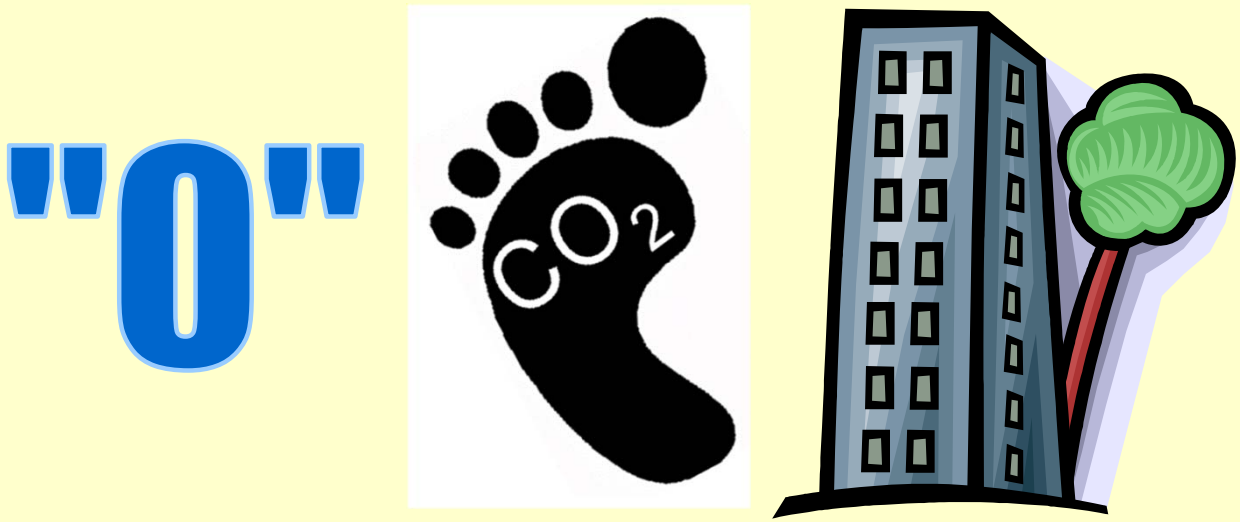
Sustainable Building 2013 HK Regional Conference:
Urban Density and Sustainability
12-13 Sep 2013 (Thu-Fri)



