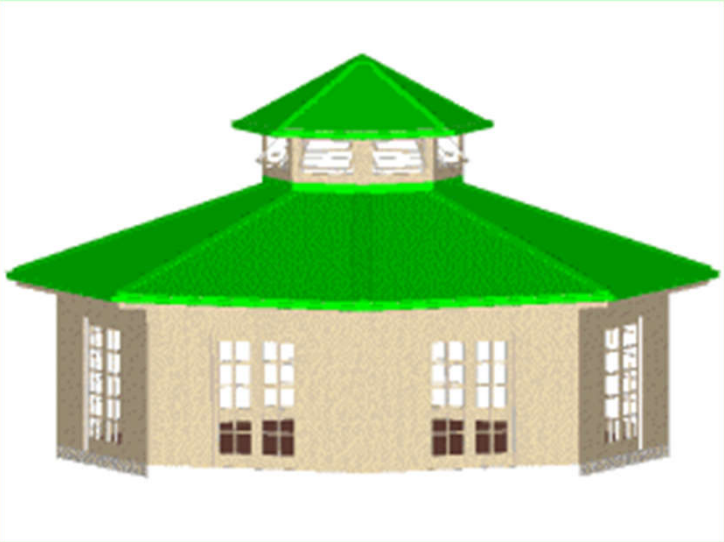
MEBS6020 Sustainable Building Design

http://ibse.hk/MEBS6020/



Sustainable Building Concepts (I)

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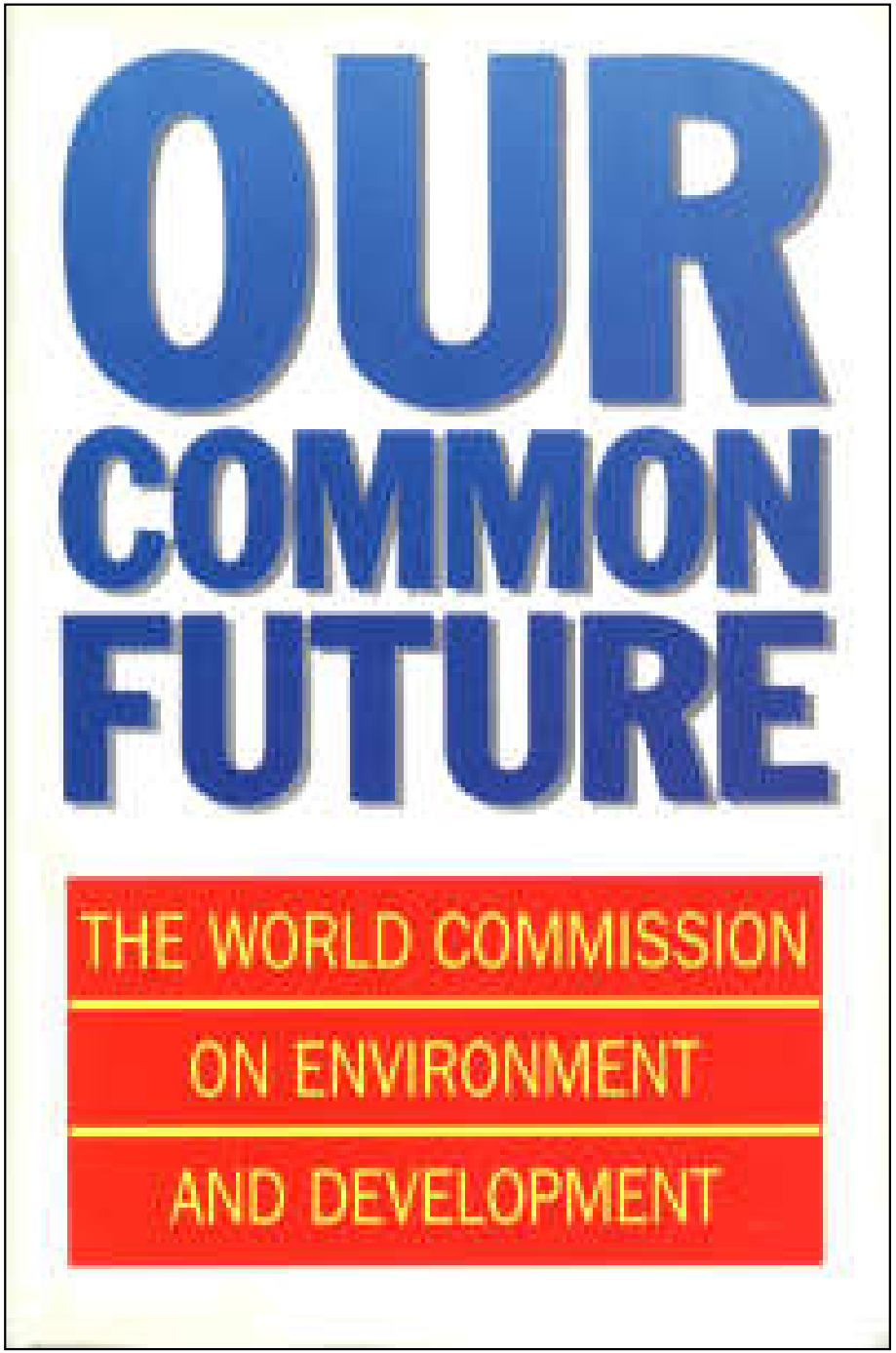
Contents

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

What is Sustainable Development?

(Ref: Sustainable Development in Hong Kong for the 21st Century https://www.pland.gov.hk/pland_en/p_study/comp_s/susdev/index_e.htm)



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

(See also: What is Sustainable Development? http://www.iisd.org/sd/)

Carrying capacity and ecological footprint

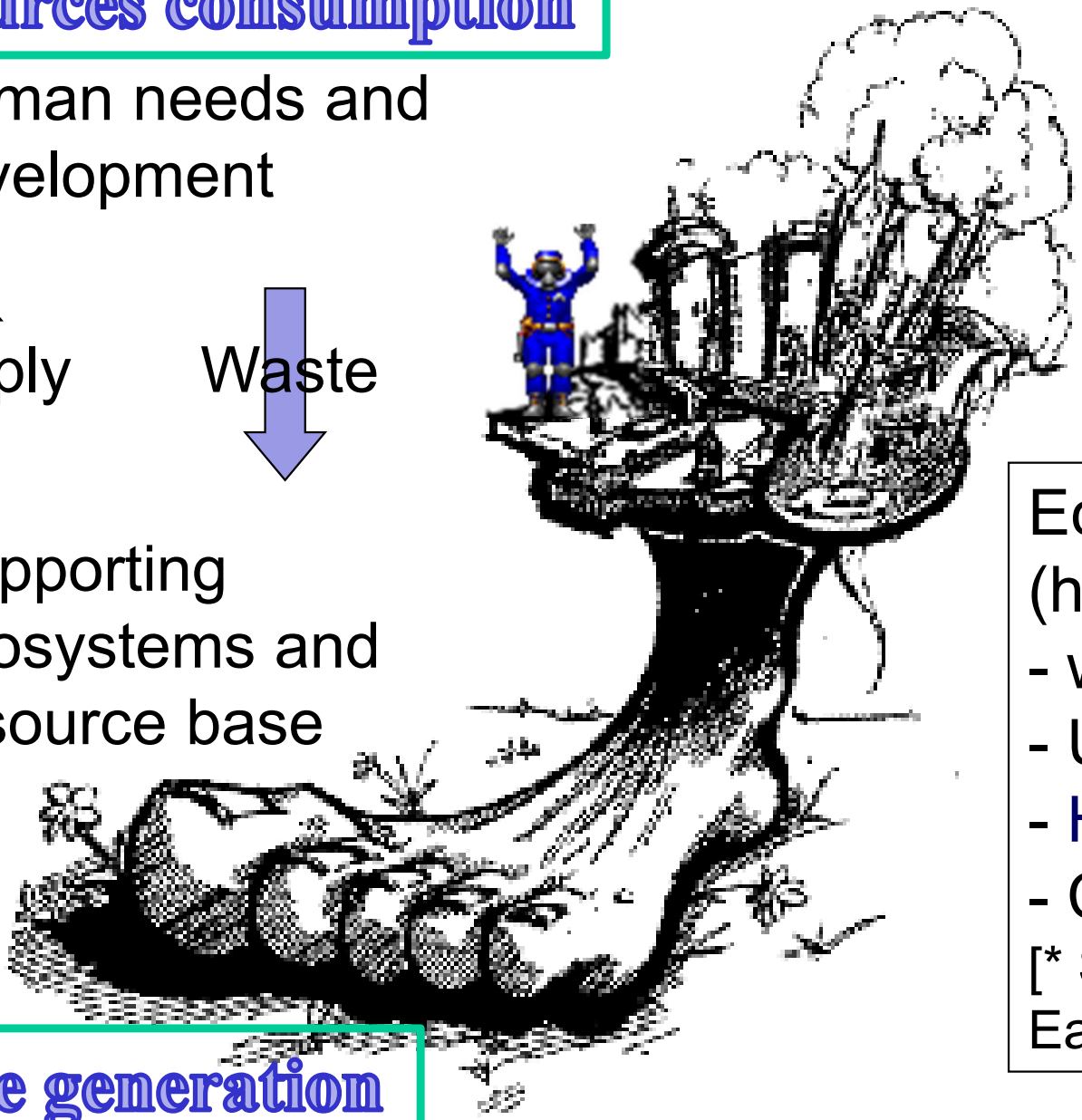
Resources consumption

Human needs and development

Supply

Waste

Supporting ecosystems and resource base



Waste generation

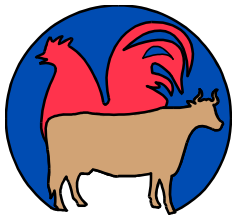
Ecological footprint (hectares/person) *:
- world average = 2.3
- USA = 10.3
- Hong Kong = 6.0
- China = 1.2

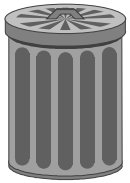
[* Source: Friends of the Earth (HK)]

(See also: Human Population Update: What is Our Ecological Footprint on this Planet? http://www.21stcentech.com/human-population-update-carrying-capacity-planet-earth/)

