



## Building environmental performance

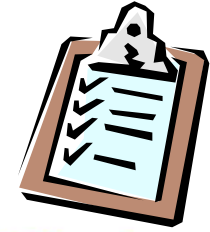


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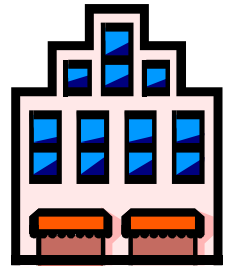
# Contents



- Building performance
- Environmental performance
- Assessment of performance
- Green/sustainable building
- Assessment methods



# Building performance



- Importance of **building sector**
  - Globally, buildings account for 40% of energy use, 38% of greenhouse gas emissions, 12% of potable water and 20% of solid waste streams in developed countries
  - The Intergovernmental Panel on Climate Change (IPCC) has identified buildings as the greatest impact, least costly way to reduce greenhouse gas emissions and address climate change



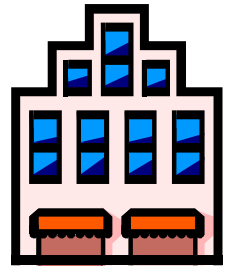
## Estimate of global resources used in buildings and cities

Resource	(%)
Energy	45-50
Water	50
Materials for buildings and road (by bulk)	60
Agricultural land loss to buildings	80
Timber products for construction	60 (90% of hardwoods)
Coral reef destruction	50 (indirect)
Rainforest destruction	25 (indirect)

## Estimate of global pollution that can be attributed to buildings and cities

Pollution	(%)
Air quality (cities)	23
Global warming gases	50
Drinking water pollution	60
Landfill waste	50
Ozone thinning/depletion	50

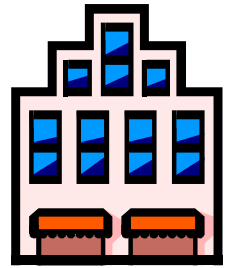
# Building performance



- What is “Performance” ?
  - Performance is *meeting expectations*
  - How well it works
- CIB definition \*:
  - “*The objectively identifiable qualitative or quantitative characteristics of the building which help determine its aptitude to fulfil the different functions for which it was designed.*”

(\* CIB = International Council for Research and Innovation in Building & Construction)

# Building performance

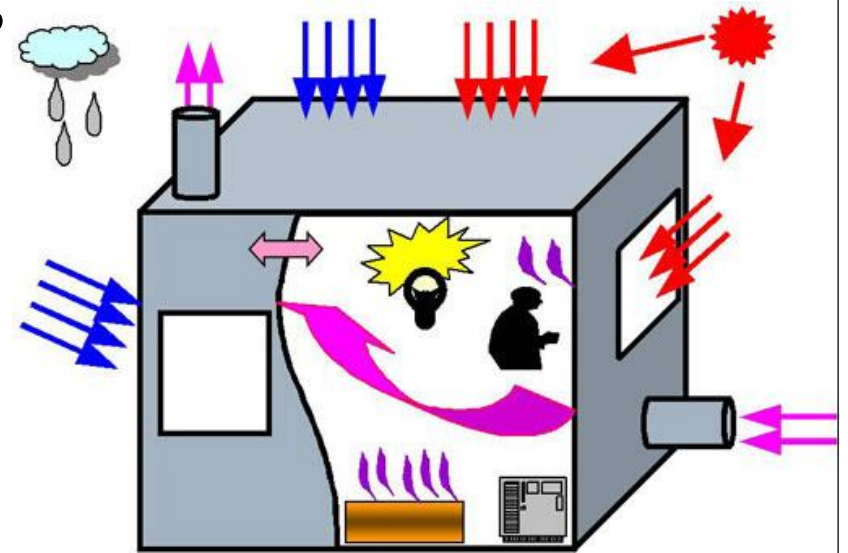


- Building performance issues

- Functionality
- Serviceability (usableness)
- Building-occupant comfort

- Trends

- Use it as the major criteria for building design
  - Performance-based design and building codes
- The need to study, measure, and predict the level of building performance (to quantify)



## Performance of a car



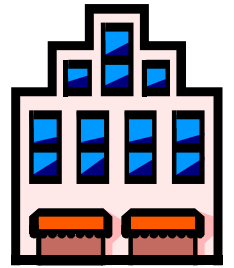
(Such as fuel efficiency)

## Performance of a building/flat



We get info. about performance of a car, what about buildings?

# Building performance



- Parameters of building performance
  - Structural
  - Fire and life safety
  - Accessibility
  - Durability
  - Sound insulation (acoustic)
  - **Environmental**
  - **Energy efficiency**



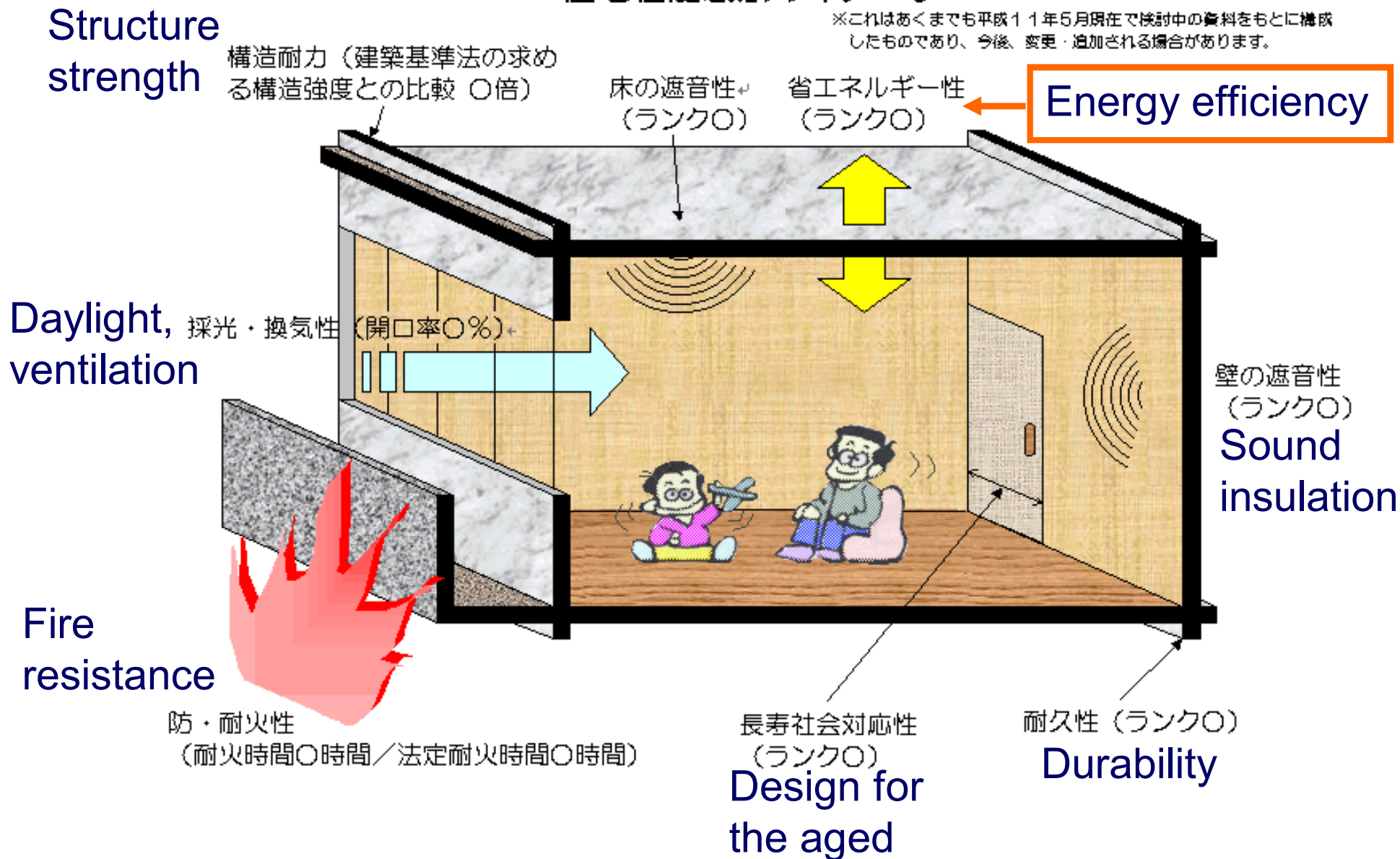


I noticed this when I was working and living in Japan in 1998.