Assessing carbon footprints of zero carbon buildings

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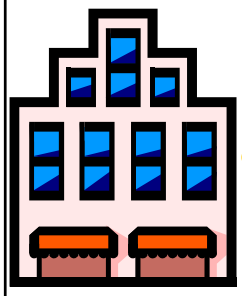
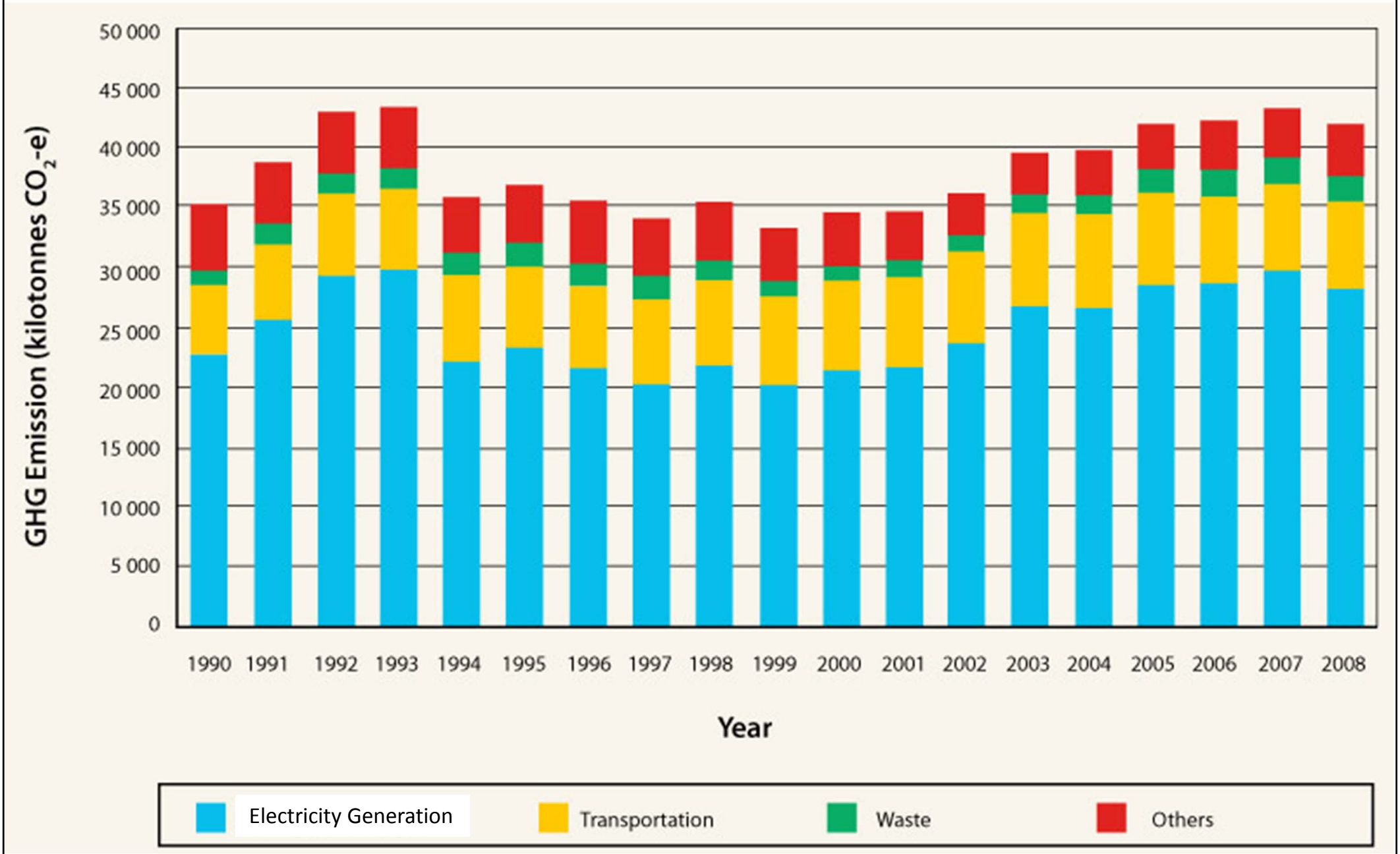
Introduction

