

Sustainable Building Concepts (I)



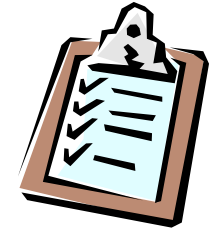
Ir Dr. Sam C. M. Hui

Department of Mechanical Engineering

The University of Hong Kong

E-mail: cmhui@hku.hk

Contents



- Sustainable development
- Sustainability of green buildings
- Sustainable built environment
- Why going green?
- Basic principles



What is

A photograph of two white swans in a pond, facing each other with their heads tilted towards the center. The swans have long, curved necks and bright orange beaks. The background is a blurred green landscape. The text 'What is Sustainable Development?' is overlaid on the image in a bold, blue font. The word 'Sustainable' is on the top line, and 'Development?' is on the bottom line, both centered within a semi-transparent yellow rectangular box.

**Sustainable
Development?**



OUR COMMON FUTURE

THE WORLD COMMISSION
ON ENVIRONMENT
AND DEVELOPMENT

Have you heard of this
report before?

The Brundtland Report
defines
“Sustainable Development”



Full text of the report:

<http://www.un-documents.net/wced-ocf.htm>



Sustainable development

- The Brundtland Report (*Our Common Future*)
 - “...is development which meets the **needs of the present** without compromising the ability of **future generation** to meet their own needs.” – World Commission on Environment and Development.
- Two important concepts 「無後為大」 – 孔子
 - Needs – maintain an acceptable life standard
 - Limits – within the carrying capacity of supporting ecosystems and resource base

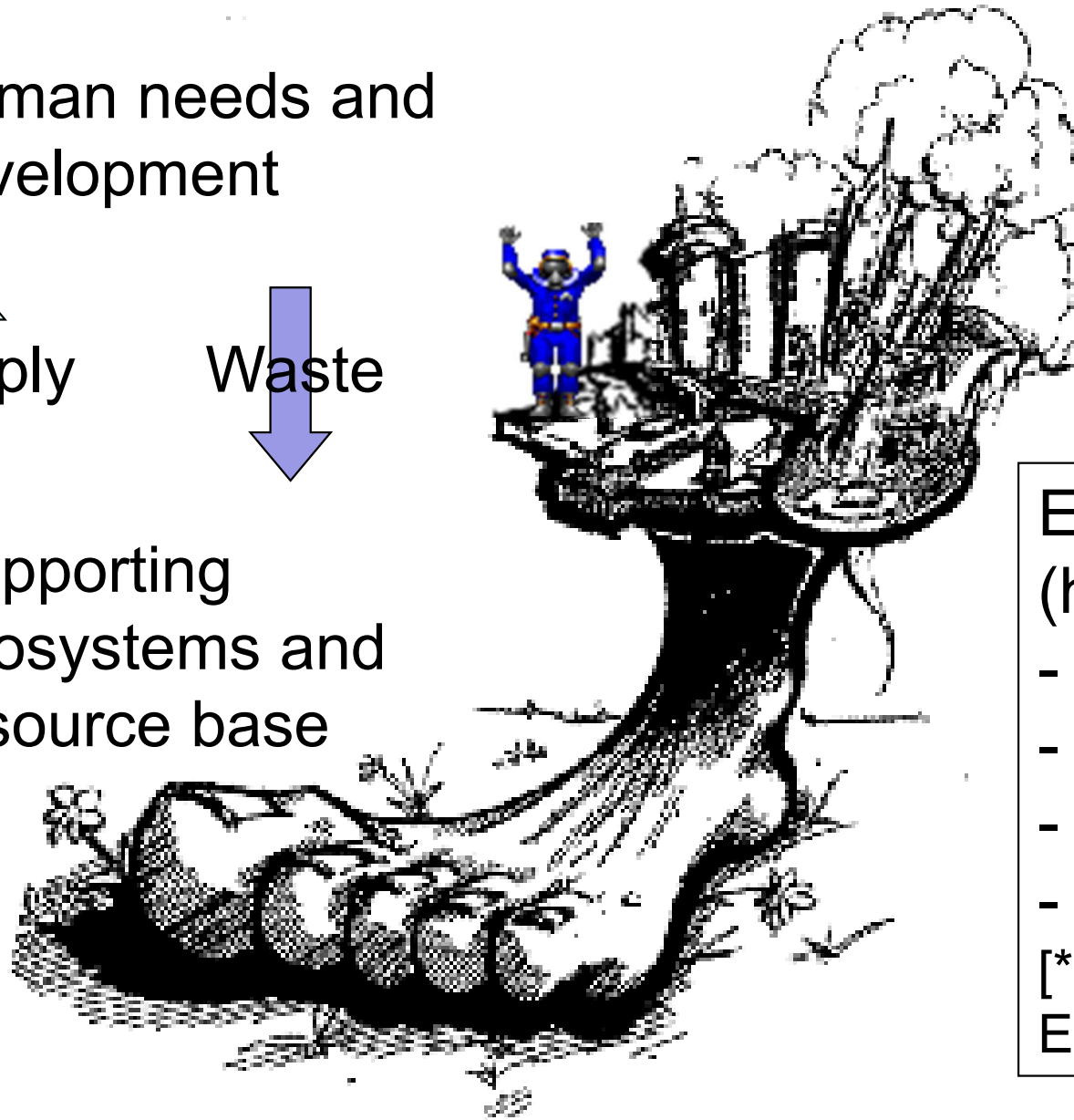
Carrying capacity and ecological footprint

Human needs and development

Supply

Waste

Supporting ecosystems and resource base



Ecological footprint (hectares/person) *:

- world average = 2.3
- USA = 10.3
- **Hong Kong = 6.0**
- China = 1.2

[* Source: Friends of the Earth (HK)]



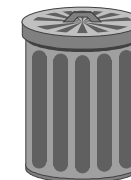
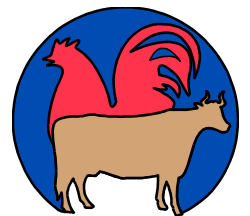
Sustainable development

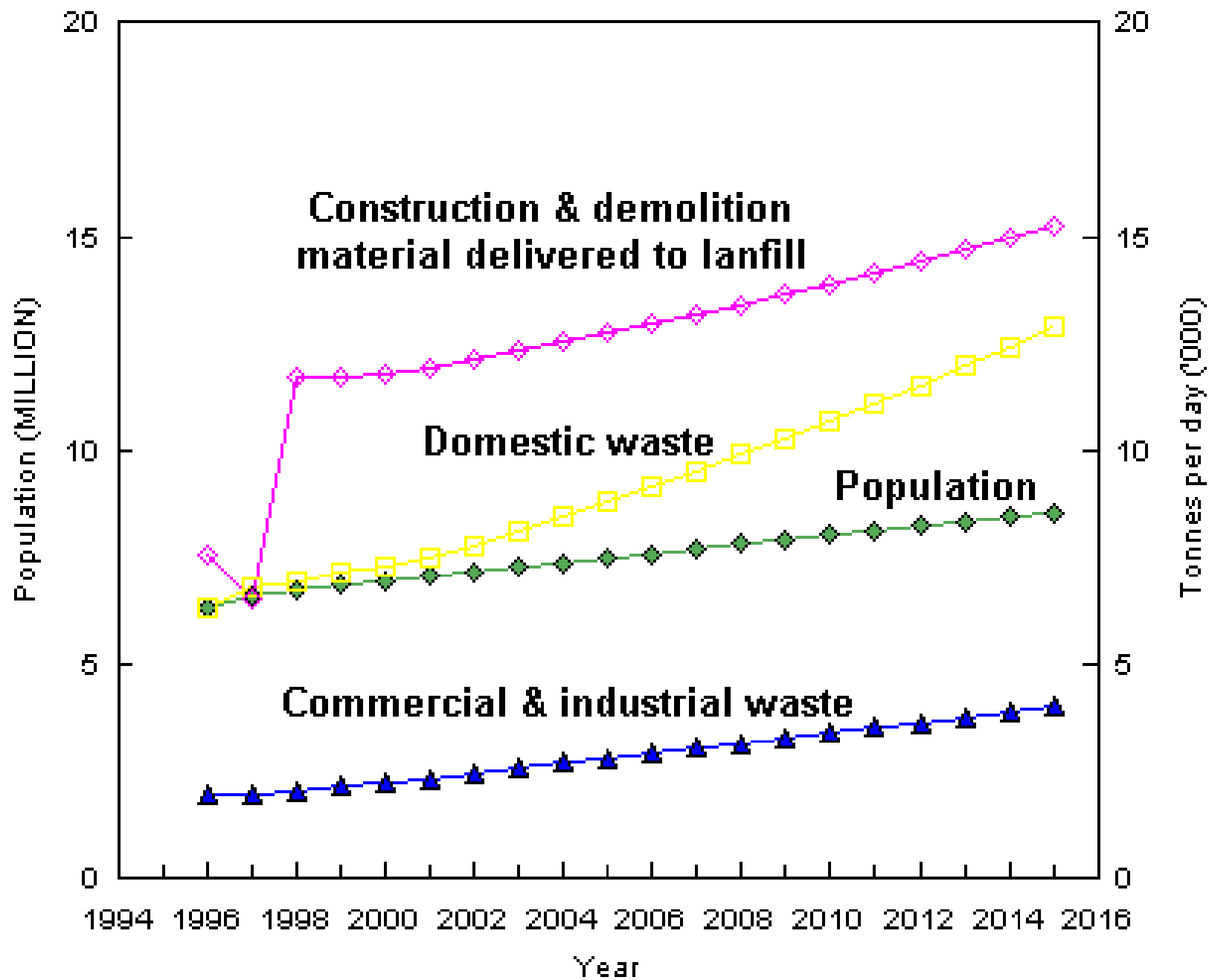
- One day in HK (population = 7 million) [2007]

- Fresh water consumption = 374 litre/person
- Electricity consumption = 17.4 kWh/person

- Food consumption:

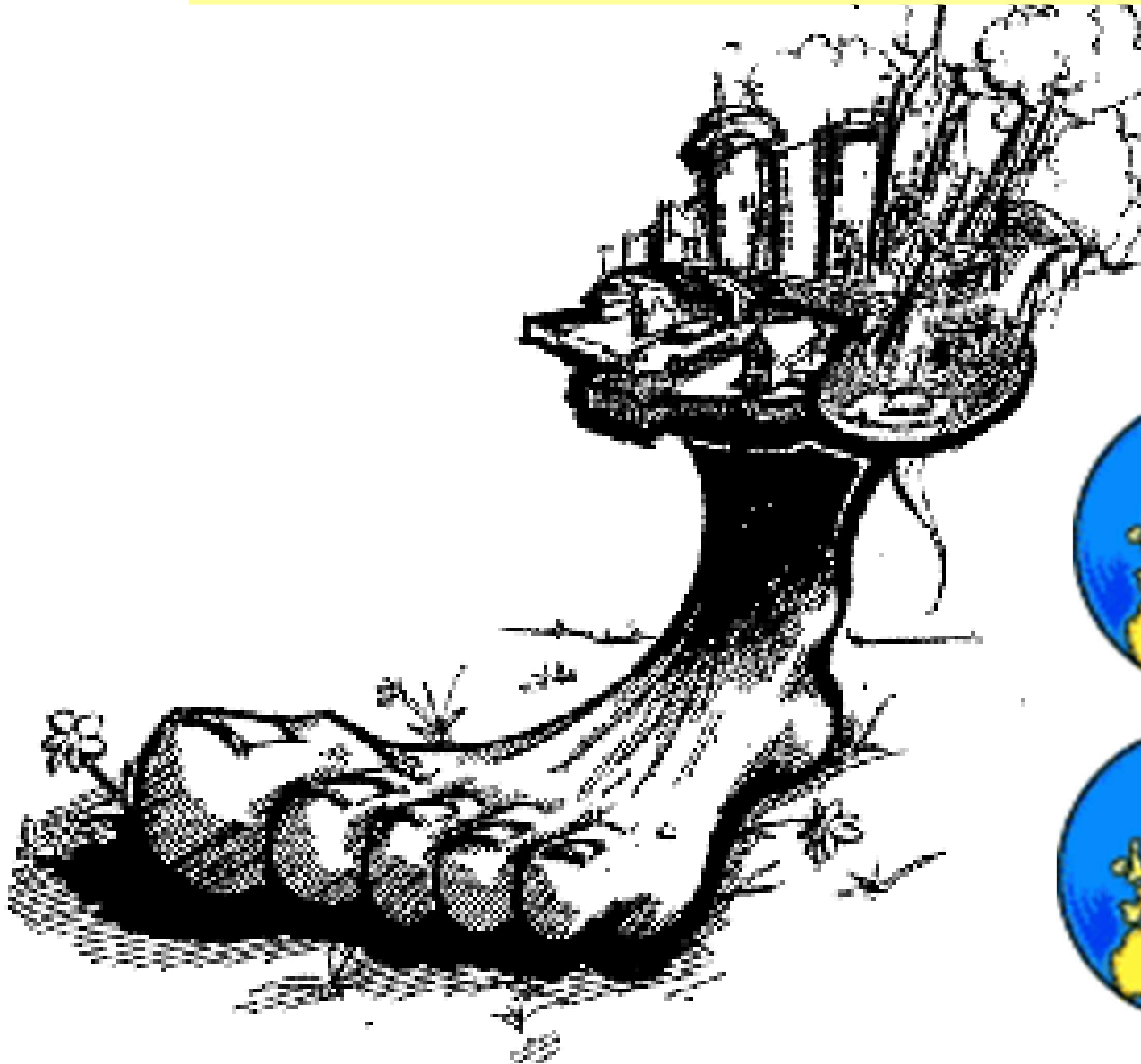
- Vegetables 1,780 tonnes; fruits 1,460 tonnes
- Live pigs 4,860 heads; live cattle 120 heads
- Live poultry 80 tonnes; fresh eggs 230 tonnes
- Freshwater fish 100 tonnes; marine fish 210 tonnes
- Solid waste production = 13,901 tonnes





Projection of waste requiring disposal and population in HK
 (source: Waste Reduction Framework Plan)

Sustain-able Future?



