Capstone Project for Building Services Engineering
Seminar, 08 Sep 2014 (Mon)

Green Building Design and Assessment

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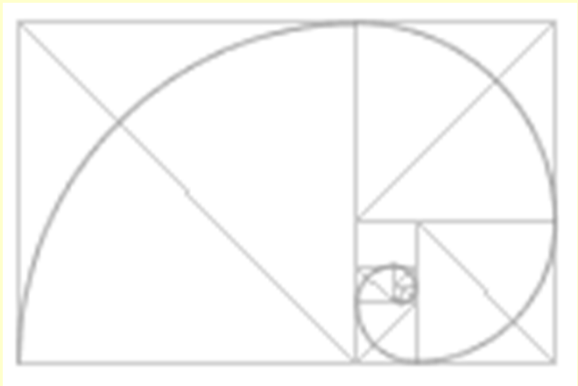
Contents

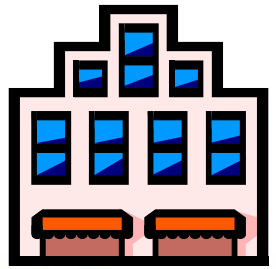
- What is green building?
- Basic principles
- Design strategies
- Green building assessment
- Assessment tools

Kyoto Face House, 1998

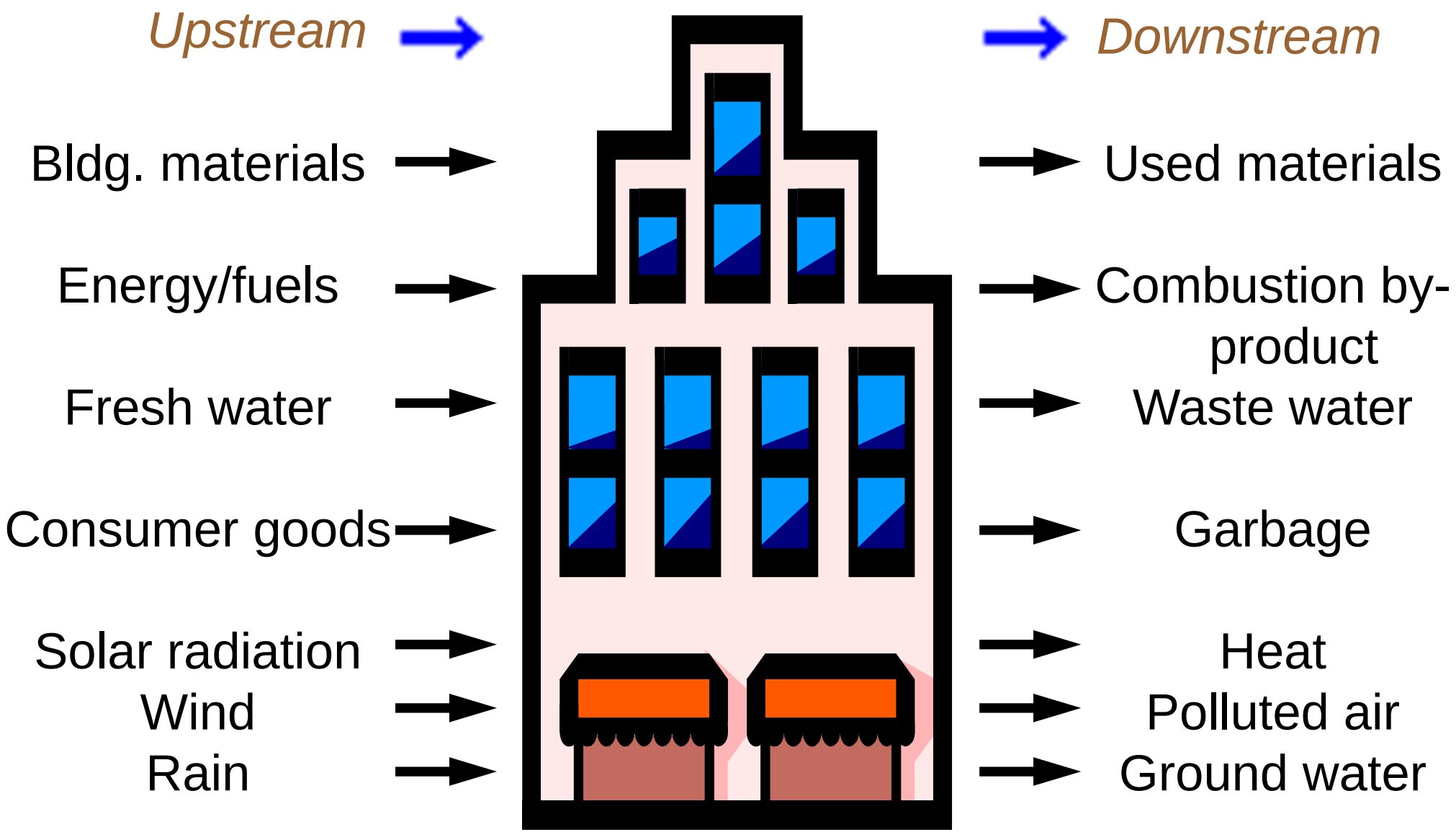
“What is green building?”



What is green building?

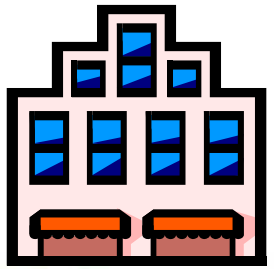


- Green buildings are
  - Energy and resource efficient
  - Non-wasteful and non-polluting
    - Sustainable design that helps minimise broad environmental impacts (e.g. ozone depletion)
  - Highly flexible and adaptable for long-term functionality
  - Easy to operate and maintain (lower running costs)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

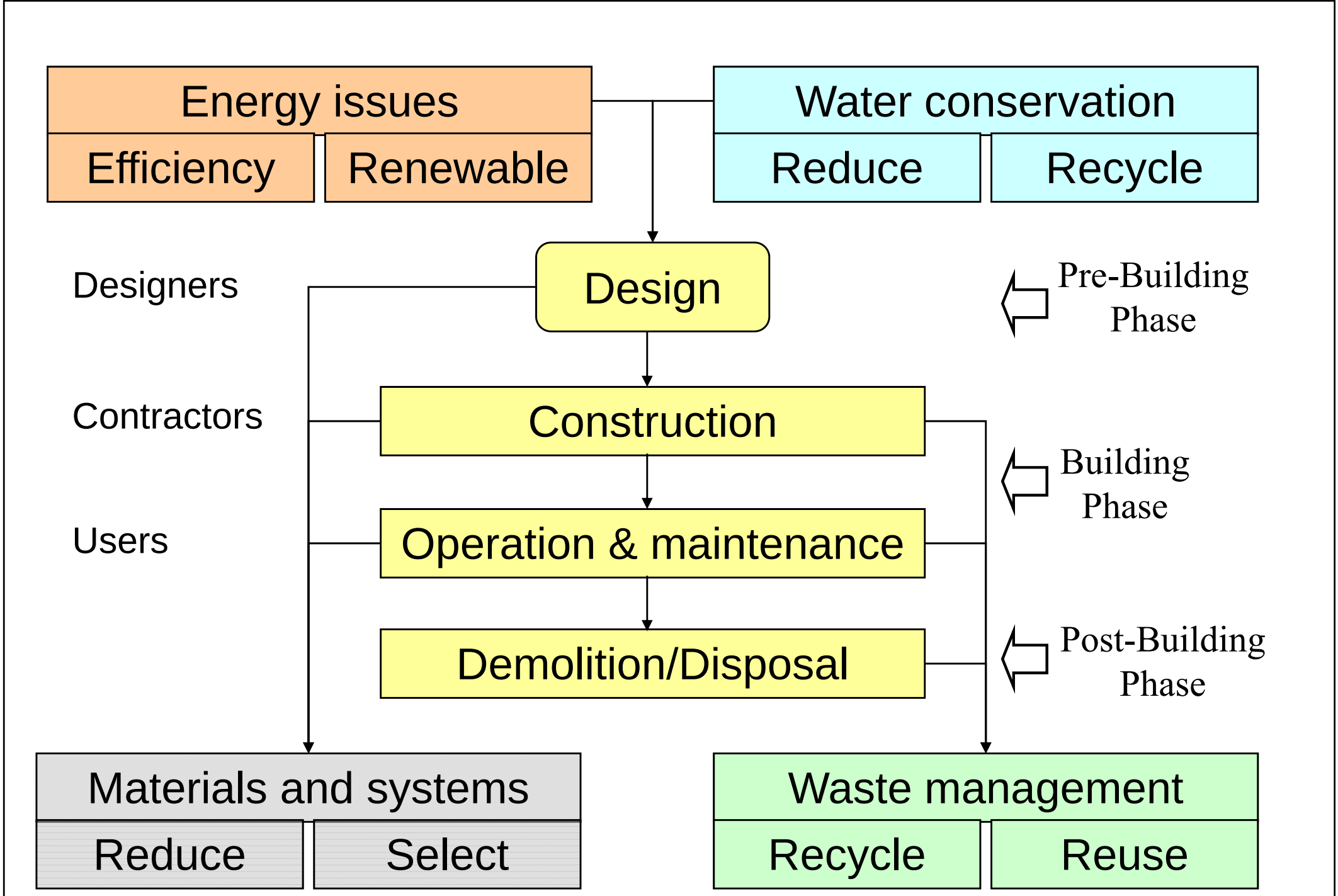


Resource and material flow in the building ecosystem

What is green building?