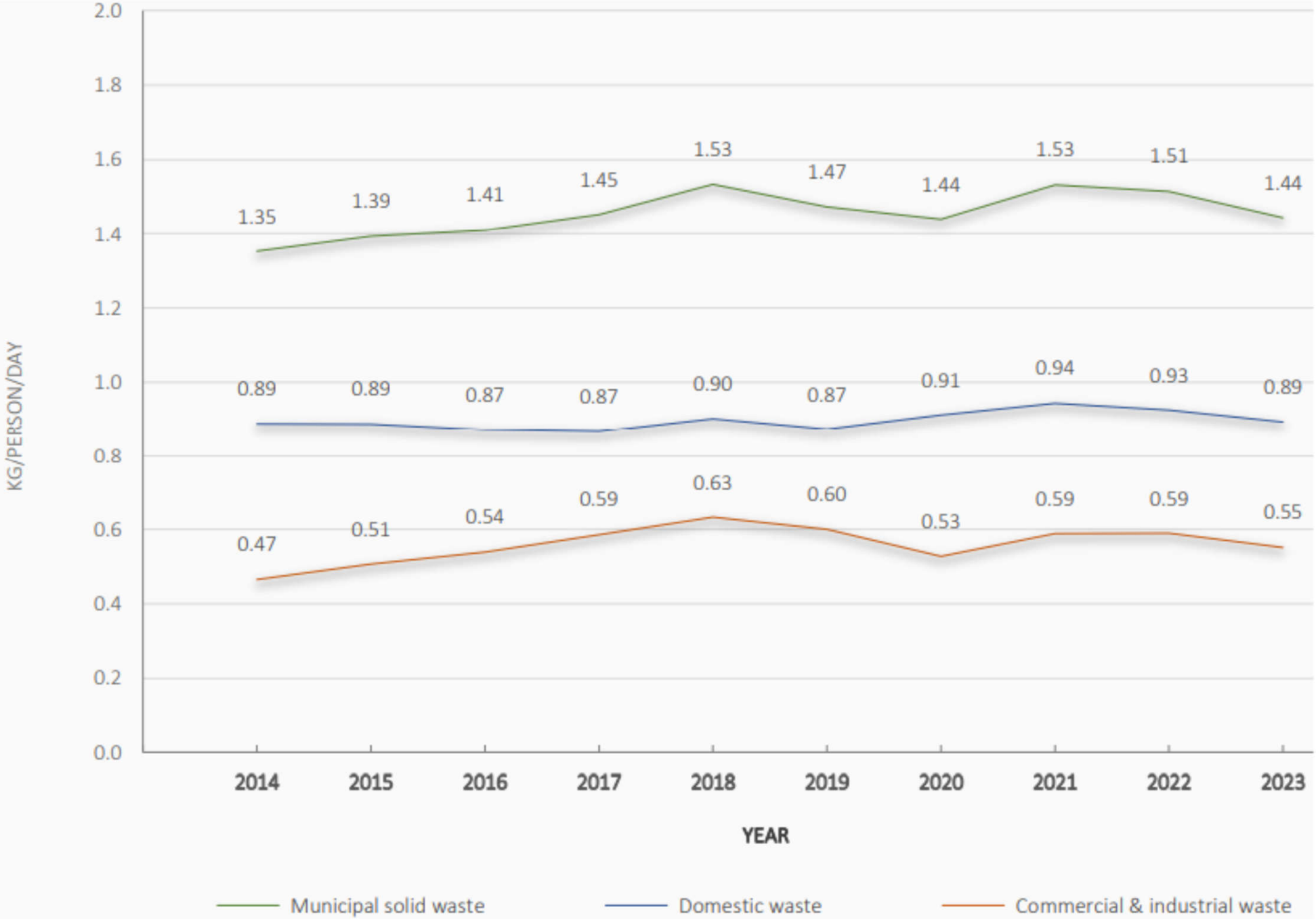
Sustainable development

- 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



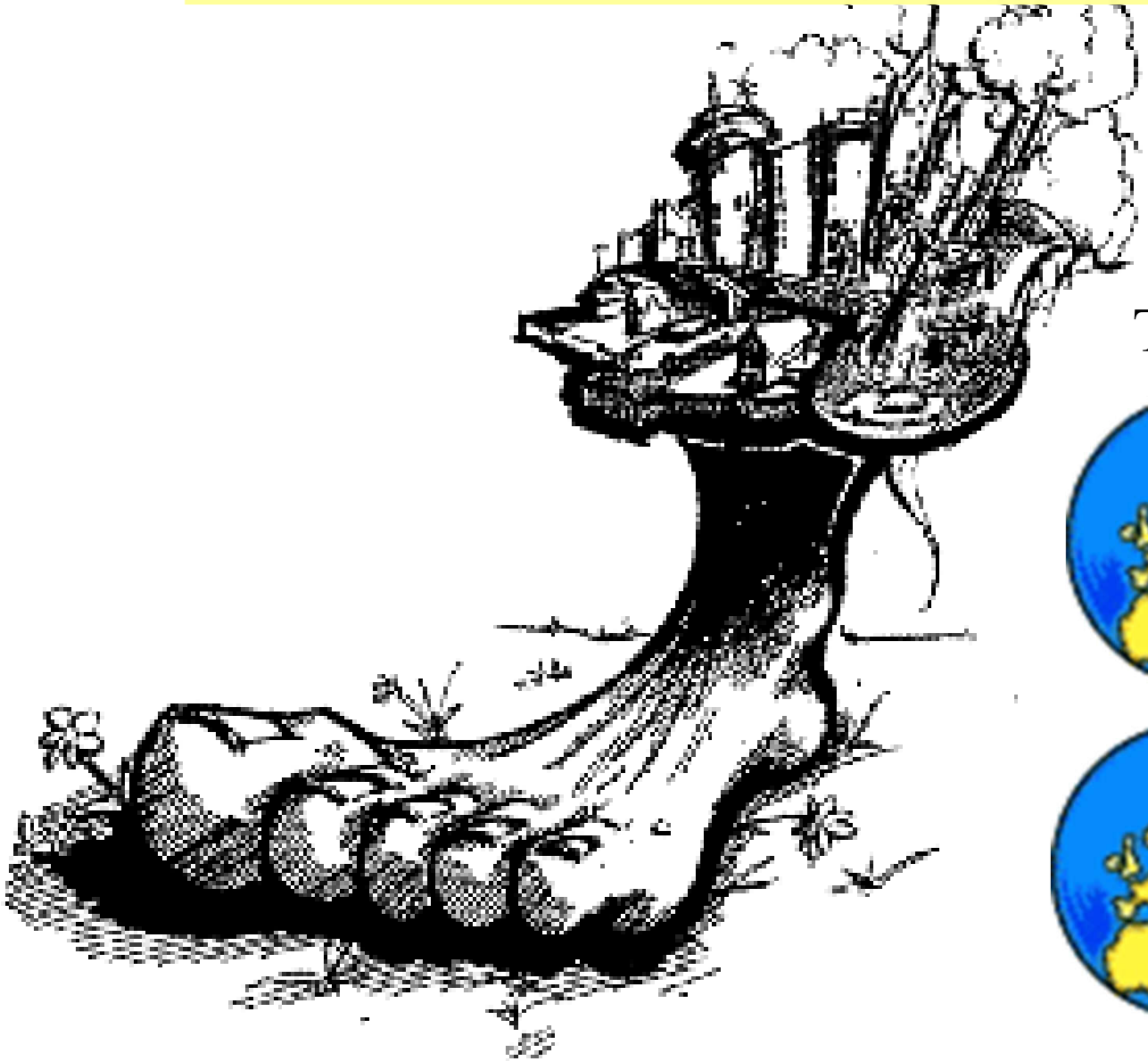


Per capita disposal rates of municipal solid waste (MSW), domestic waste and commercial & industrial waste in HK from 2014 to 2023



(See also: Waste Statistics for 2023 https://www.wastereduction.gov.hk/sites/default/files/resources_centre/waste_statistics/msw2023_eng.pdf)

Sustain-able Future?

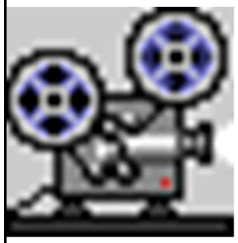


The Factor Four concept*

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

Sustainable development

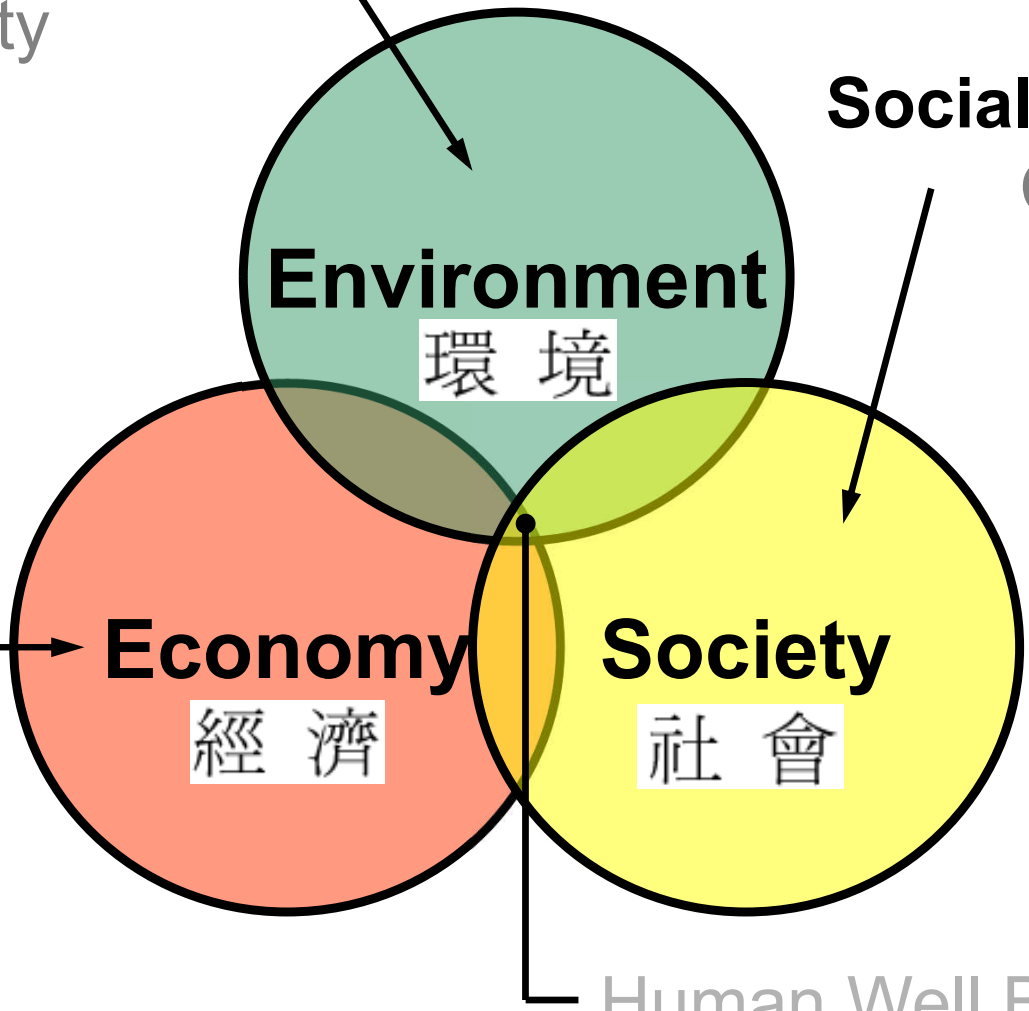
- Sustainability (可持續發展, 永續性)
  - The endurance of systems and processes
    - Improves the quality of human life while living within the carrying capacity of supporting eco-systems
- Video Presentation:
  - Sustainability explained through animation (2:00) http://youtu.be/B5NiTN0chj0
  - What is Sustainability (3:06) https://youtu.be/zx04Kl8y4dE



Three dimensions of sustainability

Environmental Sustainability

Ecosystem integrity
Carrying capacity
Biodiversity



Social Sustainability

Cultural Identity
Empowerment
Accessibility
Stability
Equity

Economic Sustainability

Growth
Development
Productivity
Trickle-down

Sustainable development

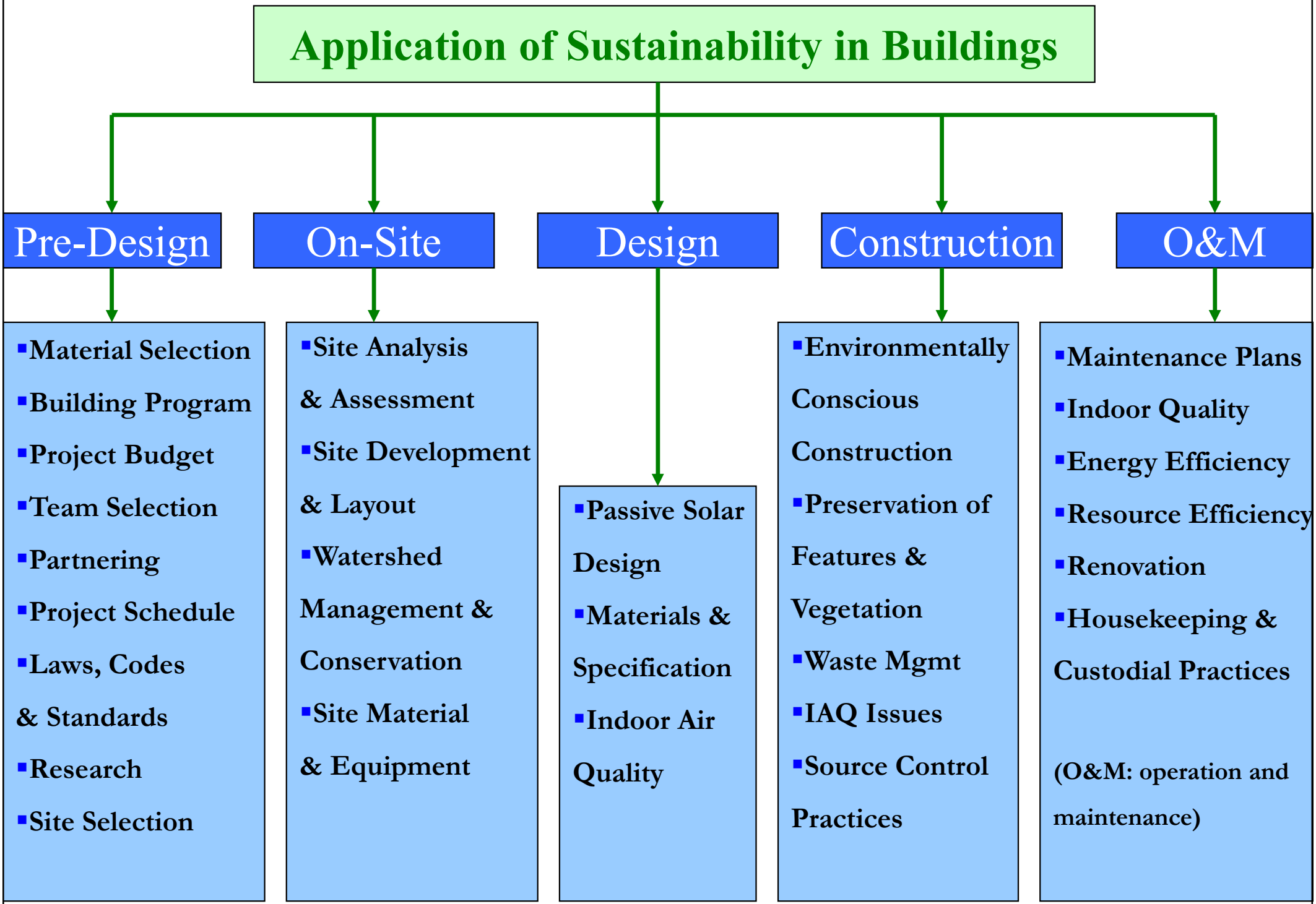
- Sustainability is about: [Mei Ng, FoE(HK)]
  - System thinking (harmonize human & living)
  - Value judgment (importance of natural capital)
  - Efficiency (resources & eco-efficiency)
  - Fair share (inter- & intra-generational equity)
  - Making informed choices
  - Quality people & quality life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

(Source: https://www.researchgate.net/publication/333784260_Green_Smart_Building_Requisites_Architecture_Challenges_and_Use_Cases)


Application of Sustainability in Buildings
Pre-Design
On-Site
Design
Construction
O&M
▪Material Selection
▪Building Program
▪Project Budget
▪Team Selection
▪Partnering
▪Project Schedule
▪Laws, Codes & Standards
▪Research
▪Site Selection
▪Site Analysis & Assessment
▪Site Development & Layout
▪Watershed Management & Conservation
▪Site Material & Equipment
▪Passive Solar Design
▪Materials & Specification
▪Indoor Air Quality
▪Environmentally Conscious Construction
▪Preservation of Features & Vegetation
▪Waste Mgmt
▪IAQ Issues
▪Source Control Practices
▪Maintenance Plans
▪Indoor Quality
▪Energy Efficiency
▪Resource Efficiency
▪Renovation
▪Housekeeping & Custodial Practices
(O&M: operation and maintenance)

Sustainability of green buildings

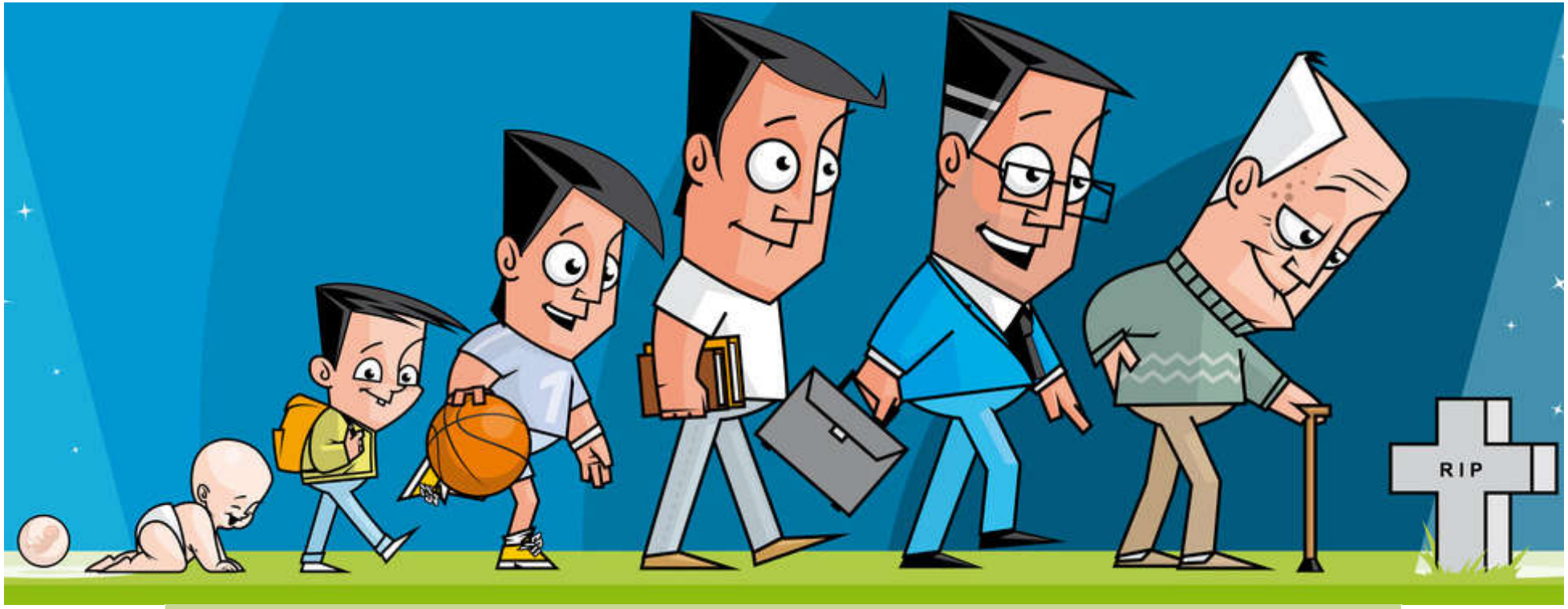
- A total plan for sustainability requires (from the Institution of Structural Engineers):
  - Reduction of emission of greenhouse gases
  - More efficient use (and reuse) of resources
  - Minimisation and constructive reuse of waste
  - Reduction of harmful effects from construction activities and building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