- Low or zero carbon design "0"
  - Achieve sustainability and combat climate change
- Buildings
  - One of the largest sources of carbon dioxide and greenhouse gas (GHG) emissions
  - Building sector presents the most cost effective opportunities for GHG reductions
  - Many countries are developing policies and measures to promote zero or low carbon buildings

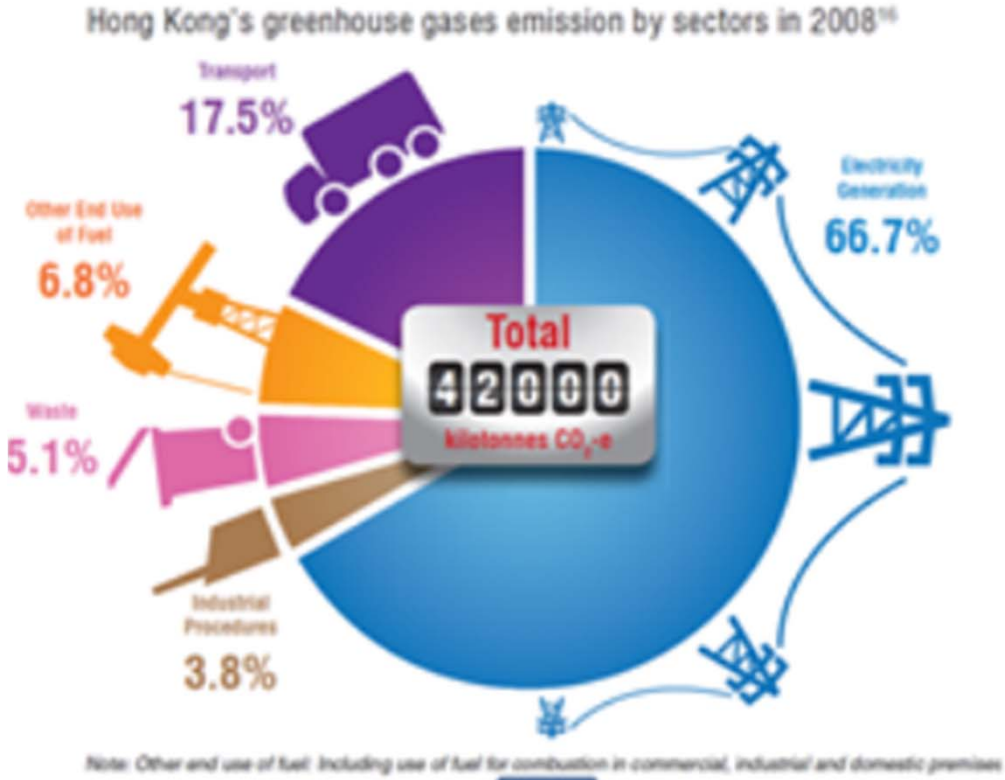


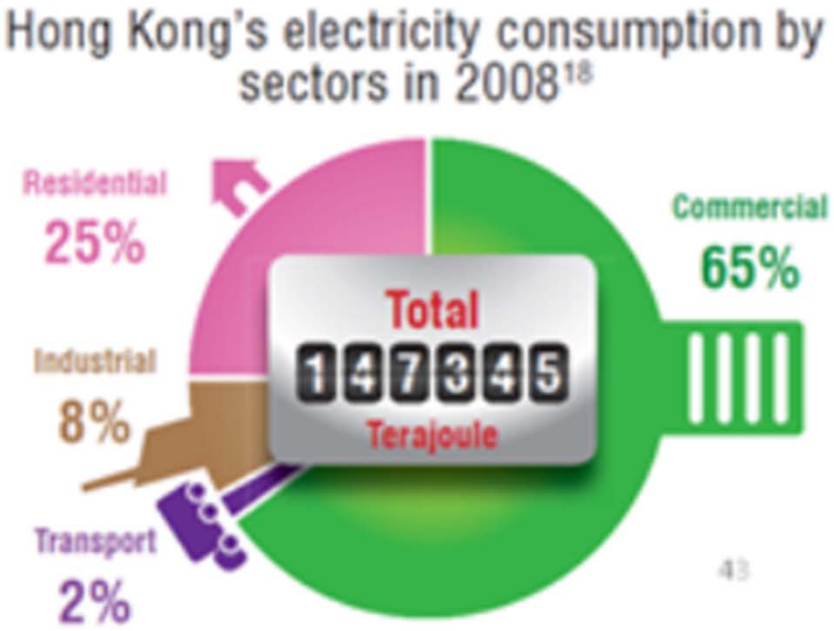
Greenhouse gas (GHG) emission trends of Hong Kong 1990-2008



(Source: www.epd.gov.hk)

Greenhouse gas (GHG) emission of Hong Kong 2008





(Source: www.epd.gov.hk)

Zero Carbon Buildings (ZCB) "0"

- Zero energy building (ZEB) 零能耗建築
  - A building that produces as much energy on-site as it consumes on an annual basis
  - "Net" zero energy building 淨零能耗建築
- In recent years, many researchers and governments investigated the definitions of ZEB and ZCB to develop an internationally agreed and consistent definition