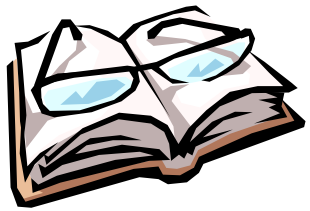


- It involves a *holistic* approach to the design and operation of buildings. It considers:
  - *1) Economy and efficiency of resources*
  - *2) Life cycle design*
  - *3) Human well-being*
- Main objectives
  - Be environmentally friendly and responsible
  - Improve the quality of built environment



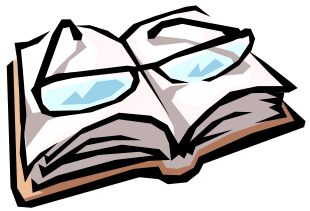
Building life cycle and sustainable construction

Basic principles

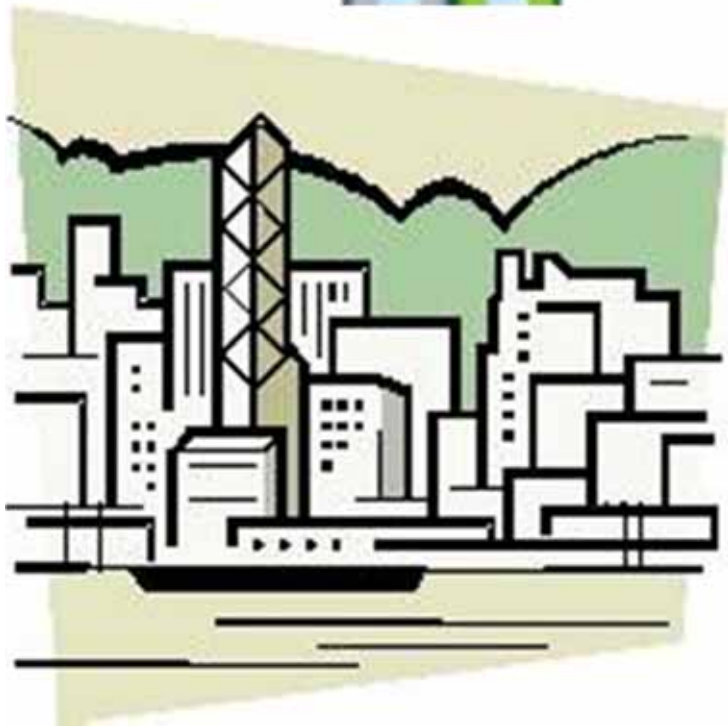


- Major concerns
  - Conserve non-renewable energy & scarce materials
  - Minimise life-cycle ecological impact
  - Use renewable energy and materials that are sustainably harvested
  - Protect & restore local air, water, soils, flora and fauna
  - Support pedestrians, bicycles and mass transit
  - Reduce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

Basic principles



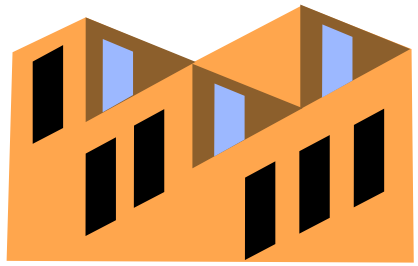
- Green building design strategies
  - Urban and site design
  - Energy efficiency
  - Renewable energy
  - Building materials
  - Water issues
  - Indoor environment
  - Integrated building design



Design strategies

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

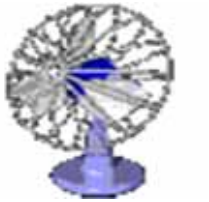
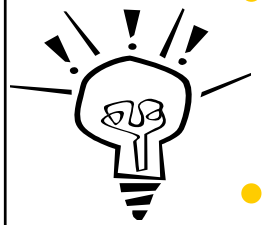
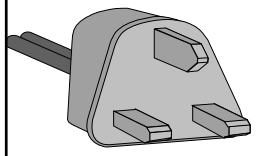
Design strategies

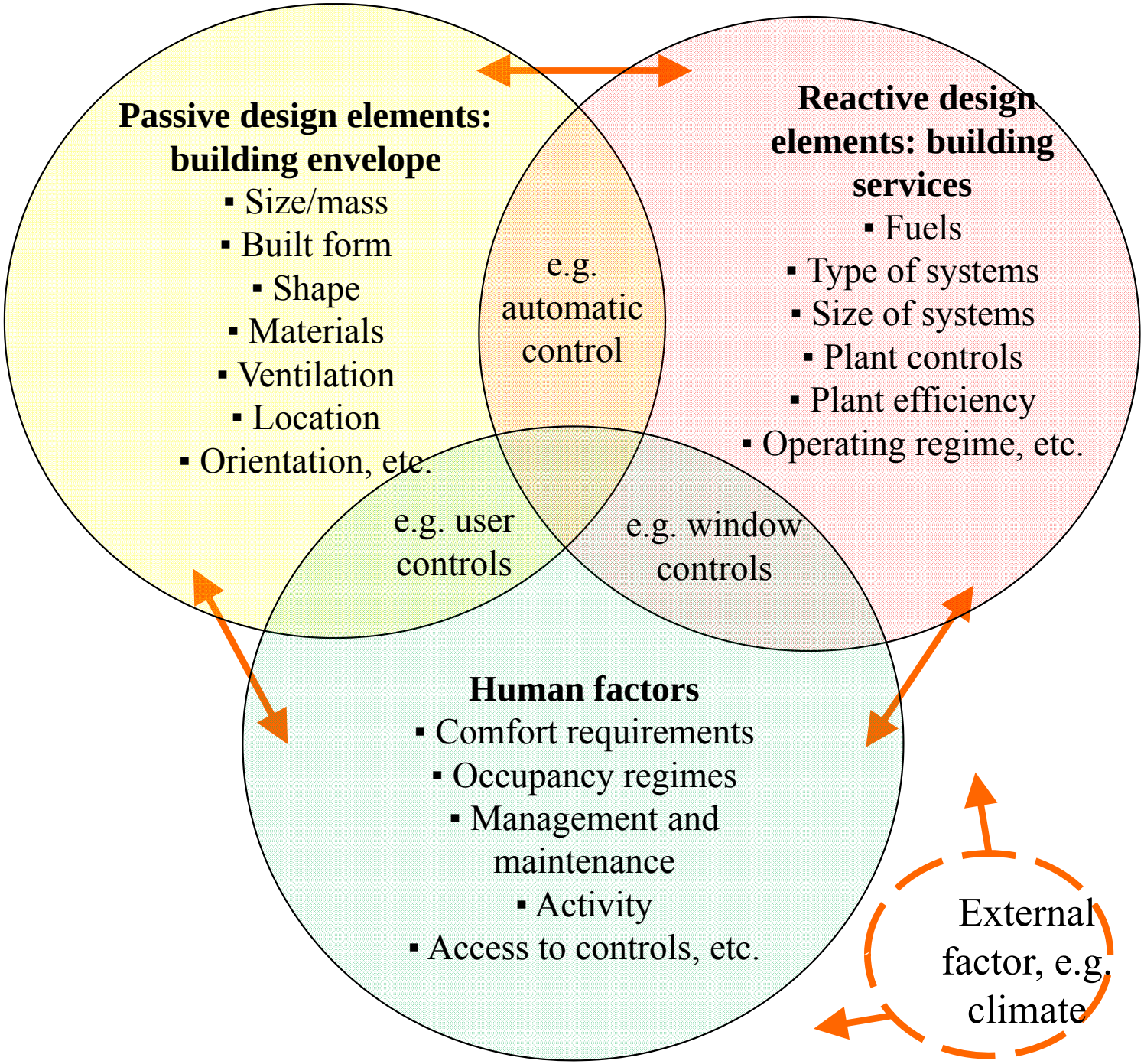


- Design issues:
  - Site selection (e.g. prefer brownfield site*)
  - Promote efficient movement network & transport
  - Control & reduce noise impacts
  - Optimise natural lighting & ventilation
  - Design for green space & landscape
  - Minimise disturbance to natural ecosystems
  - Enhance community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