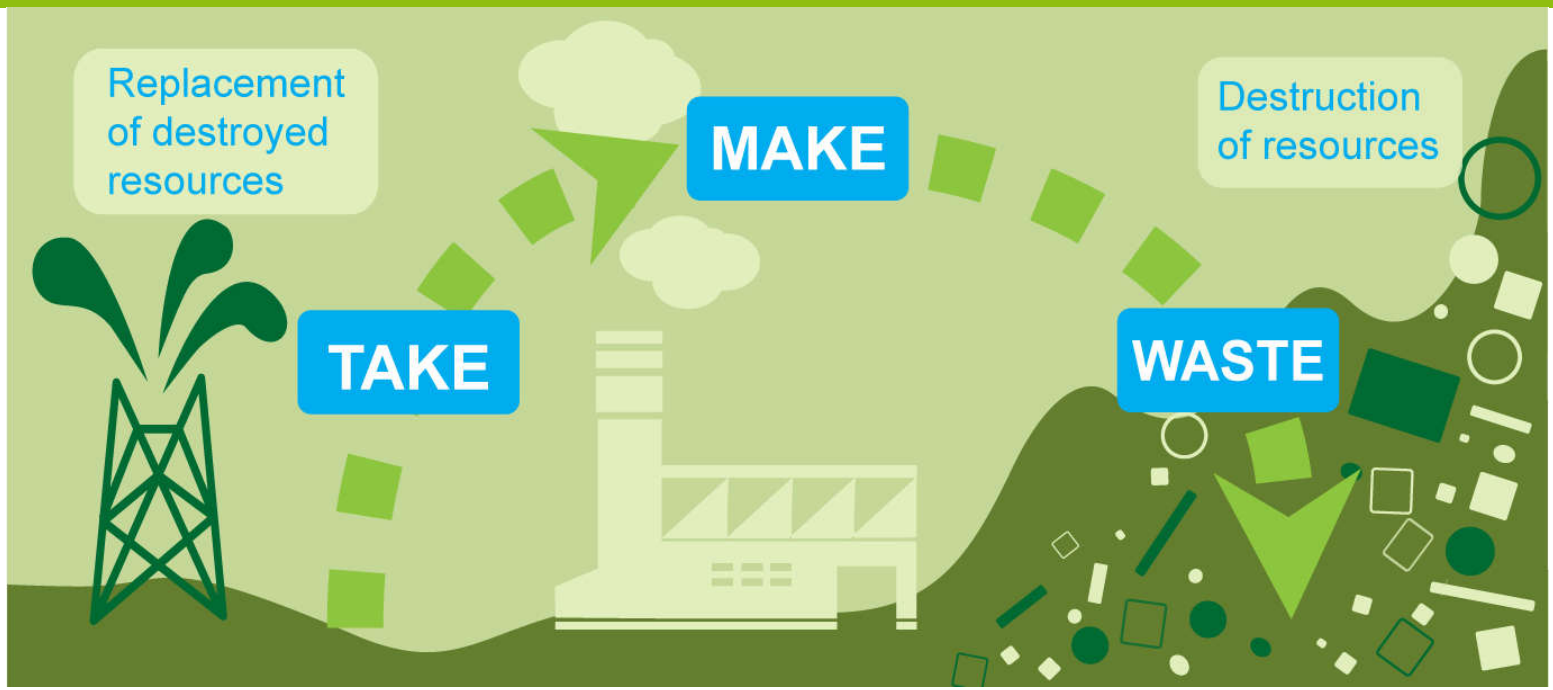
Cradle-to-Grave

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').

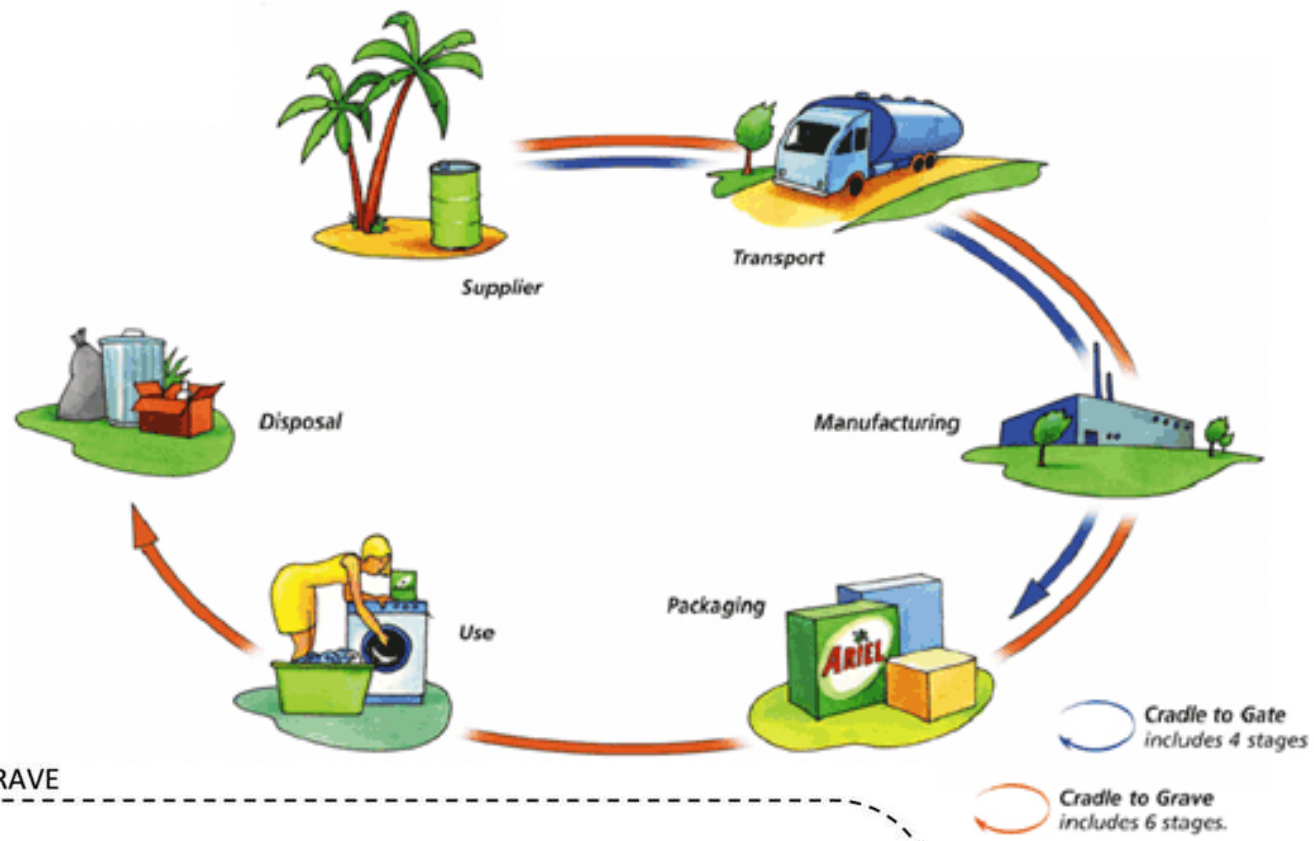
Life cycle design: Cradle to grave (從搖籃到墳墓)

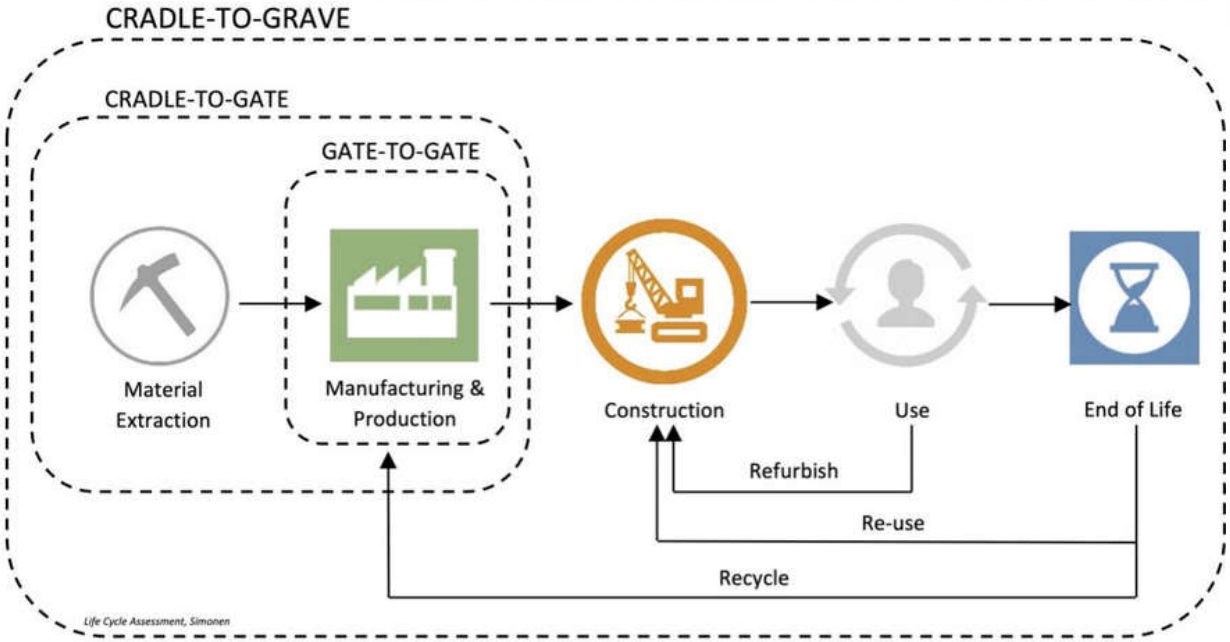




(Image source: https://www.c2cplatform.tw/)

