

# GEE5303 Green and Intelligent Building

<http://ibse.hk/GEE5303/>



## Green building design strategies



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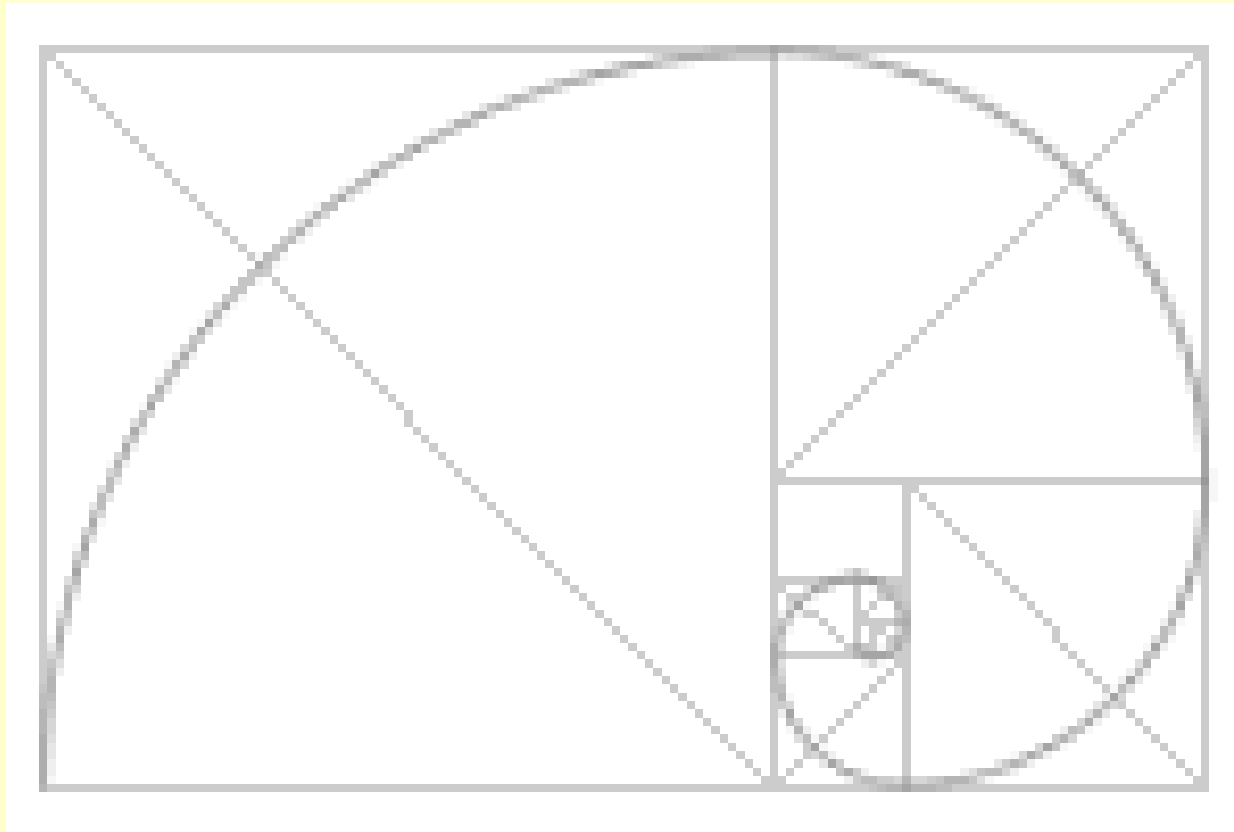
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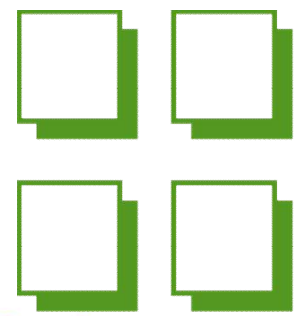


- Design strategies:
  - Urban and site design
  - Energy efficiency
  - Renewable energy
  - Building materials
  - Water issues
  - Indoor environment
  - Integrated building design



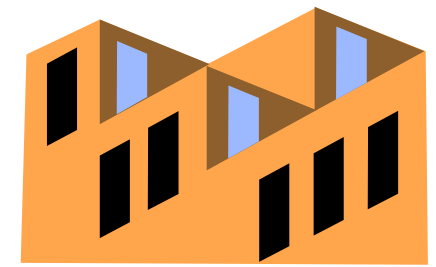


# Design Strategies



# Design strategies

- Sustainable site
  - Site selection, landscaping, building placement
- Energy and atmosphere
  - Energy sources, mechanical systems and controls
- Water efficiency
- Materials and resources
  - Design, material selection
- Indoor environmental quality



# Urban and site design

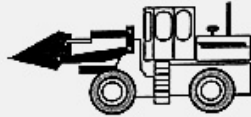
- Sustainable urban design should consider:
  - Spatial form
  - Movement
  - Design & development
  - Energy
  - Ecology
  - Environmental management
- Goal: to create livable cities