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

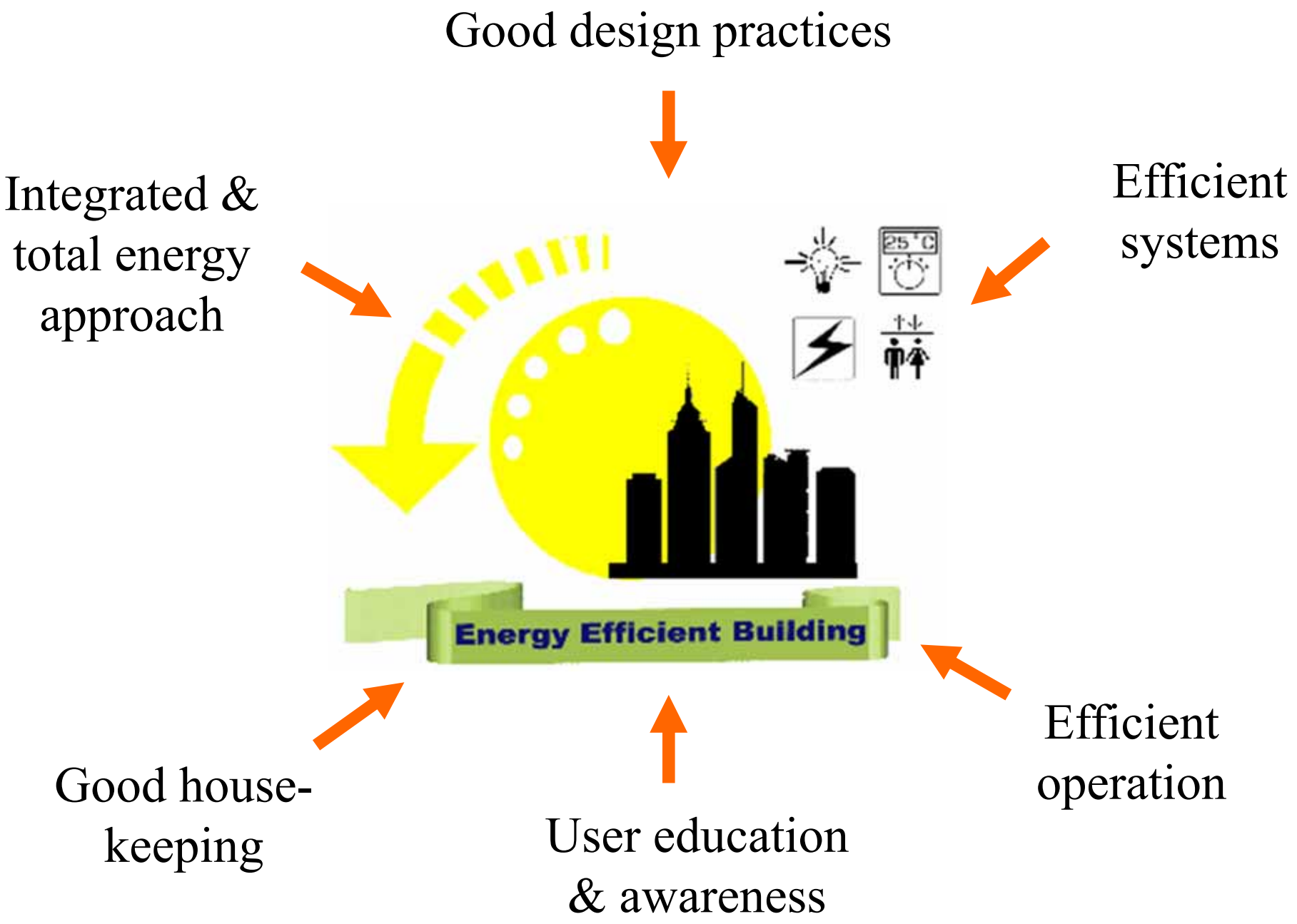
Design strategies

- Energy efficiency 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)



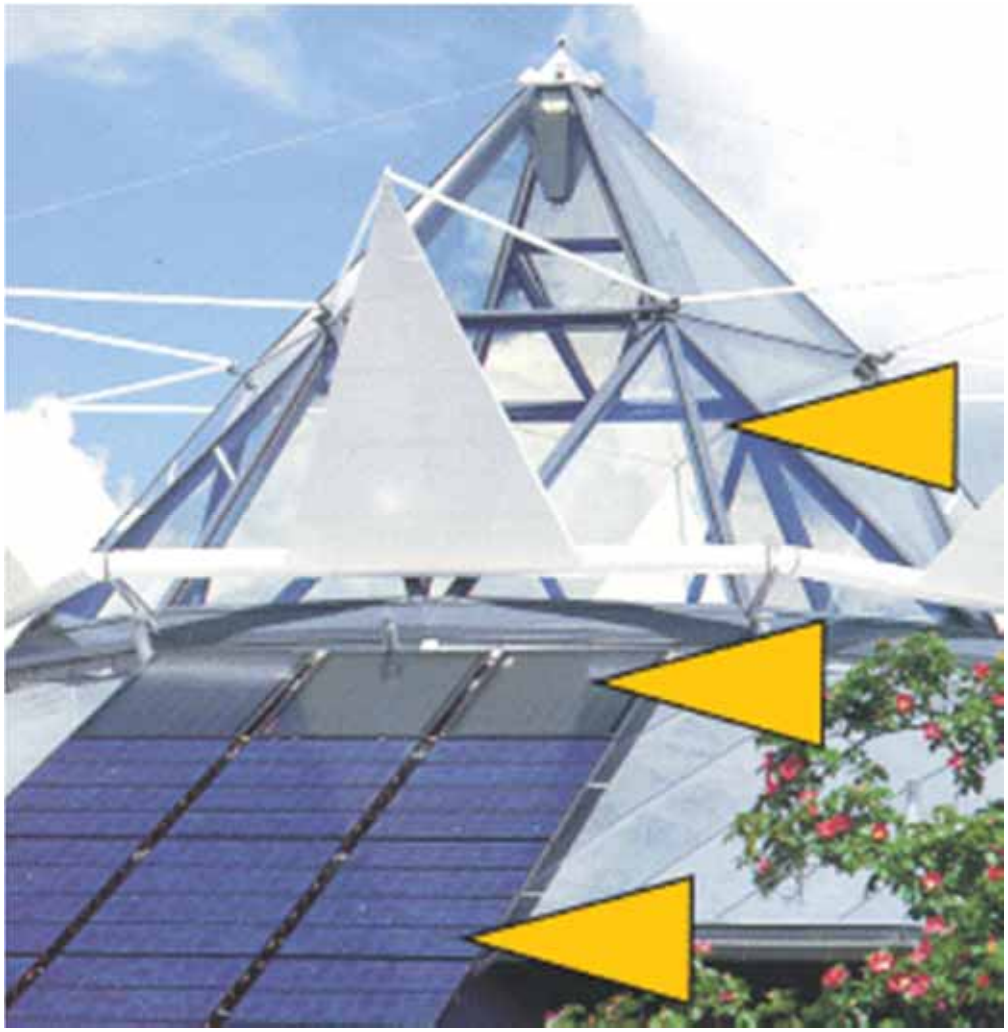
Key factors influencing energy consumption

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


Good design practices
Integrated & total energy approach
Efficient systems
25°C
Energy Efficient Building
Good house-keeping
User education & awareness
Efficient operation

Design strategies

- Renewable Energy
  - Energy that occurs naturally and repeatedly on earth and can be harnessed for human benefit
- Common applications
  - Solar hot water
  - Solar photovoltaic
  - Wind energy
  - Geothermal
  - Small hydros



Passive solar (e.g. skylight)

Active solar (solar hot water)

Photovoltaics

Integration of solar energy systems in buildings

Design strategies

- 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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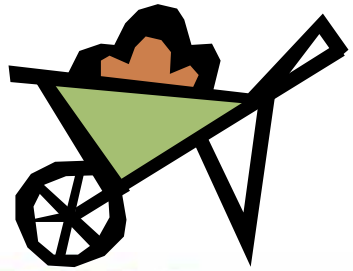
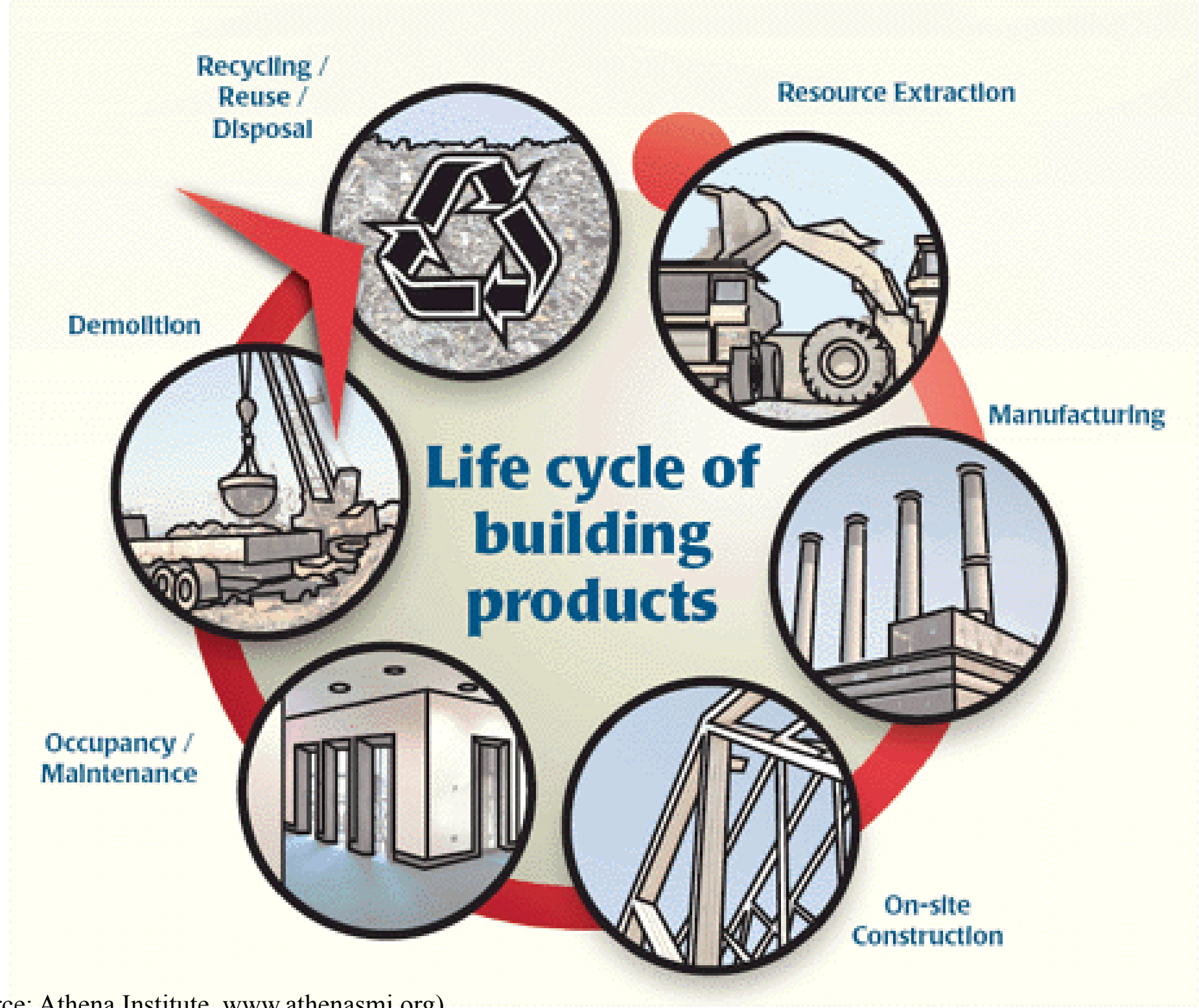
Design strategies



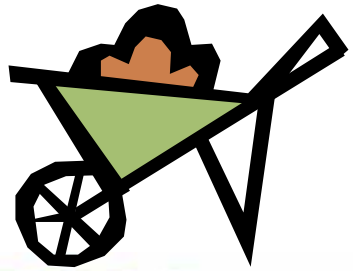
- What makes a product/material **green**?
  - Measured by their environmental impact
  - Life cycle of a sustainable material
  - Using local, durable materials
- Embodied energy*
  - 'Lifetime' energy requirement of a material
  - Energy input required to quarry, transport and manufacture the material,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

