded area facing the equator



Tilt angle
= latitude (º) + 15º

(a) Roof (horizontal)

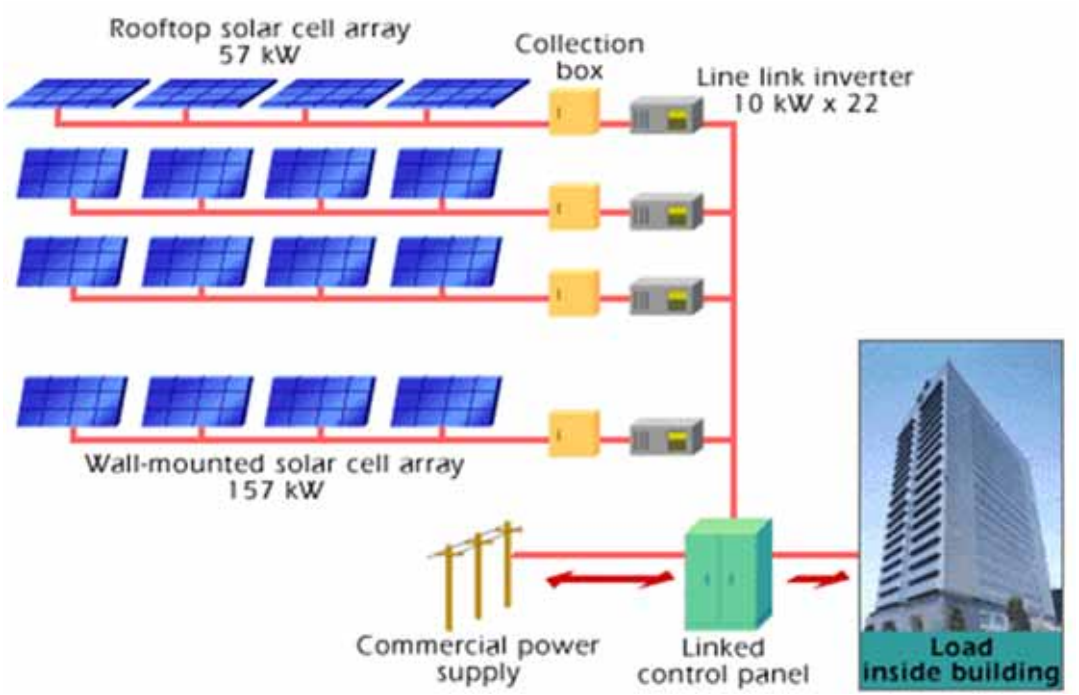


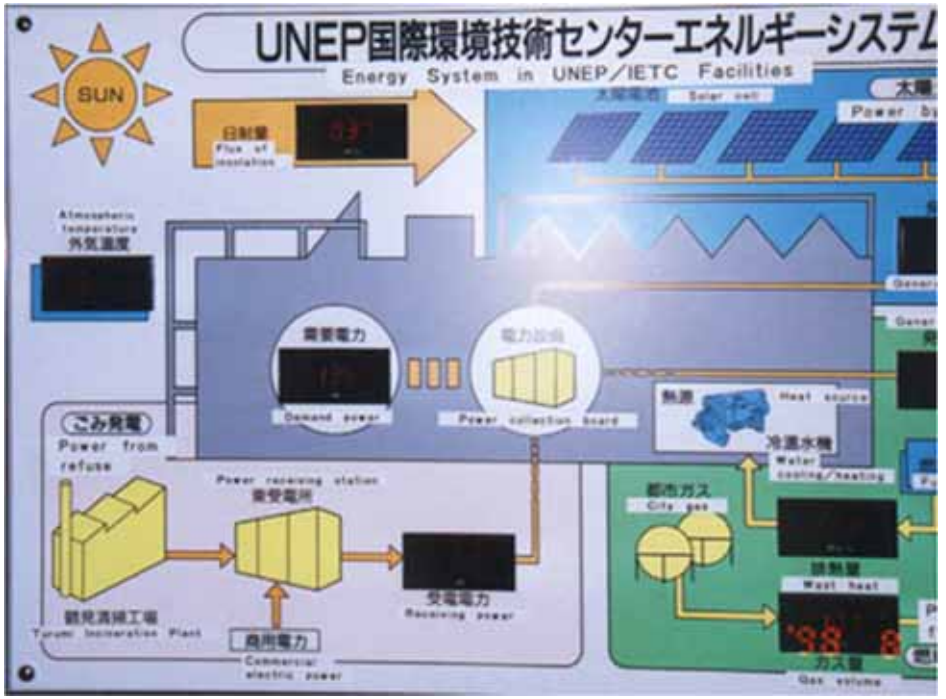
(b) Facades (vertical)

PV installations in buildings

Case studies on renewable energy

- Case Studies on Sustainable Buildings
  - http://me.hku.hk/sbe/case_study/index/top.htm
  - Kyocera New Headquarters Building, Fushimi-ku, Japan
    - www.mech.hku.hk/sbe/case_study/case/jap/kyocera/kyocera-index.html
  - UNEP International Environmental Techonology Centre, Japan
    - www.mech.hku.hk/sbe/case_study/case/jap/unep/unep-index.html





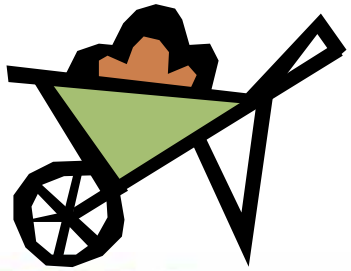
Building integrated wind turbines (World Trade Center in Bahrain)*

* Green Building - Wind Powered, NatGeo World Trade Center Bahrain 1 (14:00)
https://www.youtube.com/watch?v=TgBsf3d0u7E

Pearl River Tower, Guangzhou, China

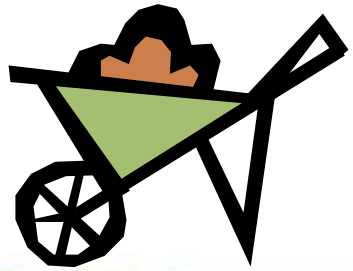
http://en.wikipedia.org/wiki/Pearl_River_Tower
http://www.som.com/projects/pearl_river_tower__sustainable_design