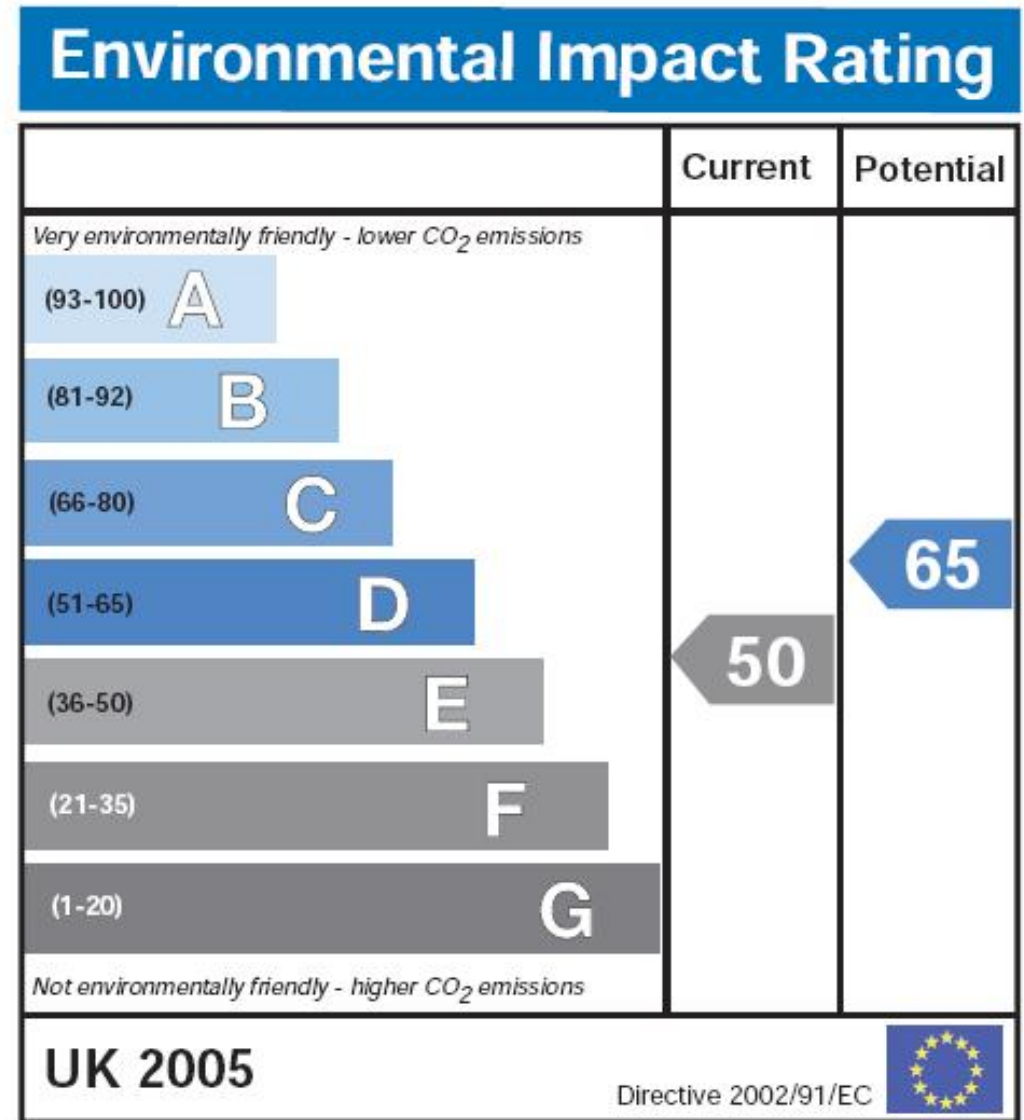
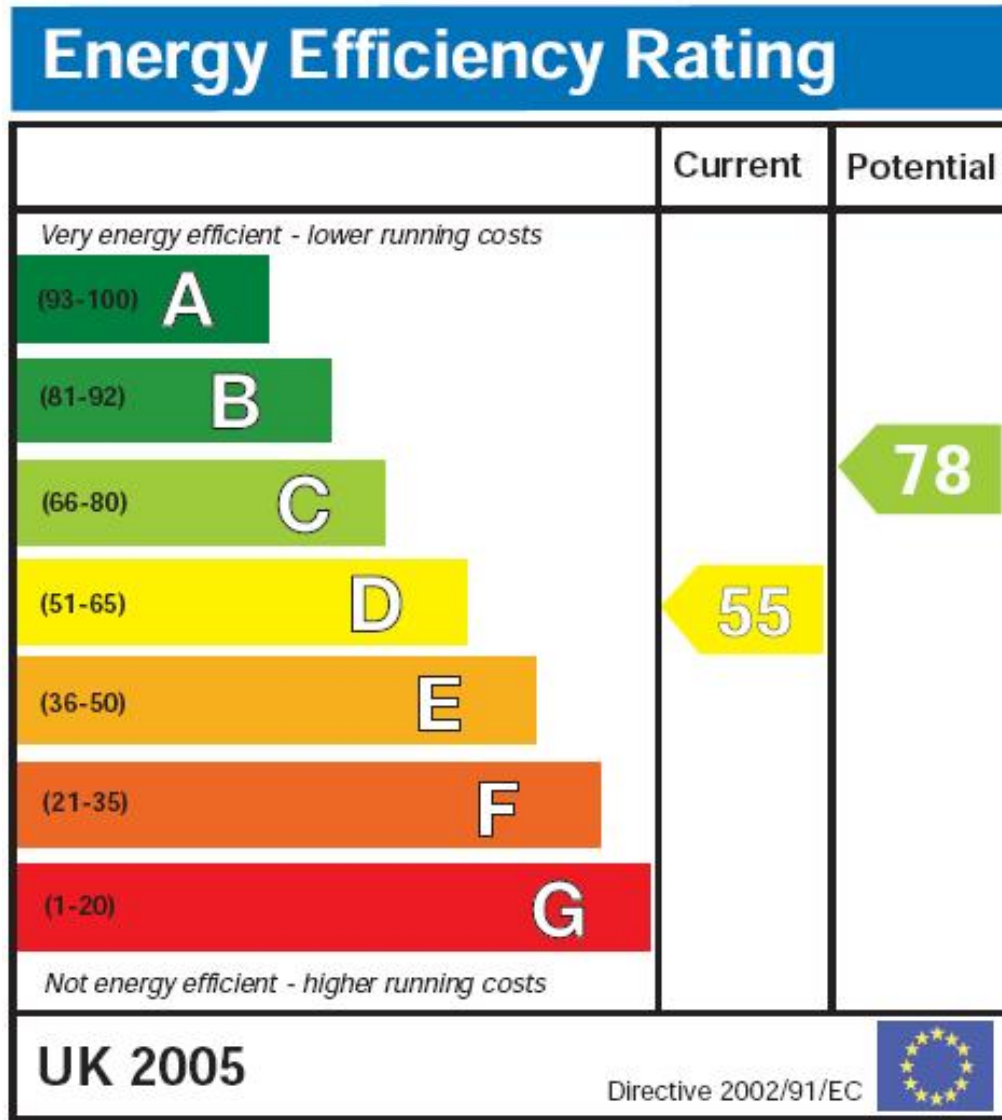
## Index of Building (Houses) Performance (Japan)

### 住宅性能表示のイメージ

※これはあくまでも平成11年5月現在で検討中の資料をもとに構成したものであり、今後、変更・追加される場合があります。



# Energy efficiency rating and environmental impact rating in UK



They are similar to the academic performance (grade/GPA) of students.

# Environmental performance



- It is the measurable results of an environmental management system, related to the control of its **environmental aspects**
- Assessment of environmental performance is based on environmental policy, environmental objectives and environmental targets
- There is a need to measure and evaluate the environmental performance of buildings in a systematic manner

Many environmental aspects





# Environmental performance



- How building construction affects the environment
  - Energy use (e.g. electricity)
  - Greenhouse gas emissions (affect climate change)
  - Water use and drainage
  - Construction materials (resource use)
  - Waste from building construction and demolition
  - Land use and impact on the nature
  - Indoor environment and health (on human beings)