The Factor Four concept*



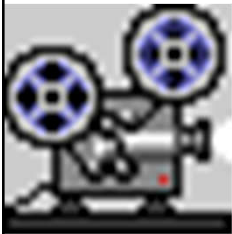
(*See also Factor 4 <http://www.gdrc.org/sustdev/concepts/12-f4.html>)



Sustainable development



- Sustainability (可持續發展, 永續性)
 - The endurance of systems and processes
 - Improves the quality of human life while living within the carrying capacity of supporting eco-systems
- Video Presentation:
 - Sustainability explained through animation (2:00)
<http://youtu.be/B5NiTN0chj0>
 - What is Sustainability? (1:51)
<http://youtu.be/hH109q5kk0k>



Three dimensions of sustainability

Environmental Sustainability

Ecosystem integrity
Carrying capacity
Biodiversity

Environment

環境

Social Sustainability

Cultural Identity
Empowerment
Accessibility
Stability
Equity

Society

社會

Economic Sustainability

Growth
Development
Productivity
Trickle-down

Economy

經濟

Human Well Being





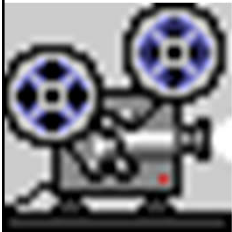
Sustainable development

- Sustainability is about: [Mei Ng, FoE(HK)]
 - System thinking (harmonize human & living)
 - Value judgment (importance of natural capital)
 - Efficiency (resources & eco-efficiency)
 - Fair share (inter- & intra-generational equity)
 - Making informed choices
 - Quality people & quality life
 - Self-reliance (self-help & regeneration)



Sustainable development

- Sustainability is also about green building
(6:18) https://youtu.be/v_dyWaT9g24
 - How can we help preserving the environment and the well-being of their occupants by constructing eco-friendly buildings?
 - What is an eco-building?
- Building design, construction & operation to reduce negative impacts, and create positive impacts on our climate & natural environment



Dimensions of sustainability of green buildings



Application of Sustainability in Buildings

Pre-Design

- Material Selection
- Building Program
- Project Budget
- Team Selection
- Partnering
- Project Schedule
- Laws, Codes & Standards
- Research
- Site Selection

On-Site

- Site Analysis & Assessment
- Site Development & Layout
- Watershed Management & Conservation
- Site Material & Equipment

Design

- Passive Solar Design
- Materials & Specification
- Indoor Air Quality

Construction

- Environmentally Conscious Construction
- Preservation of Features & Vegetation
- Waste Mgmt
- IAQ Issues
- Source Control Practices

O&M

- Maintenance Plans
 - Indoor Quality
 - Energy Efficiency
 - Resource Efficiency
 - Renovation
 - Housekeeping & Custodial Practices
- (O&M: operation and maintenance)

Sustainability of green buildings



- A total plan for sustainability requires (from the Institution of Structural Engineers):
 - Reduction of emission of greenhouse gases
 - More efficient use (and reuse) of resources
 - Minimisation and constructive reuse of waste
 - Reduction of harmful effects from construction activities and building occupation
- Life cycle assessment to evaluate environmental impacts: [cradle to grave](#)

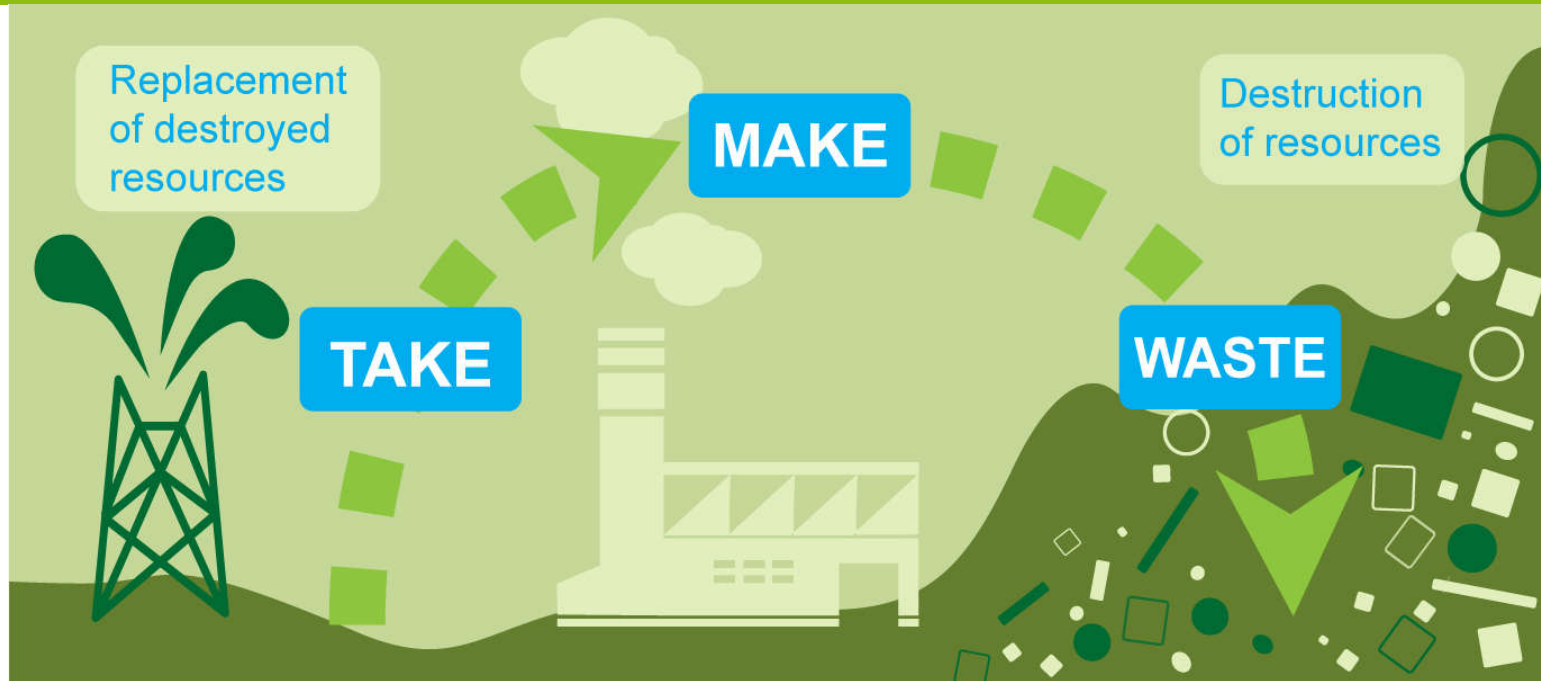
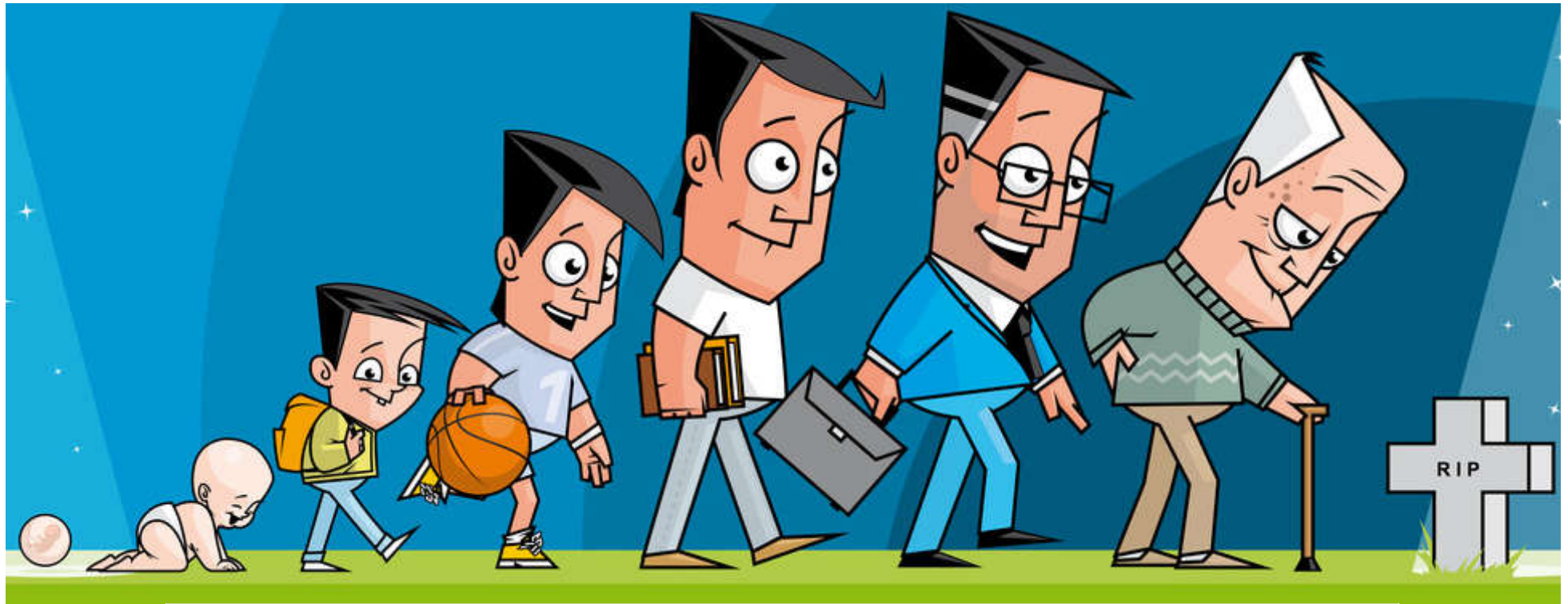
Cradle-to-Grave