Building materials



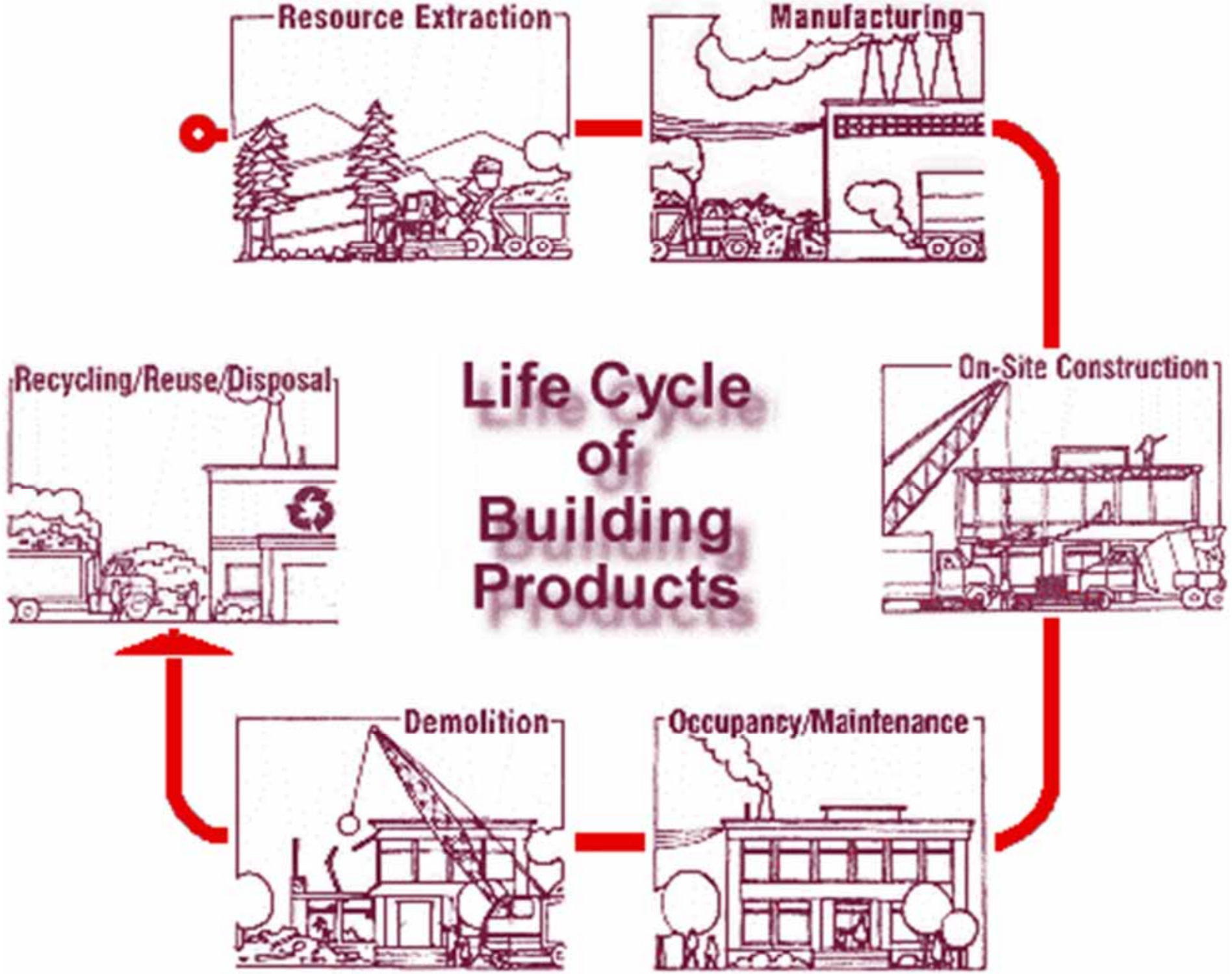
- Environmental impact of building materials
  - Through consumption of resources
  - Through production of resources (by-products, wastes, pollution, recyclables)
- Objectives
  - Make informed environmental choices about building materials and systems
  - Careful design & understanding about materials

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

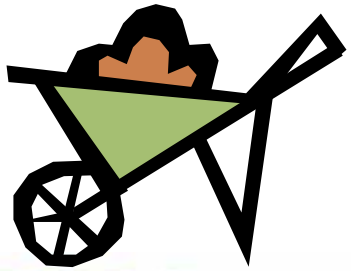
[* http://en.wikipedia.org/wiki/Embodied_energy]


Resource Extraction
Manufacturing
On-Site Construction
Occupancy/Maintenance
Demolition
Recycling/Reuse/Disposal
Life Cycle of Building Products

Green Features

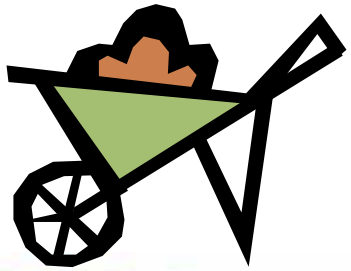
Manufacturing Process (MP)	Building Operations (BO)	Waste Mgmt. (WM)
Waste Reduction (**WR**)	Energy Efficiency (**EE**)	Biodegradable (**B**)
Pollution Prevention (**P2**)	Water Treatment & Conservation (**WTC**)	Recyclable (**R**)
Recycled (**RC**)	Nontoxic (**NT**)	Reusable (**RU**)
Embodied Energy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

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

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)