- site selection
- urban design
- landscape planning

- CO<sub>2</sub> emissions
- acid rain
- ozone depletion
- rainforest depletion

- energy performance
- renewable energy
- water conservation

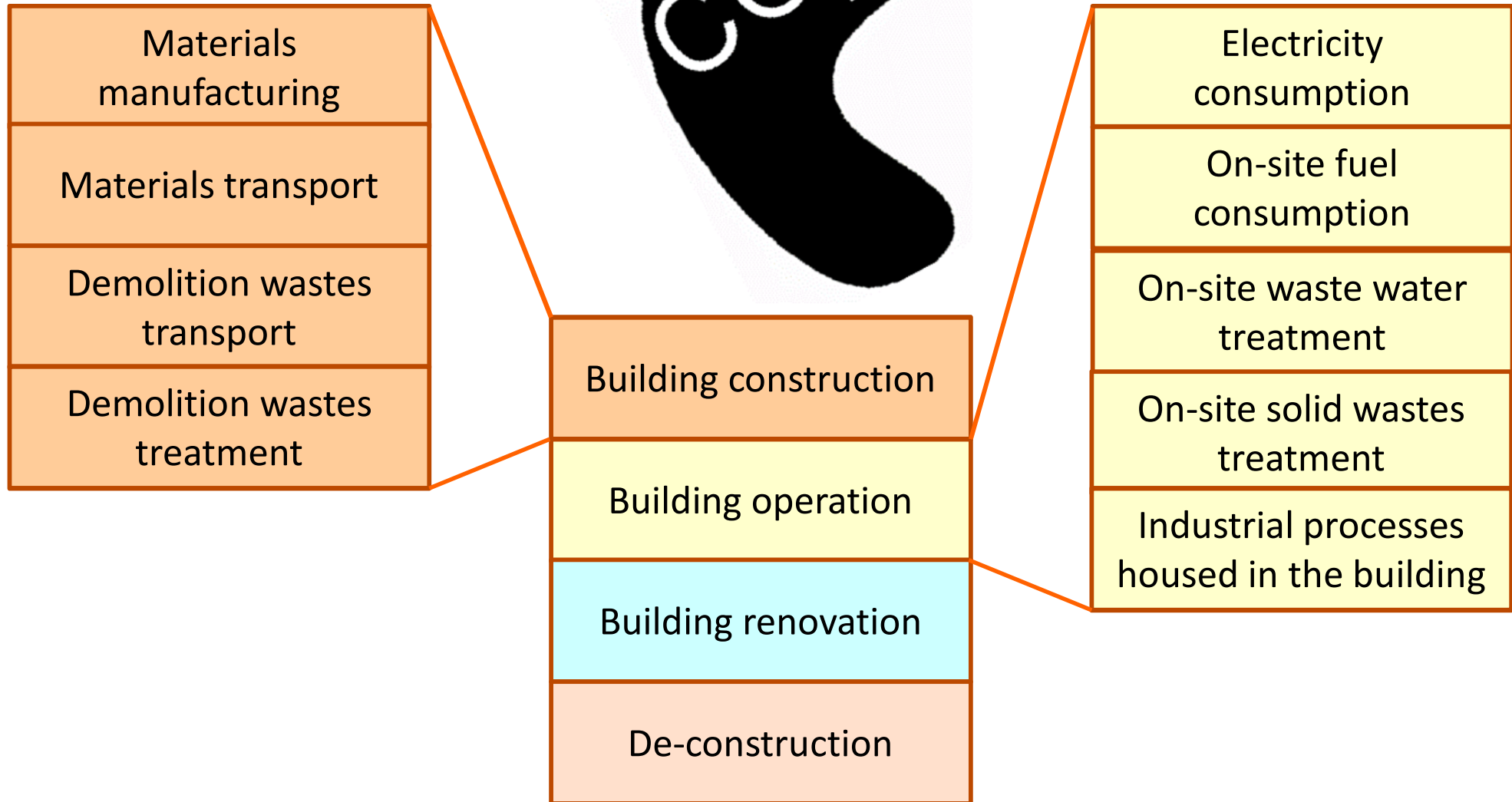
**Environmental  
Criteria &  
Factors**

- environmental policy
- transport strategy
- building maintenance

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

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

# Carbon footprint of a building and its components



# Environmental performance



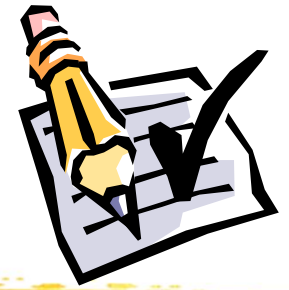
- **Building environmental performance**

- 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

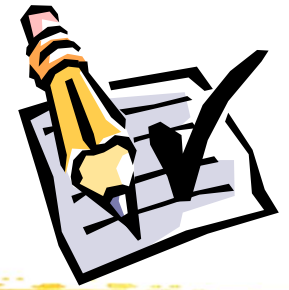


# Assessment of performance



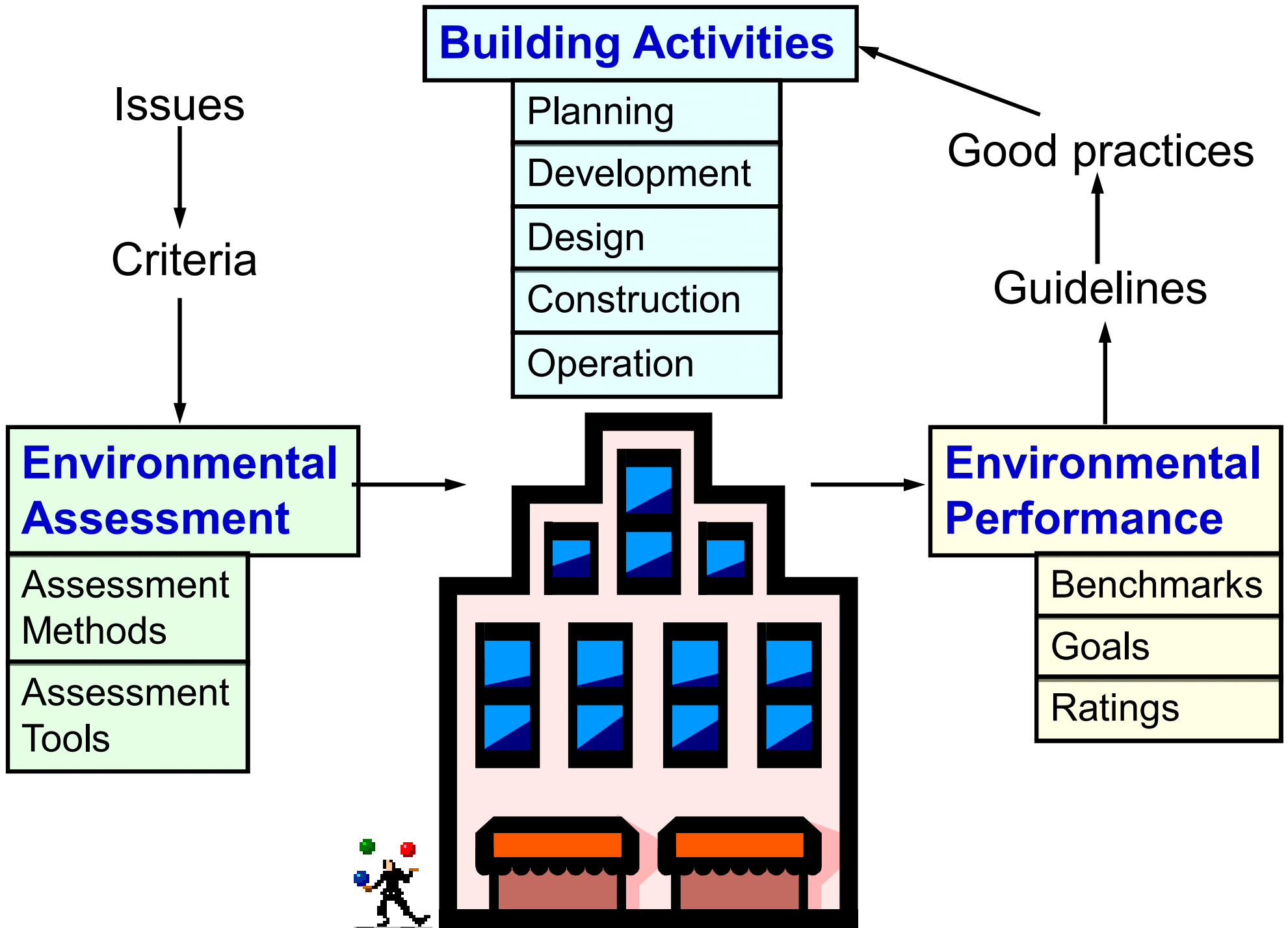
- Why assessing environmental performance?
  - Provide a common set of criteria & targets
    - Guide design decisions & choices
  - Raise awareness of environmental issues/standards
    - Recognise & encourage good practices
    - Stimulate the market for sustainable construction
  - Allow a verifiable method & framework
    - Enable policies & regulation (e.g. certificate/label)
    - Improve management & prioritization (incentives)