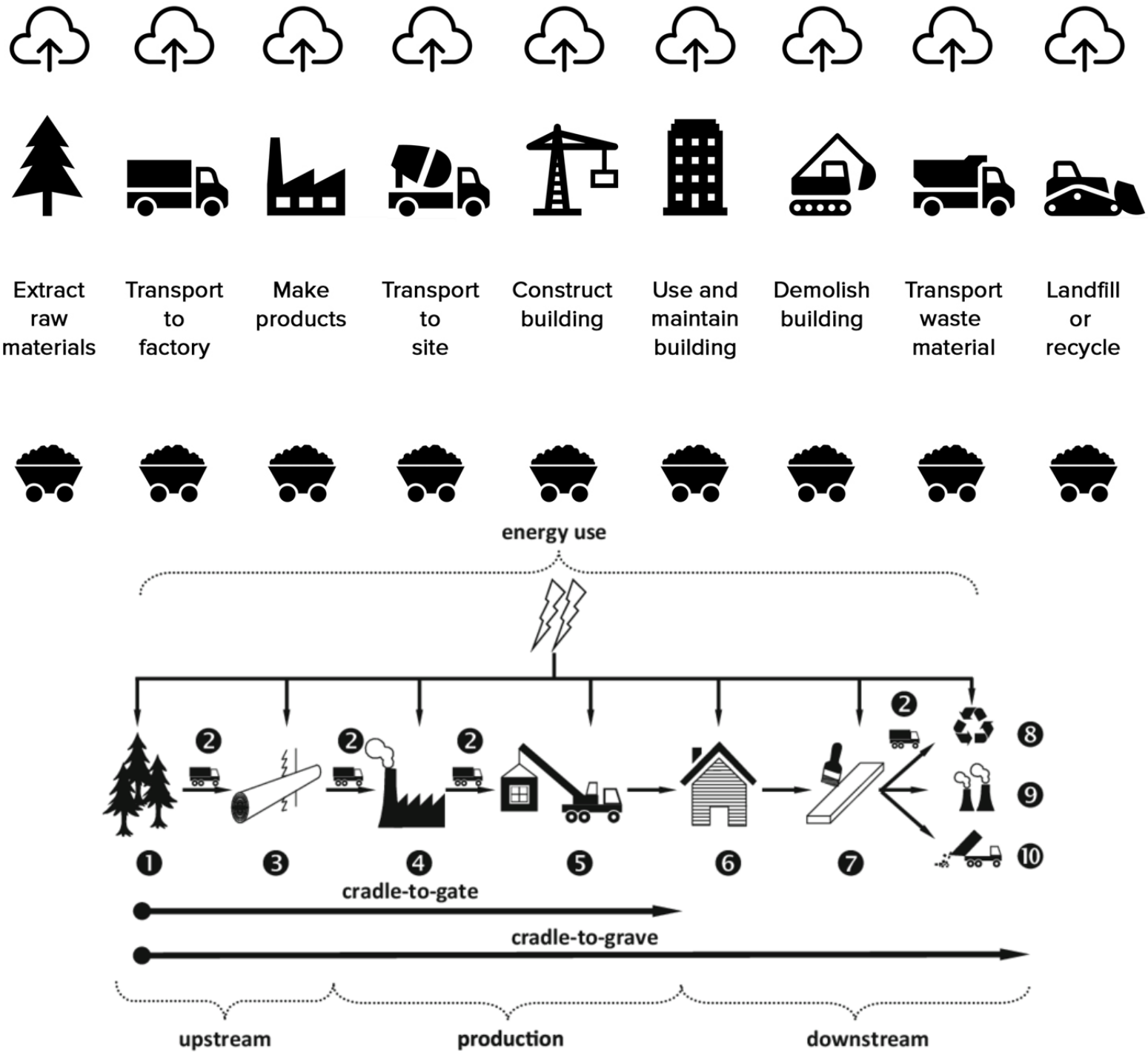
Cradle-to-Gate and Cradle-to-Grave





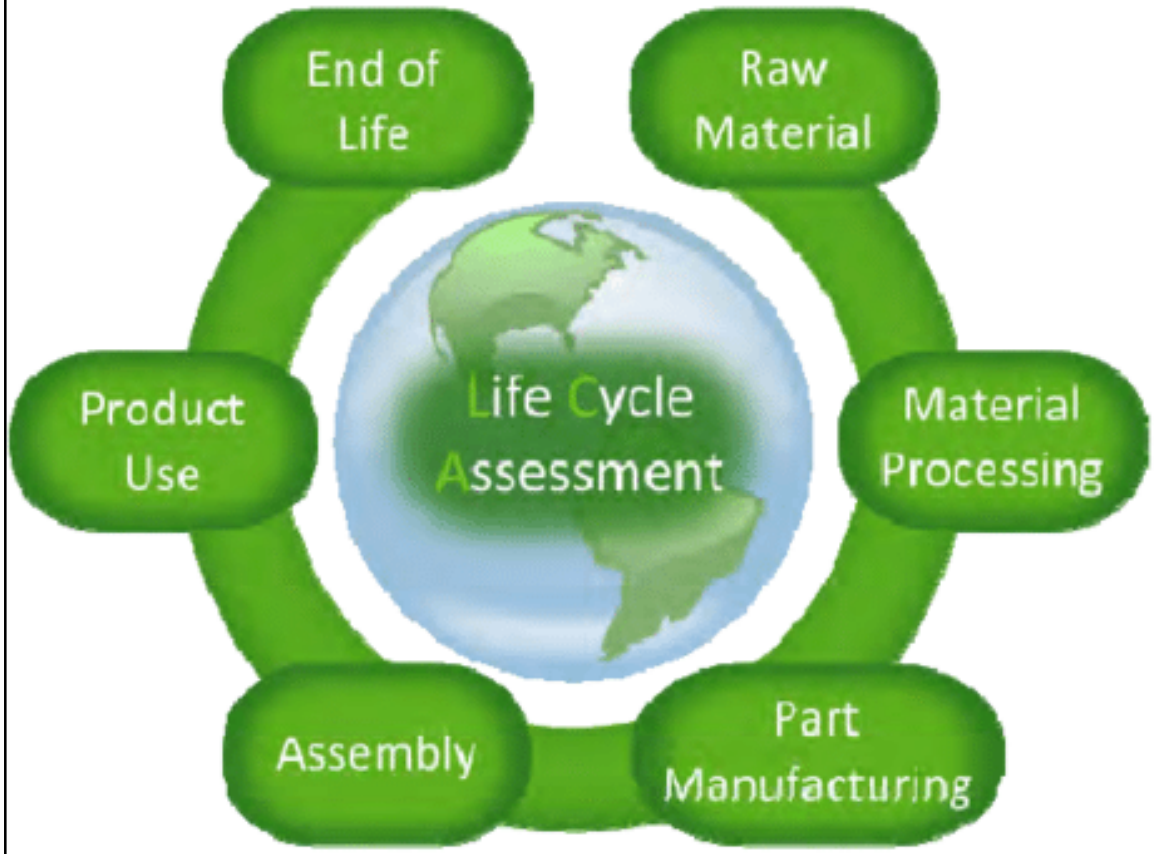
(Source: www.scienceinthebox.com & https://www.frostburg.edu/programs/life-cycle-fac-management/Illistrated-Cradle-to-Grave-Process.php)

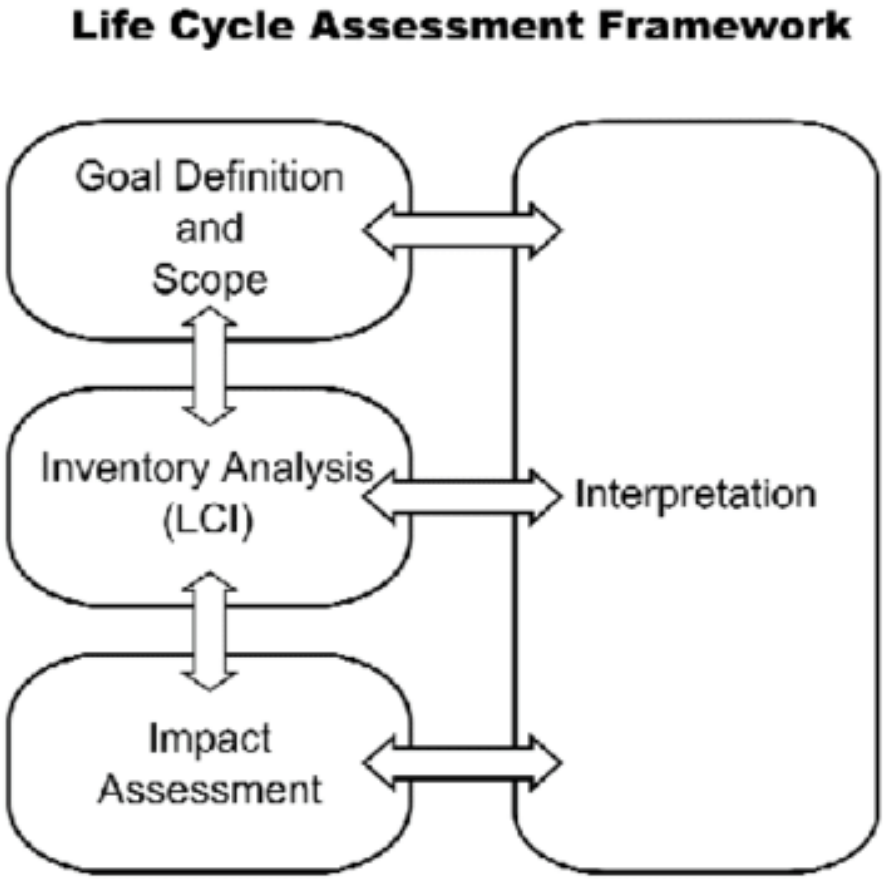
Cradle to grave for building and construction



(Source: https://www.canadianarchitect.com/1003753921-2/cradle-to-grave/ & https://www.researchgate.net/publication/331507898_Biomaterials_for_Building_Skins)

Cradle-to grave Life Cycle Assessment





(Source: https://www.researchgate.net/publication/221929088_Life_Cycle_Assessment_of_Organic_Photovoltaics)

Sustainable built environment

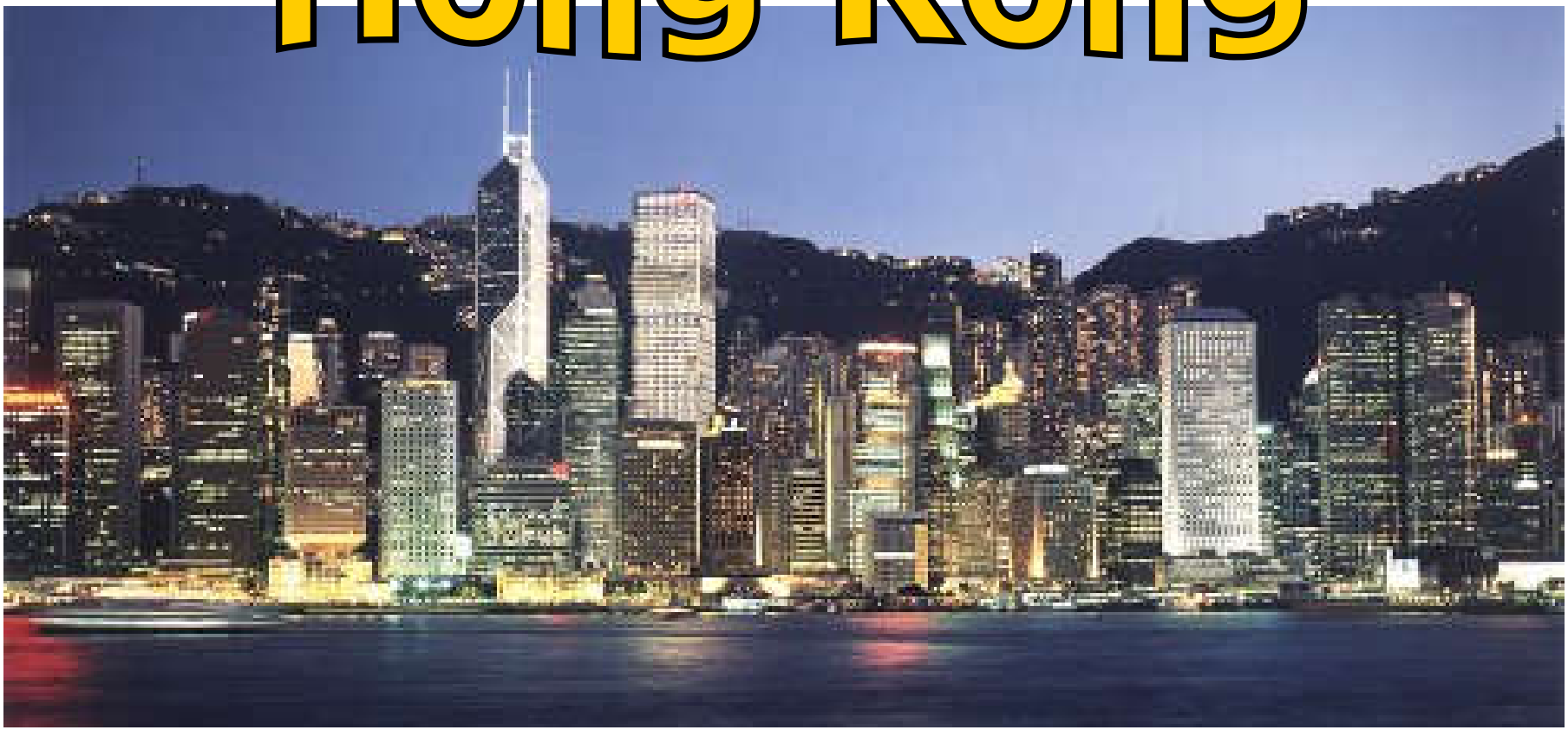
"We shape our buildings and thereafter they shape us."
(Winston Churchill)

Satellite picture from Dr. Remetey Gabor (Hungarian Association for Geo-information)

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

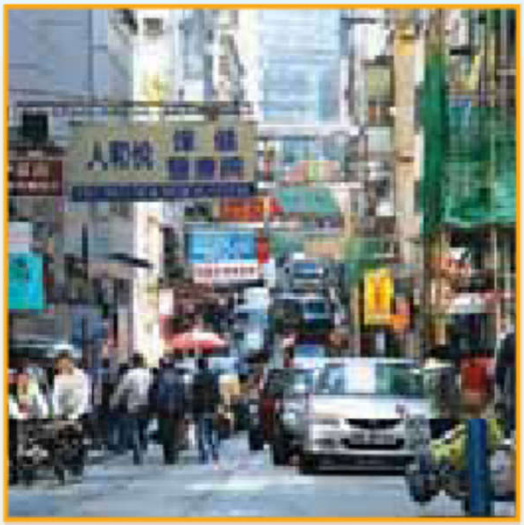
Affordable, efficient and comfortable public transport system

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

(Source: www.susdev.org.hk)

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

(Source: www.susdev.org.hk)

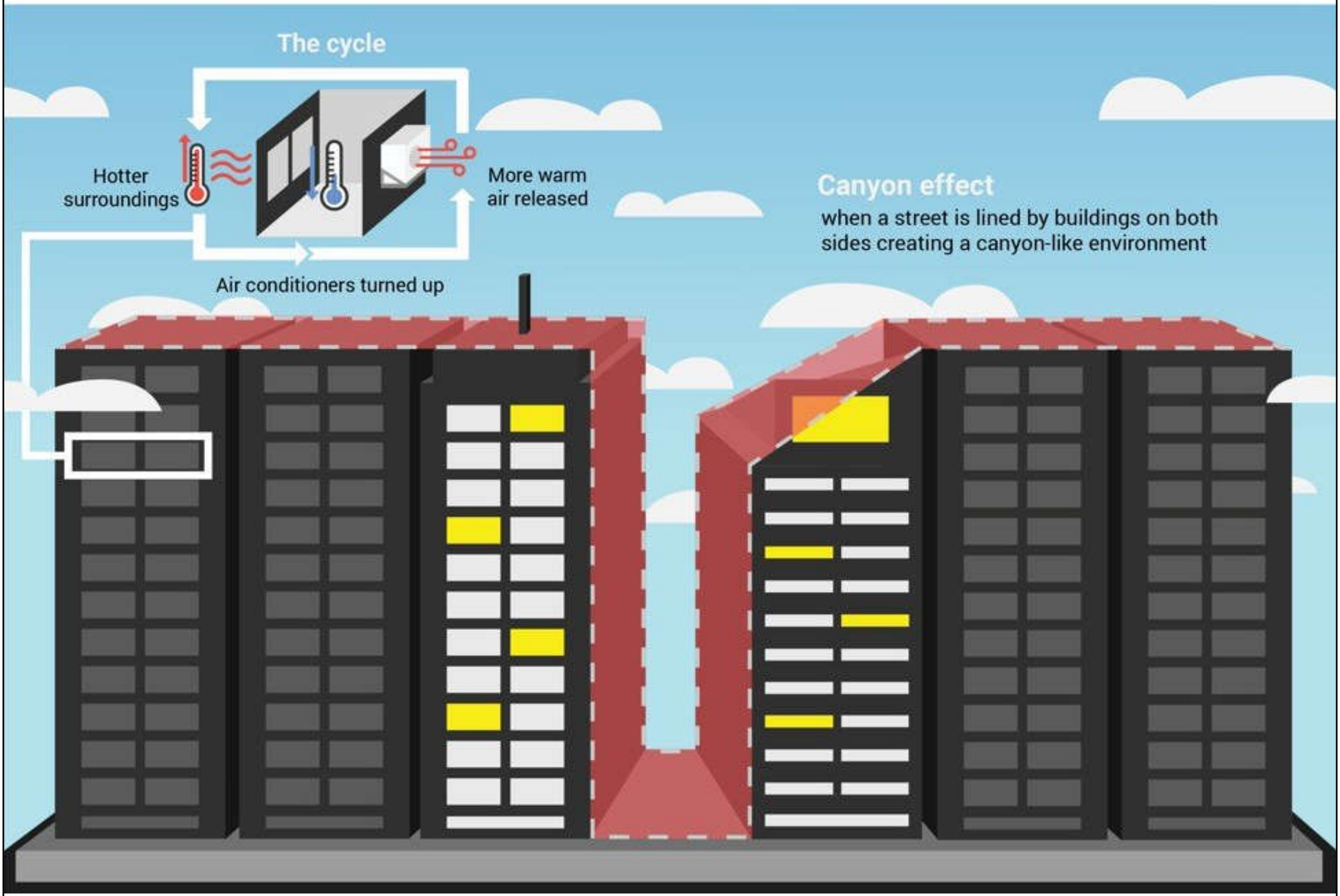
Sustainable built environment

- 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

(Source: https://www.gameover.com.hk/news/271103)