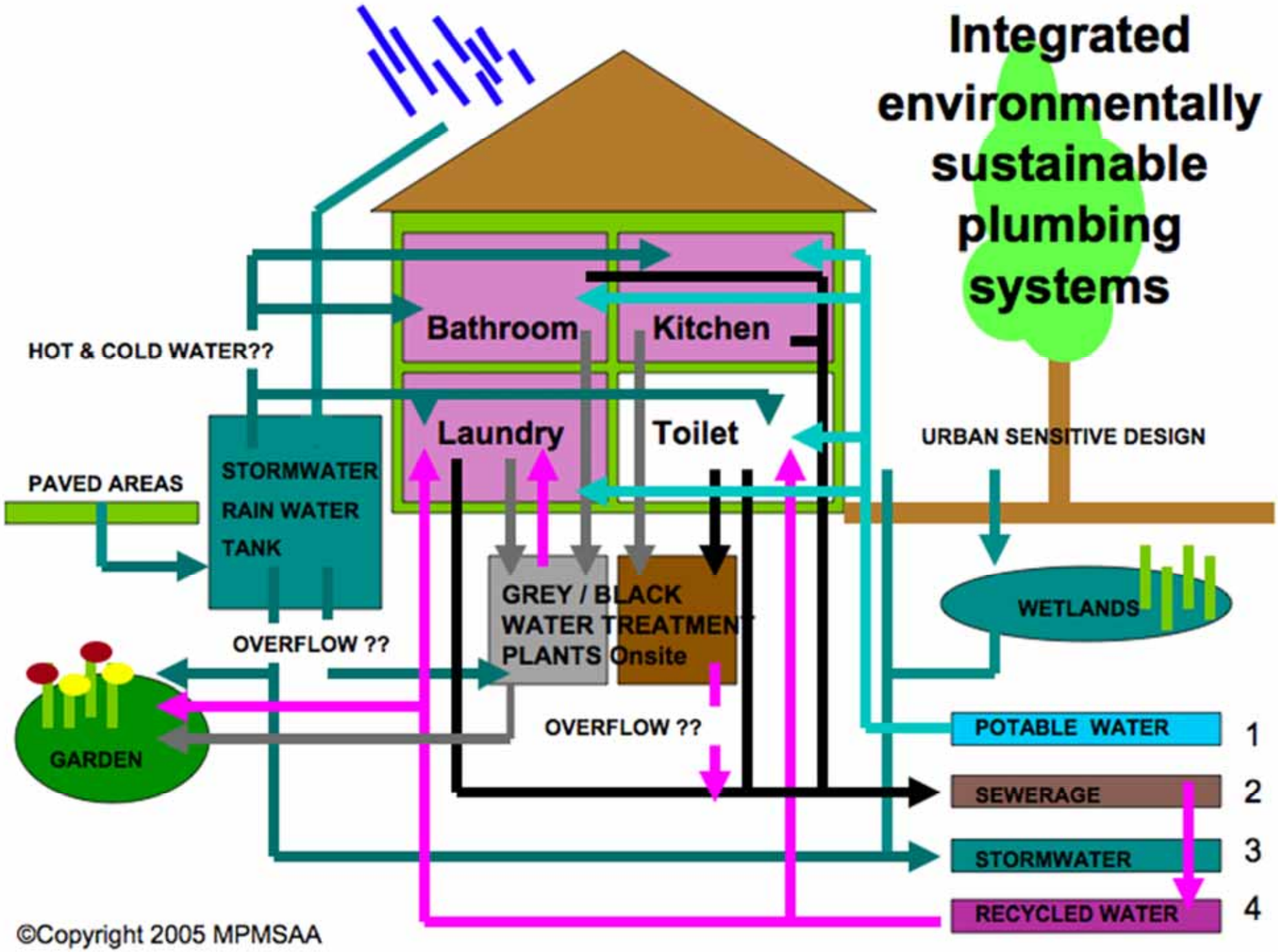
Case studies on building materials

- Case Studies on Sustainable Buildings
  - http://me.hku.hk/sbe/case_study/index/top.htm
  - Duisburg Nord Landscape Park, Germany
    - www.mech.hku.hk/sbe/case_study/case/ger/Duisburg/Duisburg.htm
  - Tsing Yi Green Site Office, Hong Kong
    - www.mech.hku.hk/sbe/case_study/case/hk/gn/top.htm

Water issues

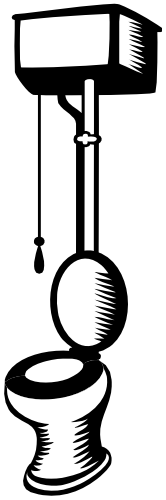
- Stormwater or watershed protection
  - Control rainwater runoff, flooding and erosion
    - Preservation of soils and drainage ways
    - Porous paving materials
    - Drainage of concentrated runoff
  - Avoid pollution and soil disturbance

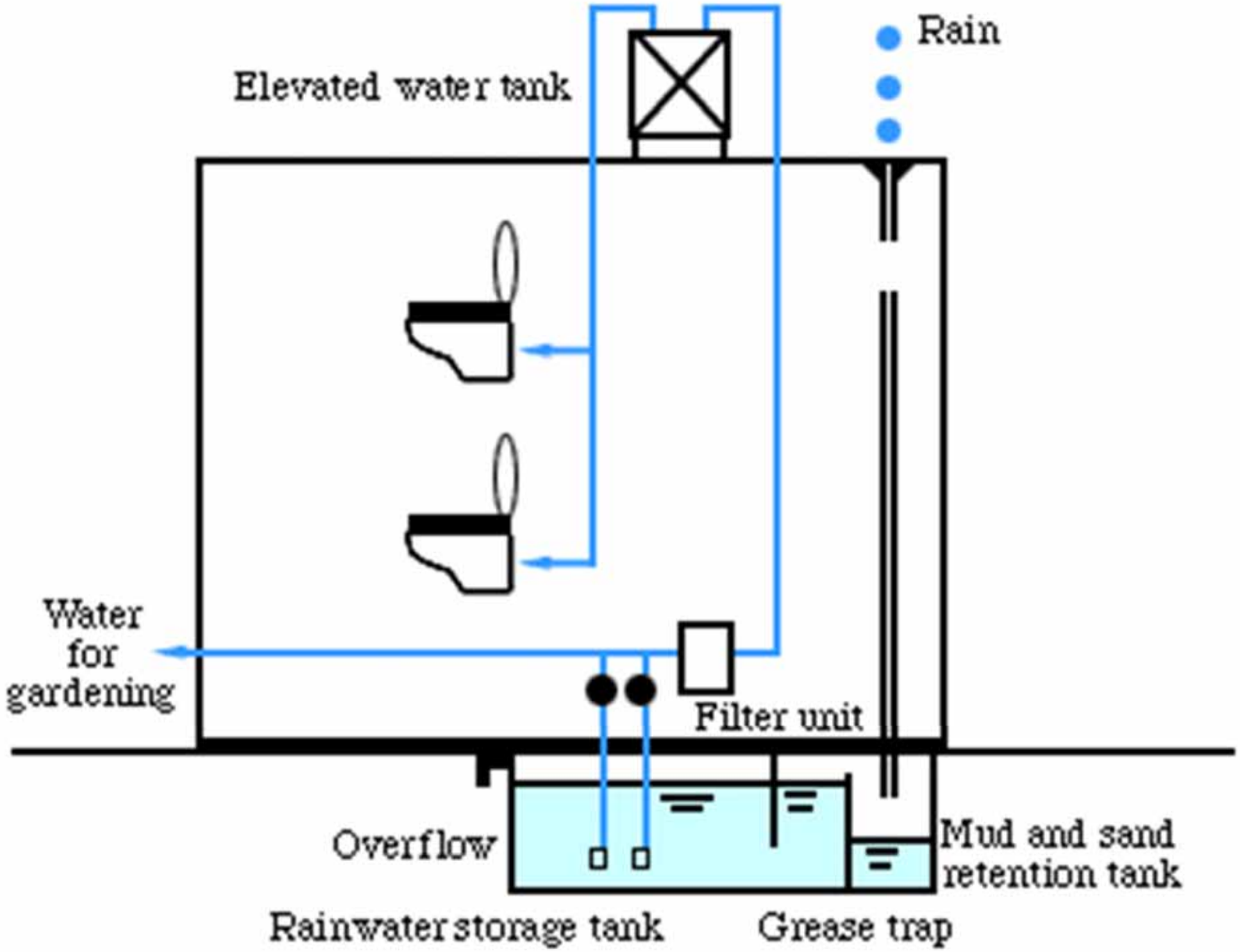
- Water efficiency and conservation
  - Saving of water and money: water-use charge, sewage treatment costs, energy use, chemical use