# Assessment of performance

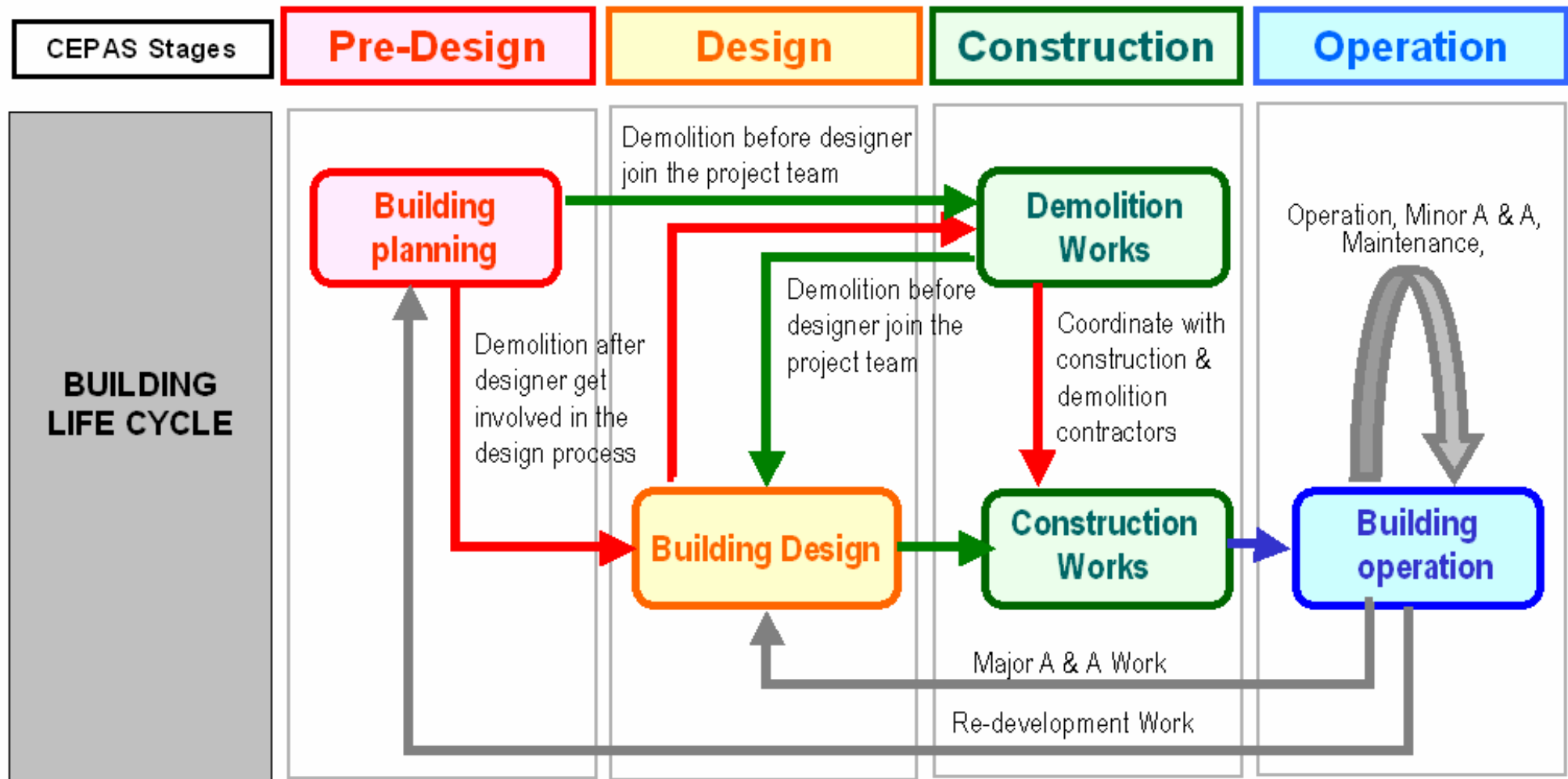


- Design guidelines provide a broader range of issues; Assessment methods give structure and priority, and provide strategic advice
  - Enhance environmental knowledge
- Enable *building performance* to be described
  - Performance-based indicators
  - Declared benchmarks
  - Prescriptive requirements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

# Basic principles of building environmental assessment



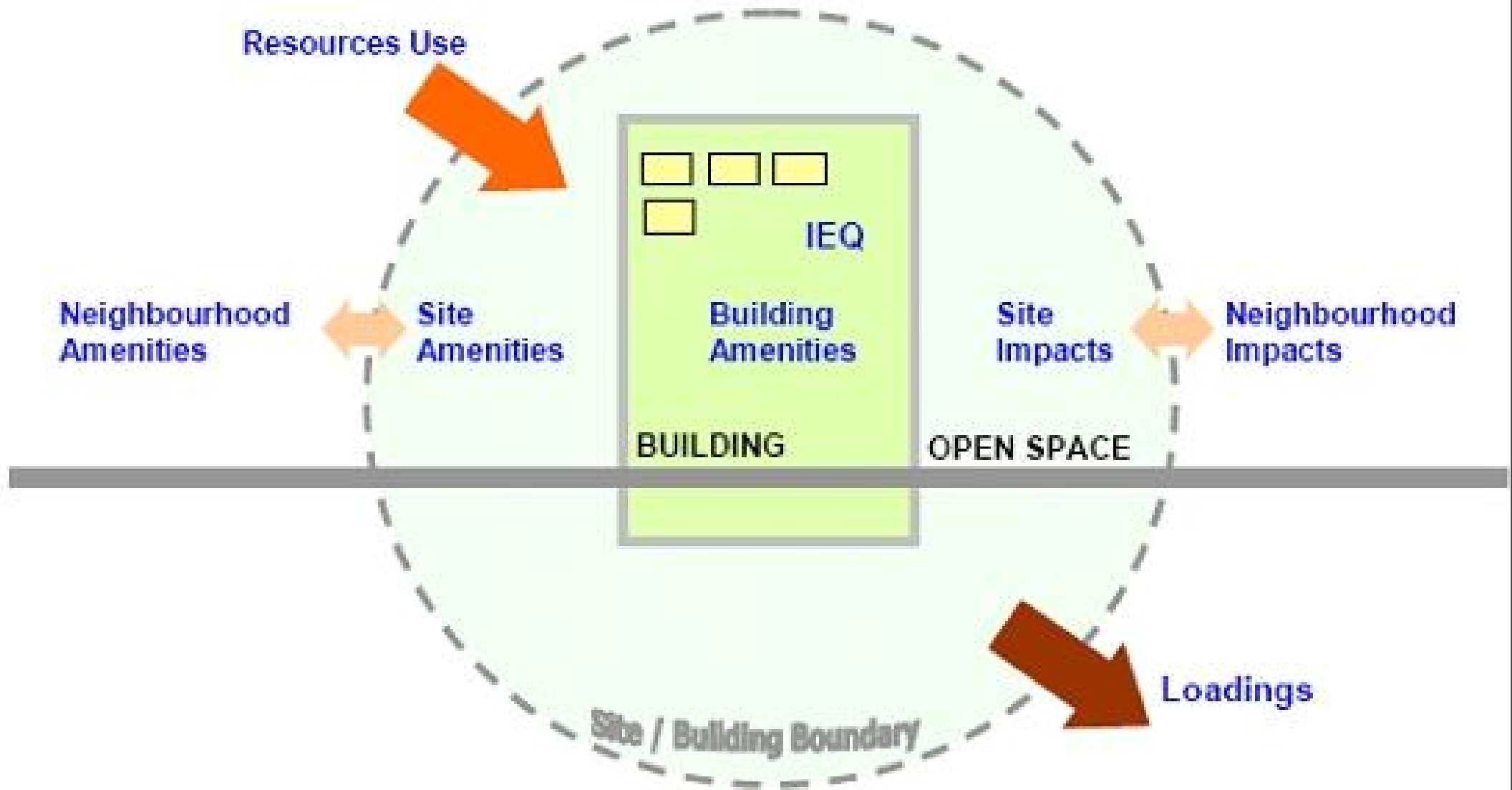
# Building life cycle stages



(Source: Comprehensive Environmental Performance Assessment Scheme for Buildings (CEPAS))

[http://www.bd.gov.hk/english/documents/index\\_CEPAS.html](http://www.bd.gov.hk/english/documents/index_CEPAS.html) )

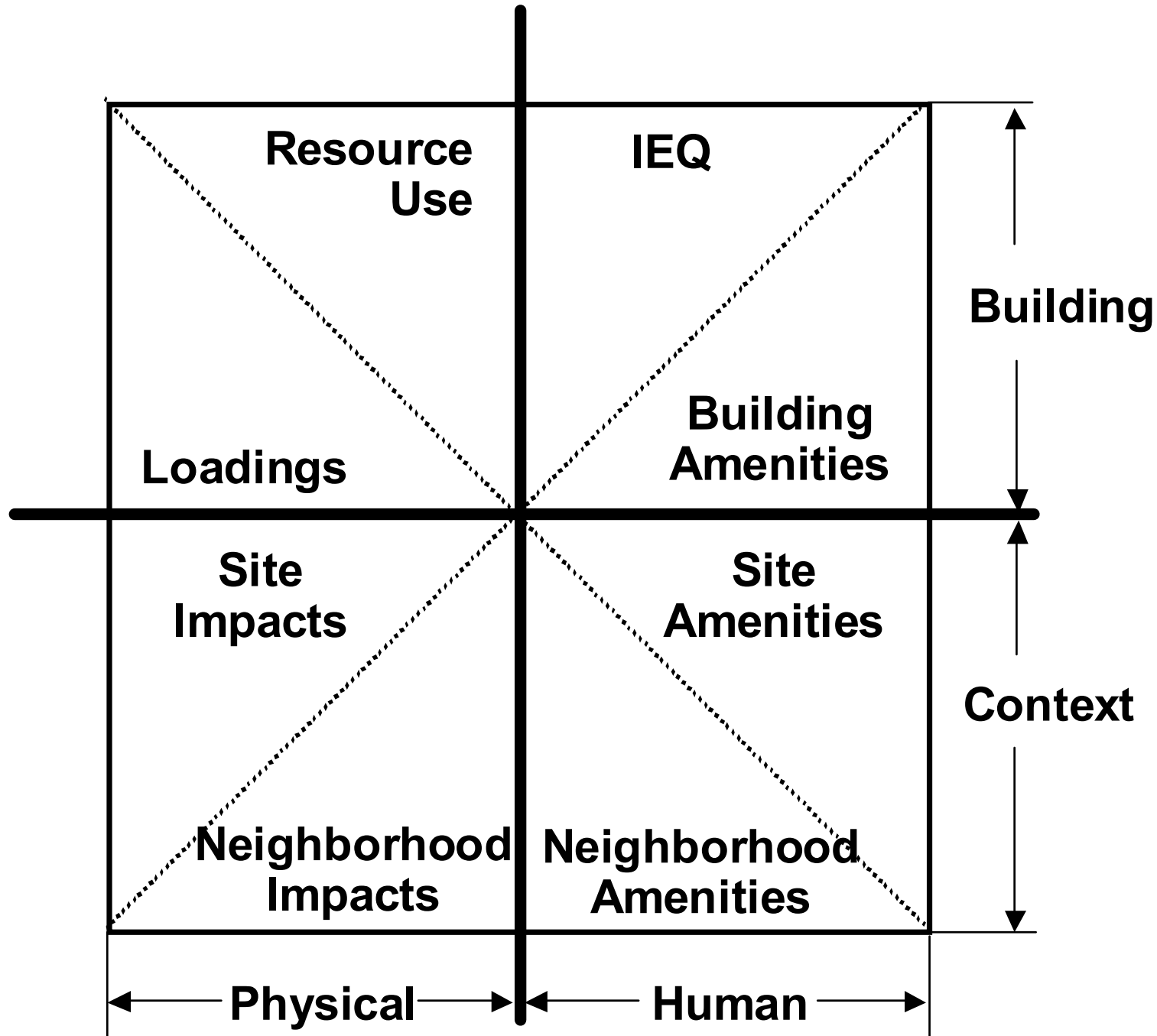
# Physical relations of performance categories