### 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



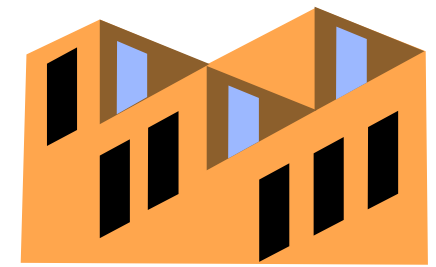
### DESIGN & DEVELOPMENT

- ◆ 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

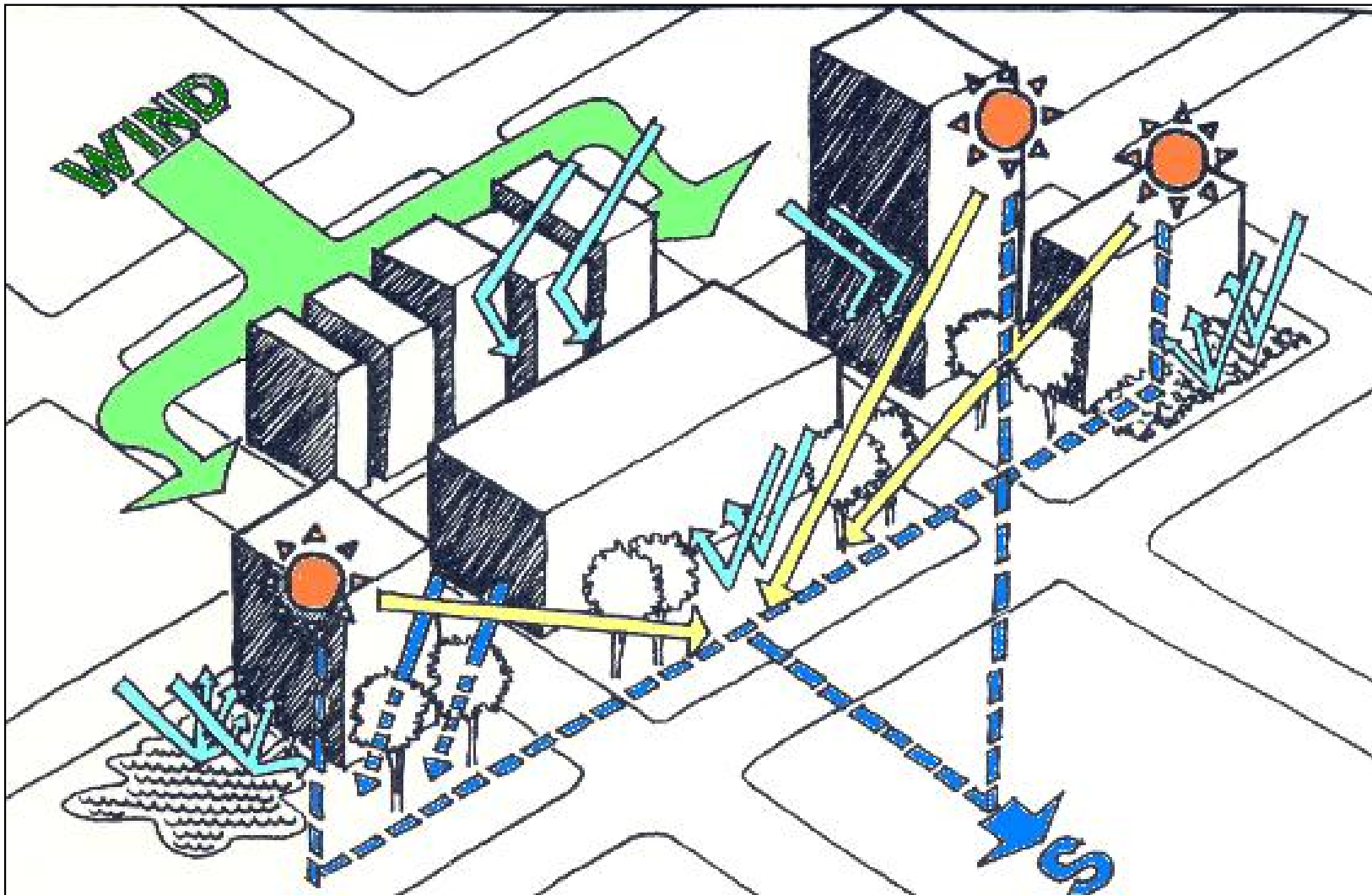
[\* Brownfield sites are abandoned or underused industrial and commercial facilities available for re-use.]

風

Wind

光

Light



水

Water

物

Matter

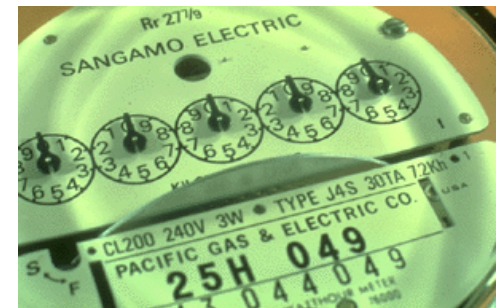
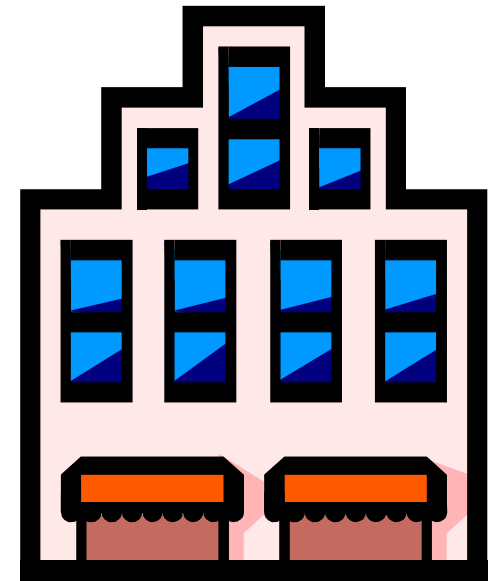
Site analysis and understanding of the environmental factors is important