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

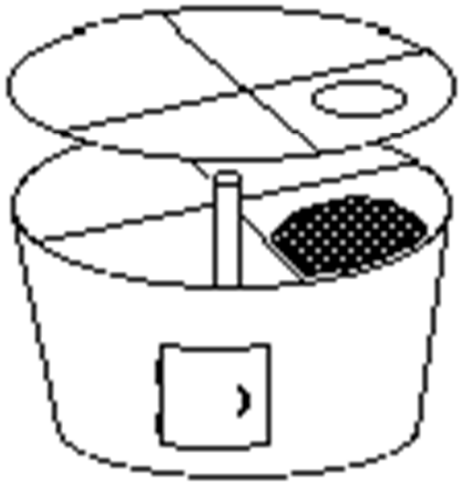
Water issues

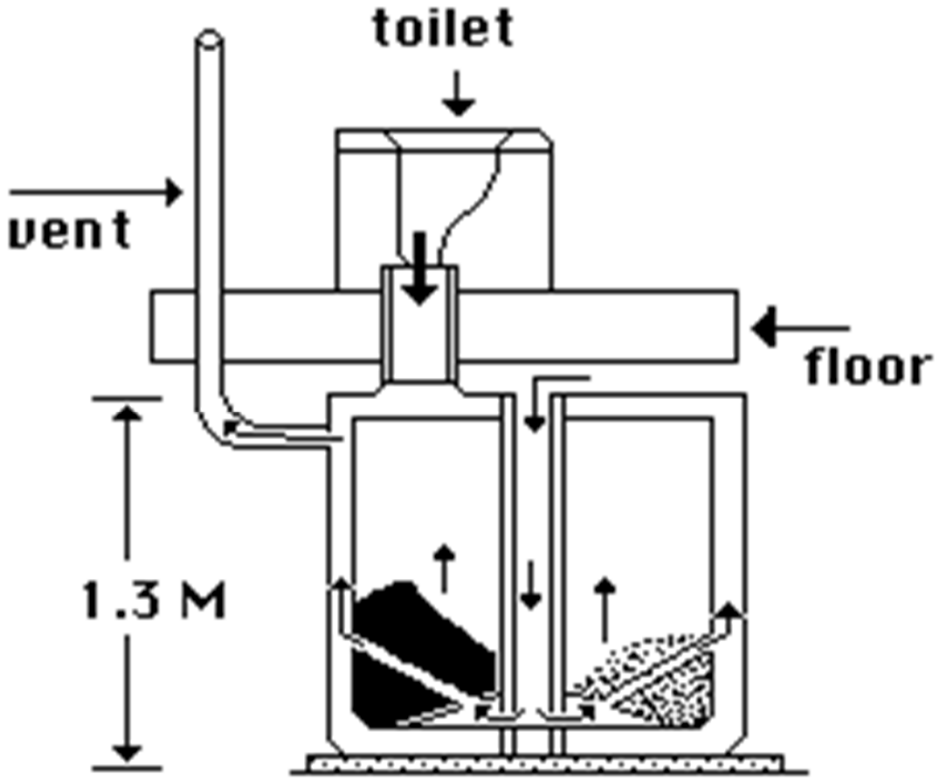
- Design strategy for water efficiency
  - Reduce water consumption
    - Low-flush toilets & showerheads
    - Leak detection & prevention
  - Correct use of appliances (e.g. washing machine)
  - Reuse and recycle water onsite
    - Rainwater collection & recycling
    - Greywater recycling (e.g. for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