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



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

Design strategies



- 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

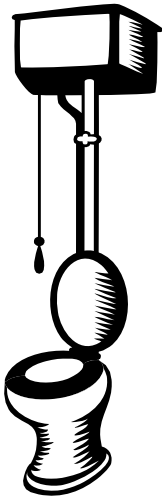
Design strategies

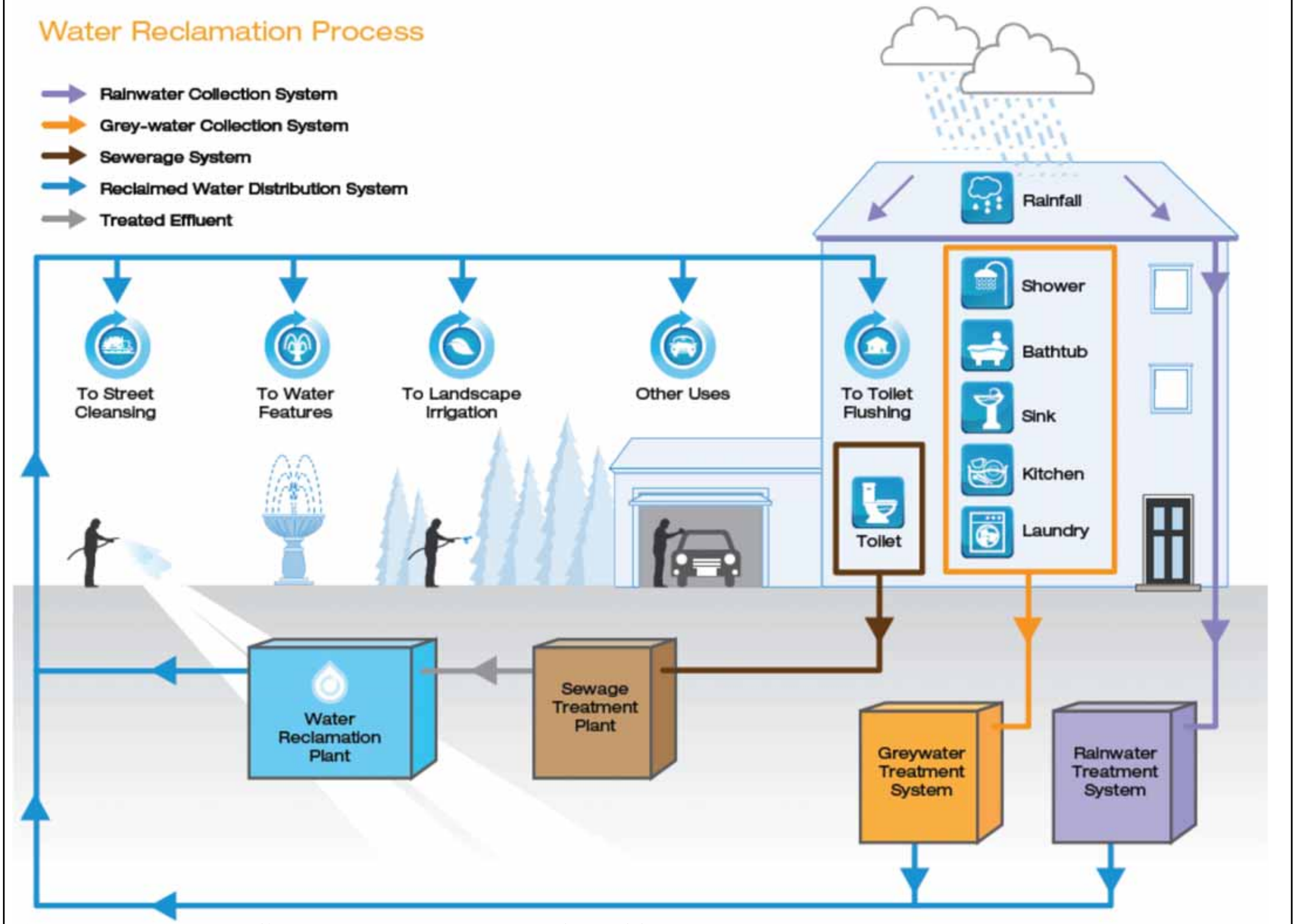
- Stormwater or watershed protection
  - Control rainwater runoff, flooding and erosion
    - Preservation of soils and drainage ways
    - Porous paving materials
    - Drainage of concentrated runoff
  - Avoid pollution and soil disturbance

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

Design strategies

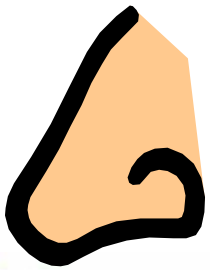
- Design strategy for water efficiency
  - Reduce water consumption
    - Low-flush toilets & showerheads
    - Leak detection & prevention
  - Correct use of appliances (e.g. washing machine)
  - Reuse and recycle water onsite
    - Rainwater collection & recycling
    - Greywater recycling (e.g. for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





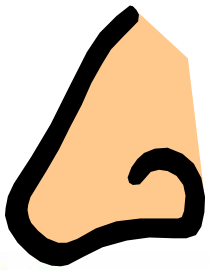
(Source: Water Supplies Department, www.wsd.gov.hk)

Design strategies



- 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 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

Four principles of indoor air quality design

1. Source Control

+

2. Ventilation Control

+

3. Occupant Activity Control

+

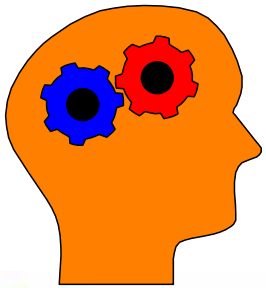
4. Building Maintenance

=

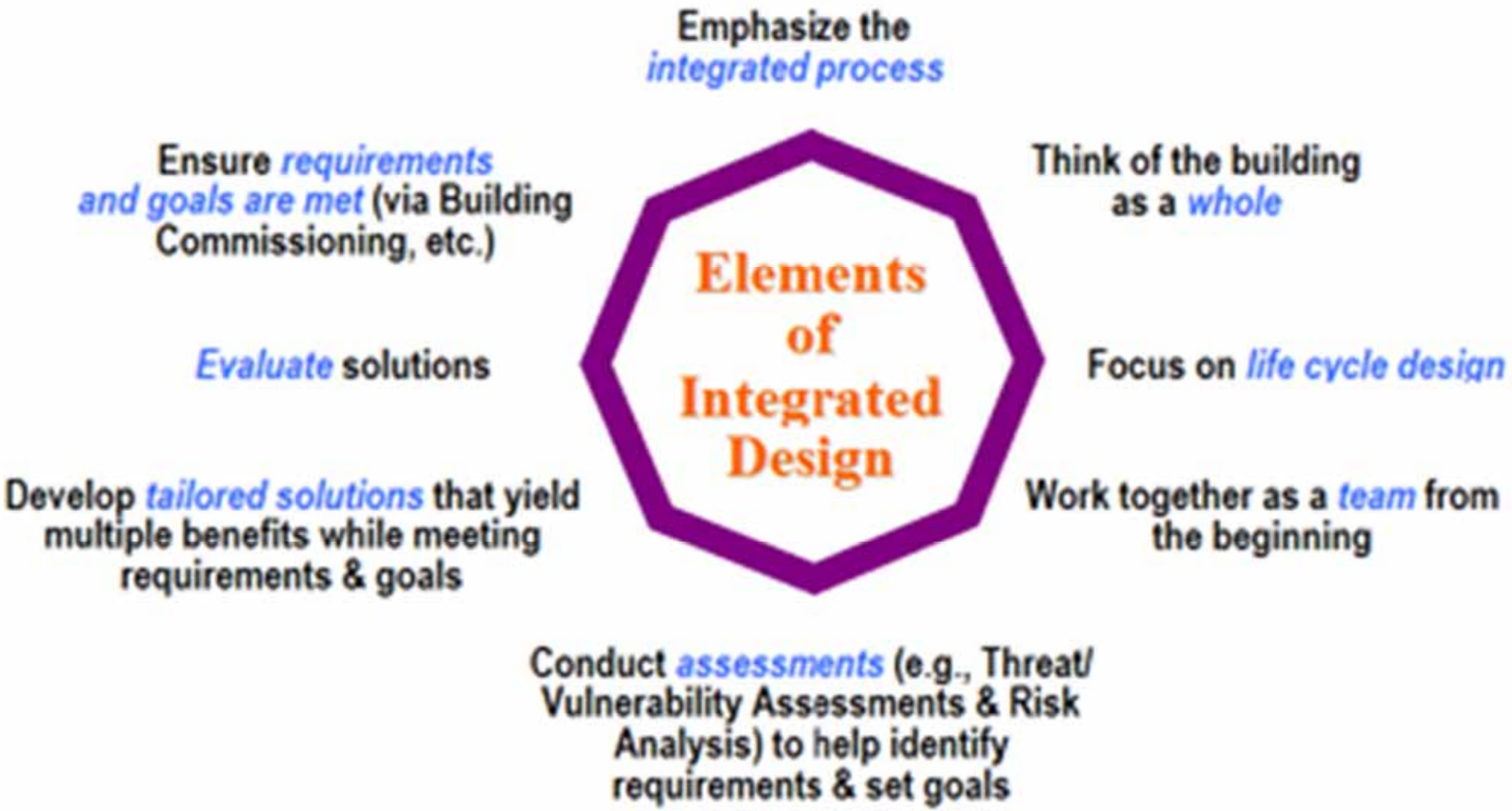
Total Indoor Air Quality

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

Design strategies

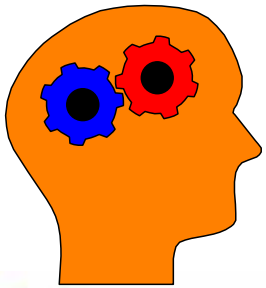


- WBDG - The Whole Building Design Guide
  - www.wbdg.org
- Two components of whole building design:
  - Integrated design approach
  - Integrated team process
- A holistic design philosophy
  - Holism + Interconnectedness + Synergy
  - "*The whole is greater than the sum of its parts*"