# Energy efficiency

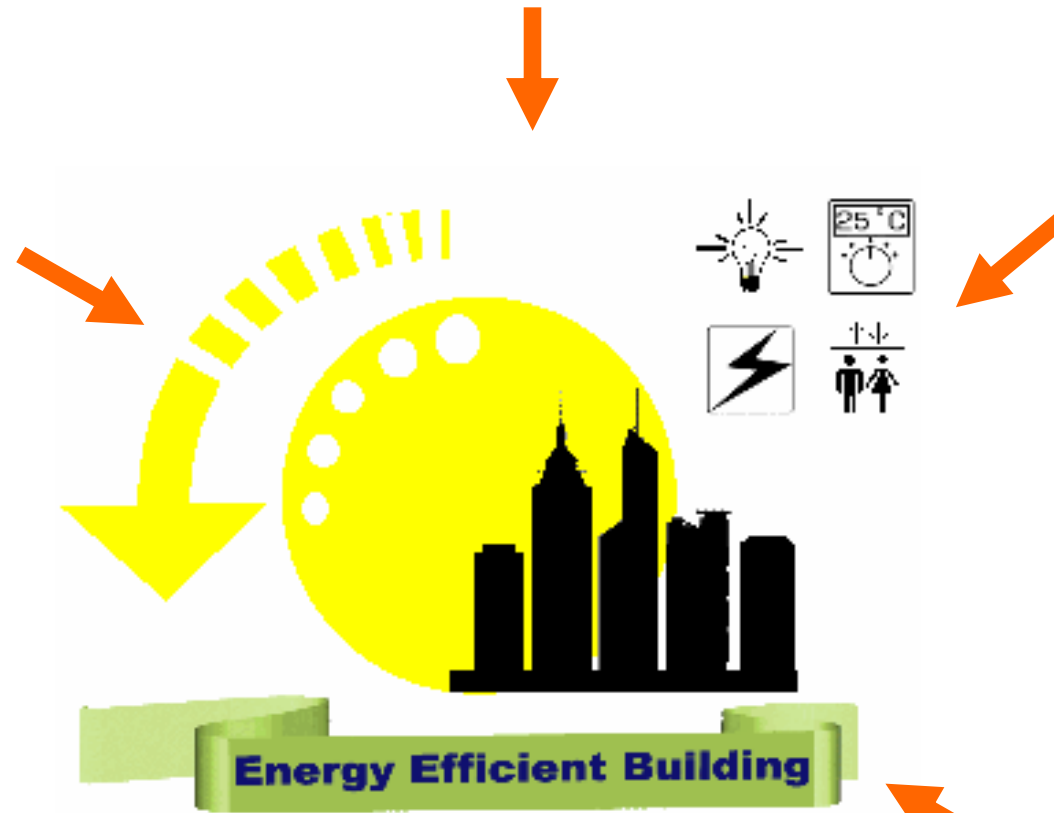
- For new buildings
  - Designing the building
    - Design strategy
    - Control strategies
    - Commissioning
- For existing buildings
  - Operating and upgrading the building
    - Building management
    - Refurbishment/renovation/retrofitting
    - Maintenance and monitoring



Good design practices

Integrated & total energy approach

Efficient systems



Good house-keeping

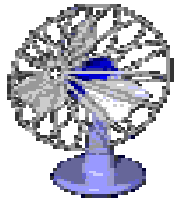
User education & awareness

Efficient operation

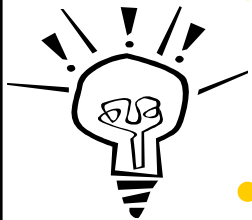


# Energy efficiency

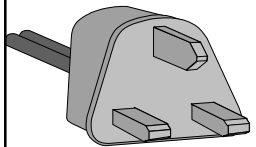
- Design strategies:



- 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

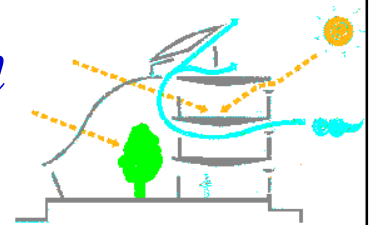


- Adopt total energy approach (e.g. district cooling, combined heat & power)



# Energy efficiency

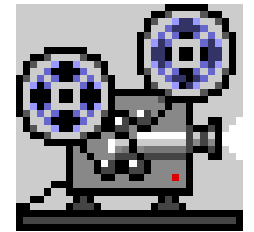
- Promote *passive design* and *natural ventilation*
  - e.g. bioclimatic buildings, passive cooling/heating
- Adopt energy efficient *building services systems*
  - Lighting, air-conditioning, electrical, lifts
- Study and optimise *thermal & energy performance*
  - e.g. by computer simulation or energy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





# Energy efficiency

- Video: **Energy 101: Energy Efficient Commercial Buildings (4:19)**



- <http://youtu.be/5VMXL31EYTI>
- Learn how commercial buildings can incorporate whole-building design to save energy and money while enhancing performance and comfort.
- This video highlights several energy-saving features of the Research Support Facility at the Energy Department's National Renewable Energy Laboratory—a model for high-performance office building design.