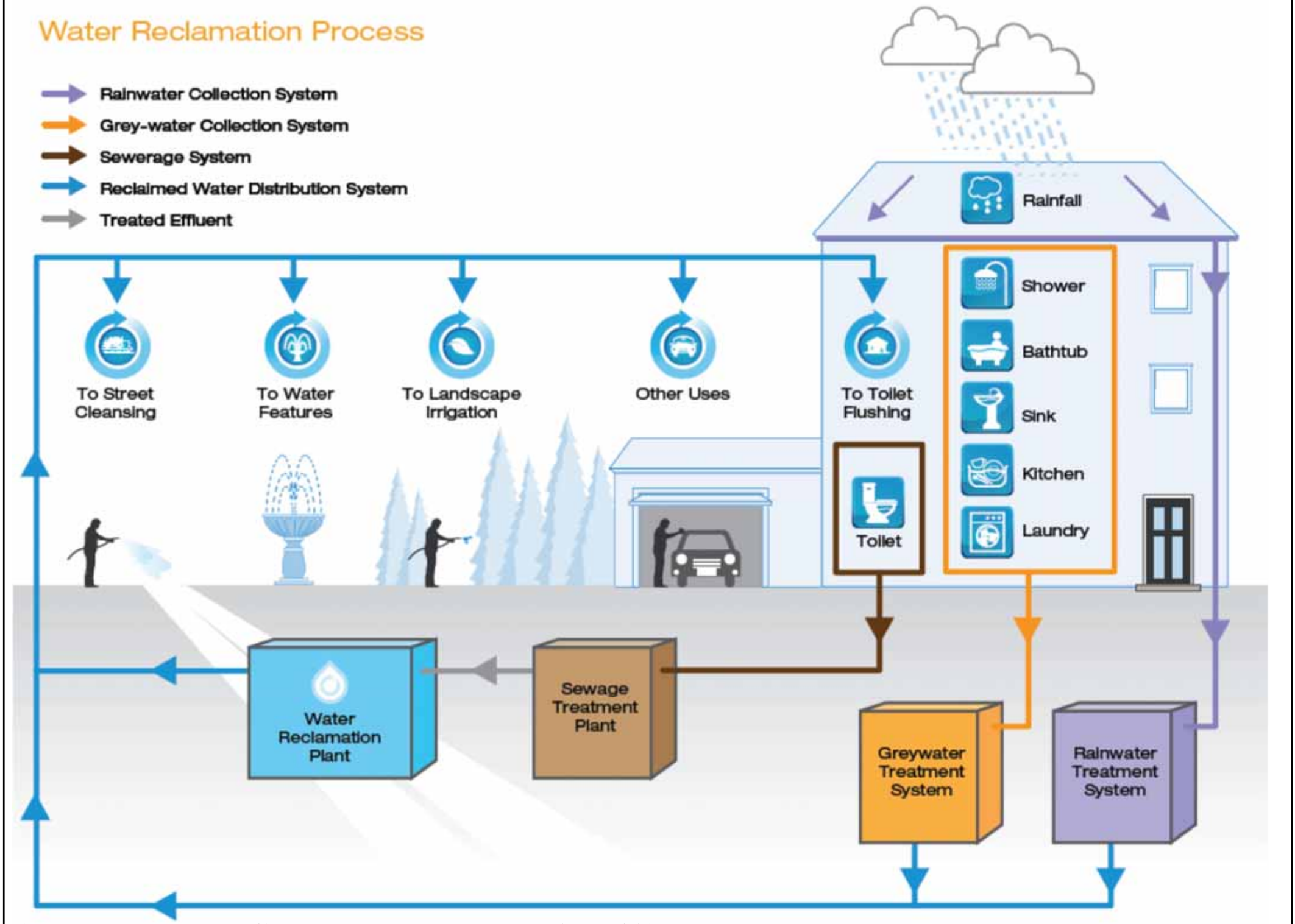


Rainwater recycling system





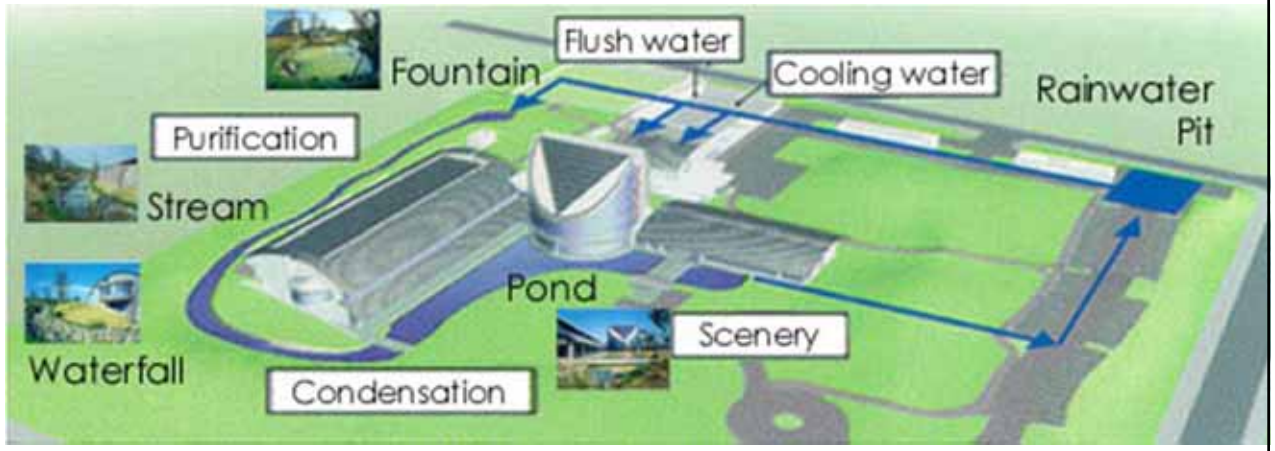
Composting toilets



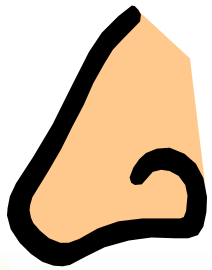
(Source: Water Supplies Department, www.wsd.gov.hk)

Case studies on water issues

- Case Studies on Sustainable Buildings
  - http://me.hku.hk/sbe/case_study/index/top.htm
  - Next 21 (Osaka Gas Expeienmental Housing), Japan
    - www.mech.hku.hk/sbe/case_study/case/jap/next21/next21-index.html
  - Research Institute of innovative Technology for the Earth (RITE) Head Office, Kyoto, Japan
    - www.mech.hku.hk/sbe/case_study/case/jap/RITE_Building/