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

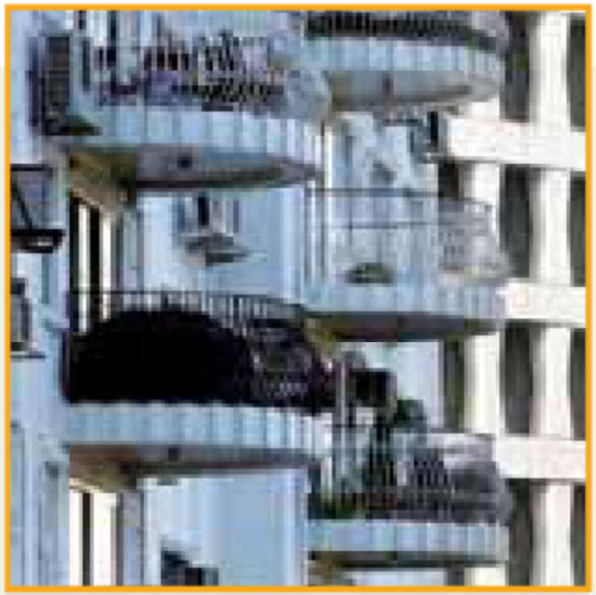


(Source: https://www.scmp.com/presented/lifestyle/topics/building-our-green-future/article/3037555/how-high-density-high-rise)

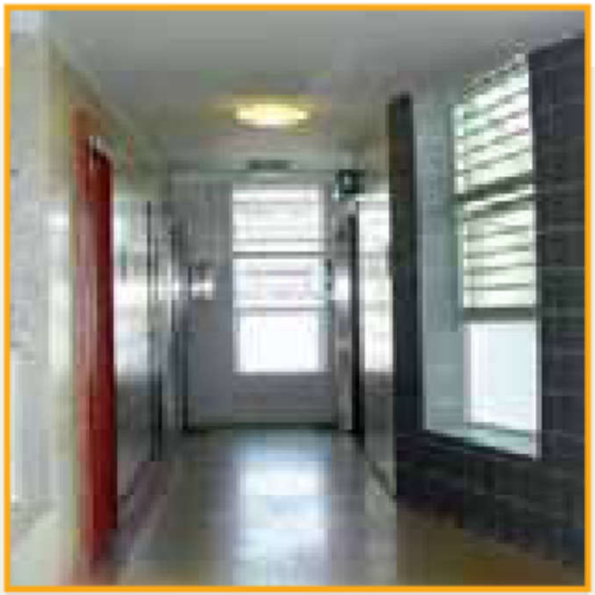
Sustainable built environment

- 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

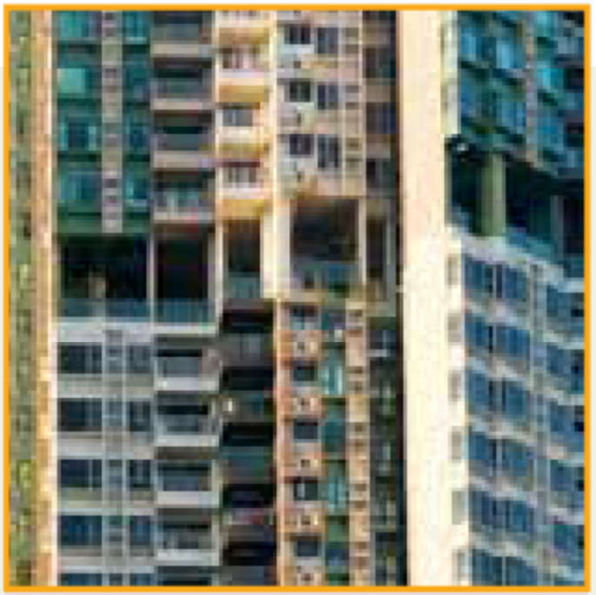
‘Green features’ under the Joint Practice Notes in Hong Kong



Balconies



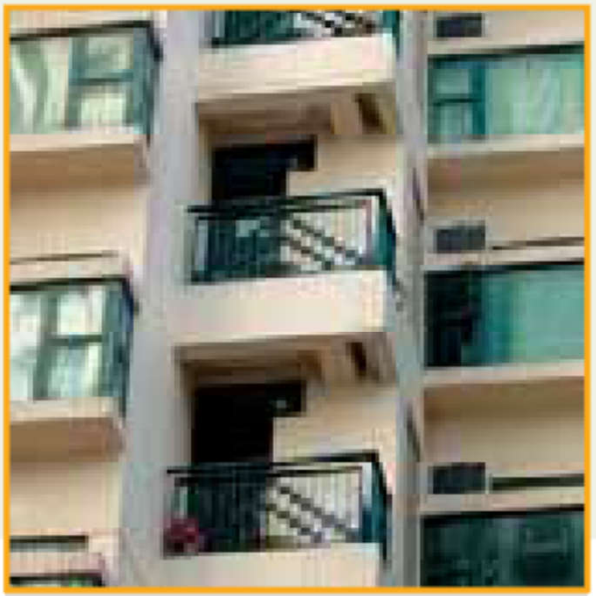
Wider common corridors



Sky gardens

Mail delivery rooms

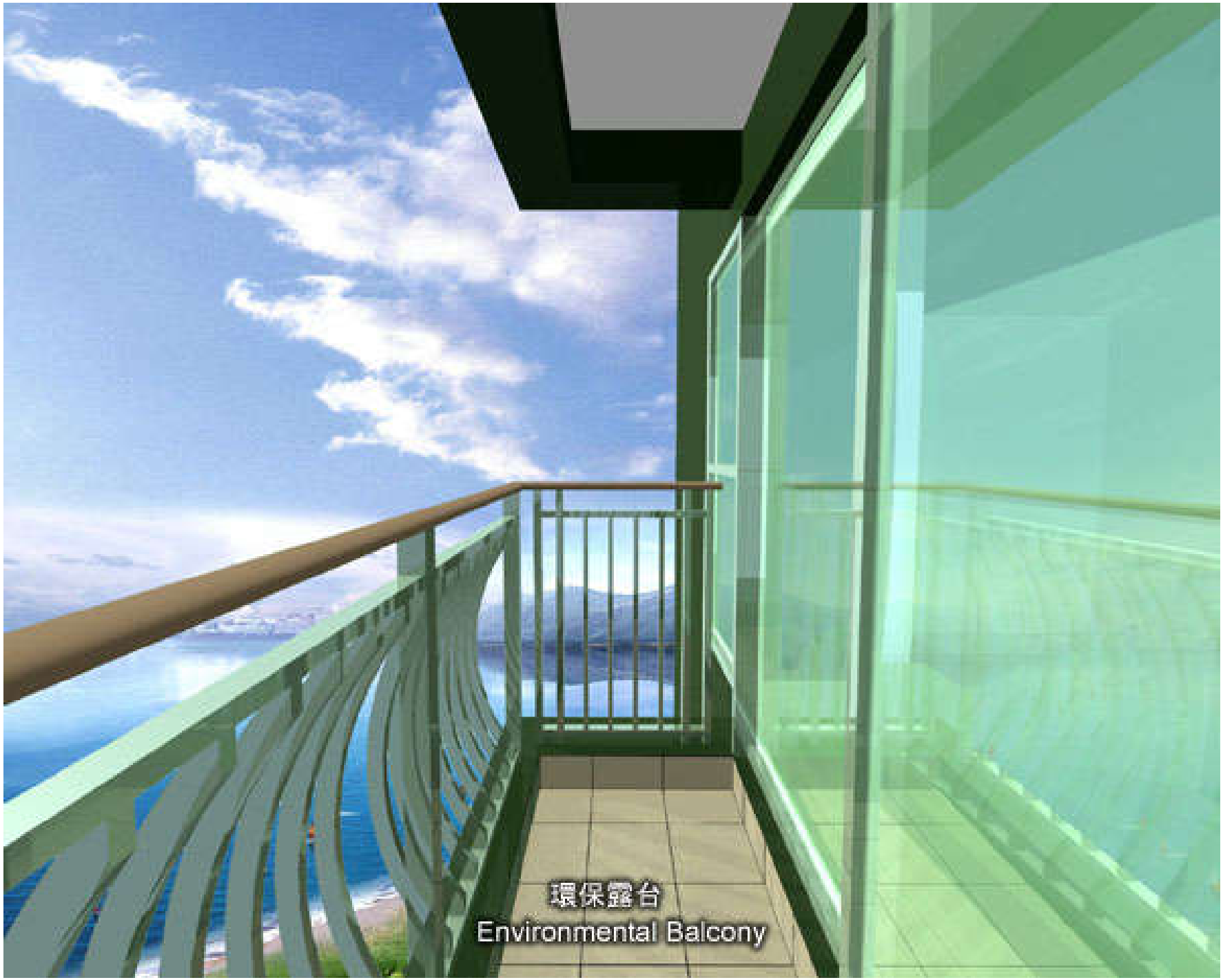
Podium gardens



Utility platforms

(Source: www.susdev.org.hk)

Environmental balcony 環保露台



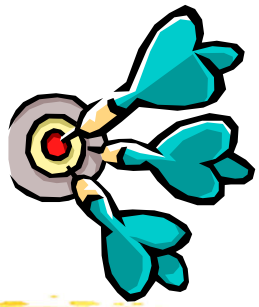
Examples of green building design features/issues

(Source: www.susdev.org.hk)

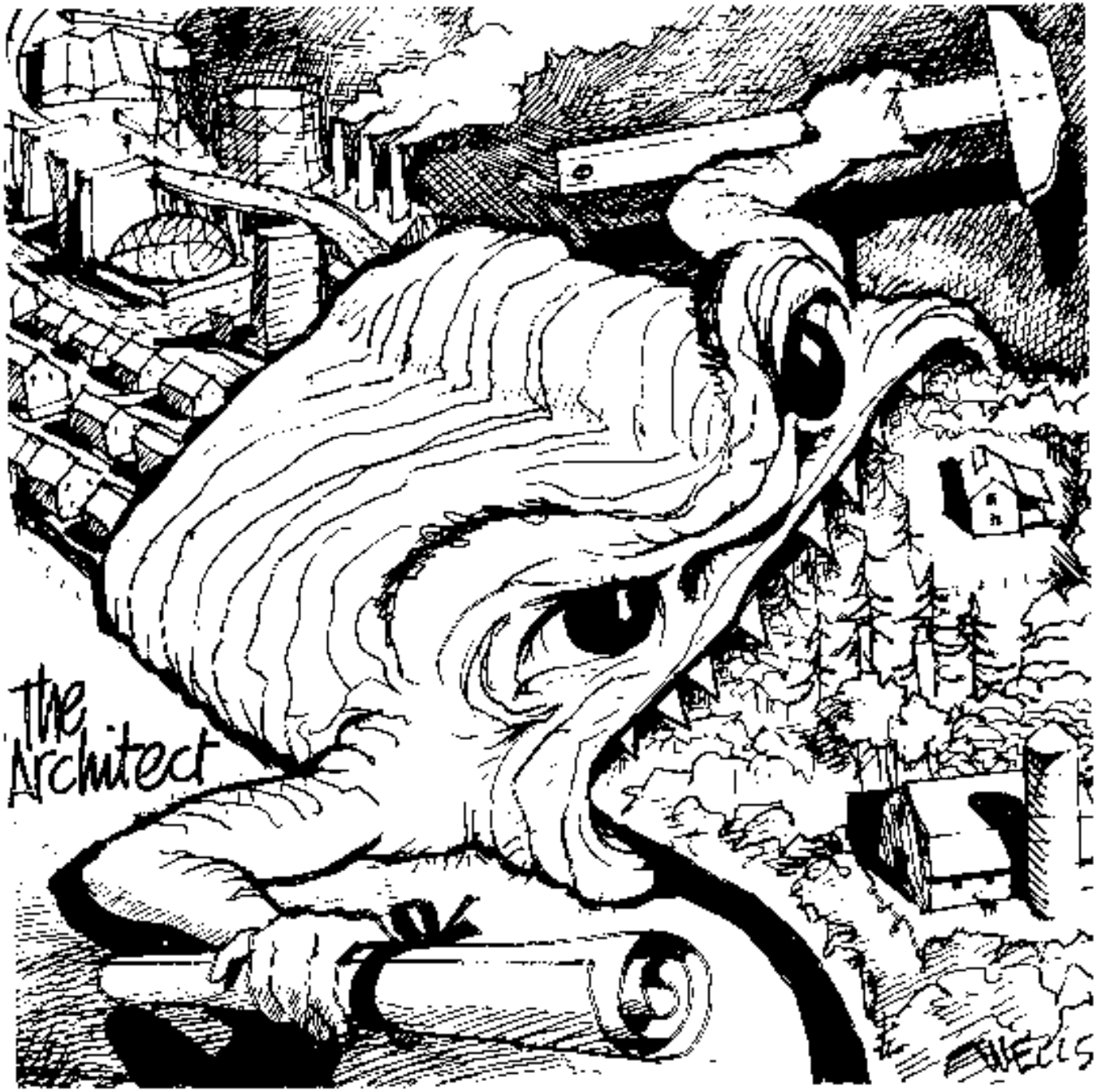
"It's not easy being green." -- Kermit the Frog, 1972.

Why going green?

Why going green?