(Source: Comprehensive Environmental Performance Assessment Scheme for Buildings (CEPAS))

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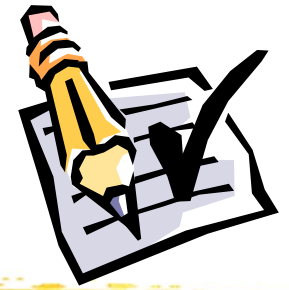
# Concept of environmental performance categories



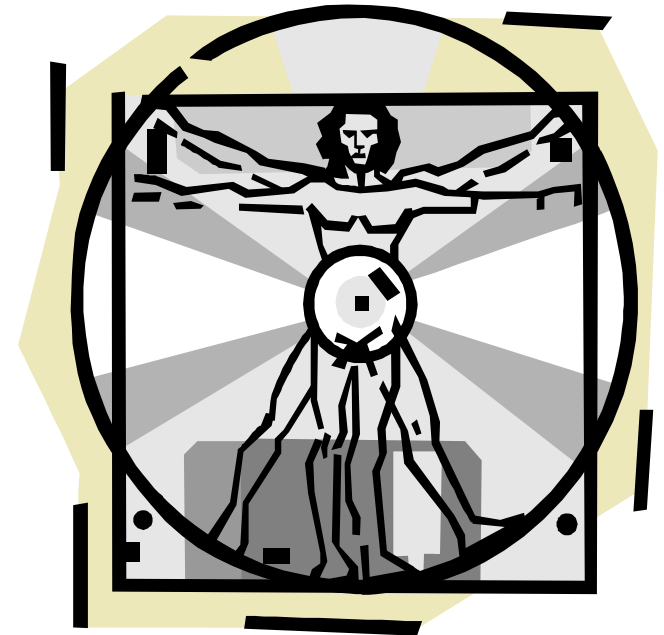
(Source: Comprehensive Environmental Performance Assessment Scheme for Buildings (CEPAS))

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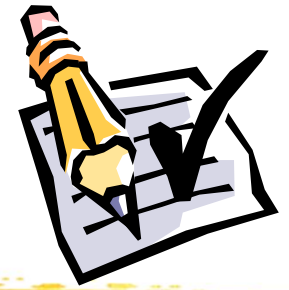
# Assessment of performance



- Scope/Scale of the evaluation
  - Building products
  - Building processes
  - Structural members/elements
  - Building systems
  - Single buildings
  - Groups of buildings
    - District, urban, regional & city
- Building types: new, existing & refurbished



# Assessment of performance

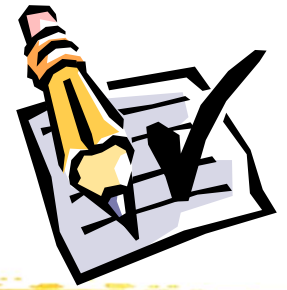


- Methods to assess the performance
  - Component by component method
    - Simple to understand and easy to implement
    - Such as HK building energy codes (prescriptive)
  - Whole building performance method
    - In kWh/m<sup>2</sup>/year or energy cost budget
    - Flexible but complicated in compliance
    - Such as HK's performance-based building energy code



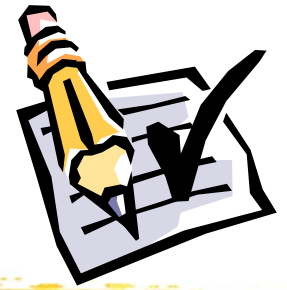


# Assessment of performance



- Energy performance
  - Not well-defined, every building is unique
  - Energy consumption as index (e.g. **kWh/m<sup>2</sup>/year**)
  - For the whole building or its components
- Other performance indices
  - Thermal performance - cooling and heating
  - **Environmental performance** - cover all other environmental impacts

# Assessment of performance



- Building energy performance depends on:
  - 1) Environmental requirements of occupants
    - Thermal comfort, ventilation, and lighting conditions
  - 2) Design of building fabric
    - Architectural design, building envelope
  - 3) Energy-consuming building services systems
    - e.g. air-conditioning, lighting
  - 4) Activity and occupancy patterns
    - Behaviour of occupants and operators



**“What is  
green  
building?”**



An example of green building in Hong Kong ?!

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



Cologne

Building  
+  
Green

Toronto



Green building is NOT just adding a green outlook

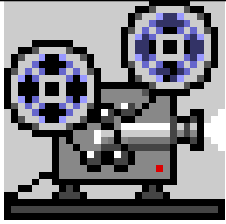


# Green/sustainable building



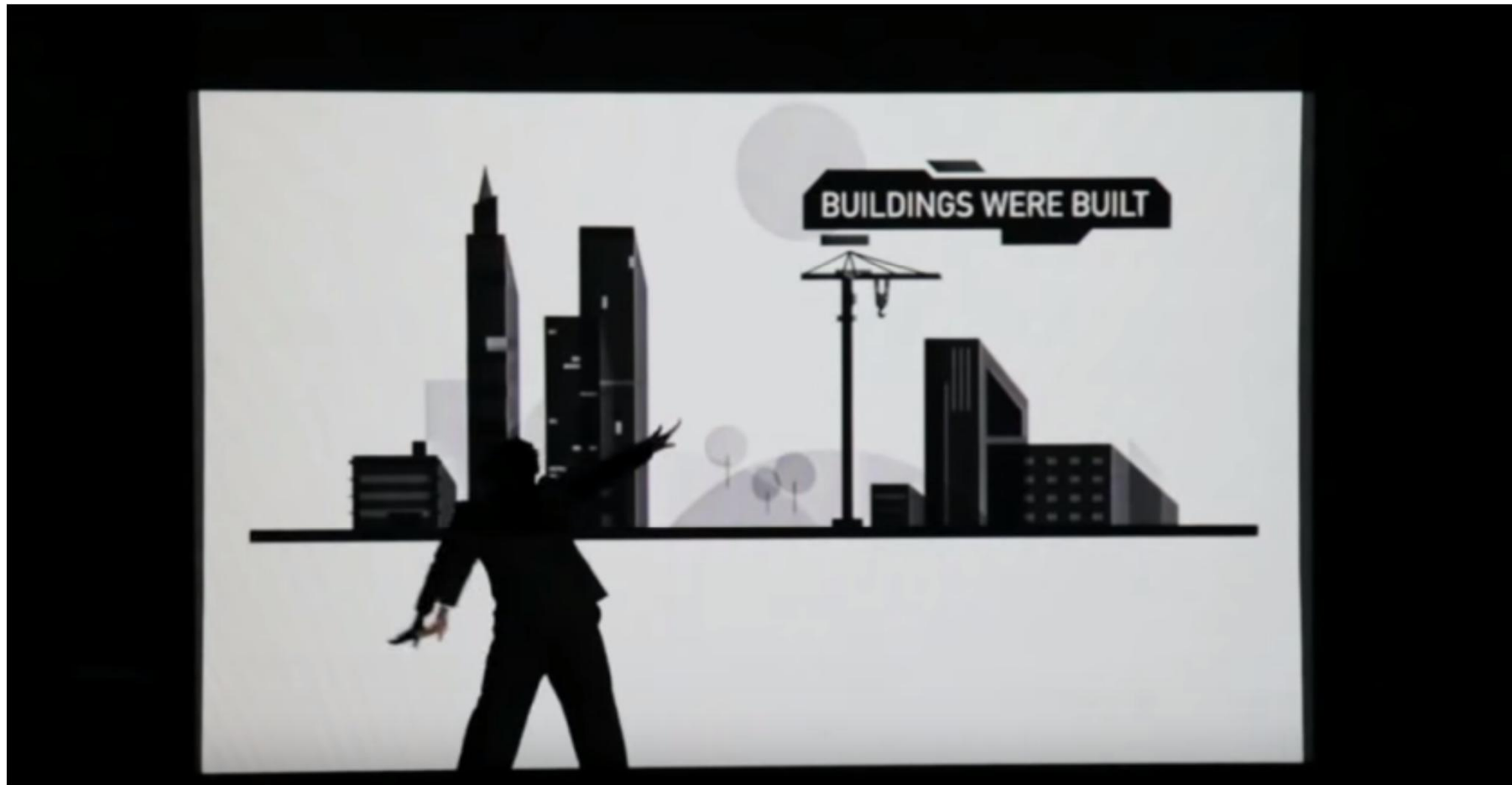
- A loosely defined collection of land-use, building design, and construction strategies that reduces the **environmental impacts**
- The term “green” is extremely wide ranging, encompassing many viewpoints and open to broad interpretation
  - Debate around green building/architecture
  - Complexity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





## Green Building Evolution (3:47)

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



WORLD  
GREEN  
BUILDING  
COUNCIL

[www.worldgbc.org](http://www.worldgbc.org)