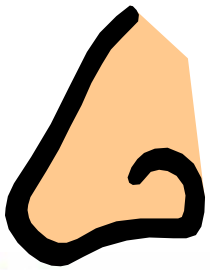


Indoor environment

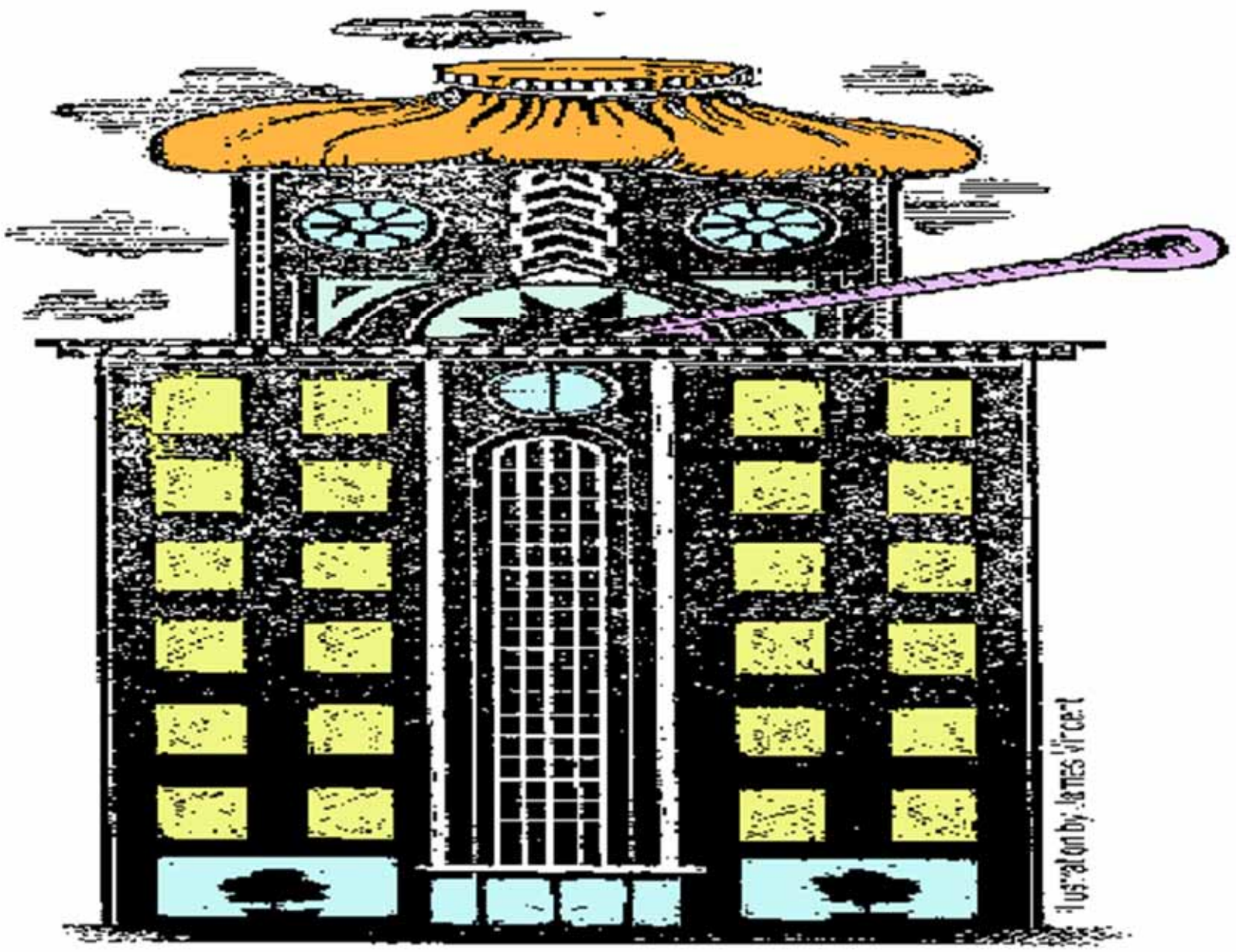


- Indoor environmental quality (IEQ)
  - Indoor air quality
    - Ensure health & well-being
  - Visual quality
    - Provide daylight & comfortable conditions
  - Acoustic quality
    - Noise control
  - Controllability
    - Allow occupant control over thermal & visual

Indoor environment

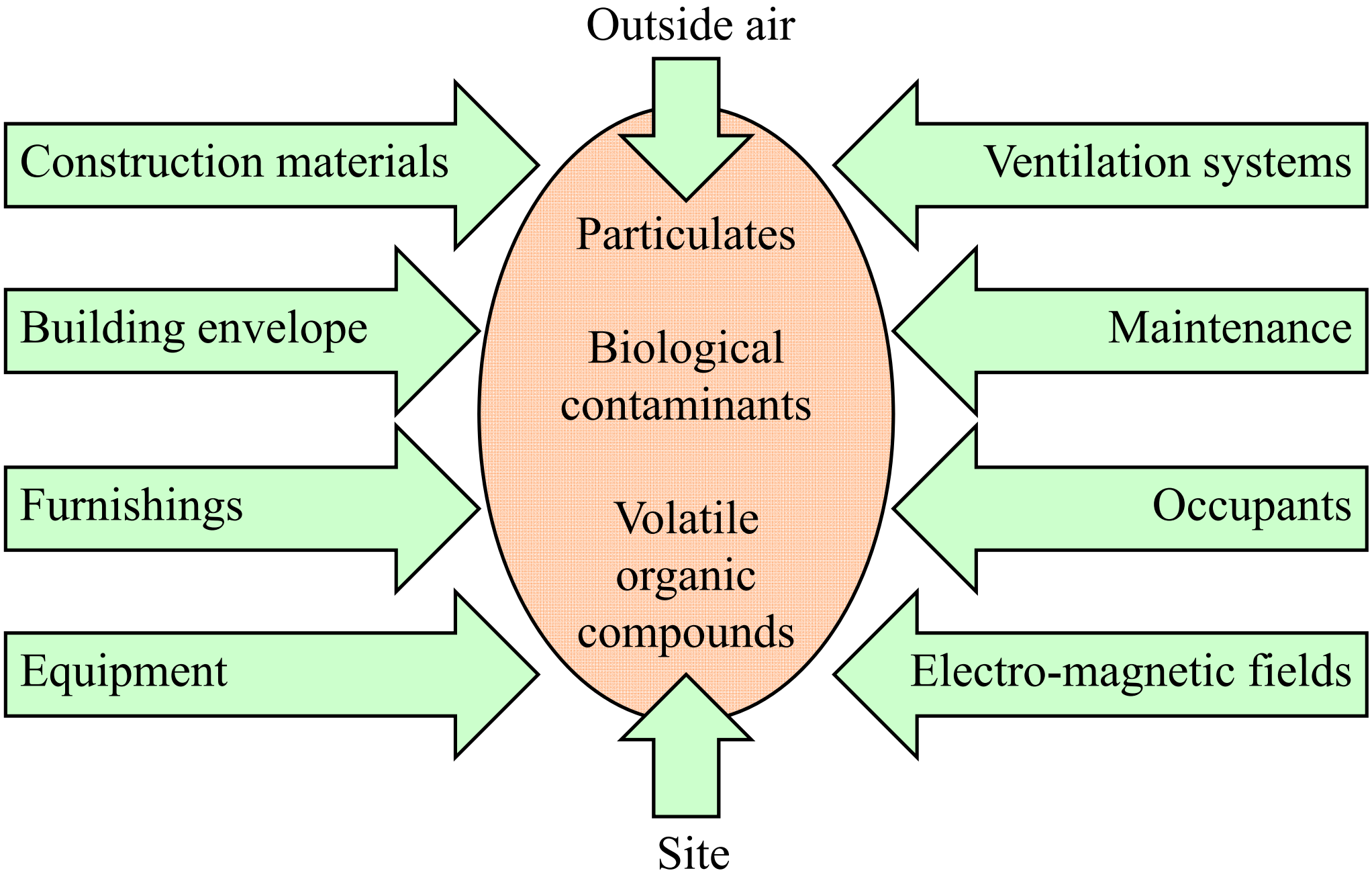


- Indoor air quality (IAQ)
  - People spend most of their time indoors
  - Pollutants may build up in an enclosed space
  - Effects on health and productivity
- Control methods
  - Assess materials to avoid health hazards
    - Such as volatile organic compounds (VOC)
  - Ensure good ventilation & building management