(Source: www.wbdg.org)

Design strategies

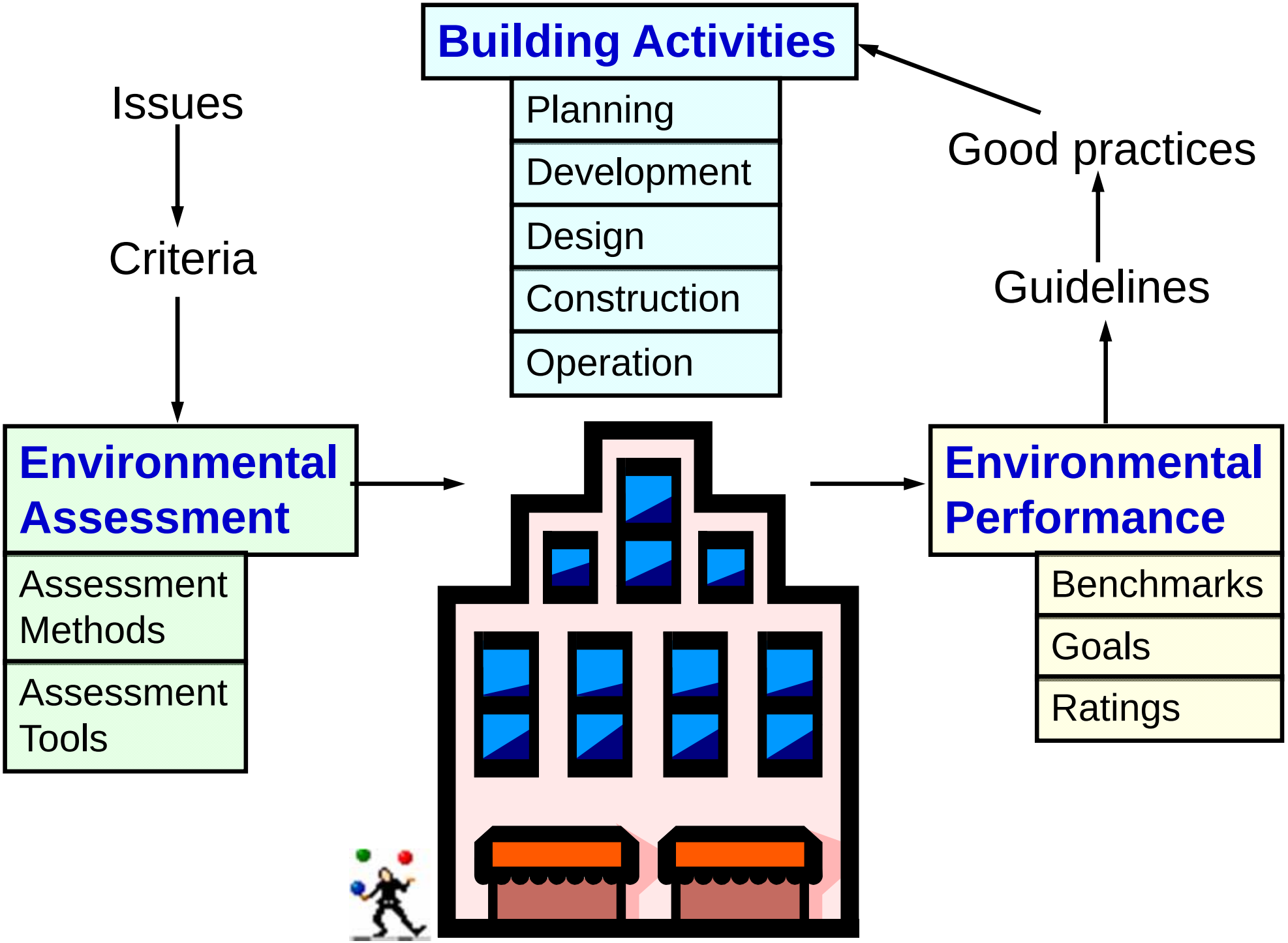


- Integrated, multidisciplinary project team
  - Owner's representative
  - Architect
  - Building Services Engineer
  - Civil/Structural Engineer
  - Construction Manager
  - Landscape Architect
  - Specialized Consultants

Green building assessment

- **Building environmental assessment***
  - Identify & evaluate the environmental effects of building development or operation
  - Inform decision making and promote sustainable design & management
- An objective assessment is a useful starting point from which to make design and building improvements

For supporting decision making

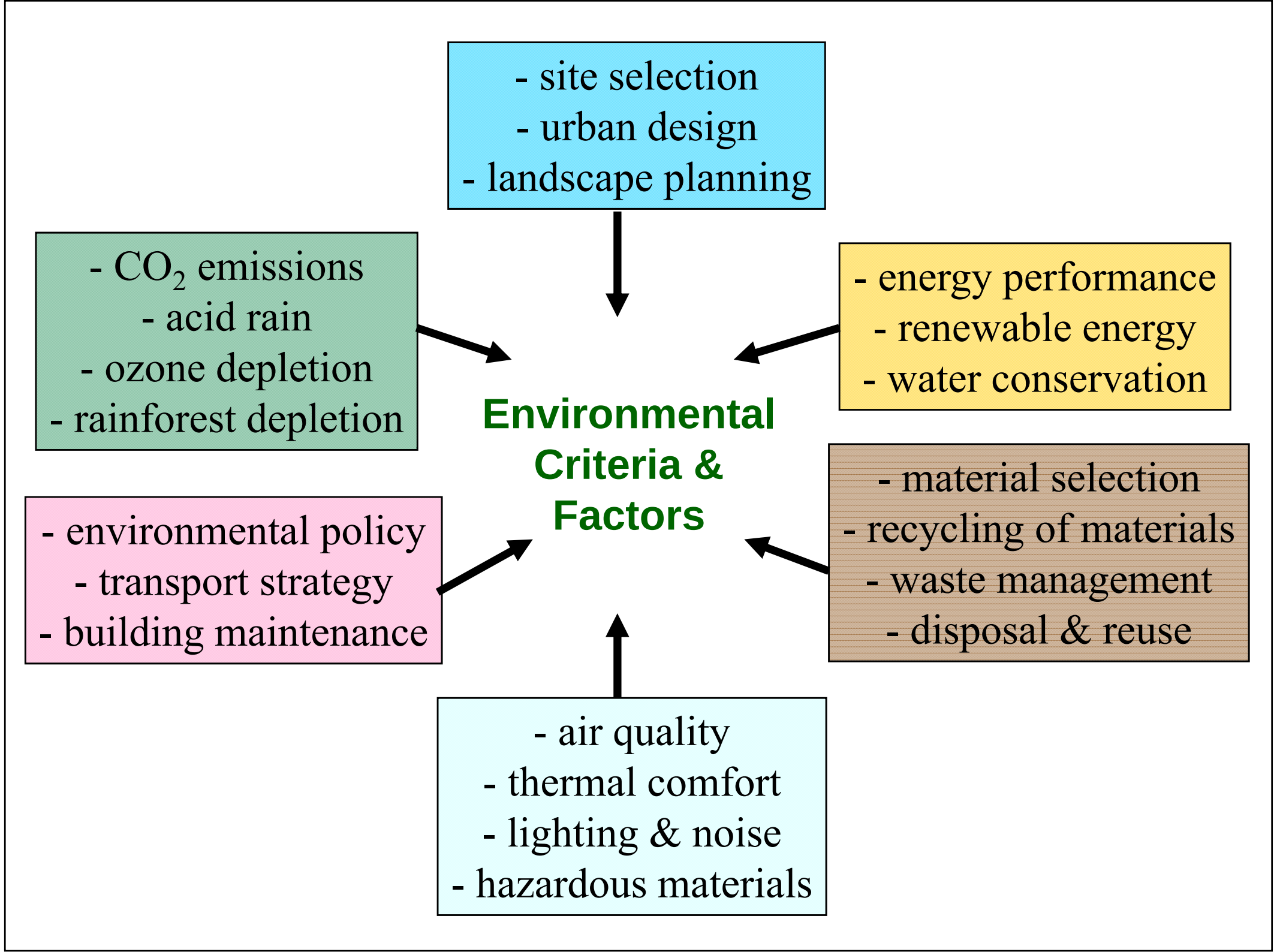

Building Activities
Planning
Development
Design
Construction
Operation
Issues
Criteria
Good practices
Guidelines
Environmental Assessment
Assessment Methods
Assessment Tools
Environmental Performance
Benchmarks
Goals
Ratings

Green building assessment

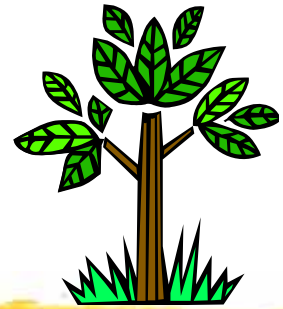
- Design guidelines provide a broader range of issues; Assessment methods give structure and priority, and provide strategic advice
  - Enhance environmental knowledge
- Enable *building performance* to be described
  - Performance-based indicators
  - Declared benchmarks
  - Prescriptive requirements (proxies for actual performance)

Green building assessment

- A broad range of criteria
  - Qualitative issues
  - Quantitative issues
- Types of criteria
  - Ecological *vs* health-related
  - Direct impacts *vs* indirect impacts
  - Immediate *vs* long-term implications
  - Global *vs* local