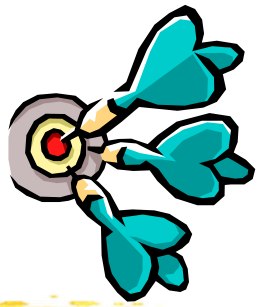


- Survival of our planet: environmental crisis
  - Air (destruction of Earth's atmosphere)
    - Global warming, climate change
  - Water (an undervalued resource)
    - Shortage and pollution
  - Fire (the problem of fuels)
    - Fossil fuel burning (coal, oil)
  - Earth (resources and materials)
 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



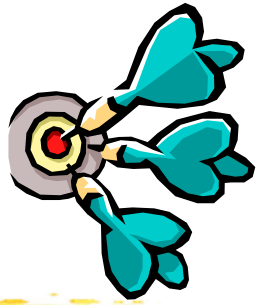
Drawing by the American architect Malcolm Wells

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

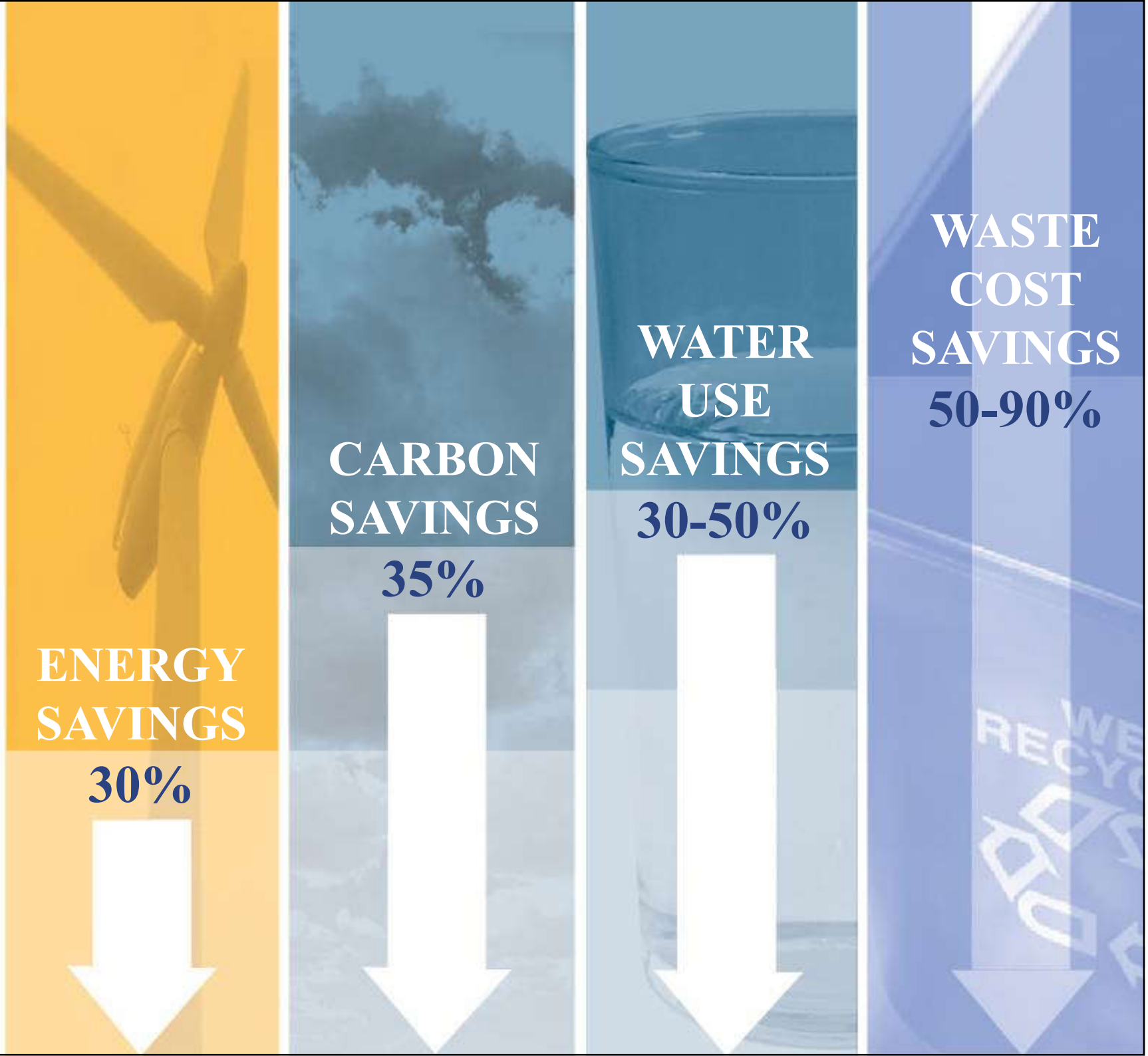
Why going green?



- Green buildings pay
  - Direct benefits (e.g. energy/cost savings)
  - Indirect benefits (e.g. healthier conditions)
  - Wider global benefits (e.g. reduced CO_2 emission)
- Life-cycle benefits
  - Total economic and environmental performance
  - Long-term "*sustainability*"

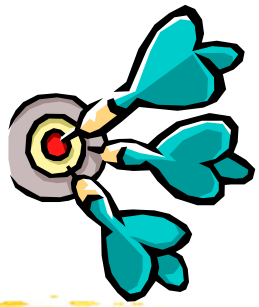
(See also: Why Build Green? (US-EPA) http://archive.epa.gov/greenbuilding/web/html/whybuild.html)

Average Savings of Green Buildings



Source:
Capital E

Why going green?

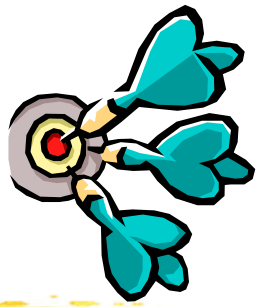


- Benefits of sustainable buildings:
  - They are designed to be cost effective
  - They boost employee productivity
  - They enhance health and well-being
  - They reduce liability
  - They create value for tenants
  - They increase property value
  - They benefit the community
  - They achieve more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

Seven ways to identify value from a sustainable built environment

(Source: https://www.worldgbc.org/business-case)

Why going green?



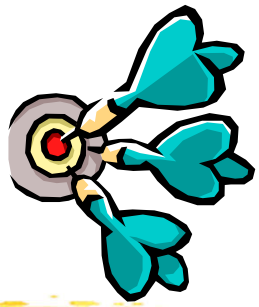
- Psychological benefits of green buildings:
  - Sense of community
  - Workplace pride
  - Space perception
  - Atmosphere
  - Space evaluation
  - Task completion
  - Stress

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

(Source: https://www.bigrentz.com/blog/benefits-of-green-buildlings)

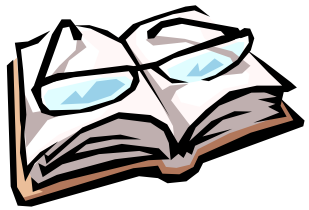
Why going green?



- 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

(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

(Video: Cappadocia, Turkey: Inside The Cave Dwellings. National Geographic (4:30) http://www.youtube.com/watch?v=xM-i3wCaXyw)

Photo credit: Renzo Piano Workshop Foundation

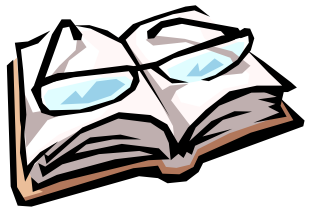
A modern example of Sustainable Architecture:

Jean Marie Tjibaou Cultural Center (by Renzo Piano)

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

(See also: http://inhabitat.com/jean-marie-tjibaou-cultural-center-inspired-by-native-architecture/)

Basic principles



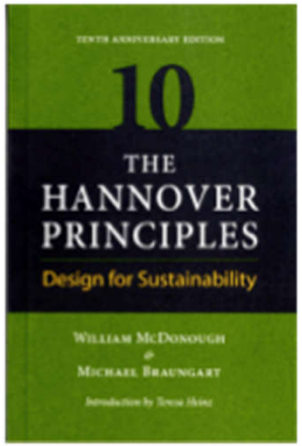
- **Principles of Sustainable Design**
  - Understanding place
  - Connecting with nature
  - Understanding natural processes
  - Understanding environmental impact
  - Embracing co-creative design processes
  - Understanding people

Main principles of sustainable design

(Source: Sustainable design https://claudiaportelli.weebly.com/blog/january-04th-2015)

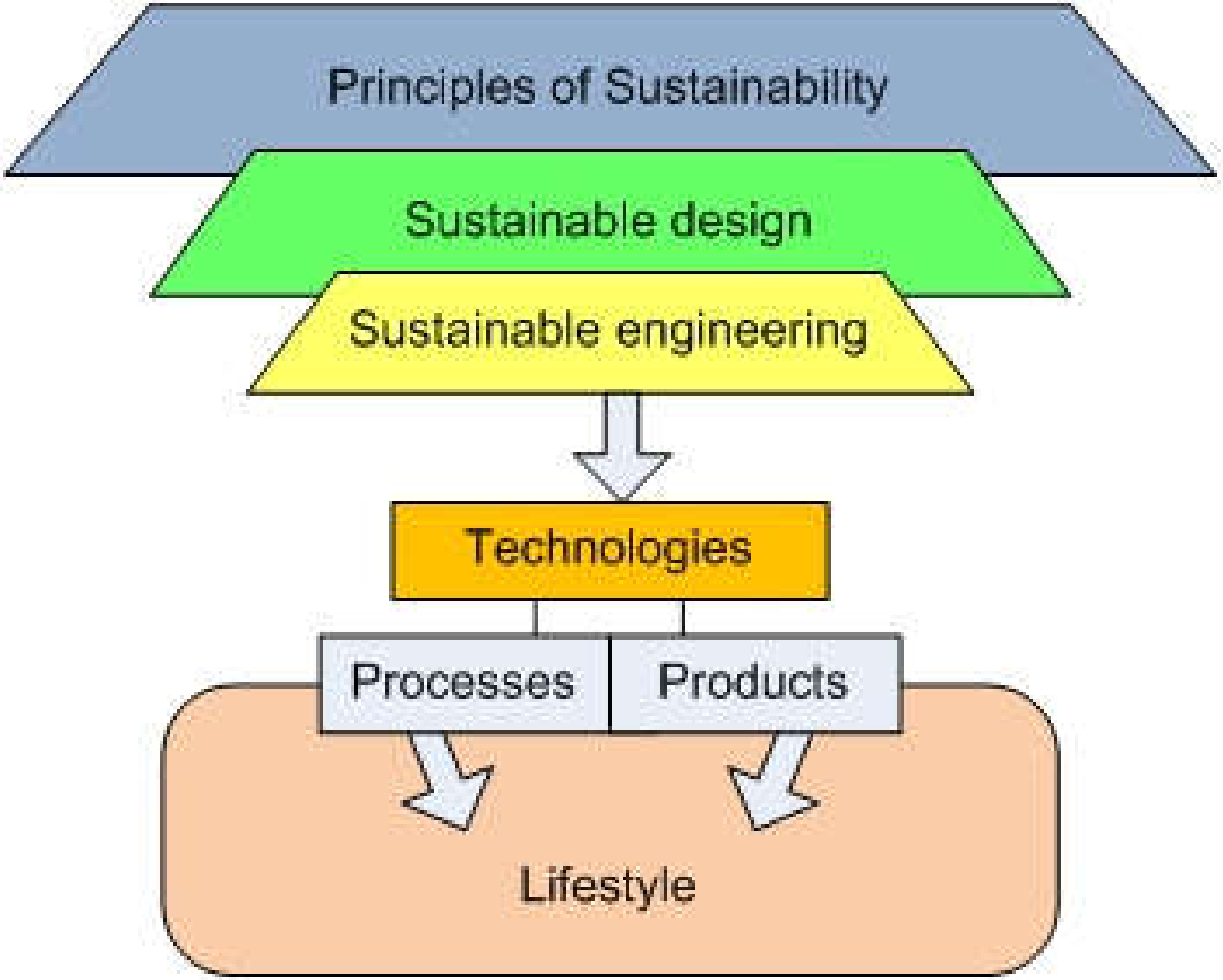
The Hannover Principles: Design for Sustainability (for Expo 2000)

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.



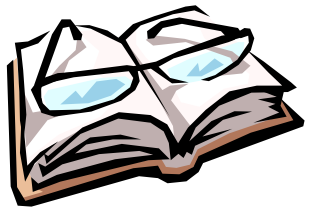
(Source: https://mcdonough.com/wp-content/uploads/2013/03/Hannover-Principles-1992.pdf)

Sustainability guidelines and role of technologies

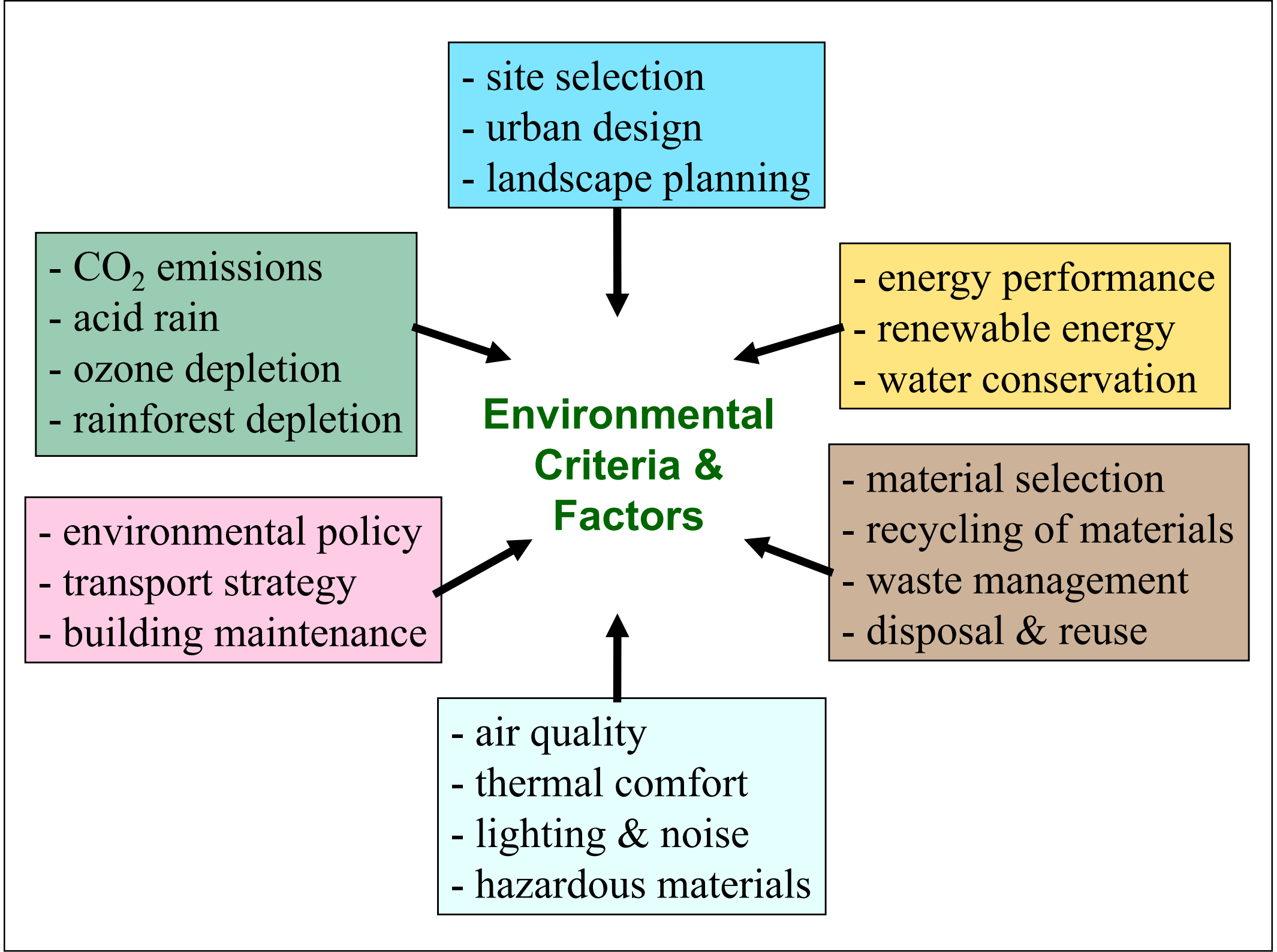


(Source: Principles of Sustainable Engineering https://www.e-education.psu.edu/eme807/node/688)