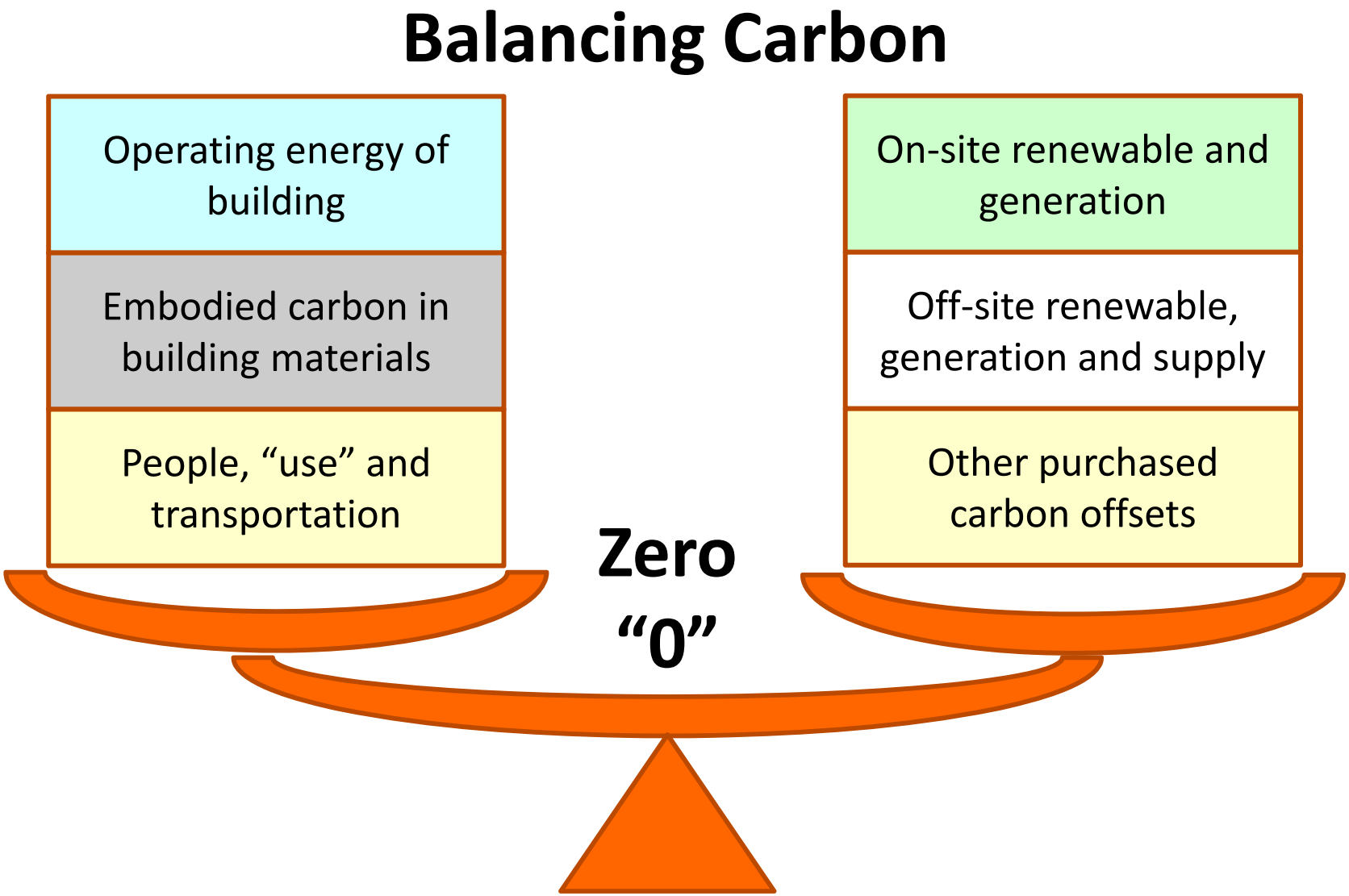
Table 1: Terms and definitions of ZEB and ZCB

Terms	Definitions/Meanings
Zero energy building (ZEB) or net zero energy building (NZEB)	A building that produces as much energy on-site as it consumes on an annual basis
Net zero site energy building (site ZEB)	Amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building
Net off-site zero energy building (off-site ZEB)	Similar to previous one, but consider purchasing of energy off-site from 100% renewable energy sources
Net zero source/primary energy building (source ZEB)	It produces as much energy as it uses in a year, when accounted for the source. For electricity, only around 35% of the energy used in a fossil fuel power plant is converted to useful electricity and delivered. Site-to-source conversion multipliers are used to calculate a building's total source energy
Net zero energy cost building (cost ZEB)	The cost of purchasing energy is balanced by income from sales of electricity to the grid of electricity generated on-site
Net zero energy emissions building, zero carbon building (ZCB), zero emission building	The carbon emissions generated from the on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production

Zero Carbon Buildings (ZCB) "0"

- ZEB is often used in conjunction with ZCB
  - ZEB: reduce the operating energy requirements → zero fossil energy
  - ZCB: use renewable and low-carbon energy sources to offset or balance carbon emissions
- ***Balancing*** carbon concept for ZCB
  - Two major types of balance:
    - Import/export balance (e.g. for ZCB)
    - Load/generation balance (e.g. for ZEB)

Balancing carbon emissions for zero carbon buildings (ZCB)



Sources of difference between definitions of ZCB

a. The metric of the balance (e.g. primary energy, final energy, carbon emission)
b. The balancing period (monthly, seasonal, operation year, life cycle)
c. The type of energy use included in the balance (e.g. HVAC, lighting, appliances)
d. The type of energy balance (import/export and load/generation)
e. The accepted renewable energy supply options
f. The connection to the energy infrastructure (grid connected or standalone)
g. Other requirements relating to energy efficiency, the indoor climate and building-grid interaction

(Source: Marszal, *et al*. (2011))

Zero Carbon Buildings (ZCB) "0"