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

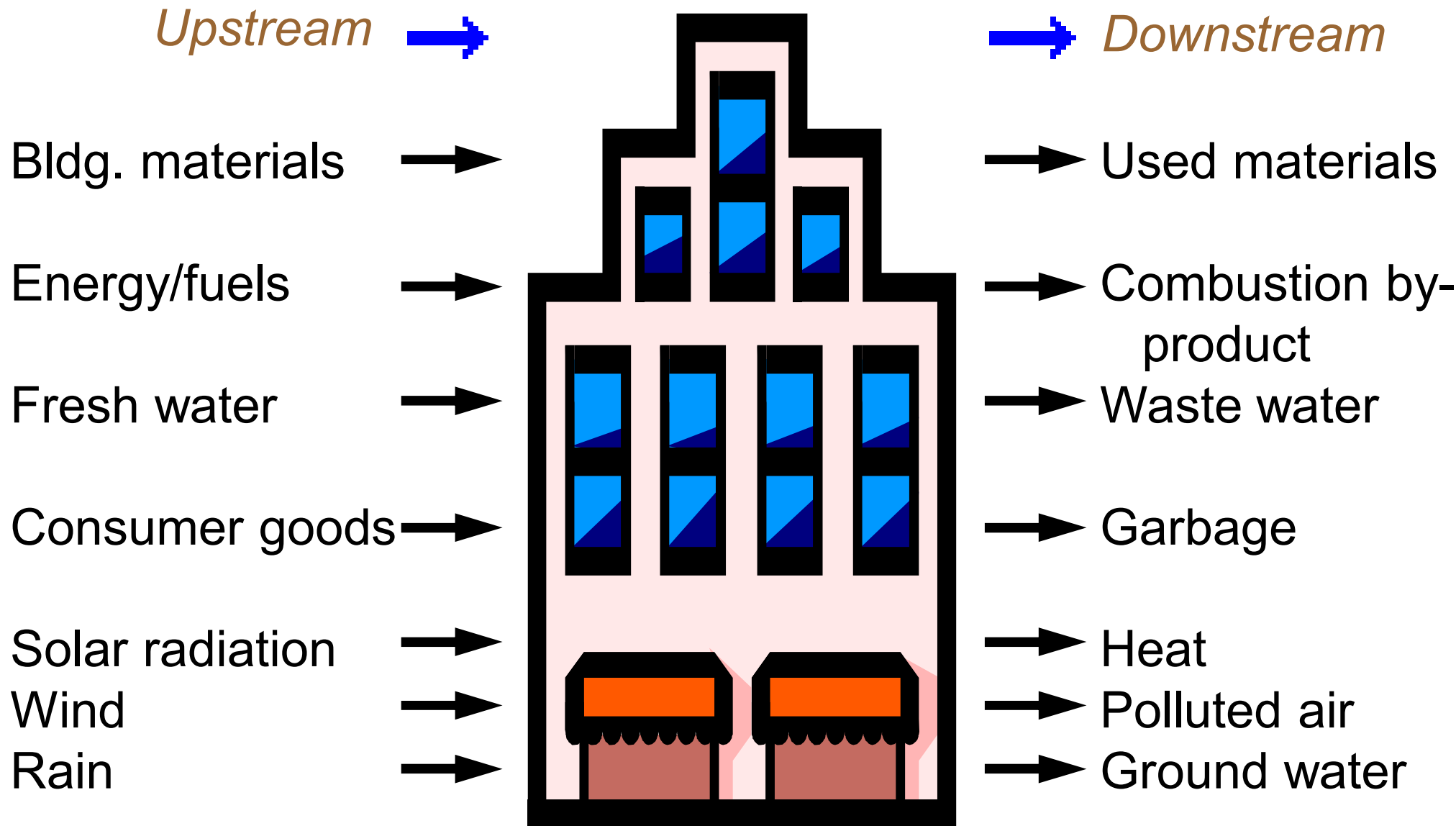
See also: World Sustainable Built Environment Conference 2017, Hong Kong

<http://wsbe17hongkong.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



Resource and material flow in the building ecosystem



# Green/sustainable building



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



# Green/sustainable building



- **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



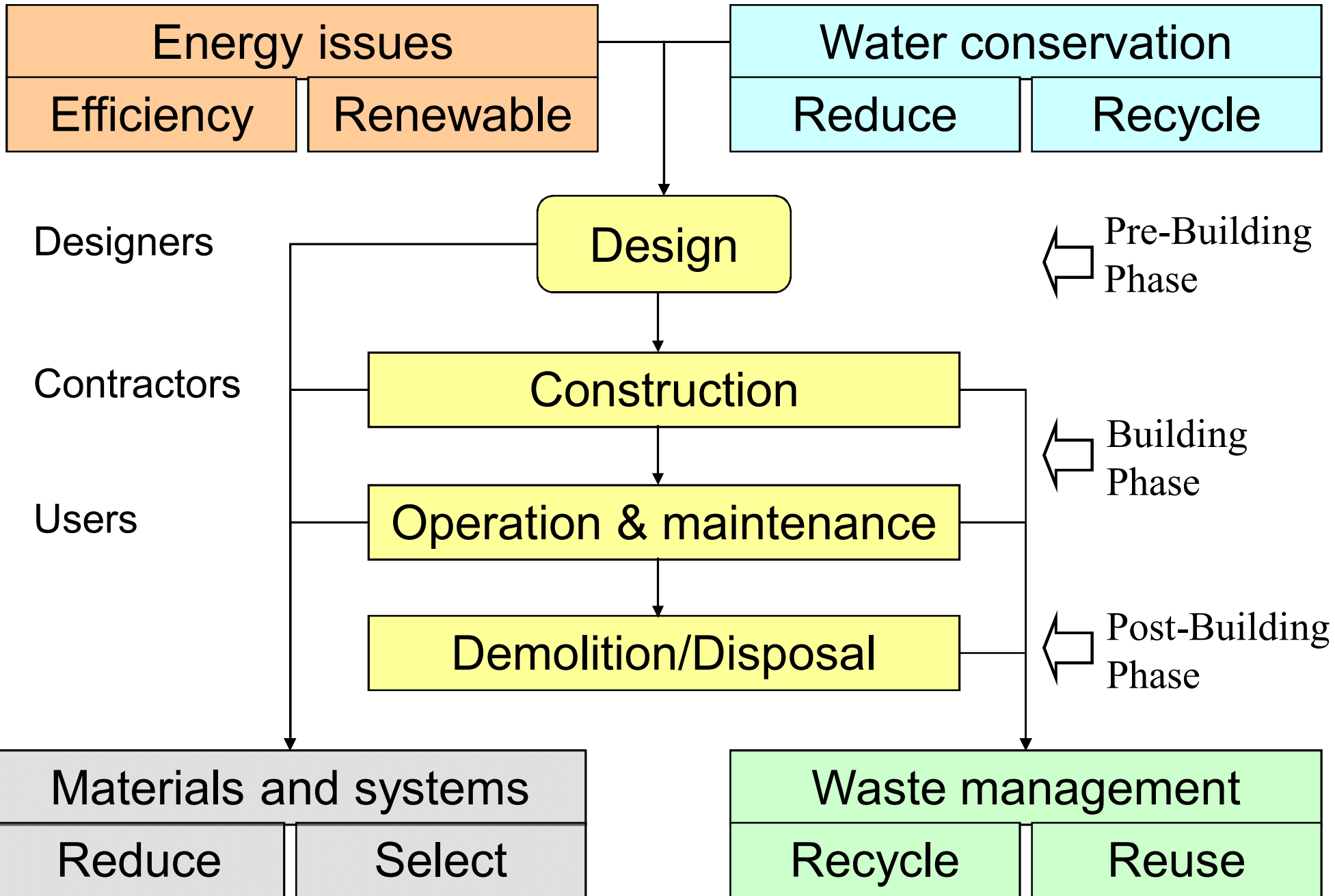
- **Sustainable Building** [HKGBC]



- 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

- **Sustainable Construction** [BSRIA]

- Is the creation and management of healthy buildings based upon resource efficient and ecological principles



Building life cycle and sustainable construction

# Green/sustainable building

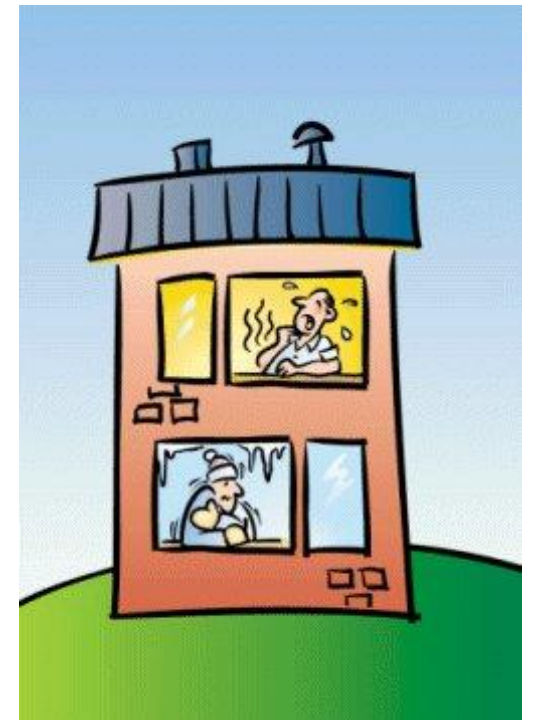


- Principles of sustainable building design
  - Optimize site potential
  - Optimize energy use
  - Protect and conserve water
  - Optimize building space and material use
  - Enhance indoor environmental quality (IEQ)
  - Optimize operational and maintenance practices
    - “If it is not maintainable, it is not sustainable”
    - Also, sustainable retrofits and adaptability