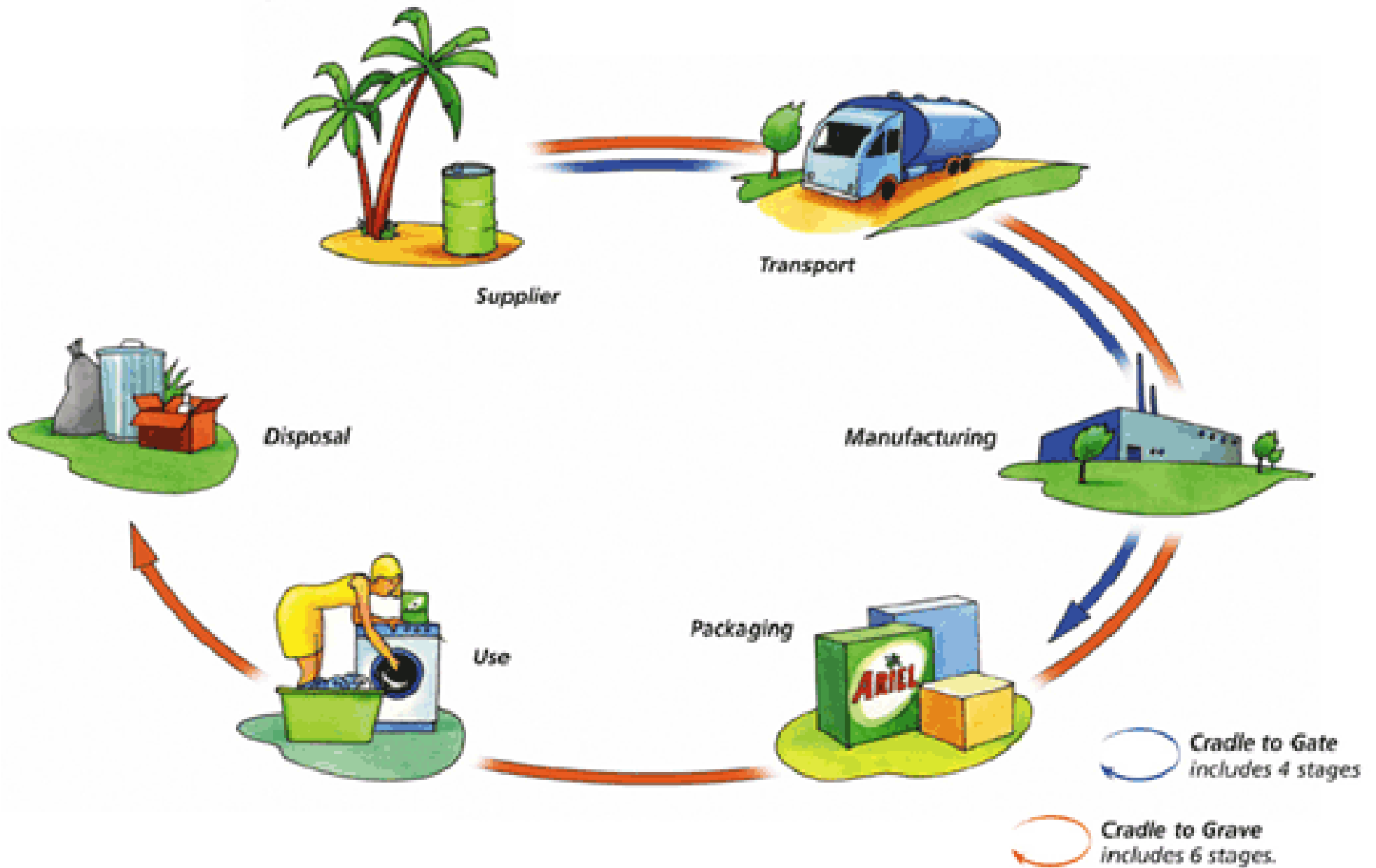
從搖籃到墳墓

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

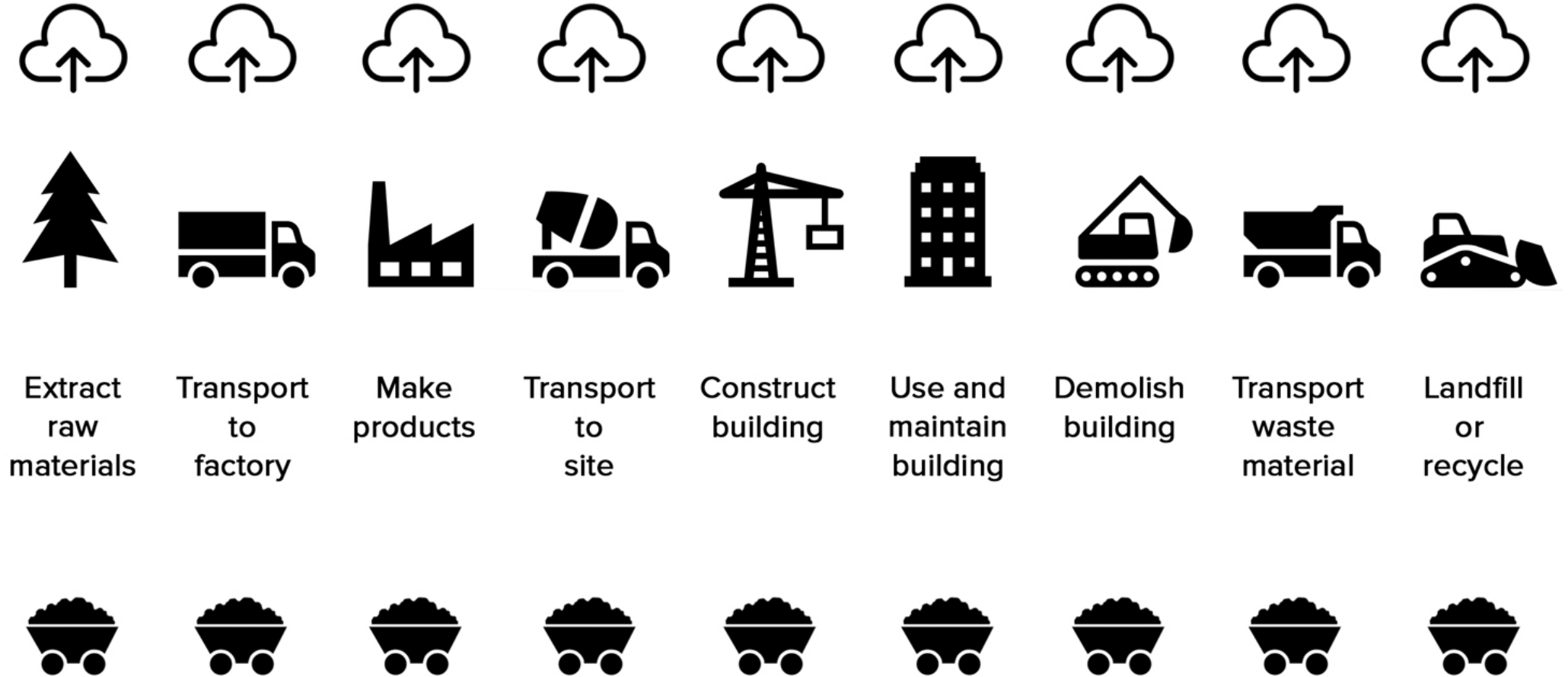
Life cycle design: Cradle to grave (從搖籃到墳墓)



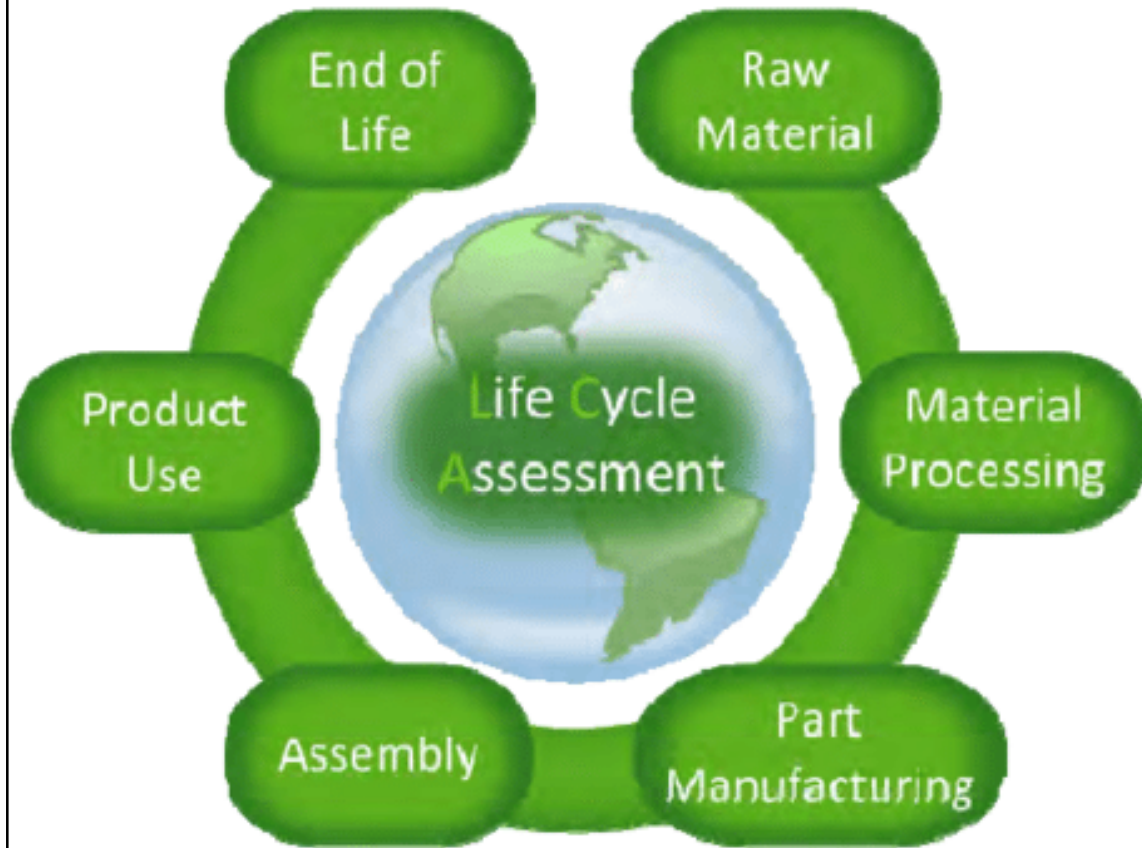
Cradle-to-Gate and Cradle-to-Grave



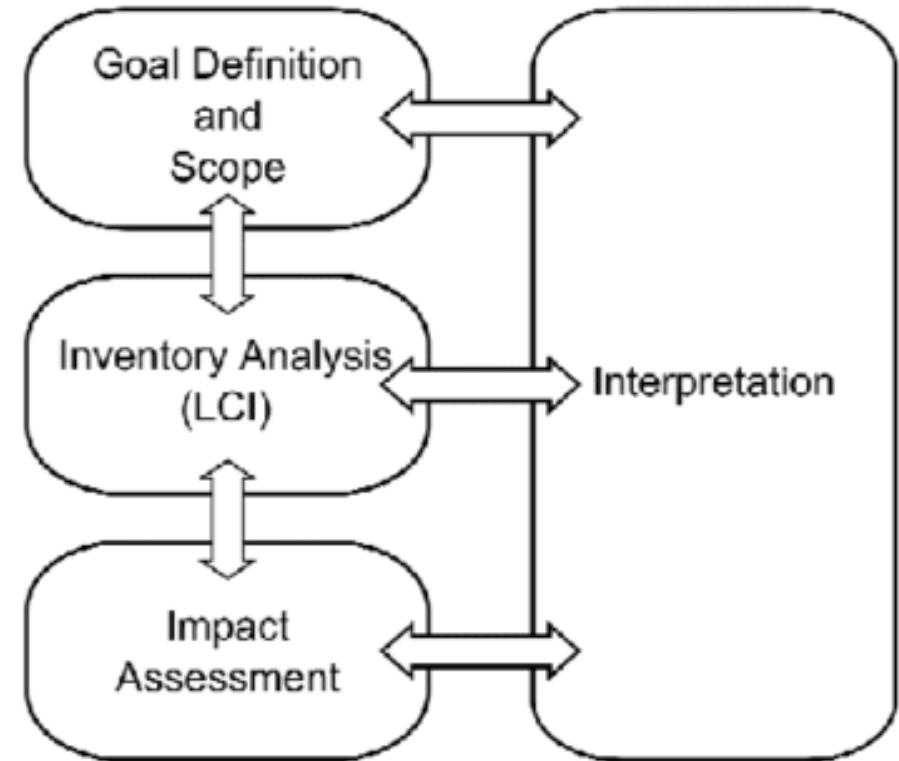
Cradle to grave for building and construction




Cradle-to grave Life Cycle Assessment



Life Cycle Assessment Framework



Sustainable built environment

A satellite photograph of a coastal city, likely Sydney, Australia, showing a dense urban area with a harbor and surrounding green hills. The city is built on a peninsula, with a large body of water to the east and south. The surrounding hills are covered in green vegetation. The harbor area is filled with buildings and infrastructure, including a large stadium-like structure in the center. The water is a deep blue, and there are several ships visible in the harbor.