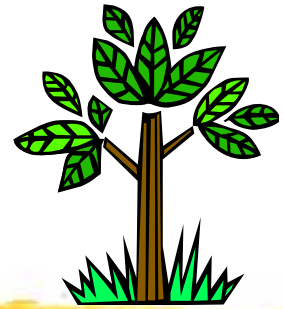

- site selection
- urban design
- landscape planning
- CO_2 emissions
- acid rain
- ozone depletion
- rainforest depletion
- energy performance
- renewable energy
- water conservation
Environmental Criteria & Factors
- material selection
- recycling of materials
- waste management
- disposal & reuse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

Green building assessment



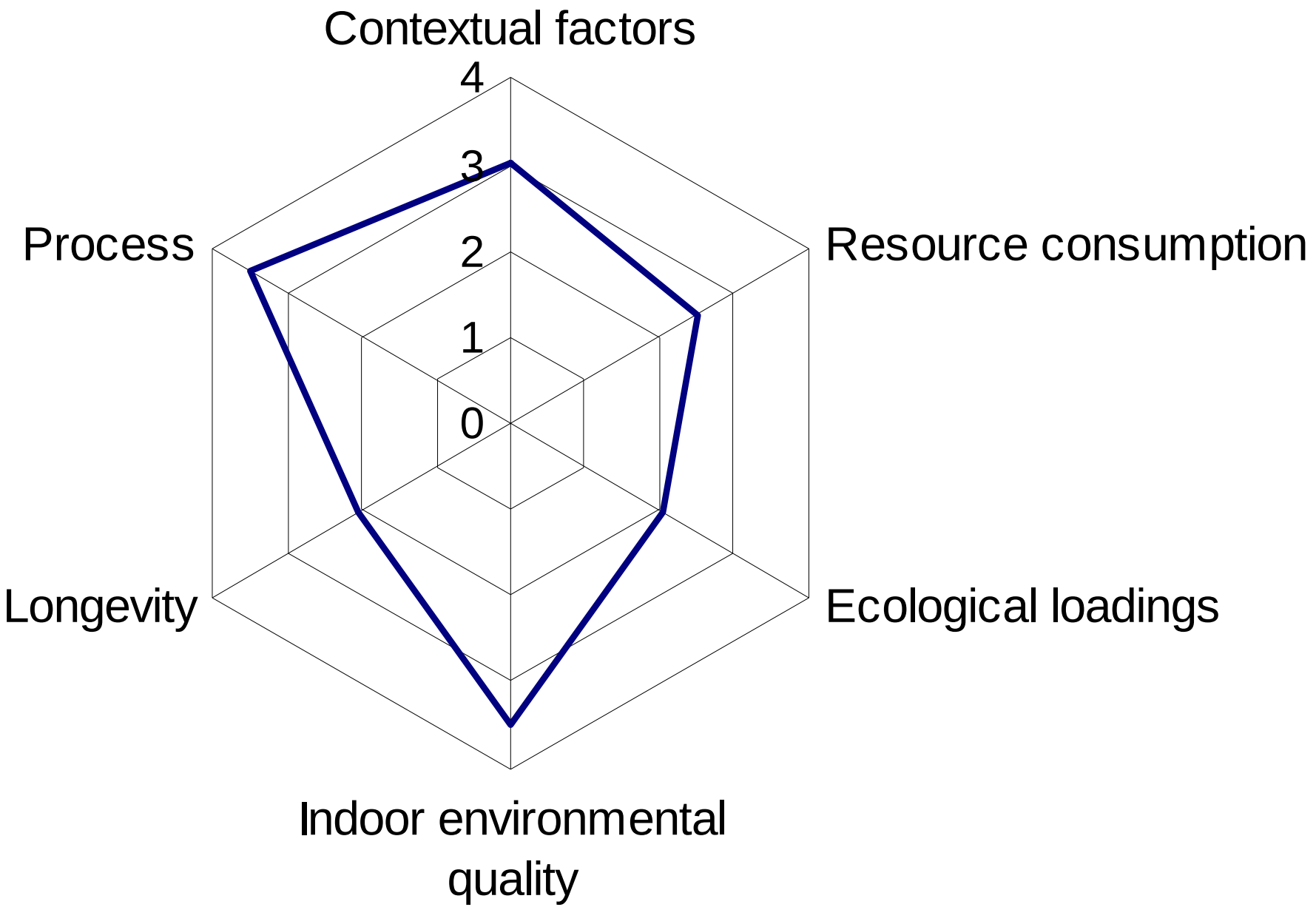
- Assessment process
  - Examine the performance of a building or its sub-system against a declared set of criteria
- Scale of performance
  - Measure & assess relative performance
  - Assign ‘points’ or ‘score’ to various aspects
    - Quantitative criteria: relative to a baseline
    - Qualitative criteria: presence/absence of such features

Green building assessment



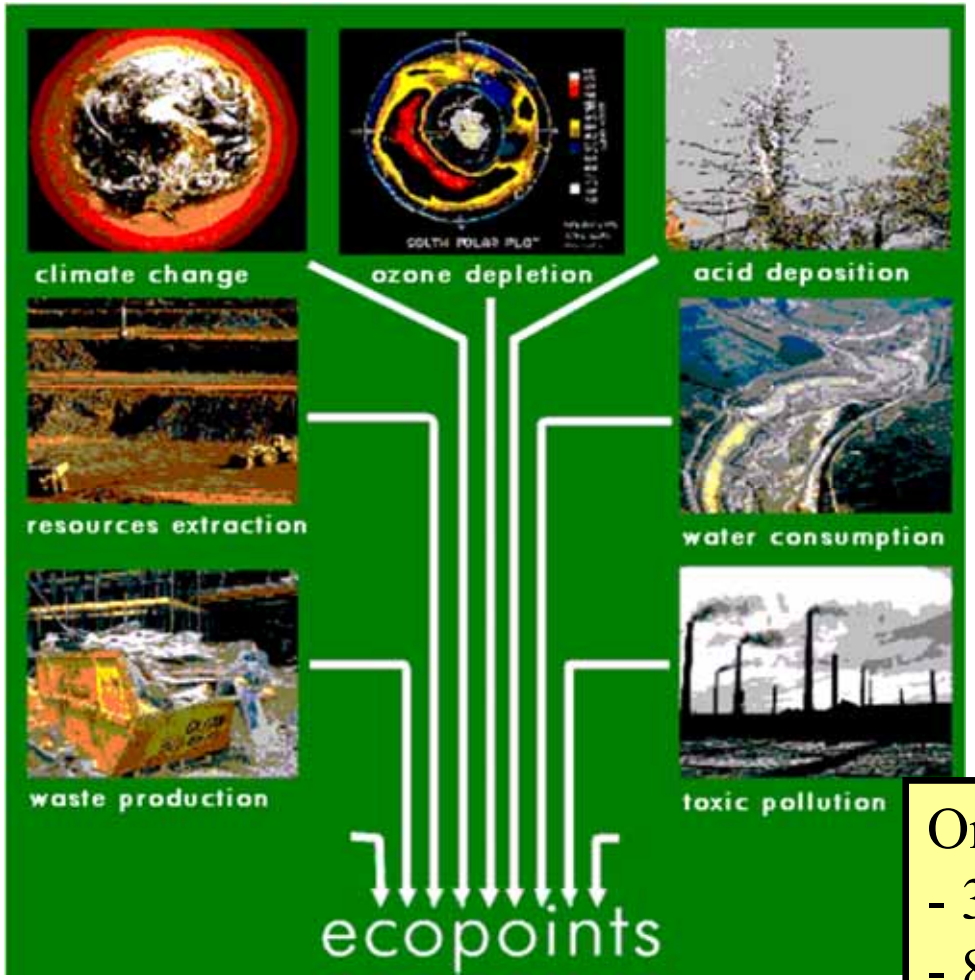
- Assessing multiple criteria
  - Indicate the ‘best’ overall performance
  - Methodology
    - Cost (or monetary value $)
    - Equivalence method (e.g. air/water pollution index)
    - EcoCost (in common Gaia scale 0-1)
    - EcoPoint or EcoProfile
- Weighting system
  - To show relative importance, scale and urgency

How to visualize assessment results?



Radar chart for assessing multiple criteria

How to combine different criteria?