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

+

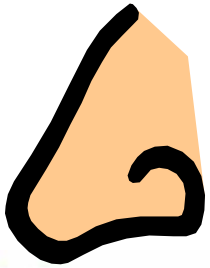
4. Building Maintenance

=

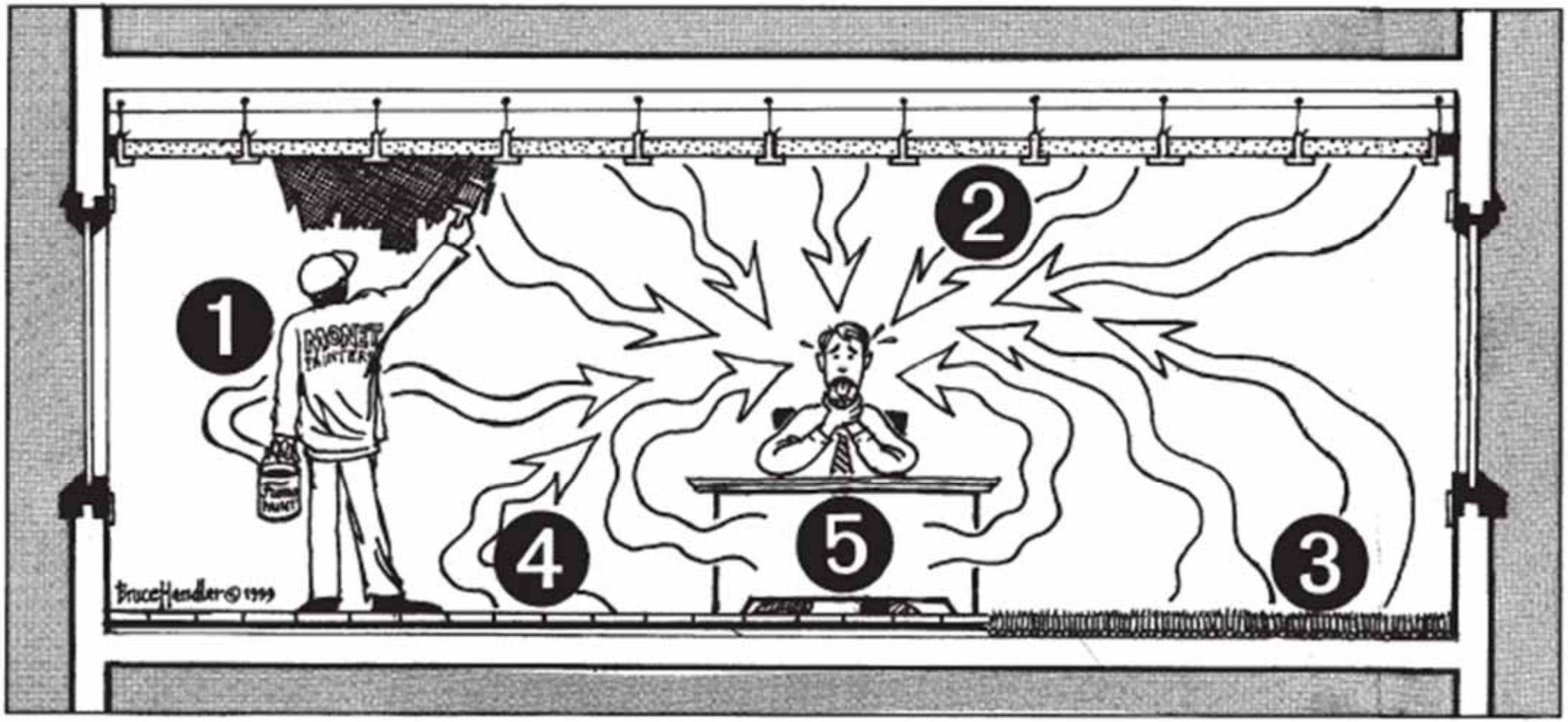
Total Indoor Air Quality

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

Indoor environment



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

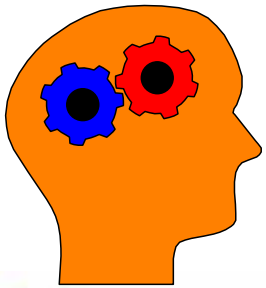


Sources of offgassing in building materials:
1) paints, 2) ceiling tiles, 3) carpeting, 4) VCT floor tiles
5) manufactured wood products