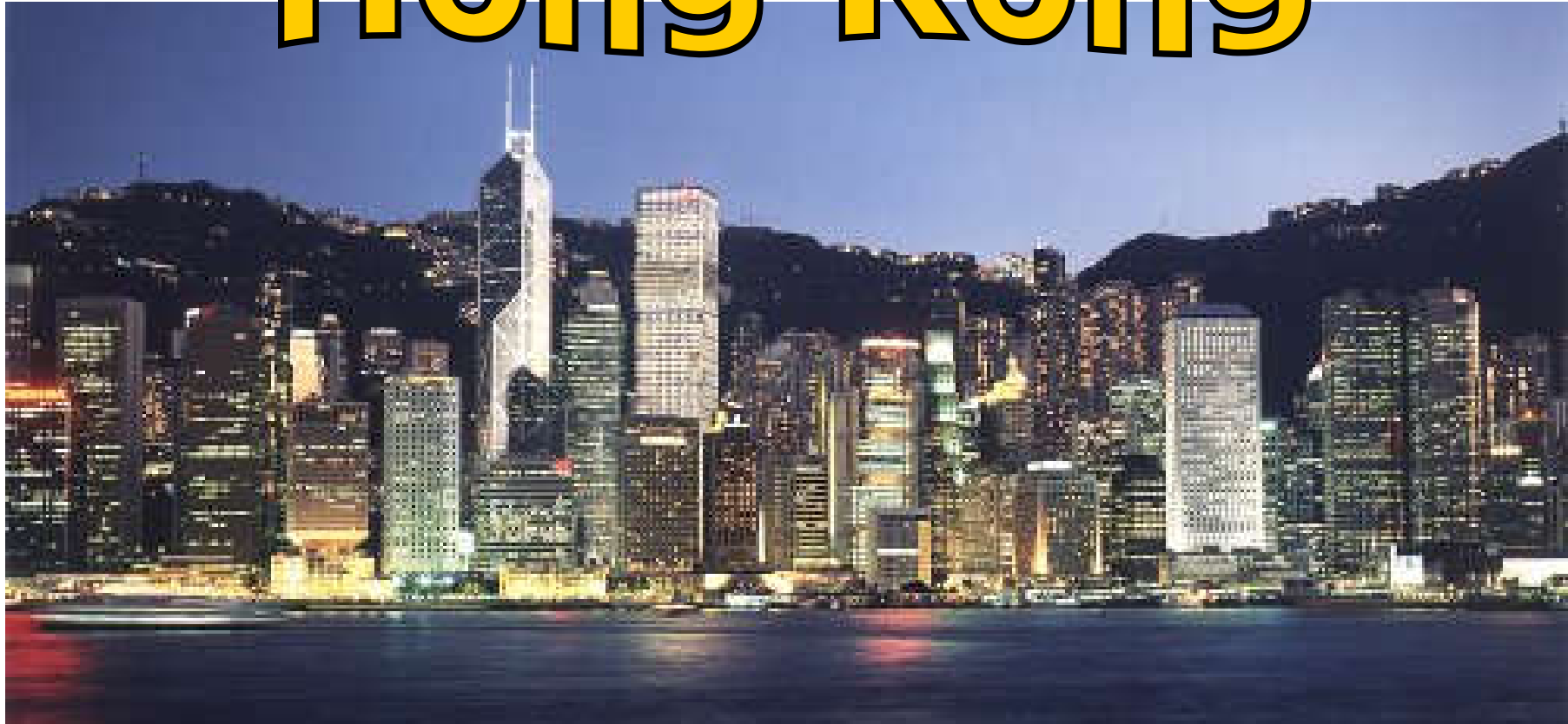
**"We shape our buildings and
thereafter they shape us."
(Winston Churchill)**

Sustainable built environment



- Built environment is everything that has been made by humans to modify the spaces in which we live and work
 - Ranges from the large-scale civic surroundings to the personal places
- Sustainable built environment
 - It is a built environment that is well balanced for the needs of the present and the future from the economic, social and environmental perspectives

Hong Kong



Major characteristics of the built environment in Hong Kong



Hong Kong has been praised as a model of "Vertical City" which surpasses New York



Hong Kong is a city famous for its dynamic lifestyle and vibrancy



Affordable, efficient and comfortable public transport system

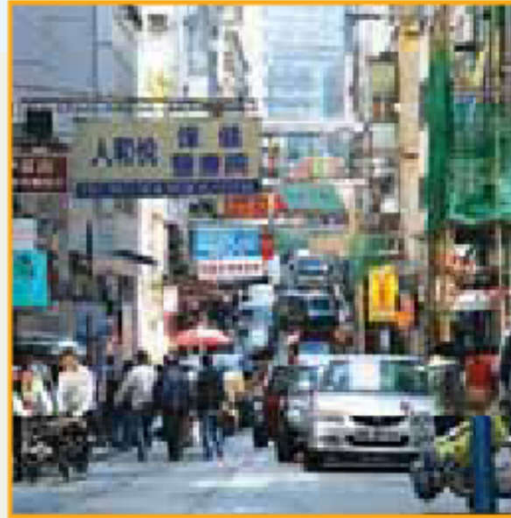


Most people enjoy having their homes, workplaces, schools, and facilities for social and other activities conveniently located and nearby each other

Typical problems of the built environment in Hong Kong



Narrow streets - Limited opportunity for urban greening or social amenity at ground level



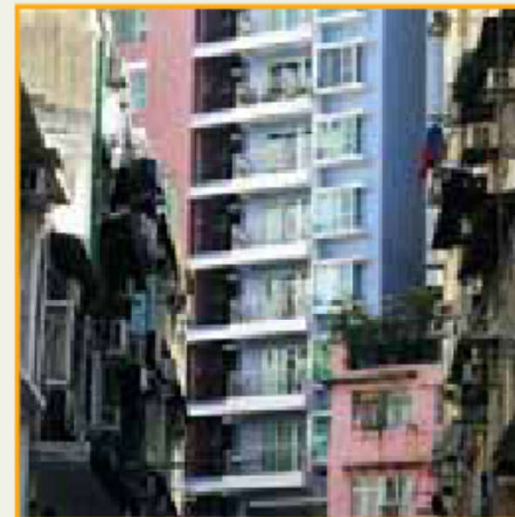
Traffic and pedestrian in conflict



Canyons - narrow streets and pavements, high walls and a poor pedestrian environment



Wall-like barriers causing negative visual impact and reducing air flow



Impact on neighbouring buildings, through overshadowing and glare

Sustainable built environment



- Built environment in HK and green building
 - Video: How high-density, high-rise Hong Kong uses green buildings to help fight climate change (2:23) <https://youtu.be/rqMrzNdyh9A>
 - Article in SCMP (13 Nov 2019) <https://www.scmp.com/presented/lifestyle/topics/building-our-green-future/article/3037555/how-high-density-high-rise>
 - Need for HK to create sustainable eco-friendly environment



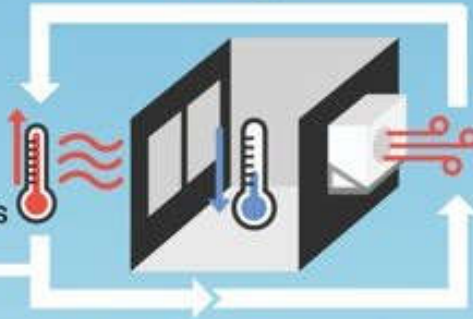
High-density, high-rise built environment in Hong Kong



HK's high-density, high-rise environment creates a 'canyon effect'

The cycle

Hotter surroundings



More warm air released

Air conditioners turned up

Canyon effect

when a street is lined by buildings on both sides creating a canyon-like environment

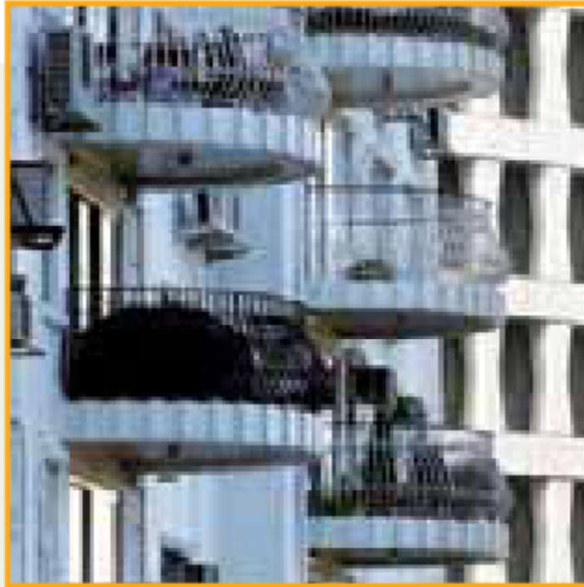


Sustainable built environment



- Related policies and practices in Hong Kong
 - Hong Kong Planning Standards & Guidelines
 - http://www.pland.gov.hk/pland_en/tech_doc/hkpsg/
 - Town planning (by outline zoning plans OZP)
 - Buildings Ordinance (Cap. 123) and the Building (Planning) Regulations
 - Practice Notes for Authorized Persons and Registered Structural Engineers (PNAPs) and Joint Practice Notes (JPNs)
 - Building energy codes