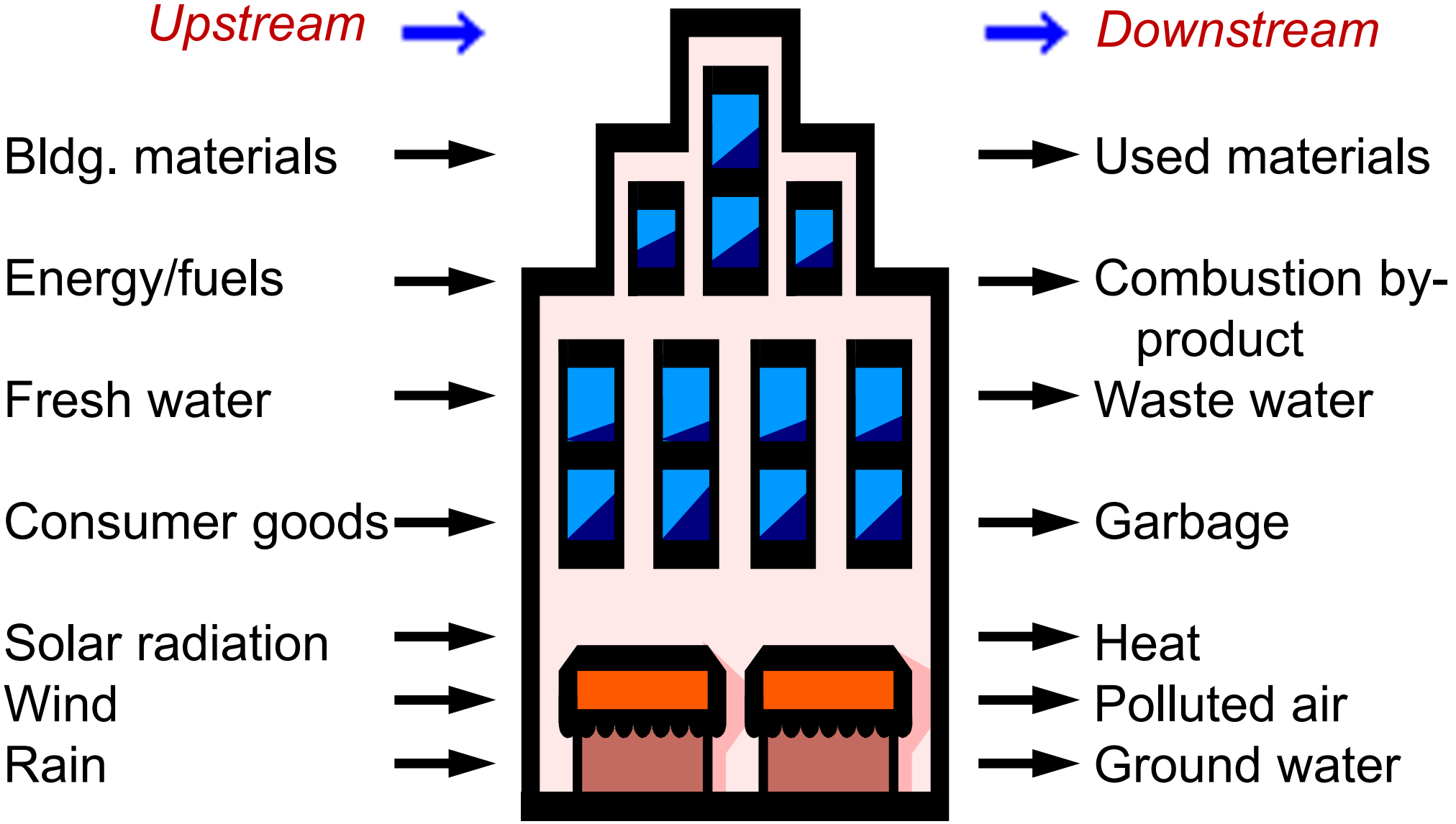
Basic principles



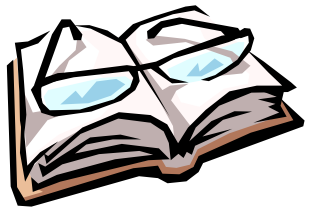
- Aims of green building design
  - Reduce energy in use
  - Minimise external pollution & environmental damage
  - Reduce embodied energy & resource depletion
  - Minimise internal pollution & damage to health
- Green design requires resolving many conflicting issues and requirements


- site selection
- urban design
- landscape planning
- CO_2 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

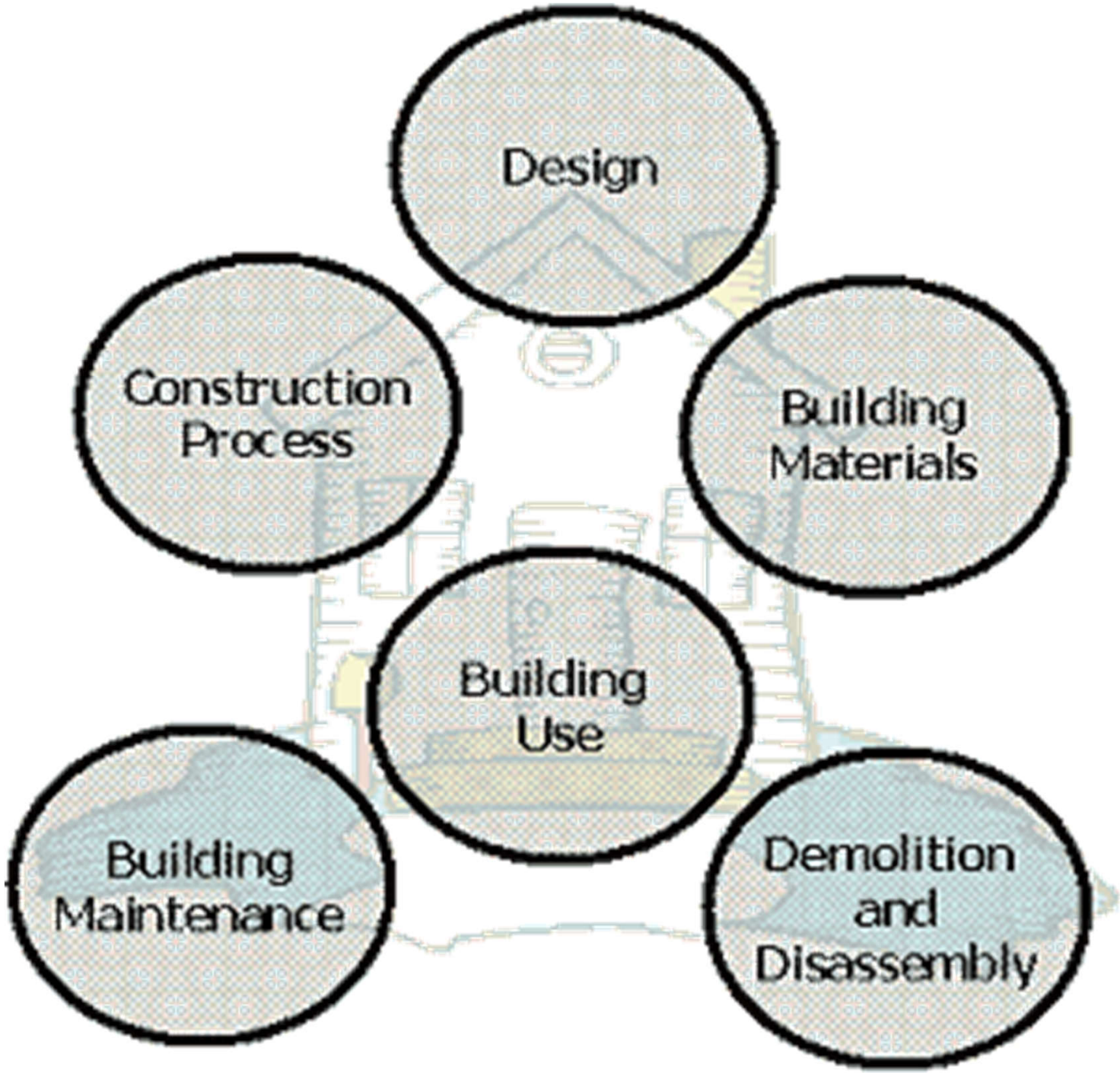


Basic principles



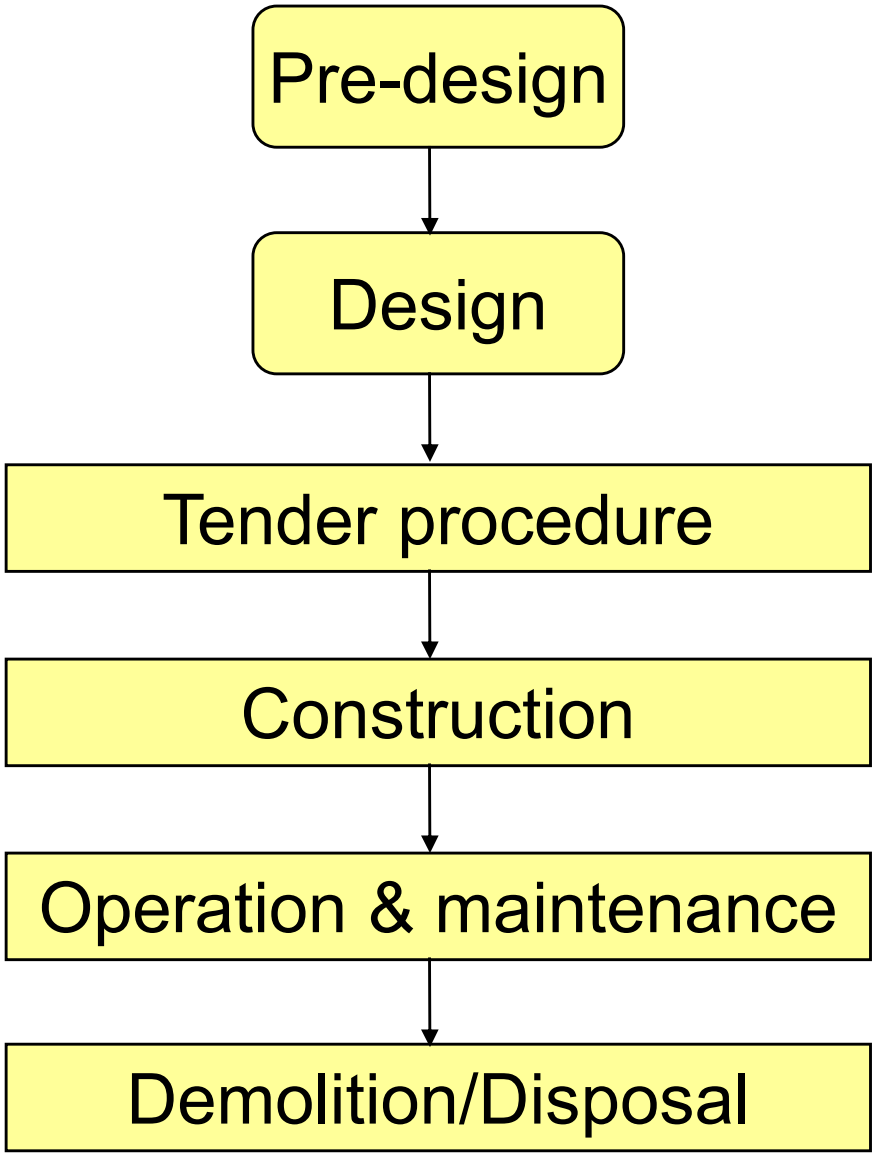
- Green building design involves
  - Holistic approach (whole systems thinking)
    - Each aspect is considered in relation to all others
  - Interdisciplinary efforts
    - Understanding & contribution from all involved
  - Understanding of building performance
    - Assessment & evaluation of performance
  - Caring for people
    - Well being of the occupants and users

Green Construction - A Sustainability Toolbox



(Source: Green Construction - A Sustainability Toolbox https://www.gdrc.org/uem/green-const/toolbox/box-index.html)

Building and construction process



- Inception
- Feasibility

- Outline proposals
- Scheme design
- Detail design

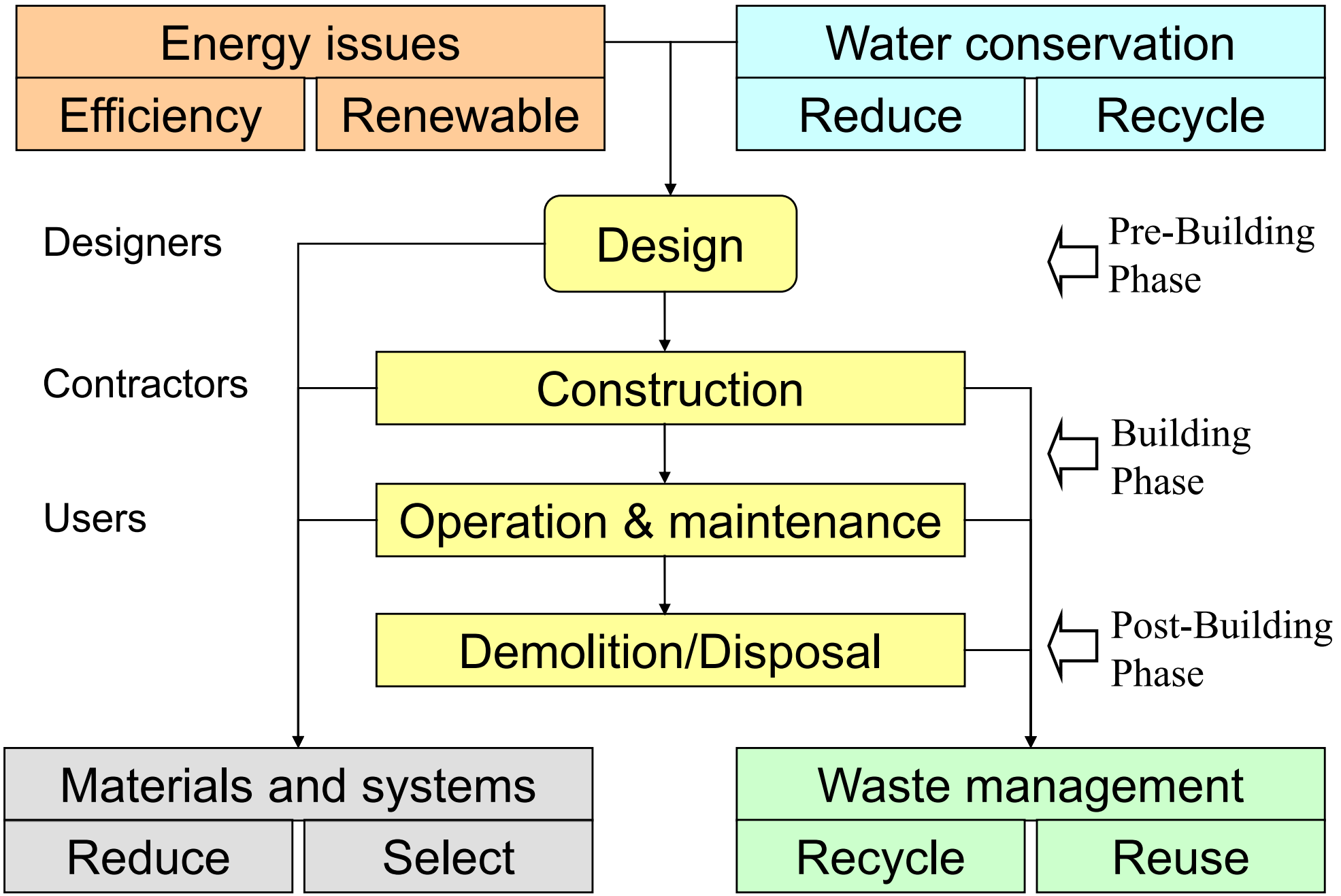
- Production info.
- BQ, tender, planning