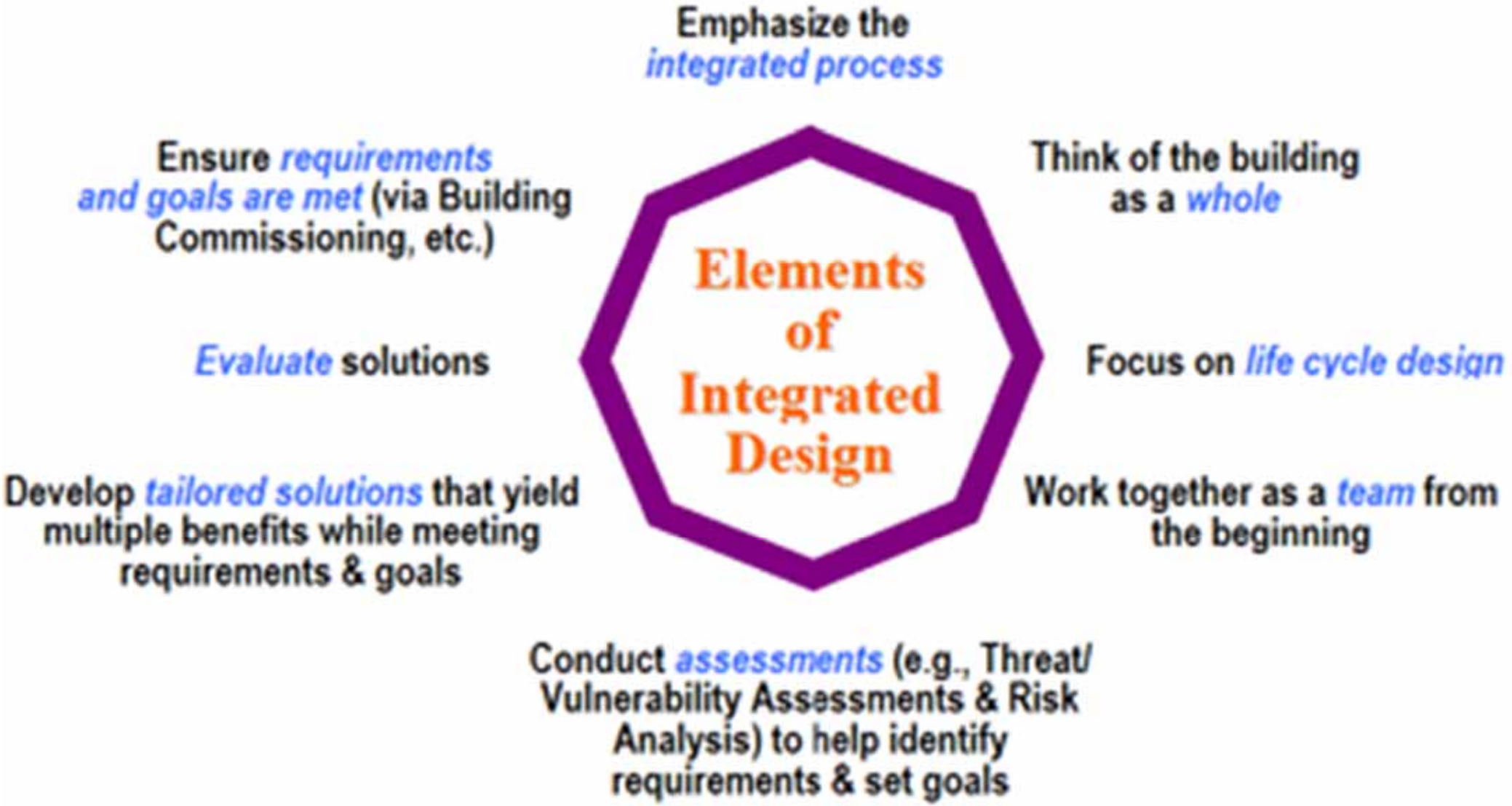
Indoor environment

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

Integrated building design

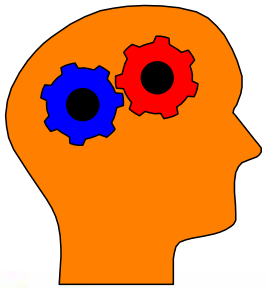


- WBDG - The Whole Building Design Guide
  - www.wbdg.org
- Two components of whole building design:
  - Integrated design approach
  - Integrated team process
- A holistic design philosophy
  - Holism + Interconnectedness + Synergy
  - "*The whole is greater than the sum of its parts*"



(Source: www.wbdg.org)

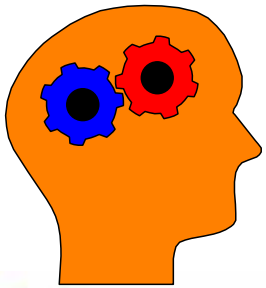
Integrated building design



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

- Usually more efforts in preparation and pre-design phases

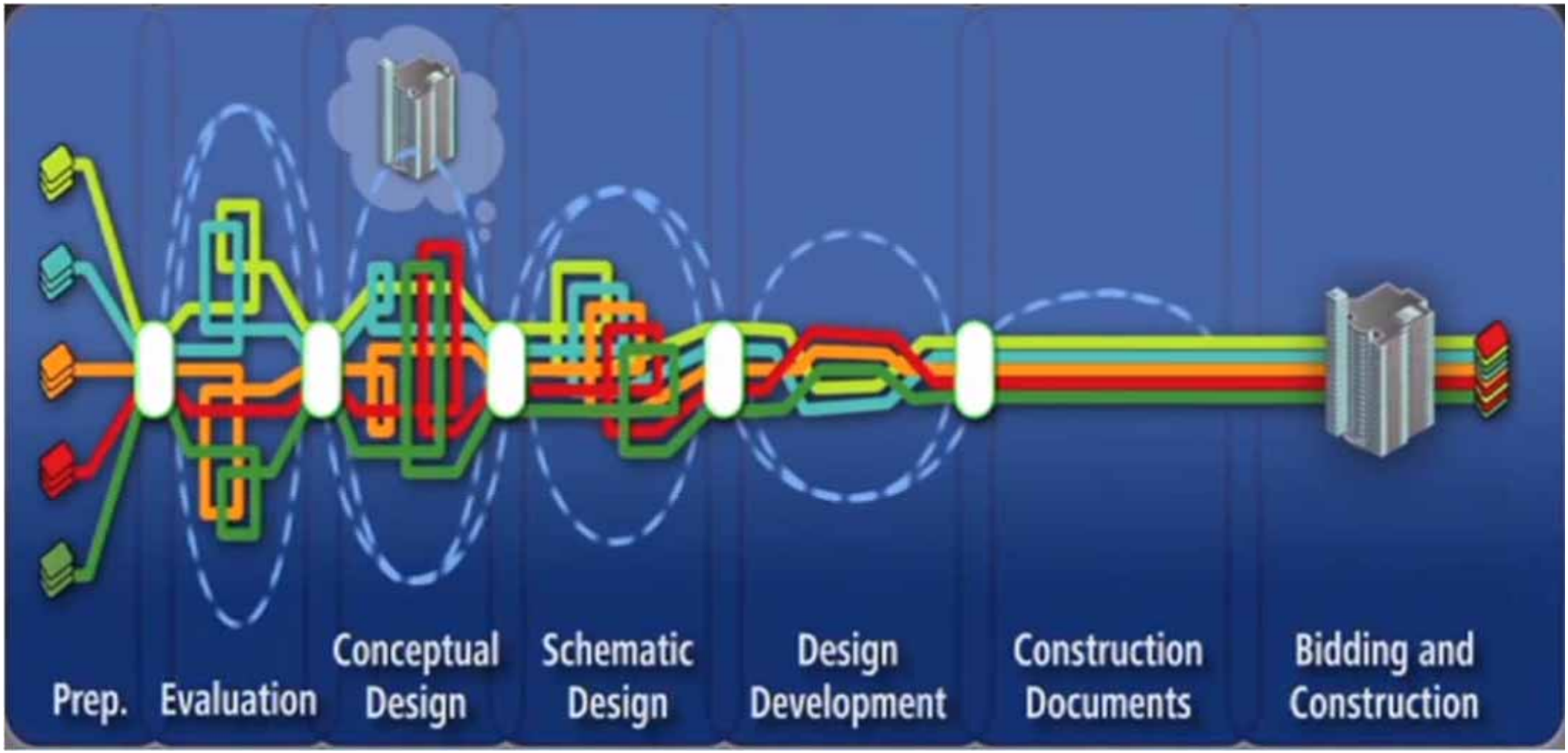
Integrated building design



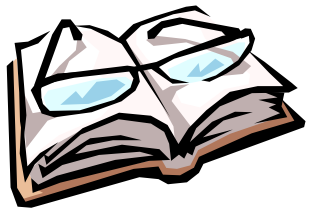
- Integrated, multidisciplinary project team
  - Owner's representative
  - Architect
  - Building Services Engineer
  - Civil/Structural Engineer
  - Construction Manager
  - Landscape Architect
  - Specialized Consultants

Case study on integrated building design

- Phipps Conservatory and Botanical Gardens, Pittsburgh, PA
  - Integrative Design - Phipps: A Case Study (6:54)
    http://www.youtube.com/watch?v=0qk4hbNEWdQ



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
- Integrated Design Process Guide
  - www.cmhc-schl.gc.ca/en/inpr/bude/himu/coedar/upload/Integrated_Design_GuideENG.pdf