‘Green features’ under the Joint Practice Notes in Hong Kong



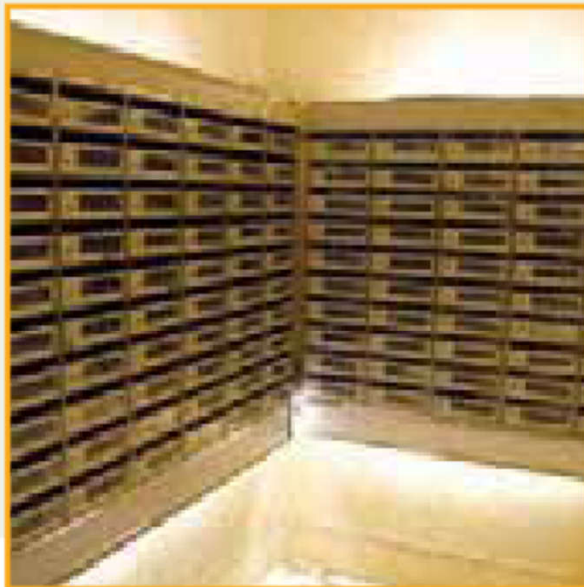
Balconies



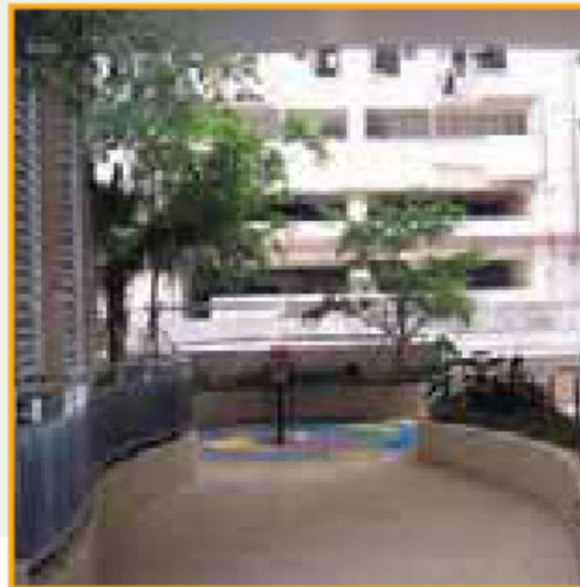
Wider common corridors



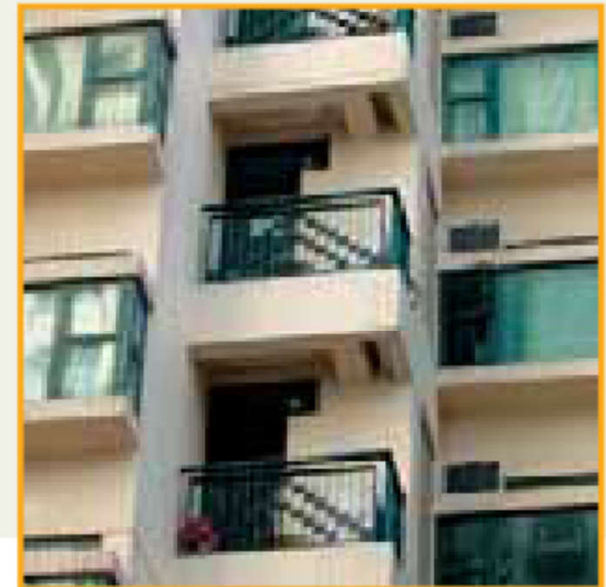
Sky gardens



Mail delivery rooms

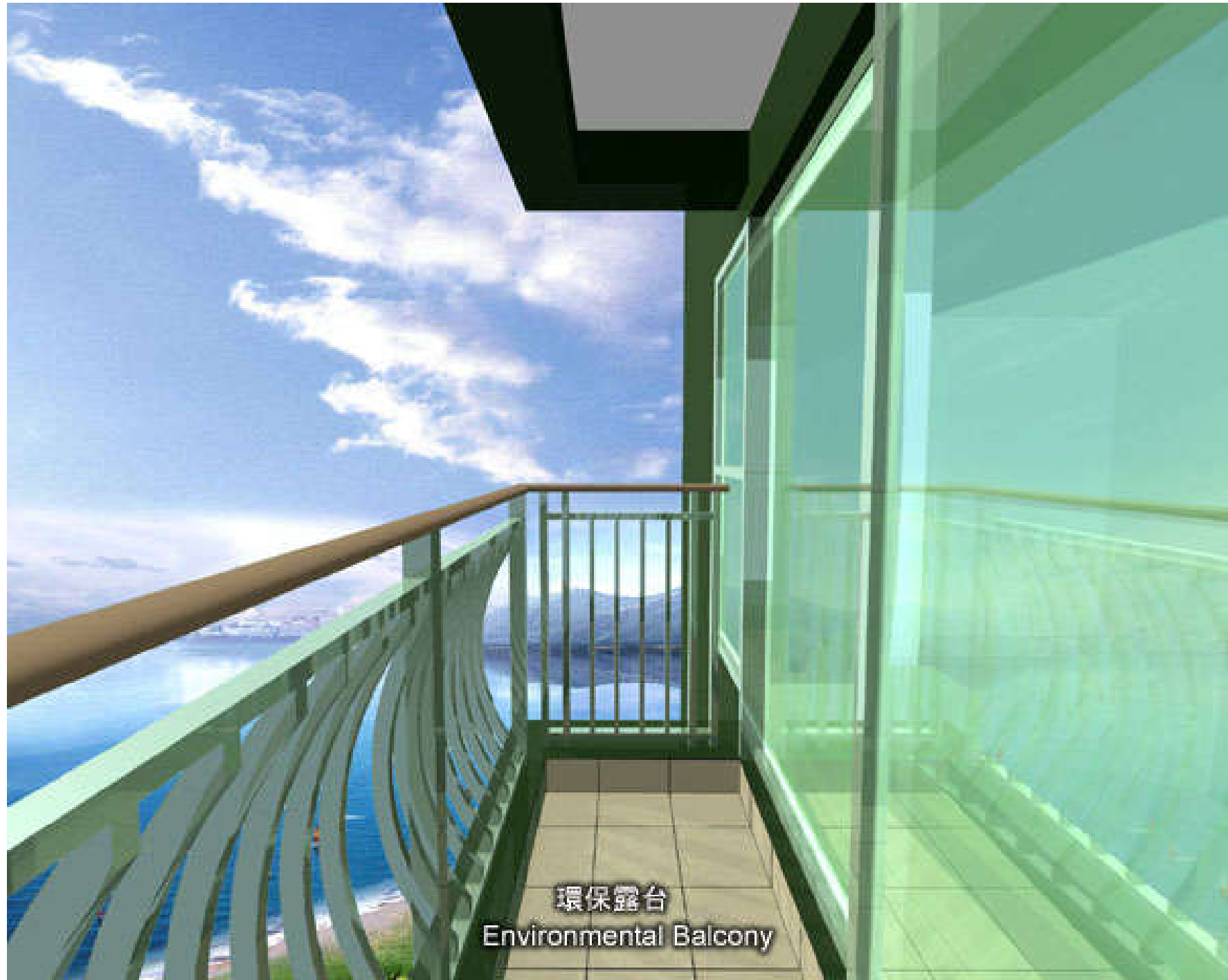


Podium gardens



Utility platforms

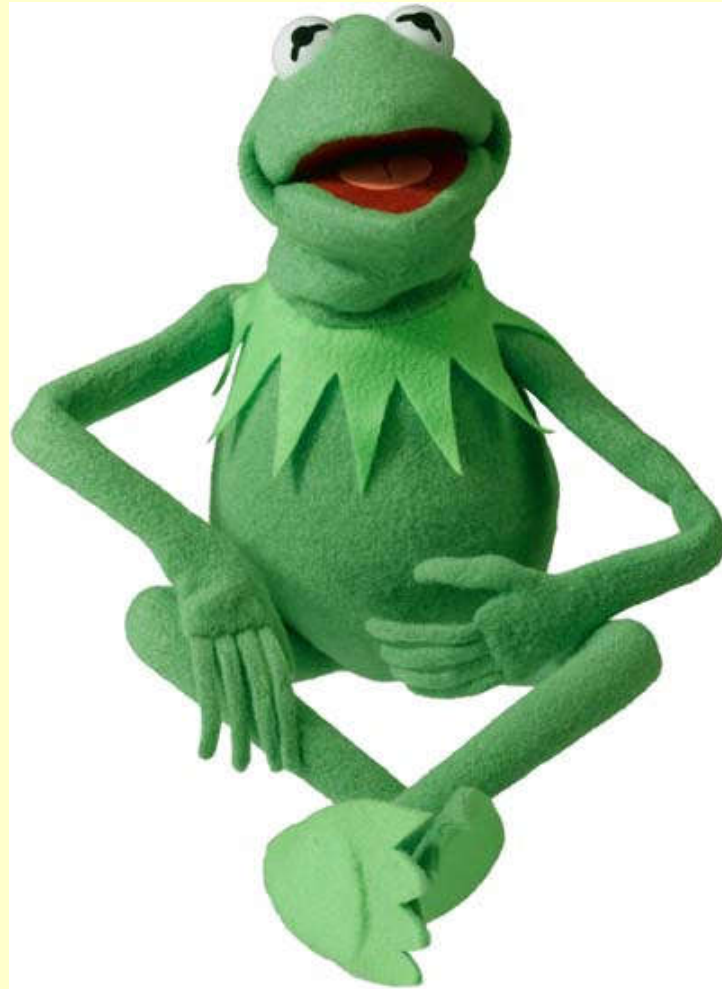
Environmental balcony 環保露台



Examples of green building design features/issues

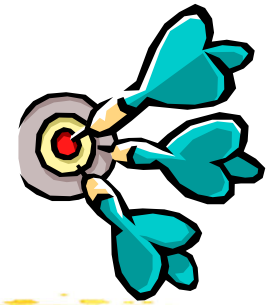


"It's not easy being green." -- Kermit the Frog, 1972.



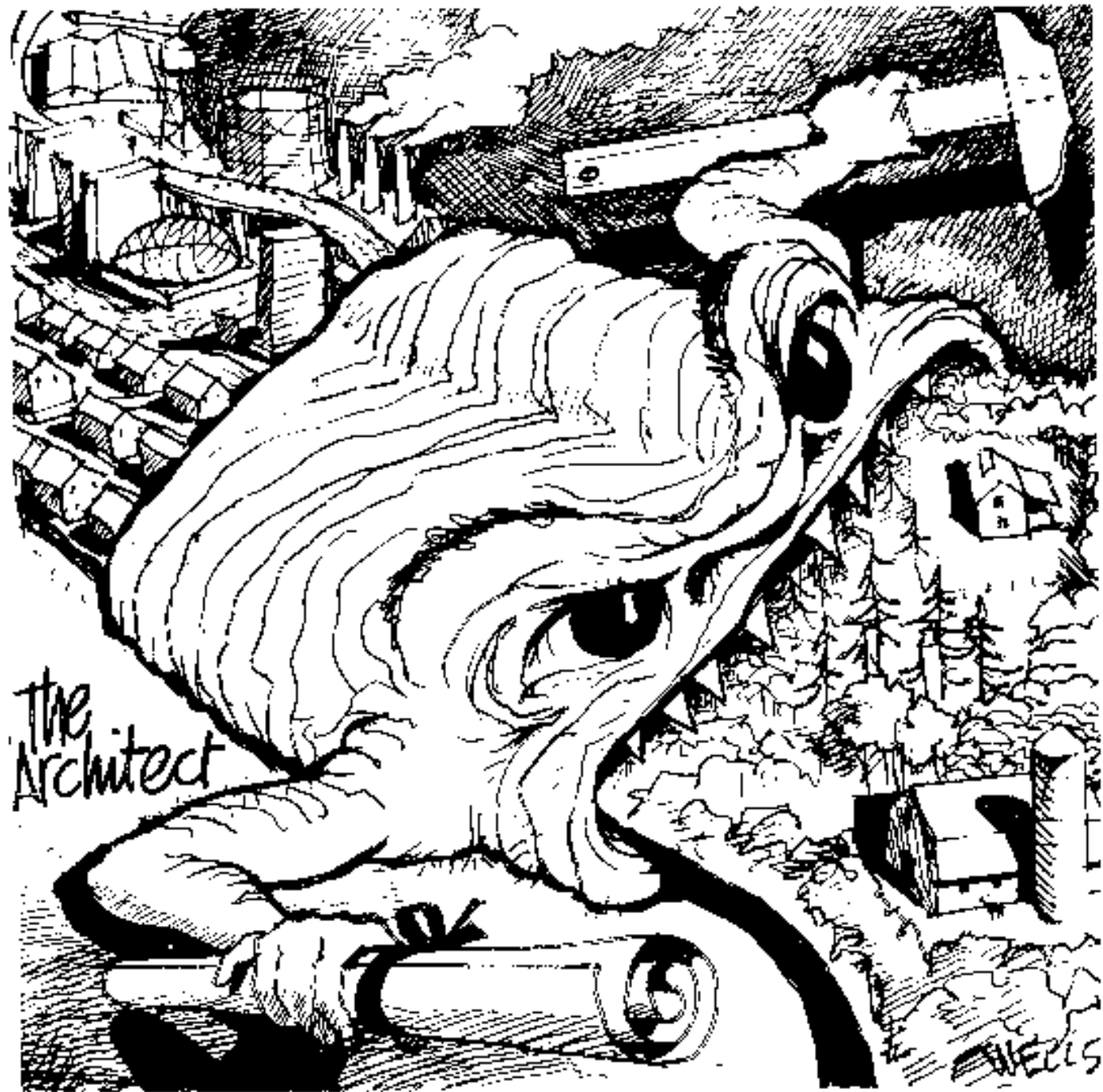
Why going green?

Why going green?



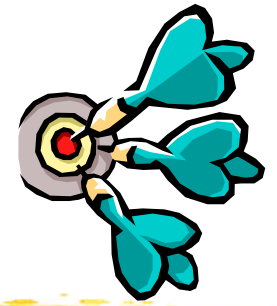
- Survival of our planet: environmental crisis
 - Air (destruction of Earth's atmosphere)
 - Global warming, climate change
 - Water (an undervalued resource)
 - Shortage and pollution
 - Fire (the problem of fuels)
 - Fossil fuel burning (coal, oil)
 - Earth (resources and materials)
 - Resources depletion





Drawing by the American architect Malcolm Wells

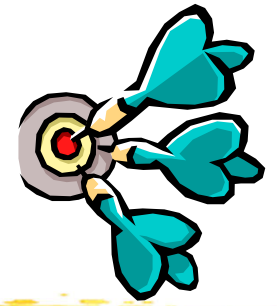
Why going green?



- Buildings consume significant resources
 - Consumption of energy & water
 - Use of building materials
 - Transport of materials & products
- Construction as the worst polluters
 - Operation on site and off site
 - Waste from construction/occupants
 - Pollutants from buildings



Why going green?



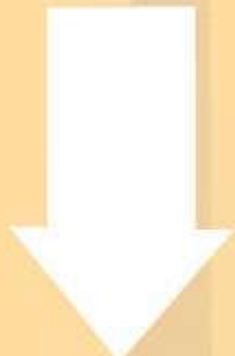
- Green buildings pay
 - Direct benefits (e.g. energy/cost savings)
 - Indirect benefits (e.g. healthier conditions)
 - Wider global benefits (e.g. reduced CO₂ emission)
- Life-cycle benefits
 - Total economic and environmental performance
 - Long-term “*sustainability*”



Average Savings of Green Buildings

ENERGY SAVINGS

30%



CARBON SAVINGS

35%



WATER USE SAVINGS

30-50%



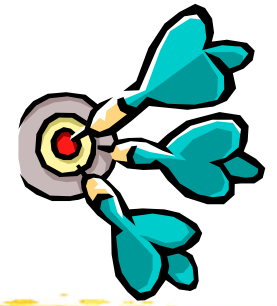
WASTE COST SAVINGS

50-90%



Source:
Capital E

Why going green?



- Benefits of sustainable buildings:
 - They are designed to be cost effective
 - They boost employee productivity
 - They enhance health and well-being
 - They reduce liability
 - They create value for tenants
 - They increase property value
 - They benefit the community
 - They achieve more predictable results



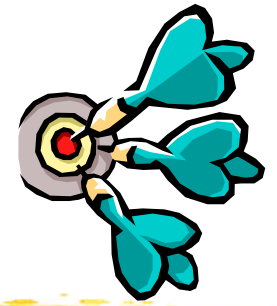
15 psychological benefits of green buildings

- Productivity
- Mental health
- Work output
- Crisis response
- Perceived well-being
- Workplace satisfaction
- Attraction
- Health perception

- Sense of community
- Workplace pride
- Space perception
- Atmosphere
- Space evaluation
- Task completion
- Stress



Why going green?