# 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



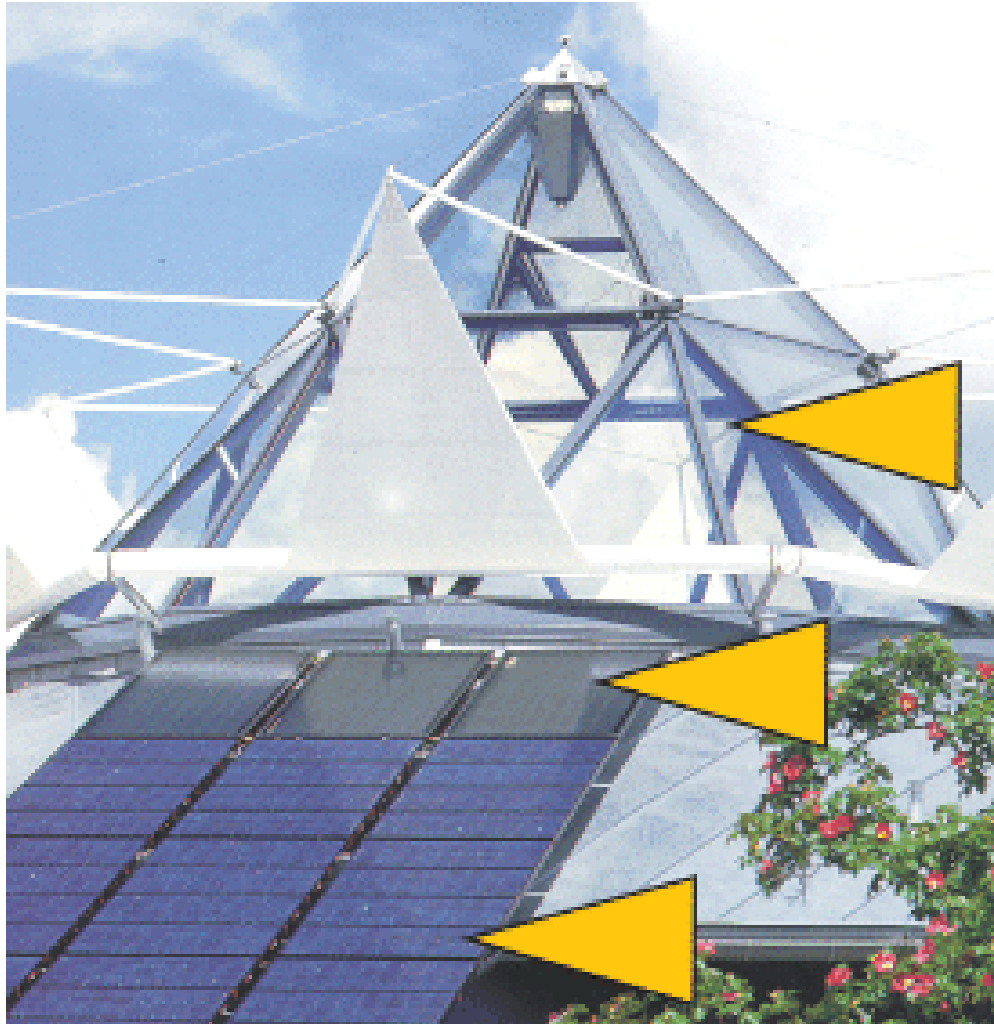
# Renewable energy



- 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)

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# Integration of solar energy systems in buildings



Passive solar (e.g. skylight)

Active solar (solar hot water)

Photovoltaics



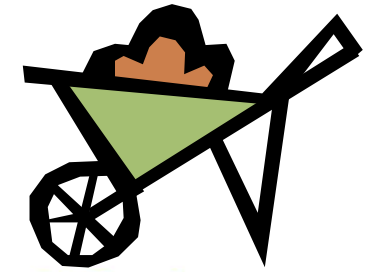
# Innovative ideas for building integrated renewable energy



Dutch pavilion,  
EXPO 2000 Hannover

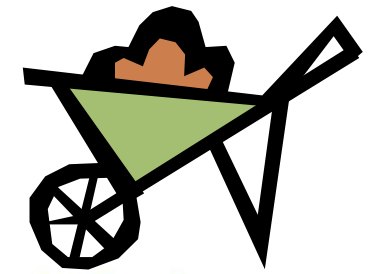


Project Zed - London



# 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

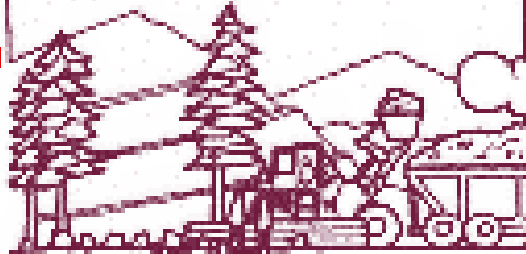


# Building materials

- 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](http://en.wikipedia.org/wiki/Embodied_energy)]

Resource Extraction



Manufacturing

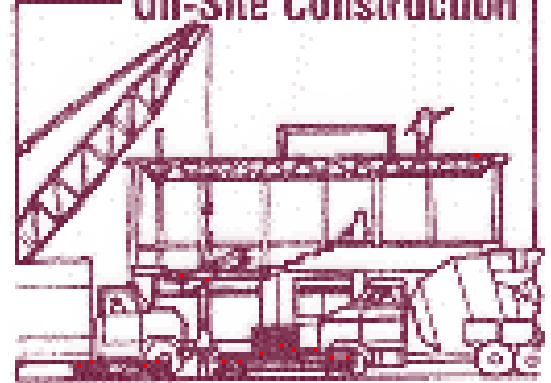


Recycling/Reuse/Disposal

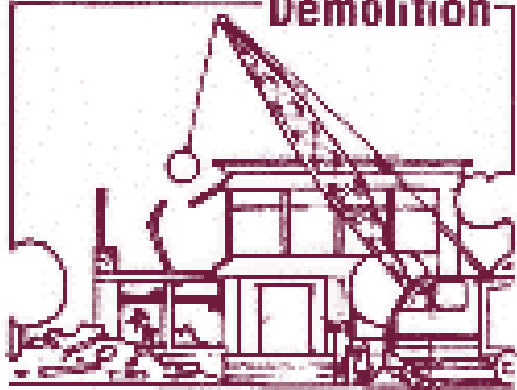


# Life Cycle of Building Products

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**)

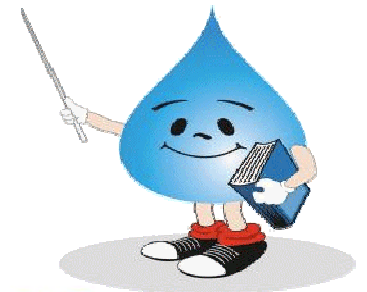
Biodegradable  
(**B**)

Recyclable  
(**R**)

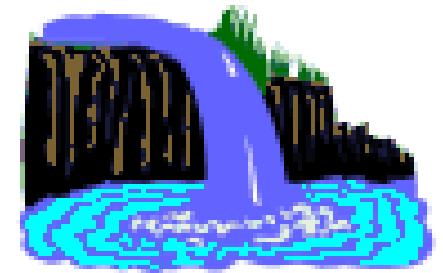
Reusable (**RU**)