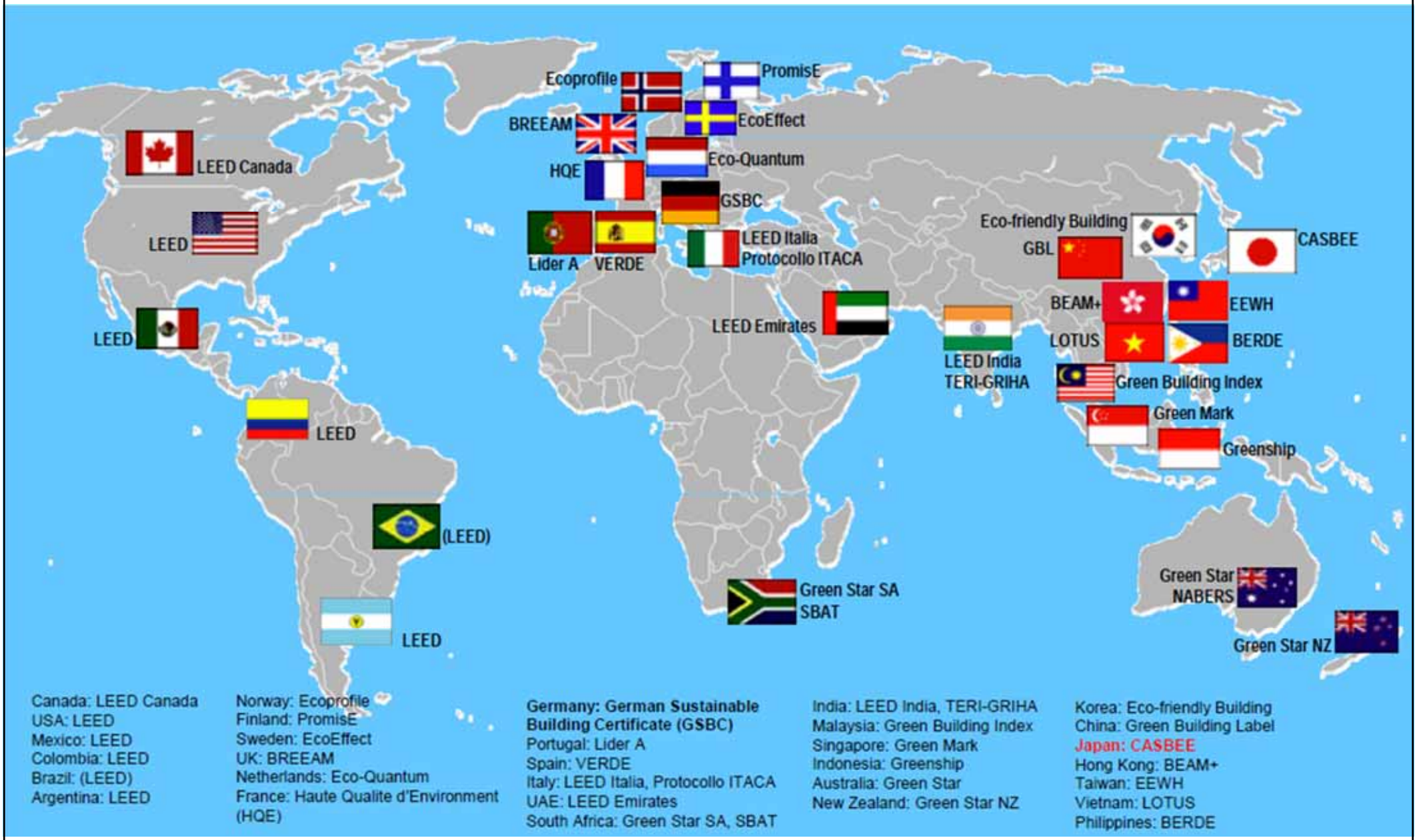
"Ecopoint" concept in the ENVEST (environmental impact estimating) tool (UK BRE)

One "**ecopoint**" is equivalent to:
- 320 kWh electricity
- 83 m^3 Water: enough to fill 1,000 baths
- 65 miles by articulated truck
- landfilling 1.3 tonnes of waste
- manufacturing 3/4 tonnes brick (250 bricks)
- 540 tonne kms by sea freight
- 1.38 tonnes mineral extraction
- 300 miles of urban driving in new petrol car

envest

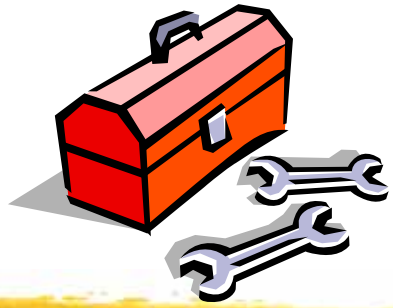
(Source: UK BRE)

Rating tools of building environmental performances around the world



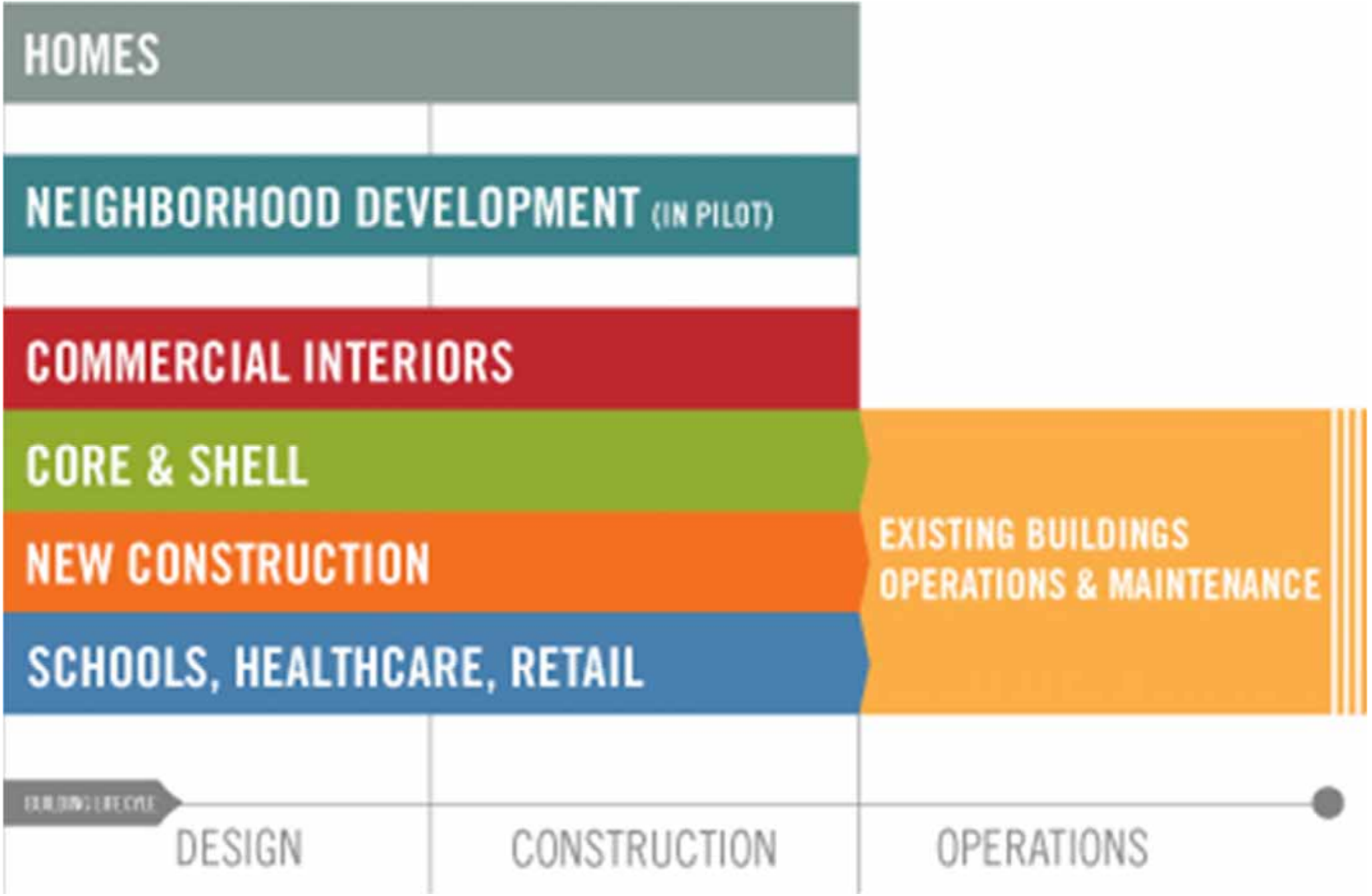
(Adapted from *CASBEE in Progress for Market Transformation in Japan*, by Prof. Kazuo Iwamura, Tokyo City University)

Assessment tools



- LEED Green Building Rating System
  - **L**eadership in **E**nergy & **E**nvironmental **D**esign
    - By US Green Building Council
  - Current LEED systems:
    - New construction (LEED-NC)
    - Existing buildings operations & maintenance (LEED-EBOM)
    - Commercial interiors (LEED-CI)
    - Core and shell (LEED-CS)
    - Homes
    - Schools, Healthcare, Retail
    - Neighborhood development (LEED-ND)

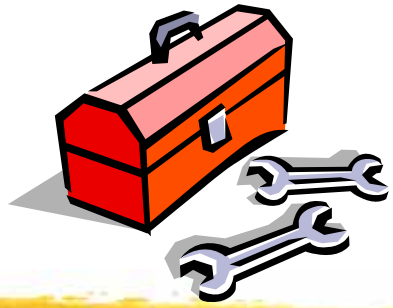
LEED Green Building Rating



(Source: USGBC)

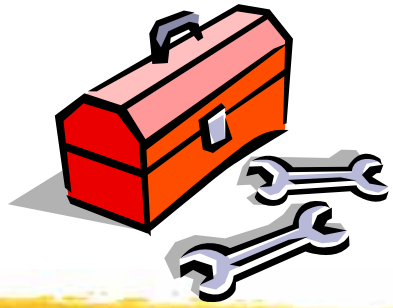
(See also: Introducing LEED v4 (1:34) http://www.youtube.com/watch?v=UJzdnykumTU)

Assessment tools



- LEED Green Building Rating System
  - Evaluates and recognizes performance in accepted green design categories, including:
    - Sustainable sites
    - Water efficiency
    - Energy and atmosphere
    - Materials and resources
    - Indoor environmental quality
    - Innovation credits
  - Website: www.leedbuilding.org

Assessment tools



- LEED version 3 and new schemes
  - Include other criteria
    - Locations & linkages
    - Awareness & education
    - Regional priority
  - LEED Professionals
    - LEED Green Associate
    - LEED AP (different types)
      - Bldg design & construction, O&M, Homes, Interior design, Neighborhood development

LEED® for New Construction

Total Possible Points**	110*
Sustainable Sites	26
Water Efficiency	10
Energy & Atmosphere	35
Materials & Resources	14
Indoor Environmental Quality	15

*Out of a possible 100 points + 10 bonus points

**Certified 40+ points, Silver 50+ points, Gold 60+ points, Platinum 80+ points

Innovation in Design	6
Regional Priority	4

LEED® for Existing Buildings

Total Possible Points**	110*
Sustainable Sites	26
Water Efficiency	14
Energy & Atmosphere	35
Materials & Resources	10
Indoor Environmental Quality	15