- **Environmental** reasons:

- The growth and development of our world has a large impact on the natural environment
- Manufacturing, design, construction, and operation of the buildings in which we live and work are responsible for the consumption of many of the natural resources

- **Personal** reasons:

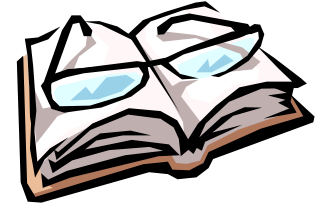
- “I want to be a **Green Building Professional.**”
- Green building jobs and market are **red hot**





Basic Principles

Basic principles



- What does green building look like? (4:53)

<https://youtu.be/ESIHwiV8l6k>



- Many elements to consider
- Location, building site, water use, energy use, materials, waste, indoor environment
- Design knowledge for sustainable building
 - City planning, urban design, architectural design, environmental design, engineering system design, product design & materials

Cave dwellings in Cappadocia, Turkey



(Photo taken during my travel to Turkey in 1992)

Sustainable Architecture

in ancient time
(cave dwellings)
(3500 years)

- cooperate with nature (climate, topography)
- durable and longlife are the trend



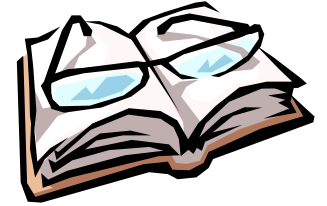
Photo credit: Renzo Piano Workshop Foundation

A modern example of
Sustainable Architecture:

Jean Marie Tjibaou
Cultural Center
(by Renzo Piano)

- Integration of
regional materials,
traditional construction
methods, contemporary
technology and
ecological design

Basic principles



- **Principles of Sustainable Design**
 - Understanding place
 - Connecting with nature
 - Understanding natural processes
 - Understanding environmental impact
 - Embracing co-creative design processes
 - Understanding people

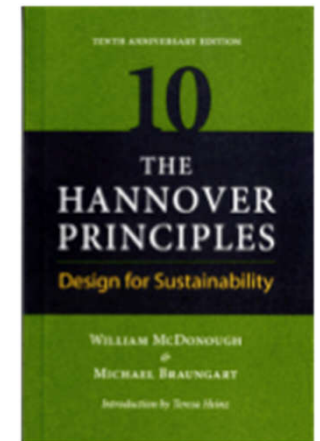


Main principles of sustainable design

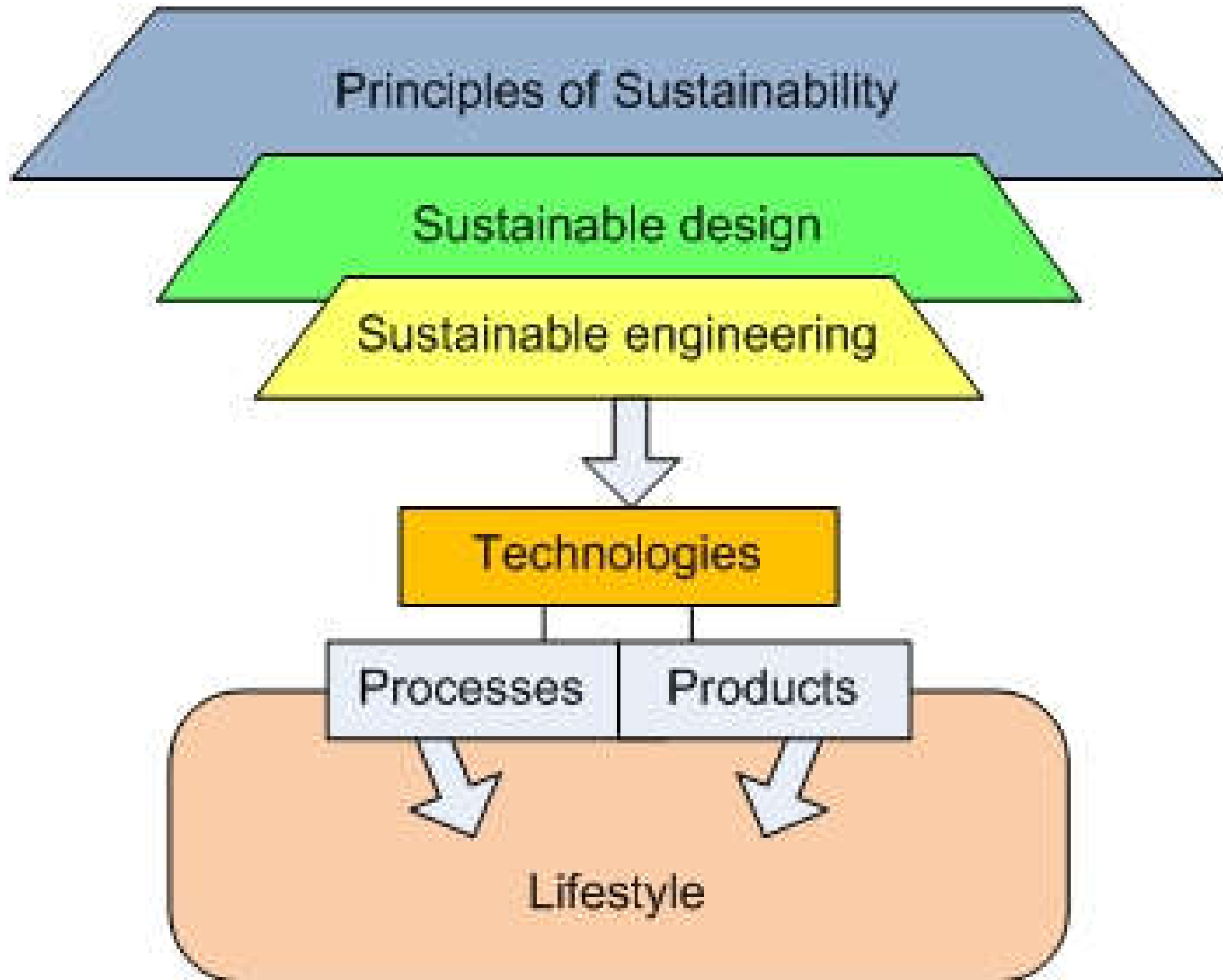


The Hannover Principles: Design for Sustainability (for Expo 2000)

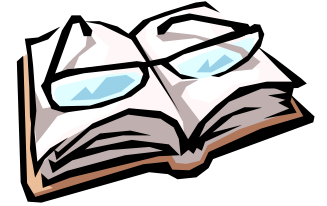
1. Insist on the right of humanity and nature to co-exist in a healthy, supportive, diverse and sustainable condition.
2. Recognize interdependence.
3. Respect relationships between spirit and matter.
4. Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems and their right to co-exist.
5. Create safe objects of long-term value.
6. Eliminate the concept of waste.
7. Rely on natural energy flows.
8. Understand the limitations of design.
9. Seek constant improvement by the sharing of knowledge.



Sustainability guidelines and role of technologies



Basic principles



- Aims of green building design
 - Reduce energy in use
 - Minimise external pollution & environmental damage
 - Reduce embodied energy & resource depletion
 - Minimise internal pollution & damage to health
- Green design requires resolving many conflicting issues and requirements



- site selection
- urban design
- landscape planning

- CO₂ emissions
- acid rain
- ozone depletion
- rainforest depletion

- energy performance
- renewable energy
- water conservation

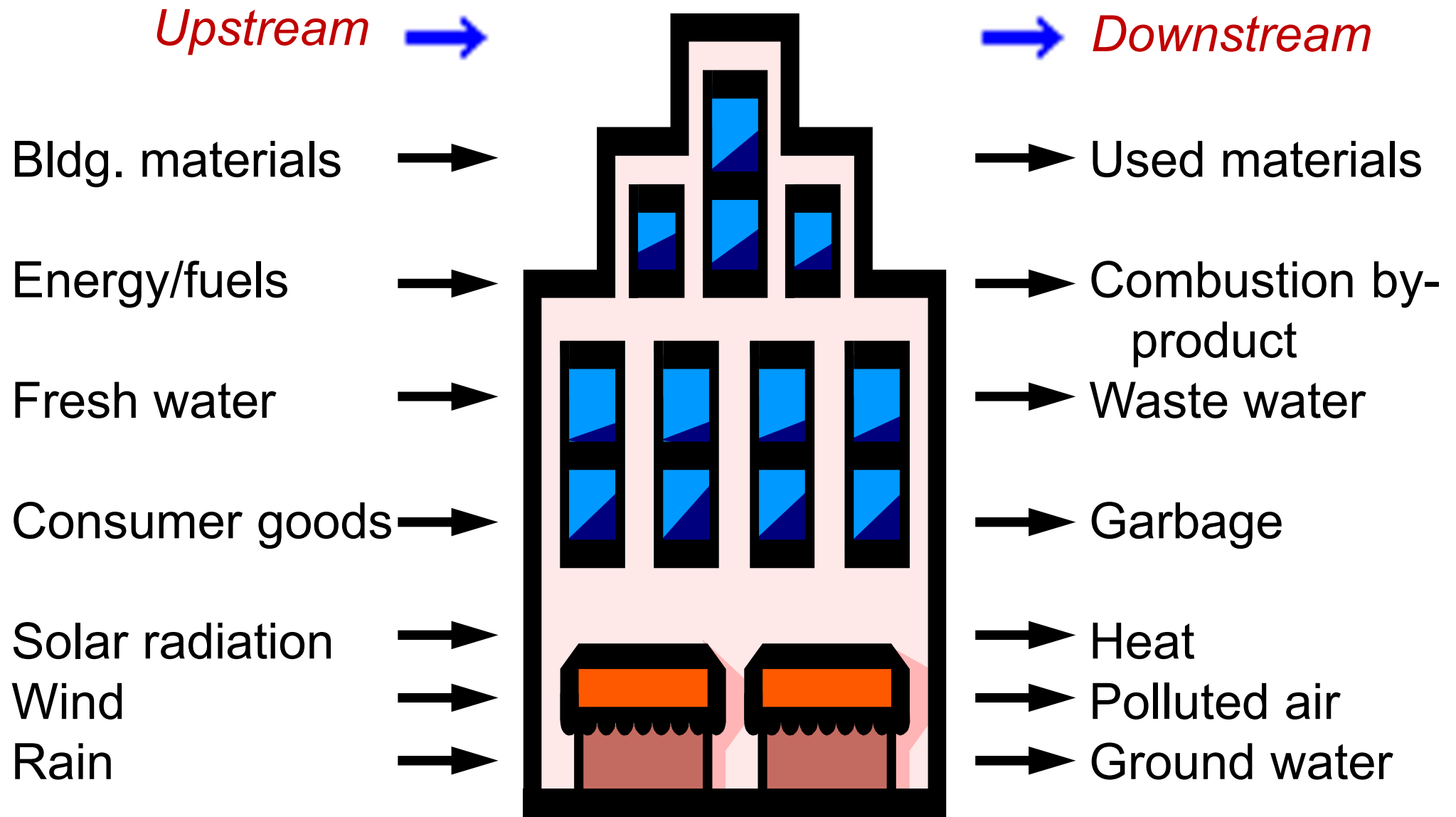
**Environmental
Criteria &
Factors**

- environmental policy
- transport strategy
- building maintenance

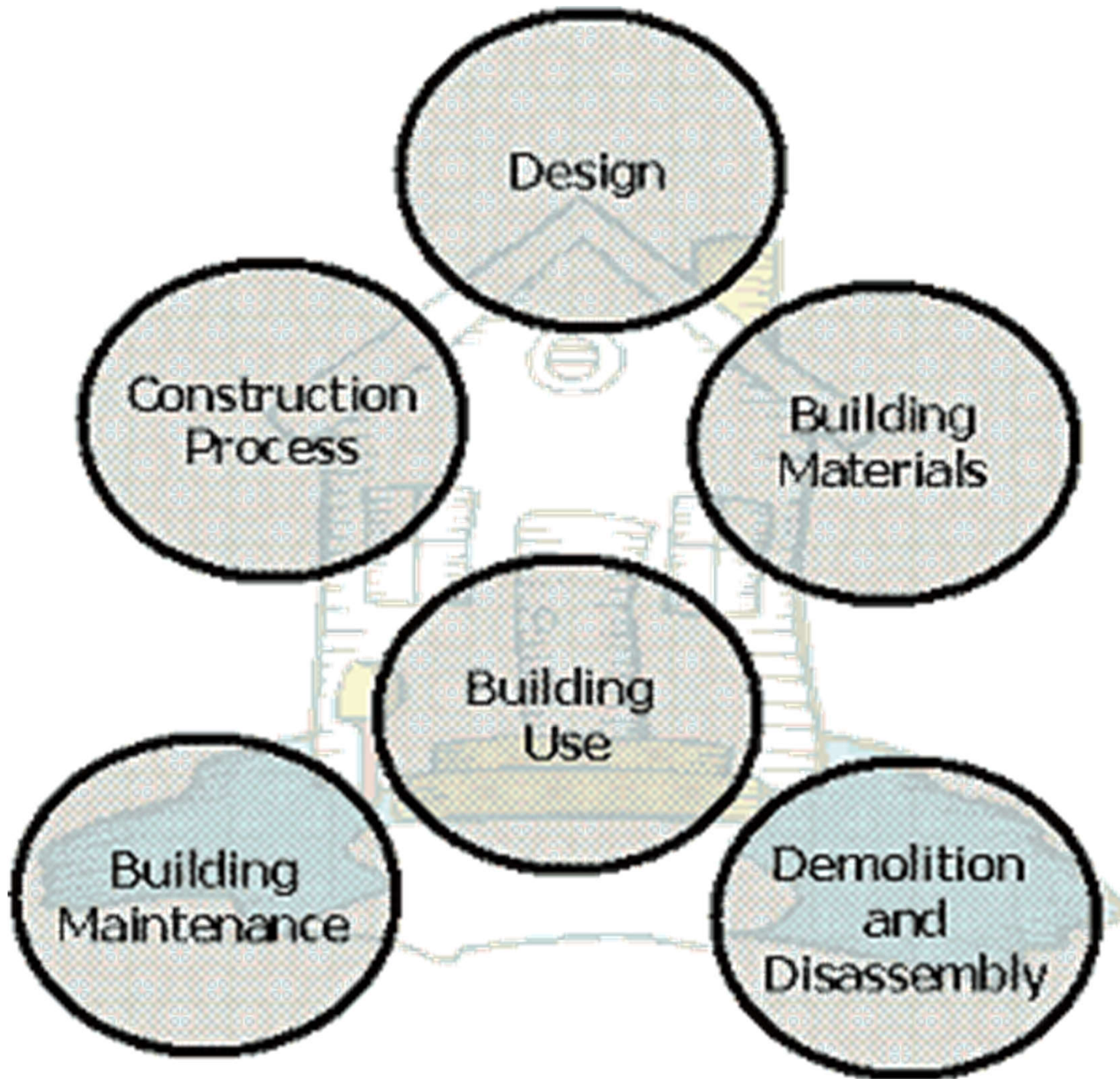
- material selection
- recycling of materials
- waste management
- disposal & reuse