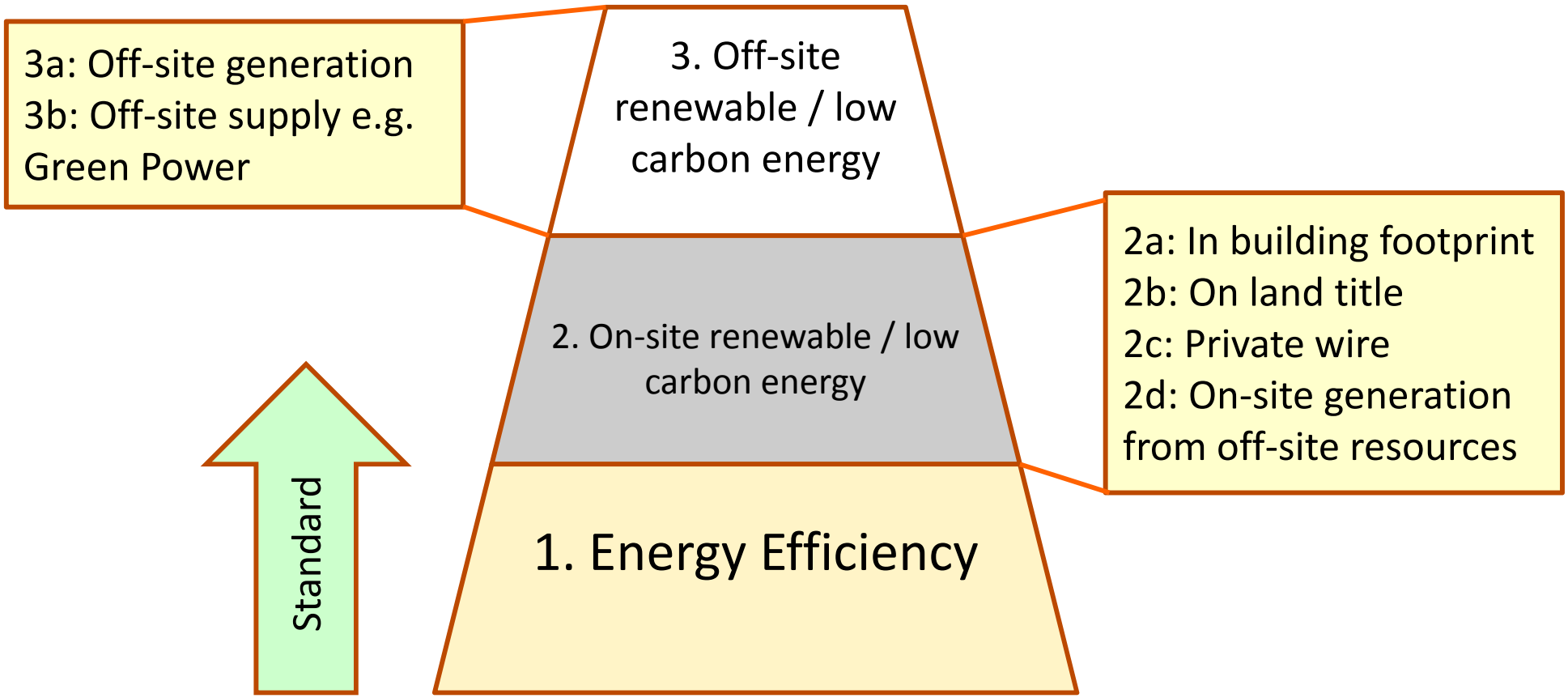
- Australia has developed a definition for ZCB
  - "A zero carbon building is one that has no net annual Scope 1 and 2 emissions from operation of building incorporated services.

    - Include building envelope, water heater, built-in cooking appliances, fixed lighting, shared infrastructure and installed renewable energy generation
    - ZCB must meet specified standards for energy efficiency and on-site generation
    - Compliance is based on modelling or monitoring of greenhouse gas emissions in kg CO2-e/m^2/yr."