Others (**O**)

# Water issues

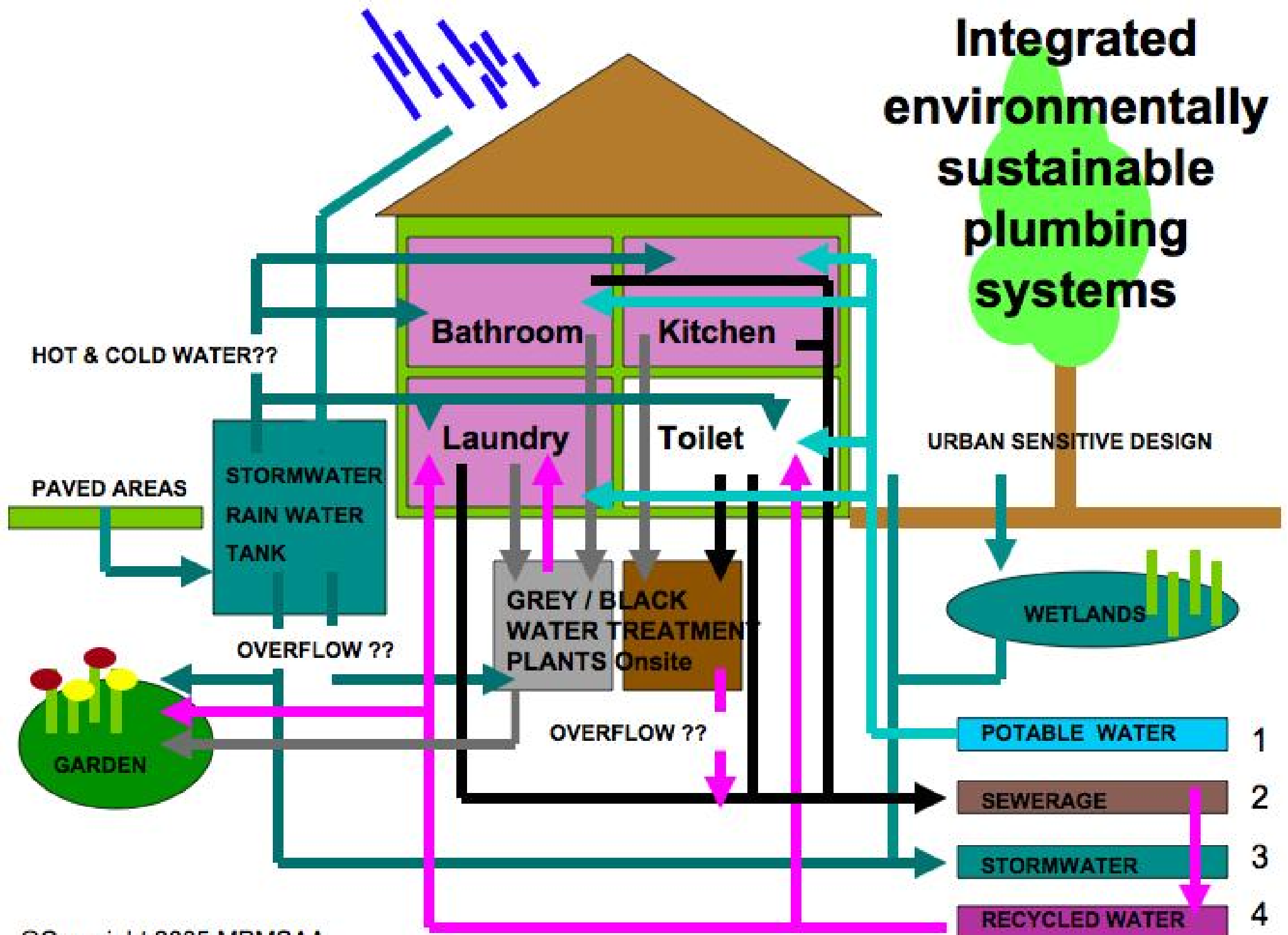


- Stormwater or watershed protection
  - Control rainwater runoff, flooding and erosion
    - Preservation of soils and drainage ways
    - Porous paving materials
    - Drainage of concentrated runoff
  - Avoid pollution and soil disturbance
- Water efficiency and conservation
  - Saving of water and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



>>> Make the best use of water resources.

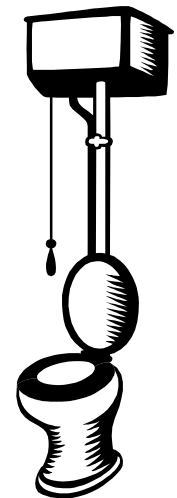
# Integrated environmentally sustainable plumbing systems