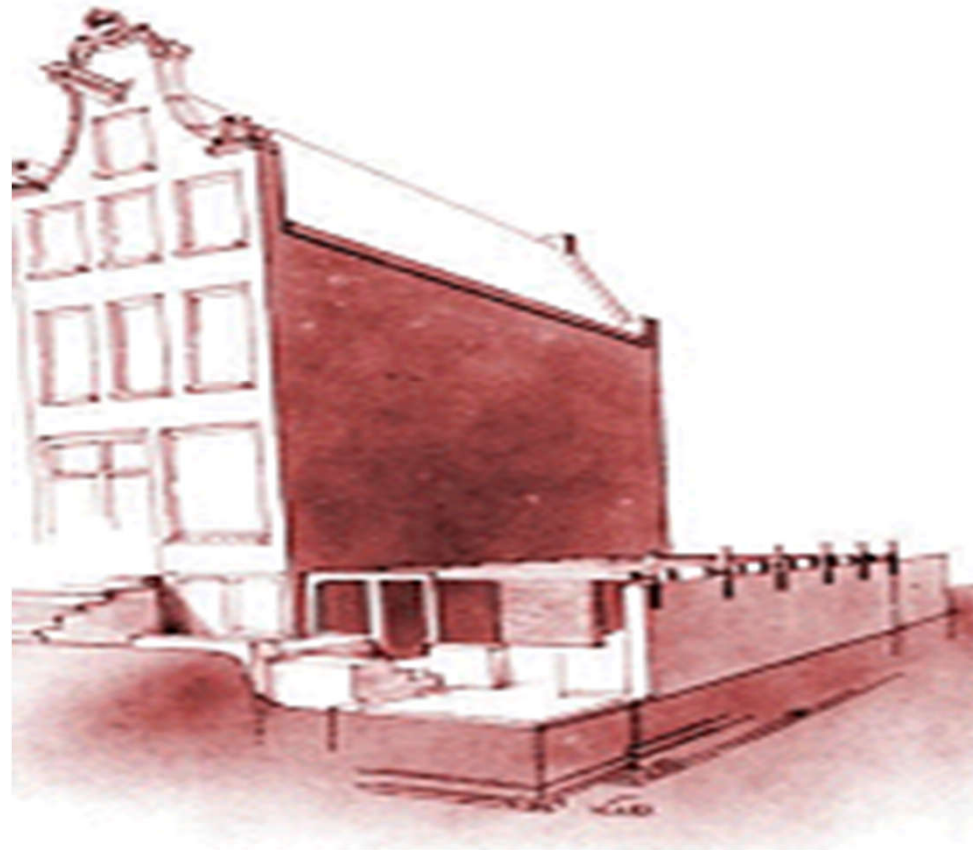
- air quality
- thermal comfort
- lighting & noise
- hazardous materials

Resource and material flow in the building ecosystem

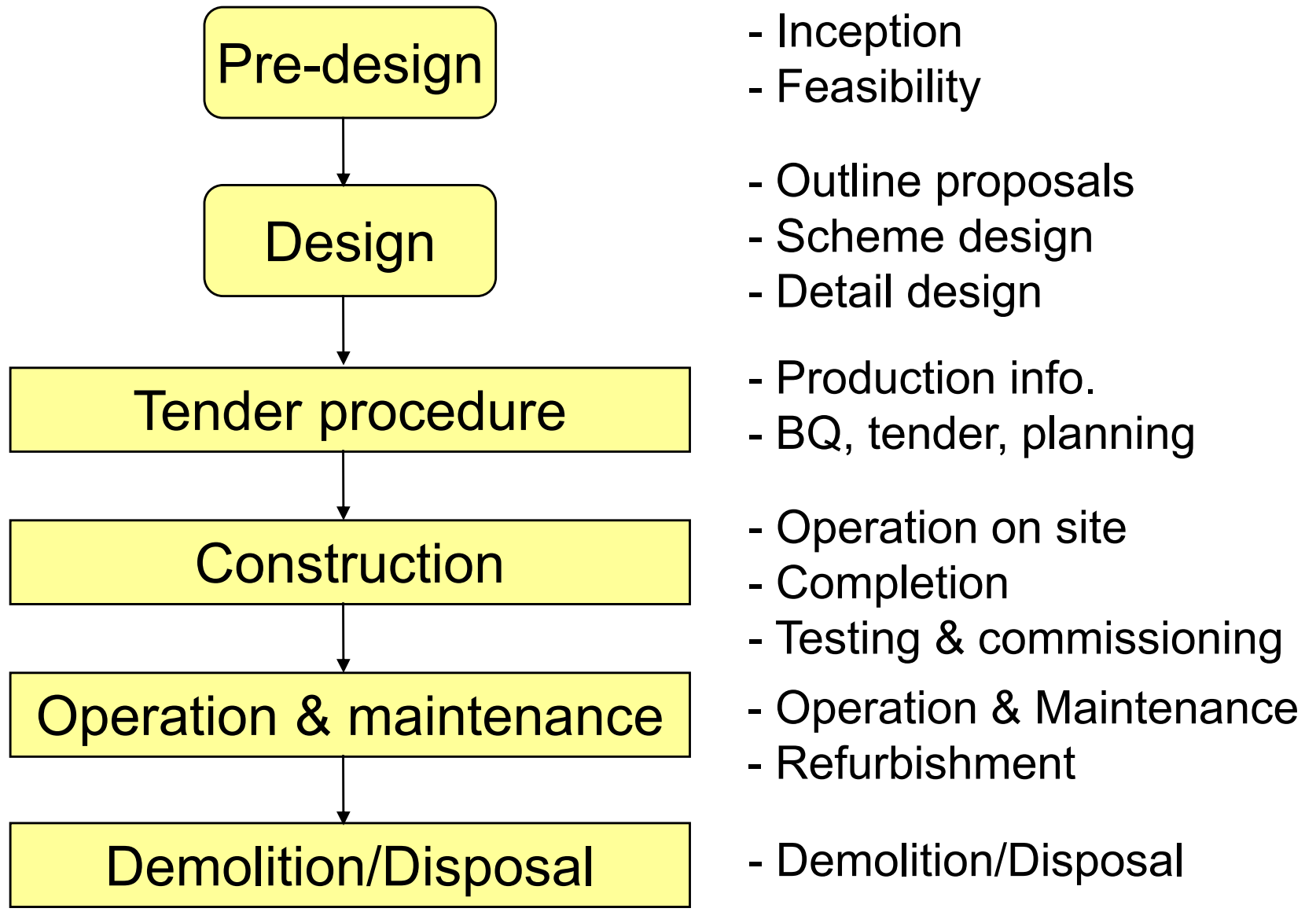


Green Construction - A Sustainability Toolbox

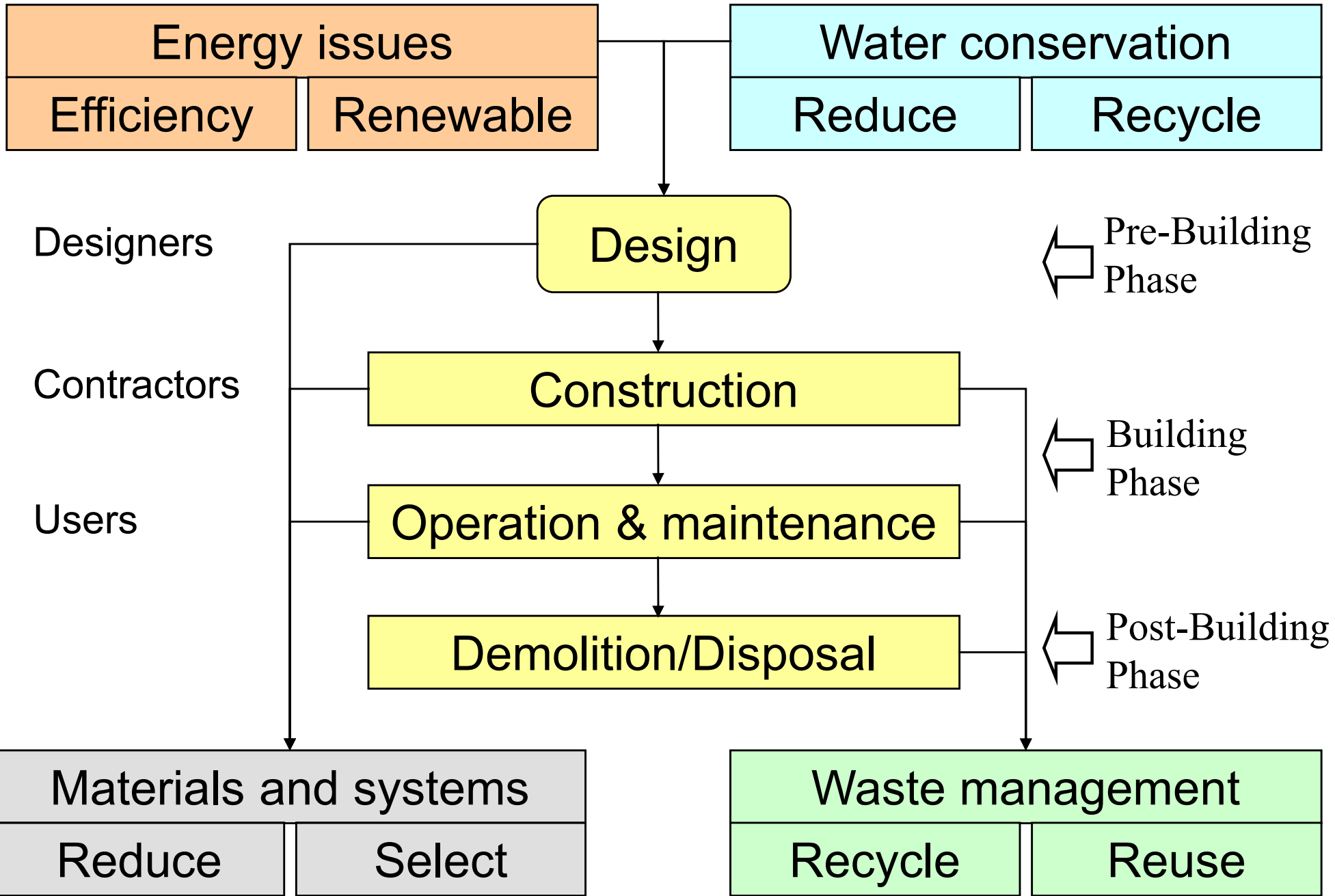




Construction Process

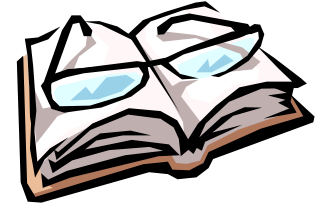


Building and construction process



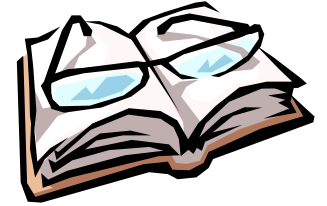
Building life cycle and sustainable construction

Basic principles



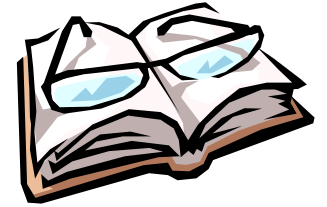
- Major concerns
 - Conserve non-renewable energy & scarce materials
 - Minimise life-cycle ecological impact
 - Use renewable energy and materials that are sustainably harvested
 - Protect & restore local air, water, soils, flora and fauna
 - Support pedestrians, bicycles and mass transit
 - Reduce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