- Operation on site
- Completion
- Testing & commissioning

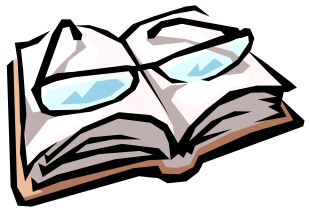
- Operation & Maintenance
- Refurbishment

- Demolition/Disposal

Building life cycle and sustainable construction

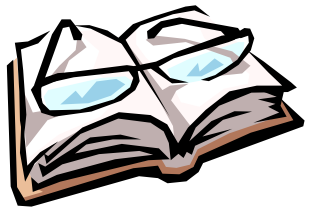


Basic principles



- 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

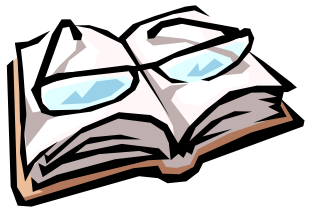
Basic principles



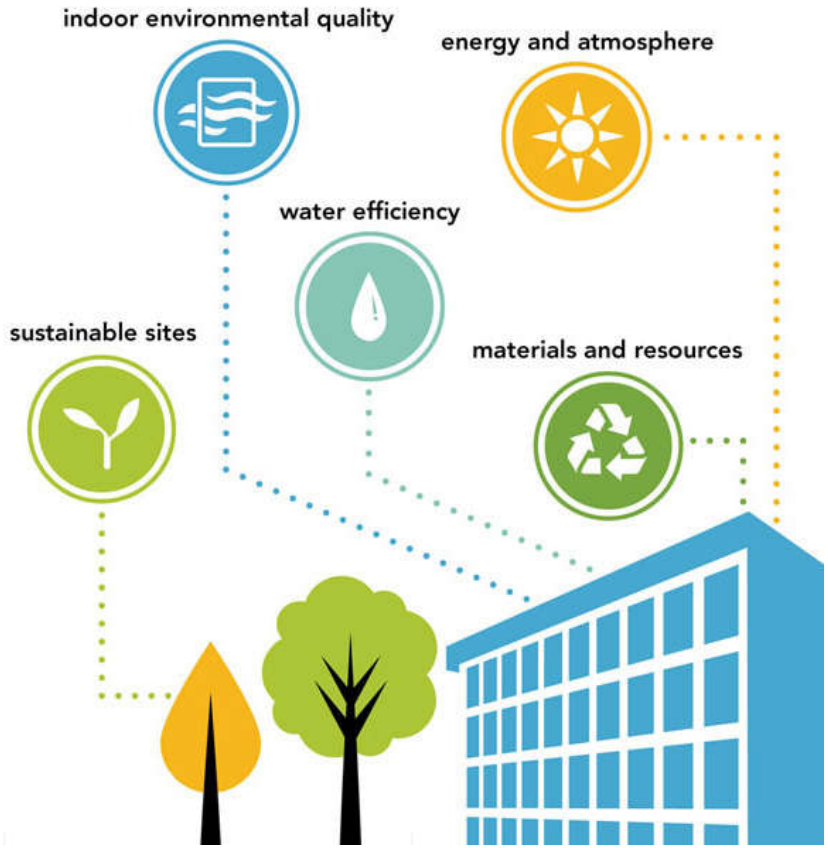
- Truly green design is more than a technological add-on. Green buildings are the one that
  - Work well
  - Suit the people in them
  - Show off the cultural context

- The need to cultivate "*sustainable thinking*"
  - Define & achieve sustainability in a given context
  - Connection to the mass of current design

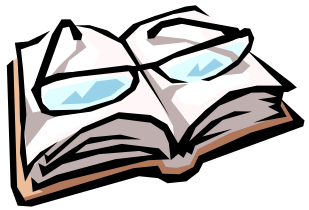
Basic principles



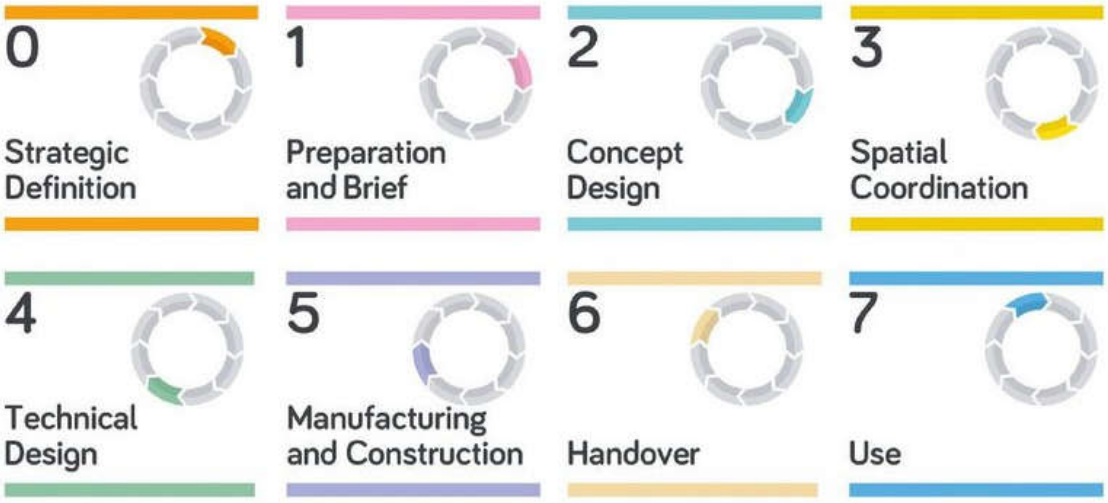
- Green building design strategies: http://ibse.hk/GB_design_strategies.pdf
  - Sustainable site
  - Energy and atmosphere
  - Water efficiency
  - Materials and resources
  - Indoor environmental quality



Basic principles

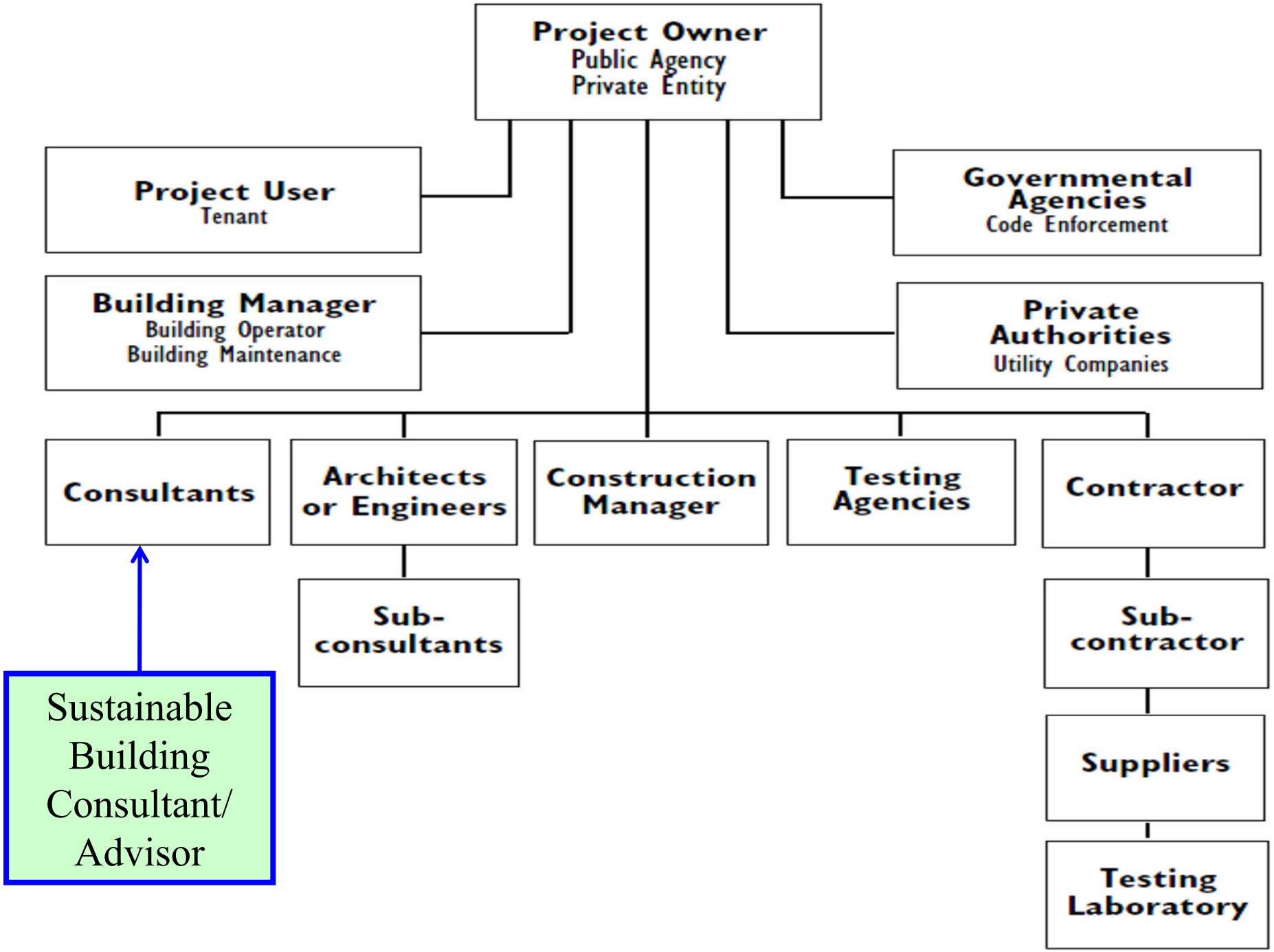


- Green strategies at different stages:
  - Inception (briefing, targets, site)
  - Design
    - Preliminary studies
    - Sketch studies
    - Pre-project
    - Basic project
    - Execution of project



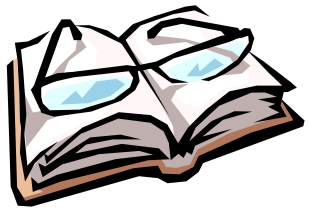
  - Construction (tendering, supervision, acceptance)
  - Maintenance & refurbishment

Typical project team in building and construction process



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

Basic principles

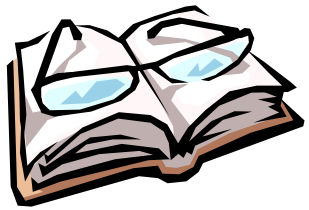


- Key areas for green specialist advice
  - Building structure & materials
  - Building envelope design
  - Heating, ventilation & air-conditioning (HVAC)
  - Lighting systems
  - Electrical power
  - Water services
  - Landscaping
  - Cost estimating (e.g. life cycle cost studies)

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

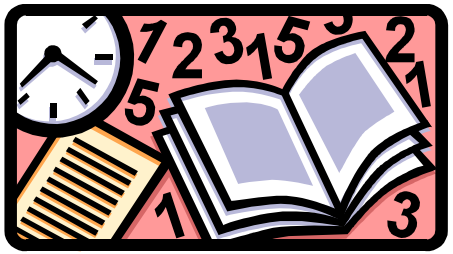


- Green building education
  - Eco-education & higher education
  - Degree in building profession
  - Degree in specialized environmental
  - Training programmes & continuing education
- Green building professionals

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

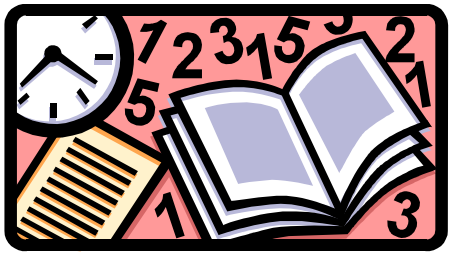
(Source: Henderson H., 2012. *Becoming a Green Building Professional*, Wiley, Hoboken.)

Further Reading



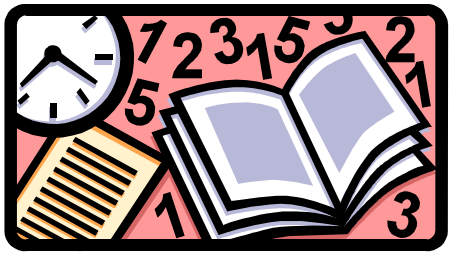
- Sustainable architecture – Wikipedia
  http://en.wikipedia.org/wiki/Green_architecture
- Sustainable design – Wikipedia
  http://en.wikipedia.org/wiki/Sustainable_design
- Sustainable development – Wikipedia
  http://en.wikipedia.org/wiki/Sustainable_development
- Green building design strategies
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

Further Reading

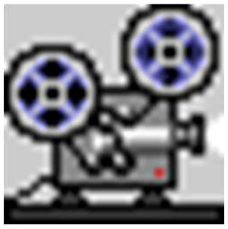


- Teaching Kit: Sustainable Design for Buildings (ArchSD)
  - https://www.archsd.gov.hk/en/teachingkits/TK1/
    - Sustainable planning
    - Sustainable building design
    - Green procurement
    - Green construction management
    - Sustainable maintenance
    - Stakeholder Engagement

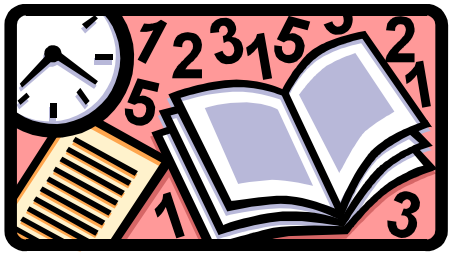
Further Reading



- 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]