# Assessment methods



- 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



# Assessment methods



- Assessment process
  - Examine the performance of a building or its sub-system against a declared set of criteria
  - Usually voluntary (aim to stimulate the market)
- 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



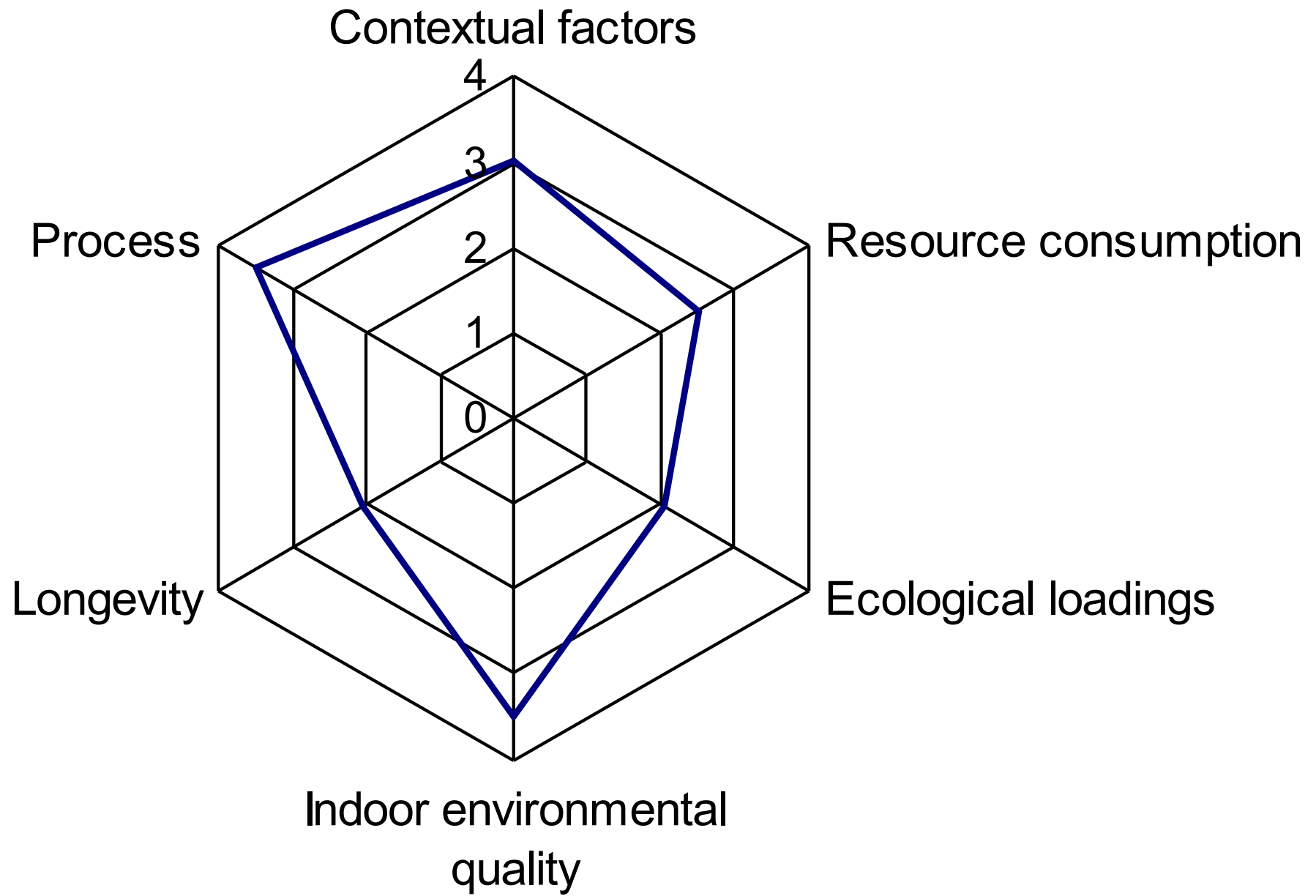
# Assessment methods



- 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

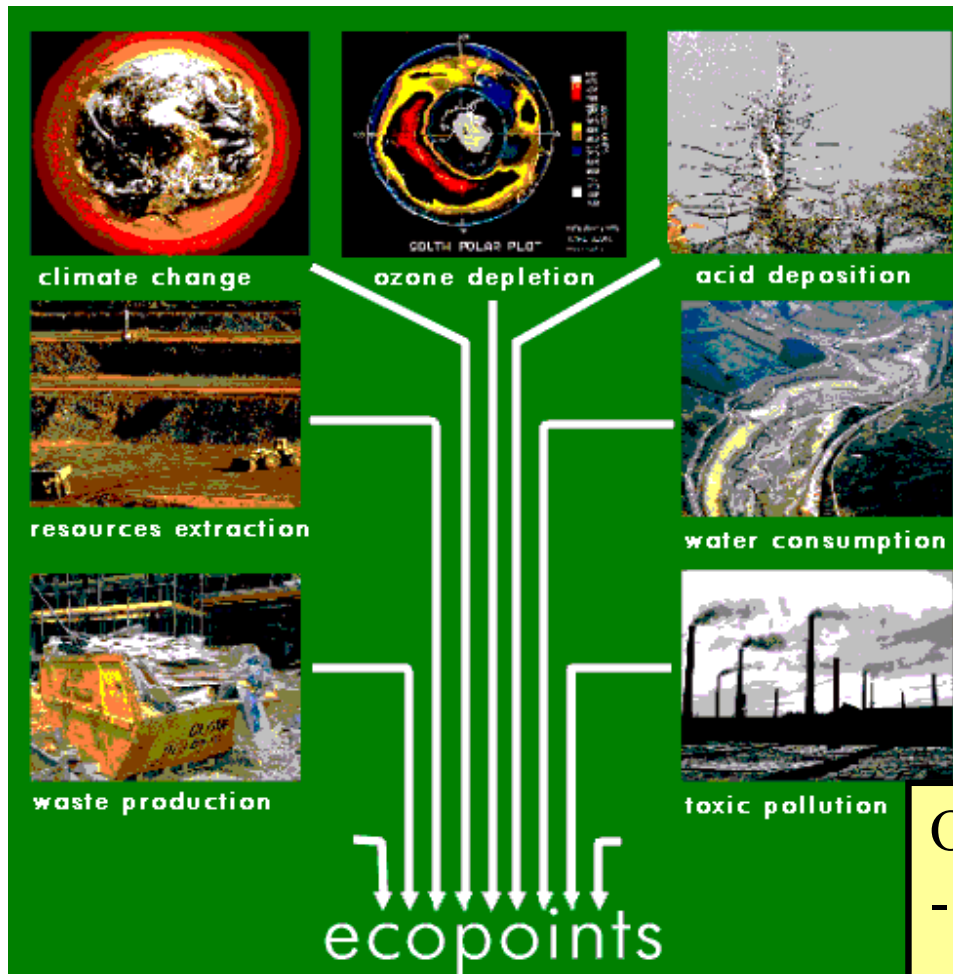


# How to visualize assessment results?



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<sup>3</sup> 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

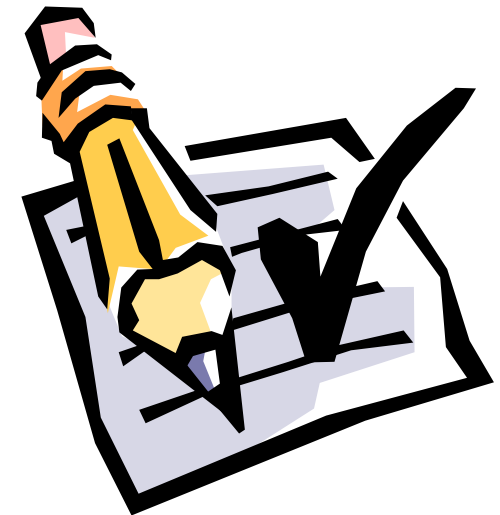


(Source: UK BRE)

# Assessment methods



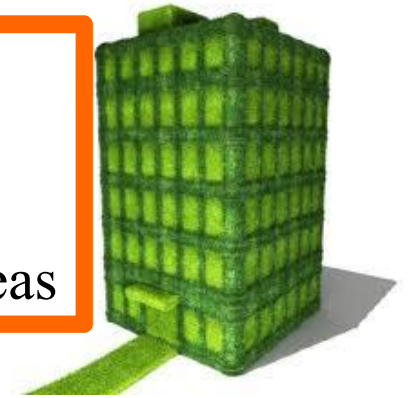
- Common approaches
  - Checklists or forms
  - Computer-based methods
    - Spreadsheet or computer programs
- Models used
  - Environment model
  - Product model
  - Life cycle model
- Data required: from simple to very detailed



# Assessment methods



- Three ways to evaluate green buildings:
  - 1. Single attribute
    - Such as energy efficiency, alternative energy, recycled green materials/products
  - 2. Multiple attribute
    - Green building rating/assessment systems
      - Multi-criteria standard, points earned in various areas
  - 3. Life cycle assessment (LCA)
    - Full and quantitative accounting of environmental impacts