# Water issues



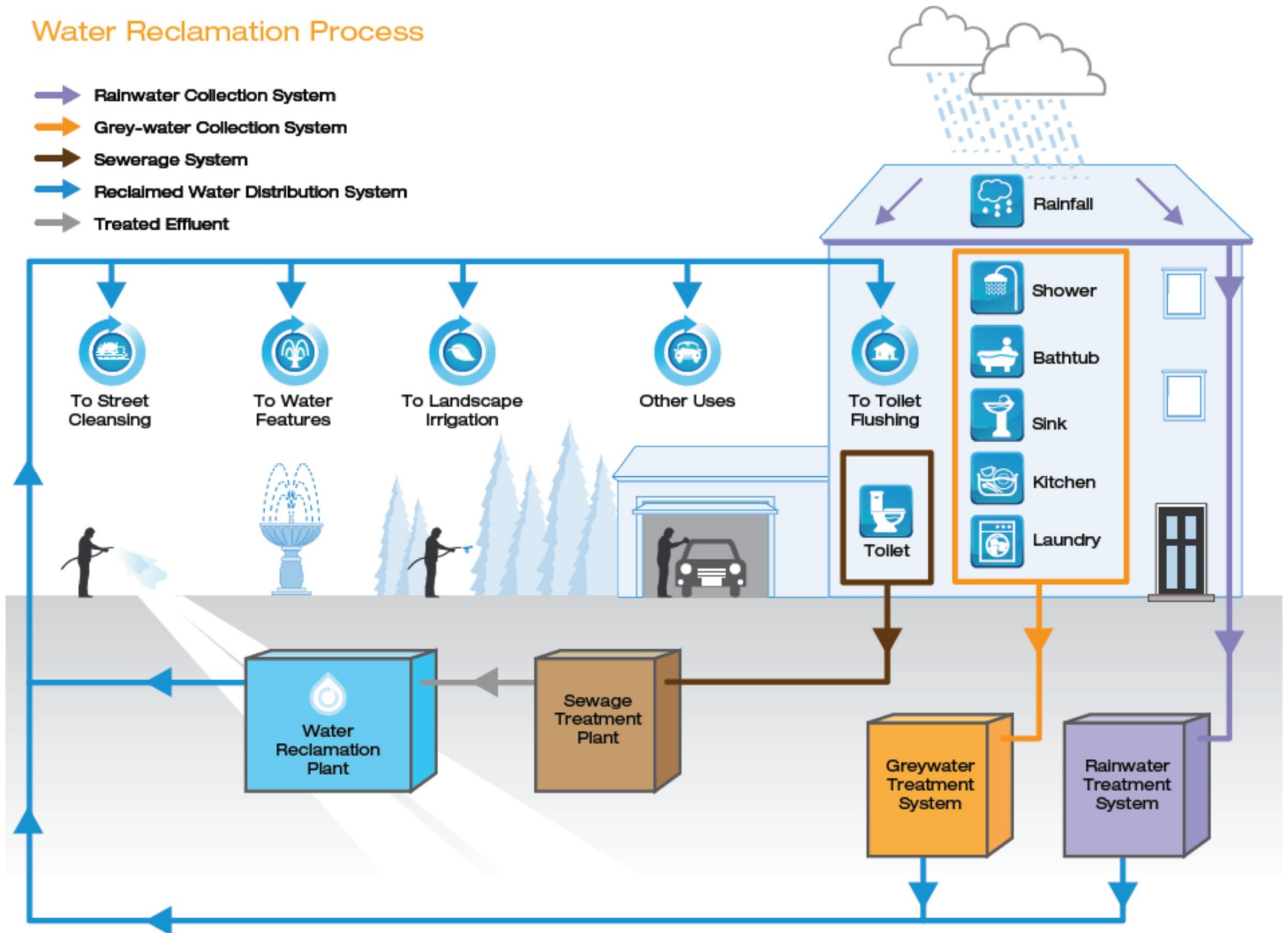
- Design strategy for water efficiency
  - Reduce water consumption
    - Low-flush toilets & showerheads
    - Leak detection & prevention
  - Correct use of appliances (e.g. washing machine)
  - Reuse and recycle water onsite
    - Rainwater collection & recycling
    - Greywater recycling (e.g. for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





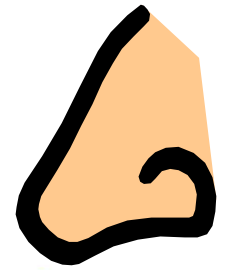
# Water Reclamation Process

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



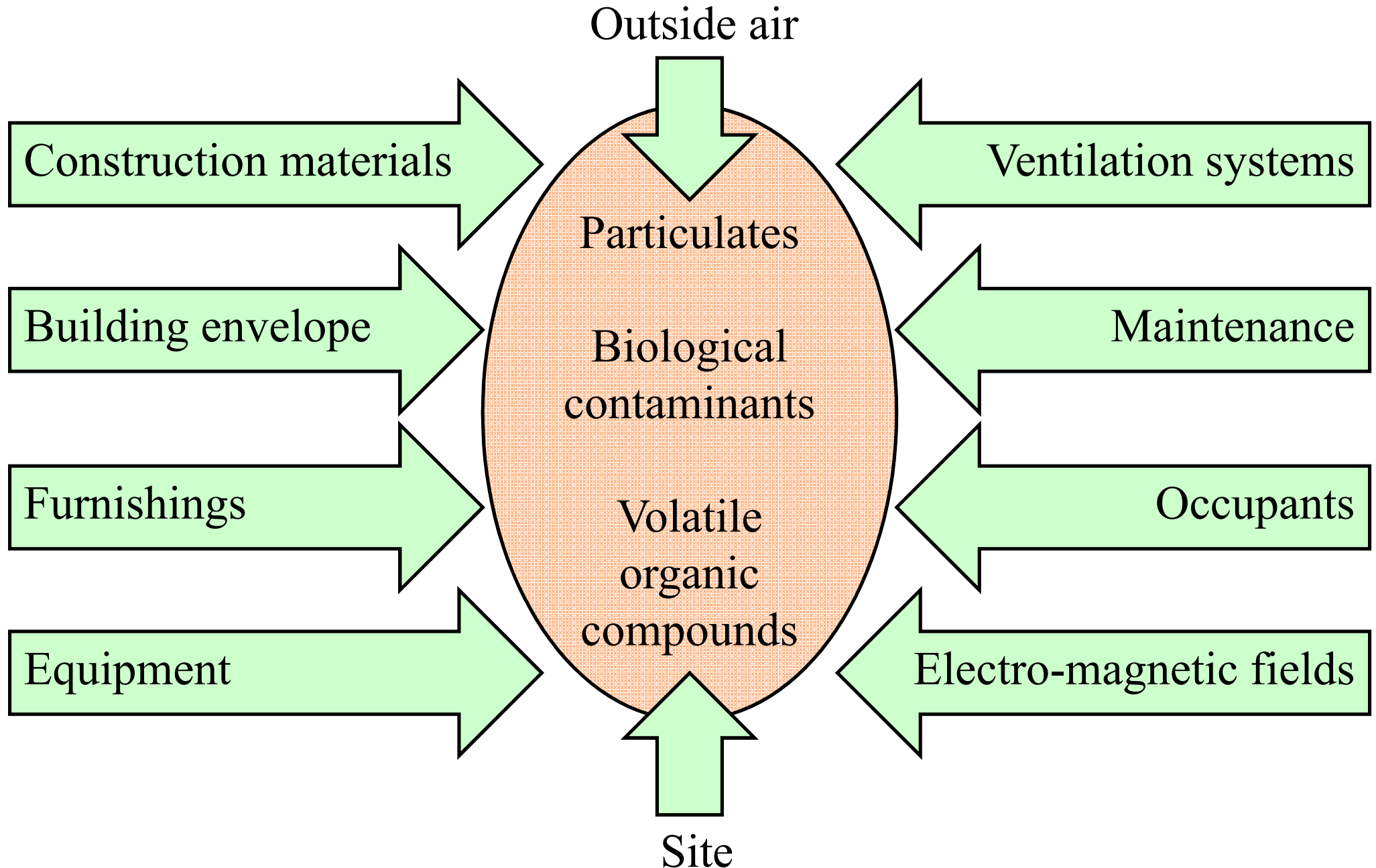
(Source: Water Supplies Department, [www.wsd.gov.hk](http://www.wsd.gov.hk))