*Out of a possible 100 points + 10 bonus points

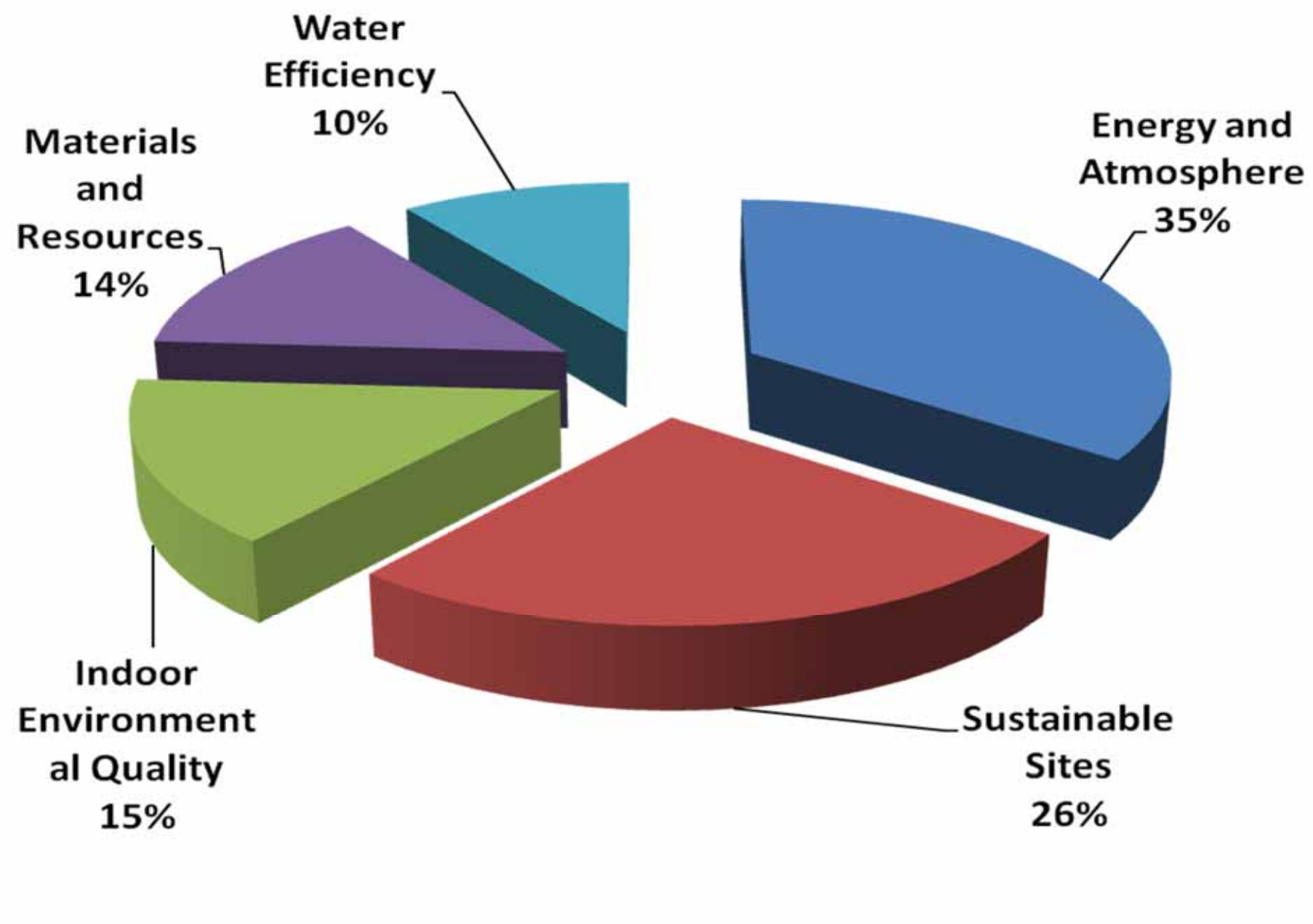
**Certified 40+ points, Silver 50+ points, Gold 60+ points, Platinum 80+ points

Innovation in Operations	6
Regional Priority	4

(Source: USGBC)

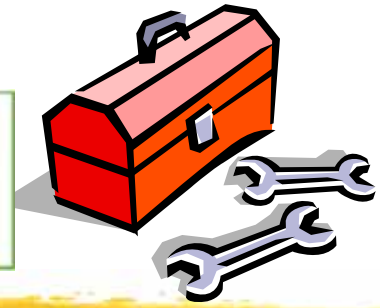
For LEED version 3

LEED NC point distribution (version 2009)



(Source: USGBC)

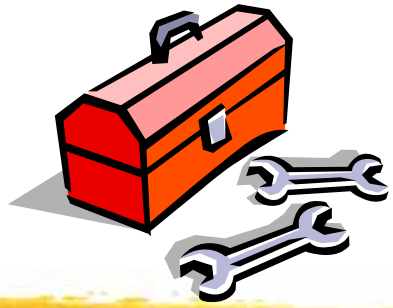
Current Tools



- LEED v4 (launched in 2014)*
  - Location & Transportation (LT)
  - Sustainable Site (SS)
  - Water Efficiency (WE)
  - Energy and Atmosphere (EA)
  - Materials and Resources (MR)
  - Indoor Environmental Quality (EQ)
  - Innovation (IN)
  - Regional Priority (RP)

(* See also http://new.usgbc.org/leed/v4)

Assessment tools



- BEAM Plus development
  - Version 2009: (Nov 2009)
    - BEAM Plus for New Buildings
    - BEAM Plus for Existing Buildings
  - Version 1.1 (Apr 2010)
    - With minor refinements
    - Introduce BEAM Professionals
  - Version 1.2 (Jul 2012)
    - Addresses issues on passive design
    - Minor amendments to other aspects
    - Starting from 1 Jan 2013, version 1.2 must be used

BEAM Society 香港環保建築協會

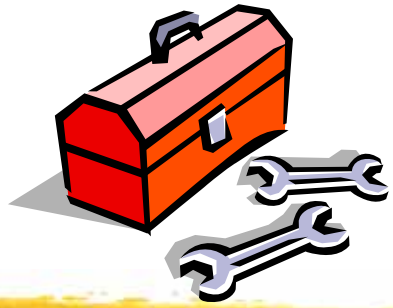
HKGBC 香港綠色建築議會

BEAM Plus assessment criteria [credits] [weighting]

New Buildings	Existing Buildings
Site aspects (SA) [22+3B] [25%]	Site aspects (SA) [18+1B] [18%]
Materials aspects (MA) [22+1B] [8%]	Materials aspects (MA) [11+2B] [12%]
Energy use (EU) [42+2B] [35%]	Energy use (EU) [39+2B] [30%]
Water use (WU) [9+1B] [12%]	Water use (WU) [7+2B] [15%]
Indoor environmental quality (IEQ) [32+3B] [20%]	Indoor environmental quality (IEQ) [30+3B] [25%]
Innovations and additions (IA) [5B+1]	Innovations and additions (IA) [5B+1]

(Source: http://www.beamsociety.org.hk)

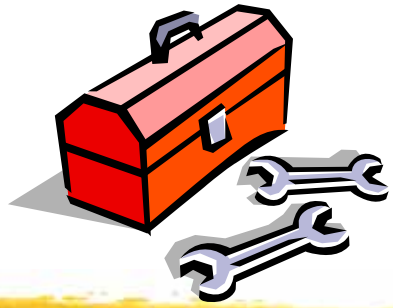
Assessment tools



- BEAM Plus (Version 1.1 or 1.2)
  - Overall grade: (with min. for SA, EU and IEQ)

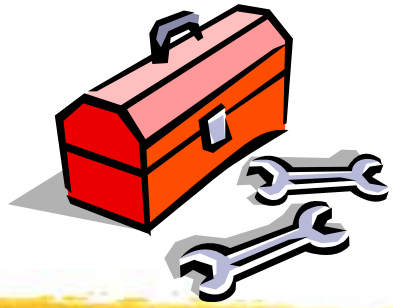
	Overall	Site Aspects	Energy Use	IEQ	Innov. & Addn.	
Platinum	75%	70%	70%	70%	3 credits	Excellent
Gold	65%	60%	60%	60%	2 credits	Very Good
Silver	55%	50%	50%	50%	1 credit	Good
Bronze	40%	40%	40%	40%	---	Above Average

Assessment tools

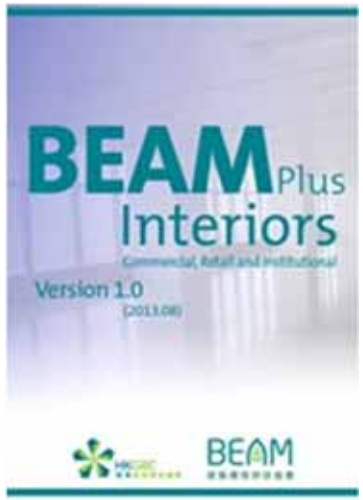


- BEAM Professionals (BEAM Pro)
  - Accredited by HK Green Building Council (HKGBC) (www.hkgbc.org.hk)
  - Facilitate BEAM Plus submission
- BEAM Assessors (BAS)
  - Undertake the building assessment on behalf of HKGBC
- BEAM Faculty
  - Experienced professionals to drive BEAM Plus & BEAM Professionals development and training

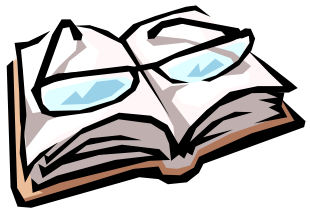
Assessment tools



- BEAM Plus Interior (Aug 2013)
  - Green Building Attributes (GBA) [8]
  - Management (MAN) [1p, 10]
  - Materials Aspects (MA) [3p, 26]
  - Energy Use (EU) [26]
  - Water Use (WU) [6]
  - Indoor Environmental Quality (IEQ) [24]
  - Innovations (IV) [10]



Further Reading



- Green Building Standards and Certification Systems [WBDG]
  - http://www.wbdg.org/resources/gbs.php
- Introduction to LEED Rating Systems | by Green Building Academy (21:30)
  - http://www.youtube.com/watch?v=hZoPENko-6U
- BEAM Plus New Bldgs & Existing Bldgs
  - http://www.hkgbc.org.hk/eng/BEAMPlus_NBEB.aspx