# Life cycle assessment (LCA) of a construction product

## Product

- Raw material supply
- Transportation
- Manufacturing

## Construction

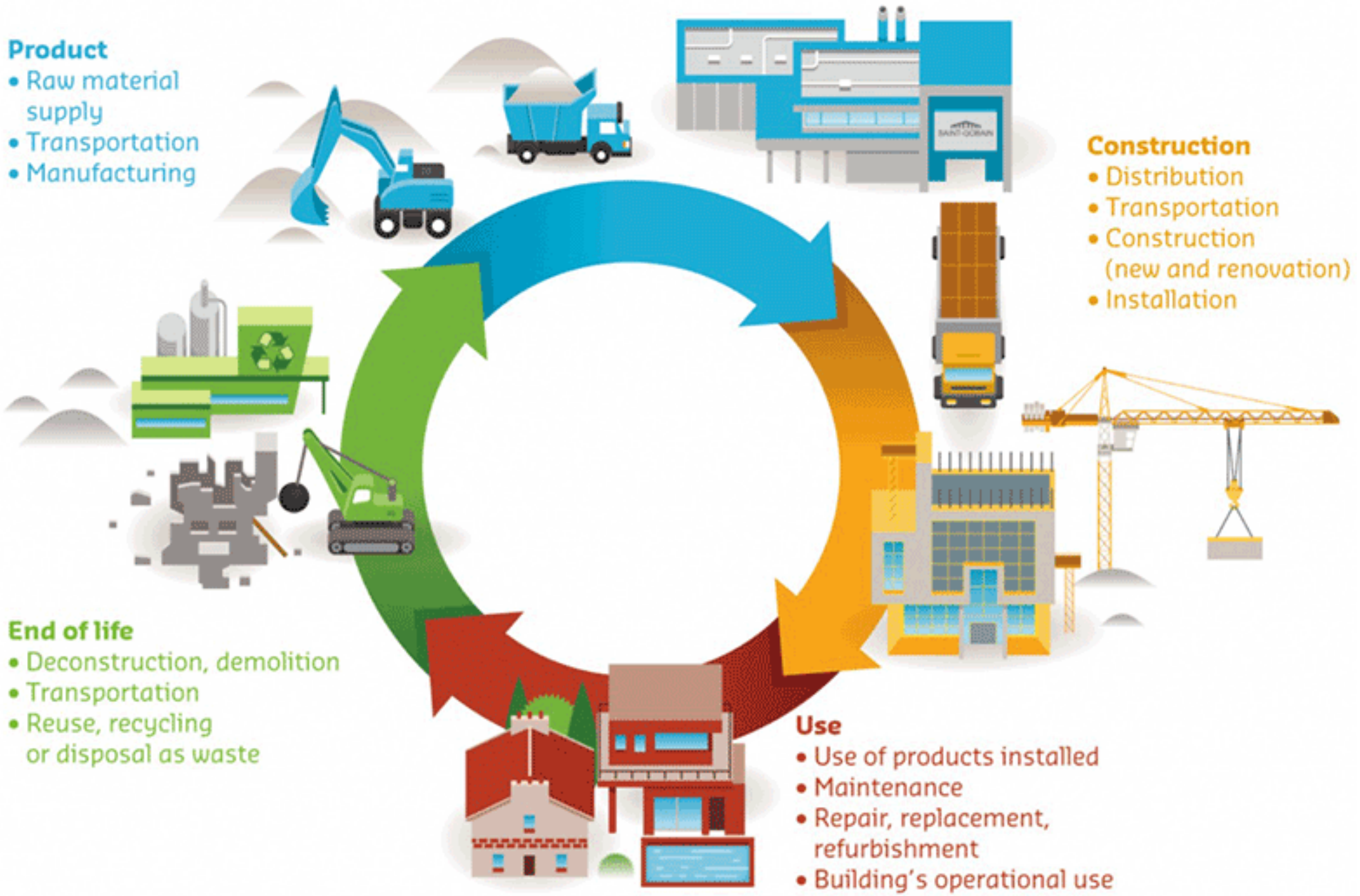
- Distribution
- Transportation
- Construction (new and renovation)
- Installation

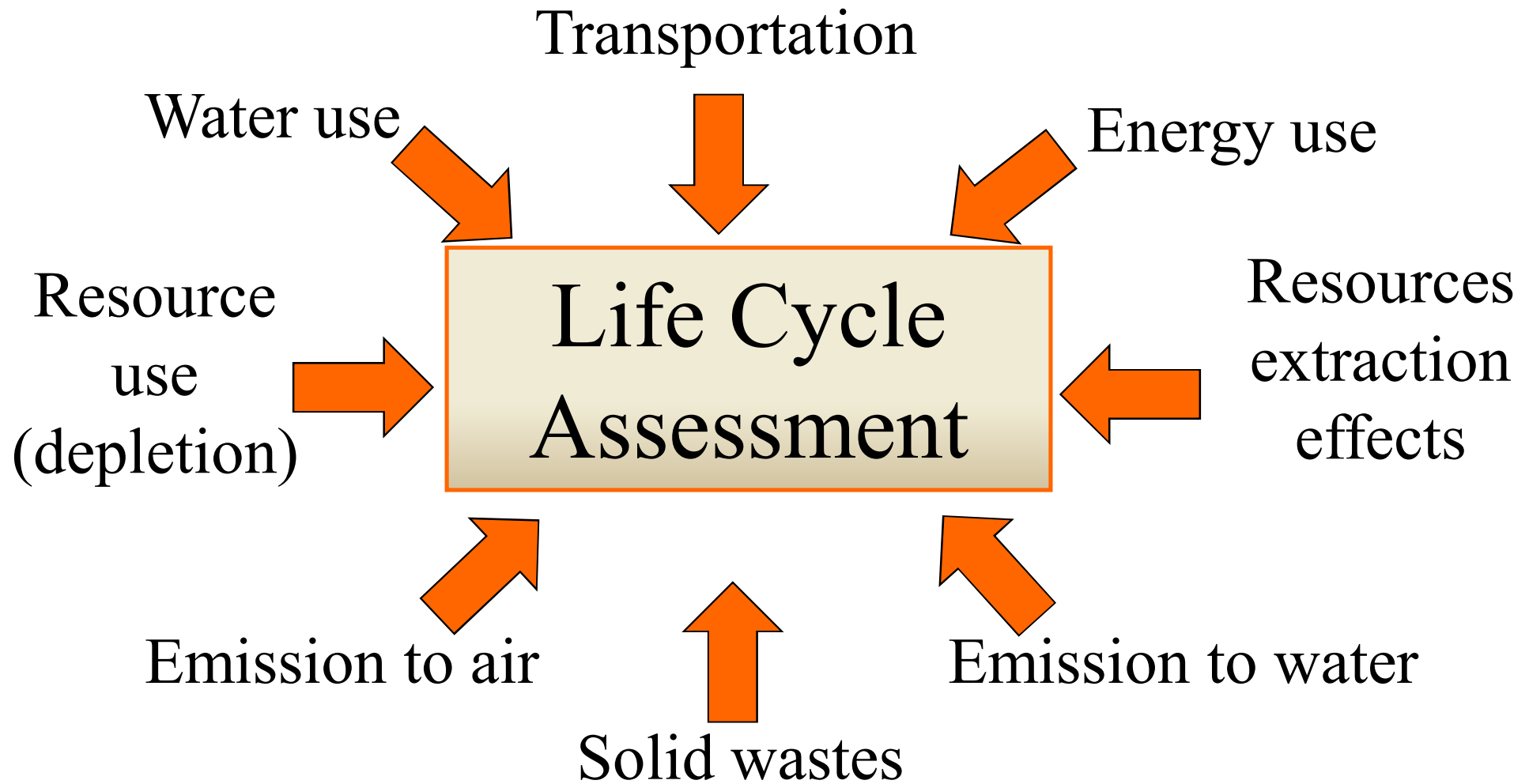
## End of life

- Deconstruction, demolition
- Transportation
- Reuse, recycling or disposal as waste

## Use

- Use of products installed
- Maintenance
- Repair, replacement, refurbishment
- Building's operational use





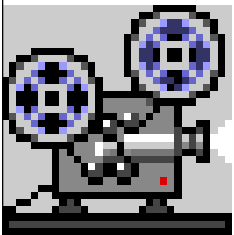
*LCA: a methodology for assessing the life cycle environmental performance of products and processes*





# Further reading

- Green building – Wikipedia
  - [http://en.wikipedia.org/wiki/Green\\_building](http://en.wikipedia.org/wiki/Green_building)
- Sustainable (Whole Building Design Guide)
  - <http://www.wbdg.org/design-objectives/sustainable>
- Video:
  - A Tale of Two Futures: Sustainable Buildings or Unsustainable Climate Change (3:22)  
<http://youtu.be/3TioZ2sVL-E>







# Examples of good practice

- Design of **new buildings**
  - MCMC Green Building (Malaysia) (5:04)
    - <http://youtu.be/mHq-oI8UijQ>
- Operation & maintenance of **existing buildings**
  - Taipei 101: Tallest green building (3:43)
    - <http://youtu.be/b7ShsogLZ7I>
  - Empire State Building: Leadership in American Progress in Sustainability (5:49)
    - <http://youtu.be/17i7Q5Dr3PA>