Basic principles

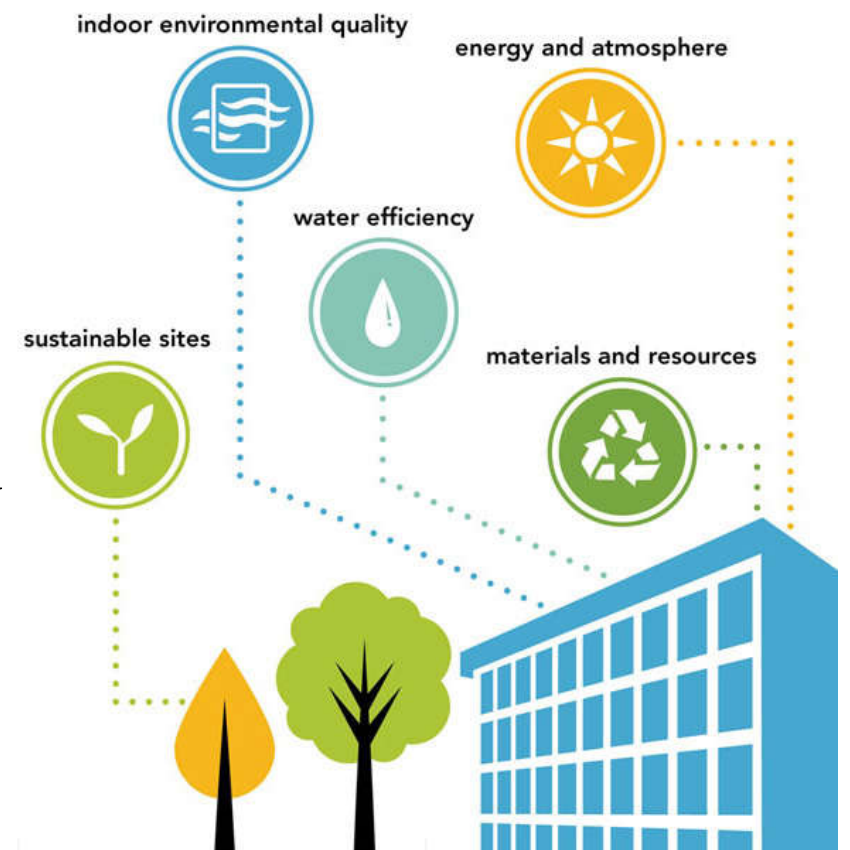


- Truly green design is more than a technological add-on. Green buildings are the one that
 - Work well
 - Suit the people in them
 - Show off the cultural context
- The need to cultivate “*sustainable thinking*”
 - Define & achieve sustainability in a given context
 - Connection to the mass of current design

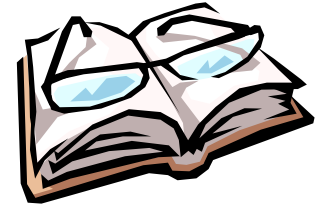
Basic principles



- Green building design strategies:
http://ibse.hk/GB_design_strategies.pdf
- Sustainable site
- Energy and atmosphere
- Water efficiency
- Materials and resources
- Indoor environmental quality



Basic principles



- Green strategies at different stages:

- Inception (briefing, targets, site)

- Design

- Preliminary studies

- Sketch studies

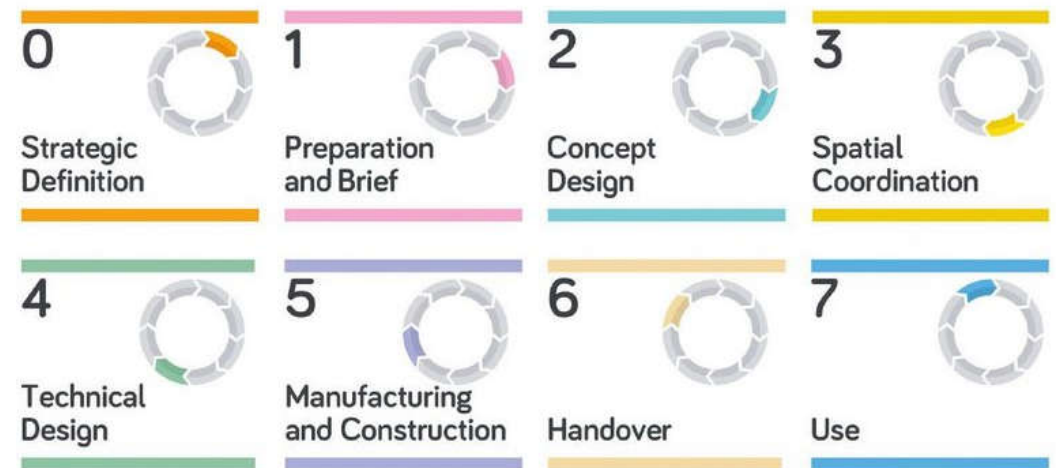
- Pre-project

- Basic project

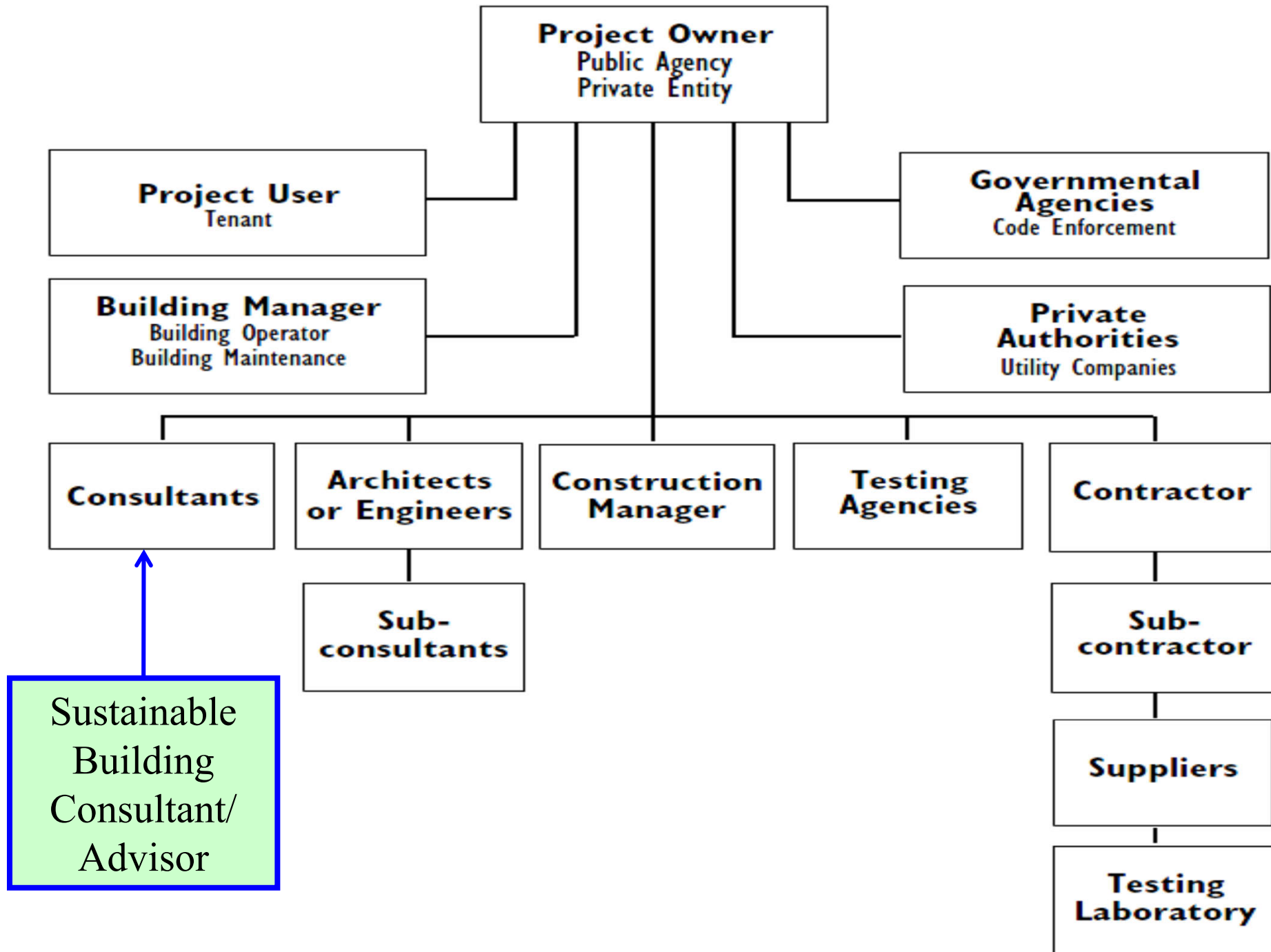
- Execution of project

- Construction (tendering, supervision, acceptance)

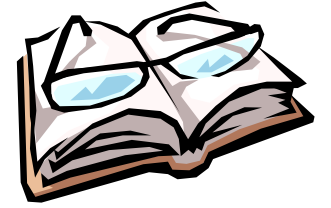
- Maintenance & refurbishment



Typical project team in building and construction process



Basic principles



- Key areas for **green specialist** advice
 - Building structure & materials
 - Building envelope design
 - Heating, ventilation & air-conditioning (HVAC)
 - Lighting systems
 - Electrical power
 - Water services
 - Landscaping
 - Cost estimating (e.g. life cycle cost studies)

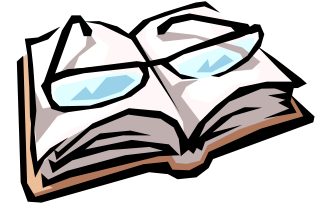


Examples of green building professional services

- Feasibility studies for the assessment of basic designs
- Green building consultancy and facilitation for green building assessment & certification schemes
- Building energy & lighting simulation and modelling
- Indoor air/environment quality sampling & testing
- Building sustainability and carbon services, including carbon footprint analysis and life cycle assessment
- Energy management services
- Energy management systems & certification (e.g. ISO 50001)
- Green building material evaluation & performance testing
- Third party commissioning & retro-commissioning



Basic principles



- Green building education

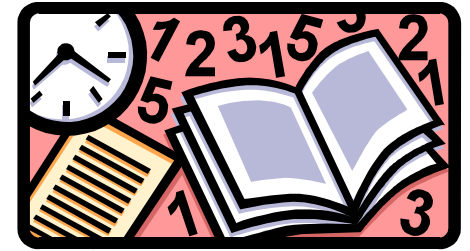
- Eco-education & higher education
- Degree in building profession
- Degree in specialized environmental
- Training programmes & continuing education



- Green building professionals

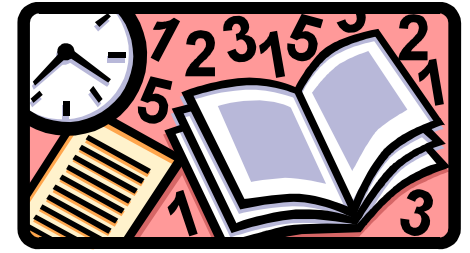
Green architect, green contractor, green engineer, green interior designer, green landscape architect, green urban planner, green real estate professional, green facility manager or owner





Further Reading

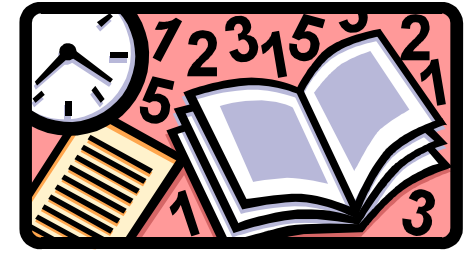
- Sustainable architecture – Wikipedia
http://en.wikipedia.org/wiki/Green_architecture
- Sustainable design – Wikipedia
http://en.wikipedia.org/wiki/Sustainable_design
- Sustainable development – Wikipedia
http://en.wikipedia.org/wiki/Sustainable_development
- Green building design strategies
http://ibse.hk/GB_design_strategies.pdf



Further Reading

- Teaching Kit: Sustainable Design for Buildings (ArchSD)
 - <https://www.archsd.gov.hk/en/teachingkits/TK1/>
 - Sustainable planning
 - Sustainable building design
 - Green procurement
 - Green construction management
 - Sustainable maintenance
 - Stakeholder Engagement

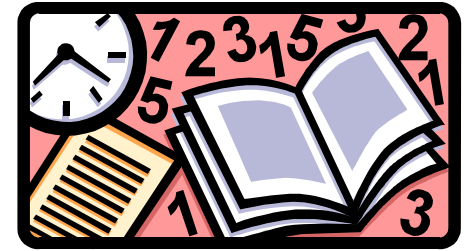




Further Reading

- Examples of green building projects (videos):
 - 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>





References

- European Commission, Directorate General XVII for Energy, 1999. *A Green Vitruvius: Principles and Practice of Sustainable Architectural Design*, James & James, London. [[720.47 G79 E](#)]
- Henderson H., 2012. *Becoming a Green Building Professional*, Wiley, Hoboken. [[720.47023 H496 b39](#)]
- Keeler M. & Burke B., 2016. *Fundamentals of Integrated Design for Sustainable Building*, 2nd edition, John Wiley & Sons, Hoboken, N.J. [[720.47 K26](#)]
- Kibert C. J., 2016. *Sustainable Construction: Green Building Design and Delivery*, 4th ed., John Wiley & Sons, Hoboken, N.J. [[690.0286 K462 s96](#)]