# 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

+

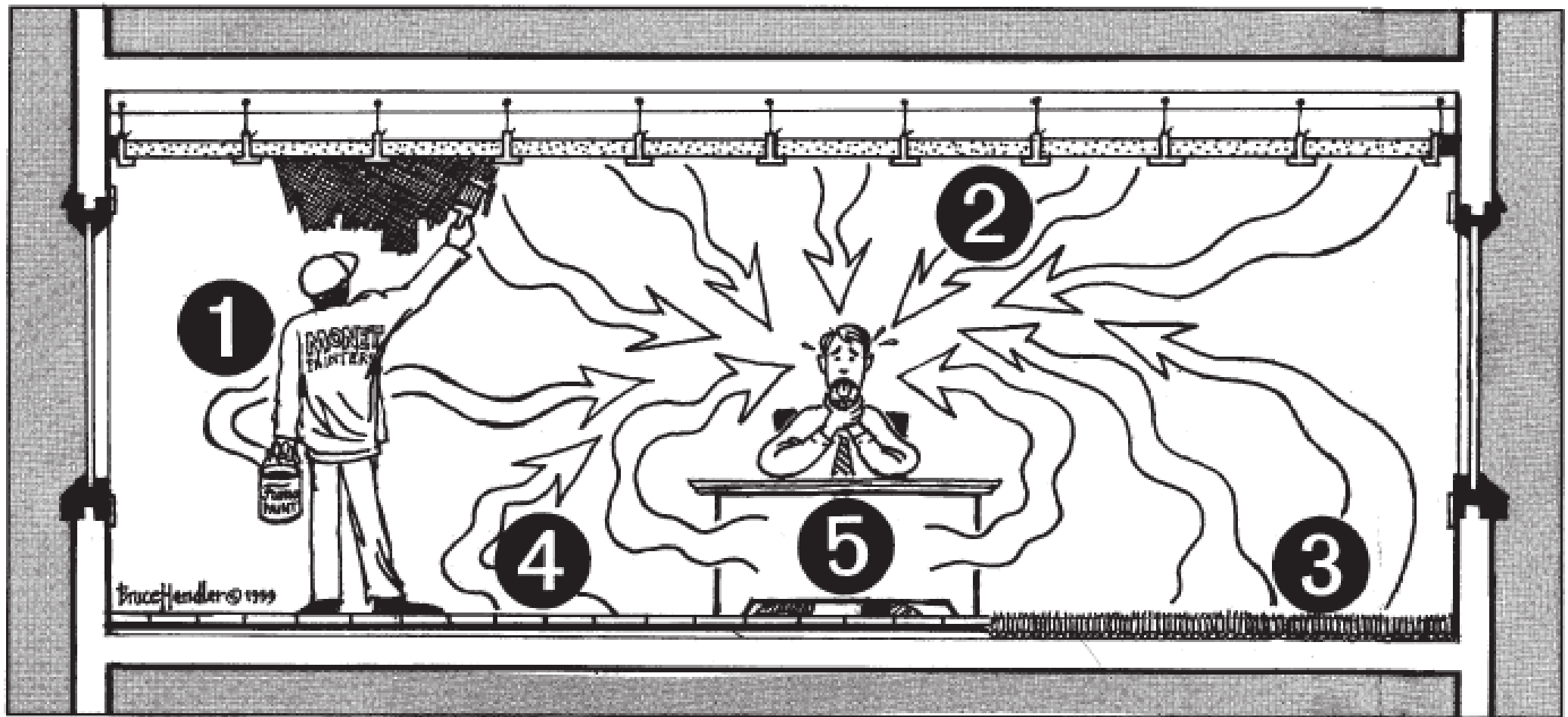
3. Occupant Activity Control

+

4. Building Maintenance

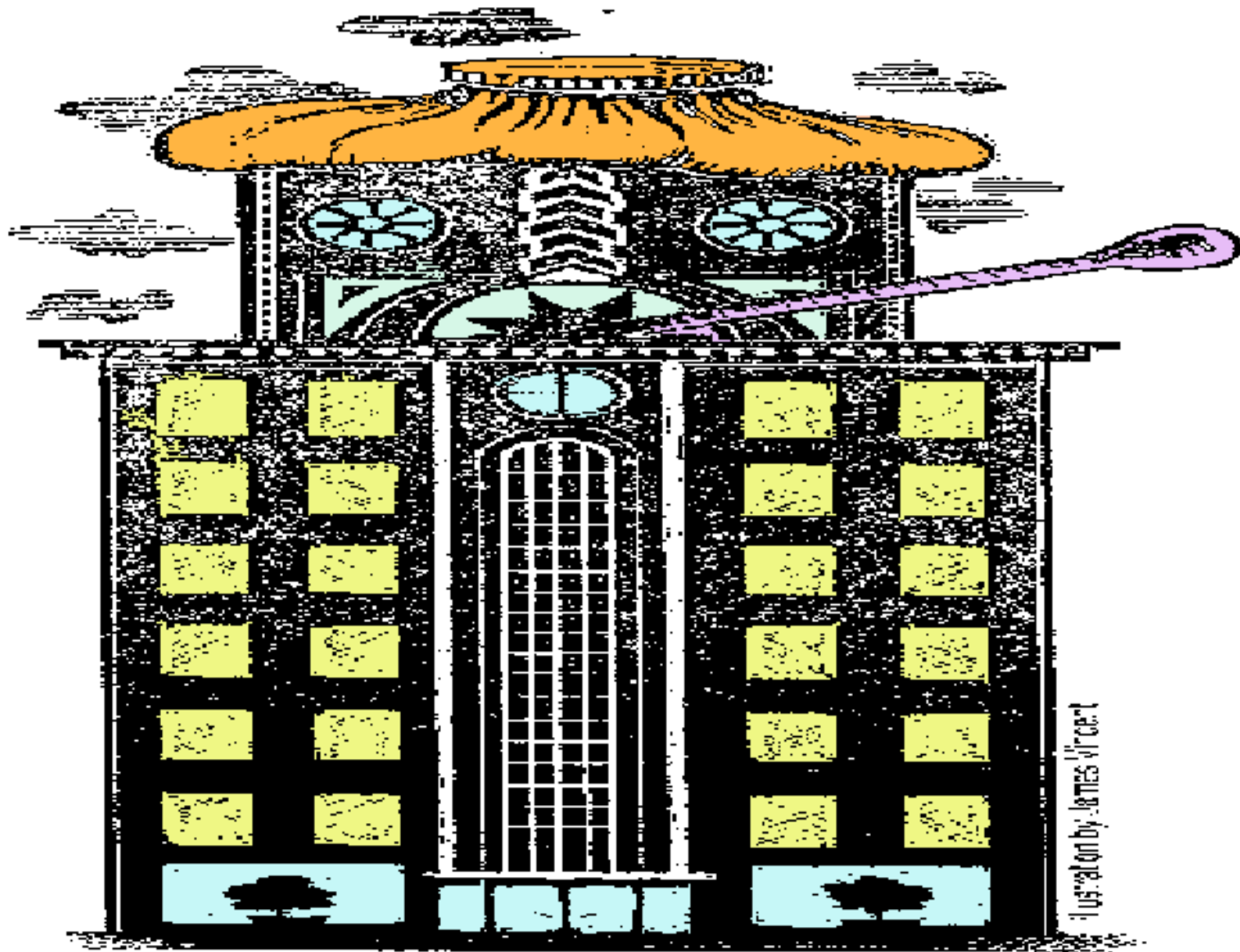
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*Total  
Indoor  
Air  
Quality*

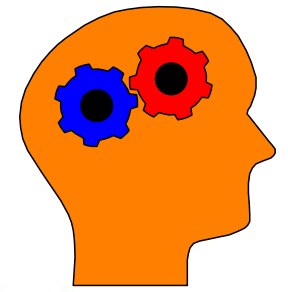


Sources of offgassing in building materials:

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



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



# Integrated building design

- WBDG - The Whole Building Design Guide
  - [http://www.wbdg.org/design/engage\\_process.php](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*

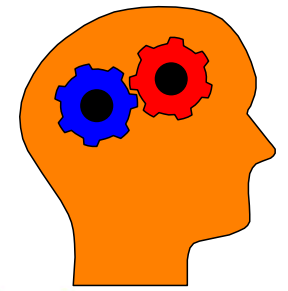
*Evaluate* solutions

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

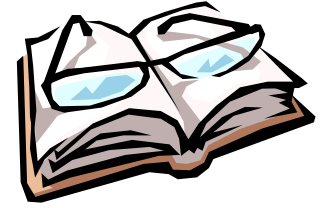


# Integrated building design

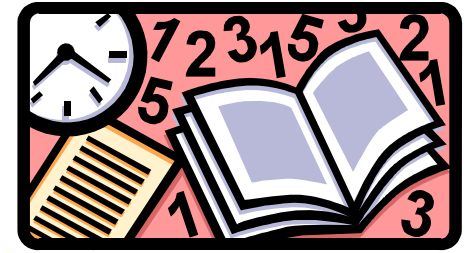
- Typical integrated design process
  - Preparation
  - Design development
  - Contract documents
  - Construction phase
  - Commissioning
  - Post-occupancy evaluation
- Usually more efforts in preparation and pre-design phases



# Further reading



- Green building design strategies
  - [http://ibse.hk/GB design strategies.pdf](http://ibse.hk/GB_design_strategies.pdf)
- Whole Building Design Guide (WBDG)
  - Sustainable, [www.wbdg.org/design/sustainable.php](http://www.wbdg.org/design/sustainable.php)
- HK Green Building Technology Net
  - <http://gbtech.emsd.gov.hk>



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  - <http://books.google.com.hk/books?id=uPvajUb2C04C>
- PTI, 1996. *Sustainable Building Technical Manual: Green Building Design, Construction and Operations*, Public Technology, Inc. (PTI), Washington, D.C.
  - <http://smartenergy.illinois.edu/pdf/archive/sustainablebuildingtechmanual.pdf>