Table 2: Variations of ZCB [adapted from ASBEC (2011)]

Zero carbon occupied building	Include occupant emissions
Zero carbon embodied building	Include embodied emissions
Zero carbon life-cycle building	Include all emission sources in the building life cycle
Autonomous zero carbon building	No grid connection
Carbon positive building	Achieves less than zero emissions

Allowable emission reduction options for zero carbon buildings



- '**Zero carbon**' demands a numerical assessment and validation of the building design

- ZCB compliance requires designers to numerically validate the effectiveness of their approaches

Assess Carbon Footprints

- **Carbon** is frequently used as shorthand for either carbon dioxide (CO_2) or carbon dioxide equivalents (CO_2-e) of greenhouse gases
  - Used as an indicator for environmental impact or sustainability level
- **Carbon footprint**
  - Measure the exclusive direct (on-site, internal), and indirect (off-site, external, embodied, upstream, and downstream) CO_2 emissions of an activity, or over the life cycle of a product, measured in kg

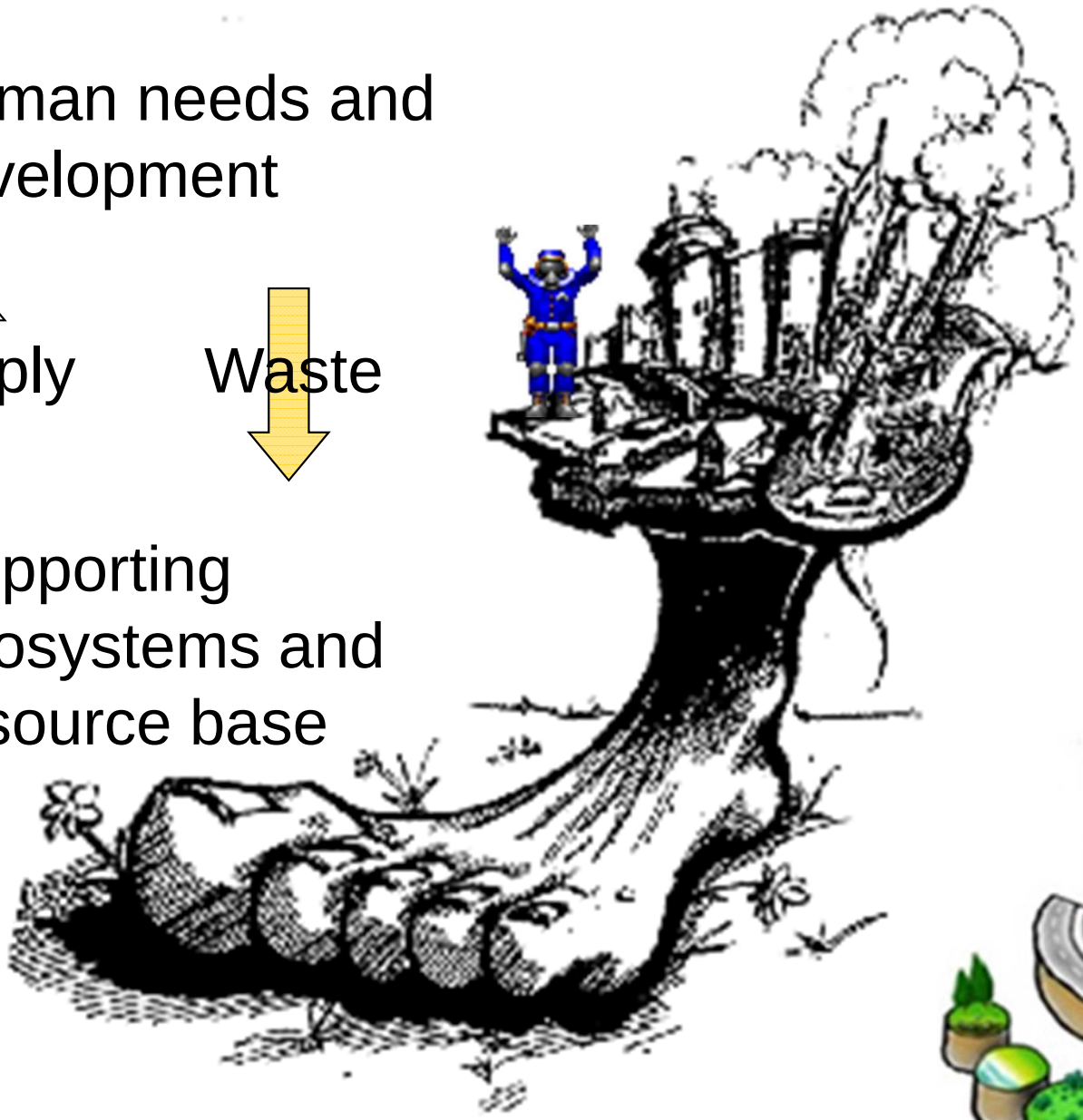
Urban cities and their ecological footprints

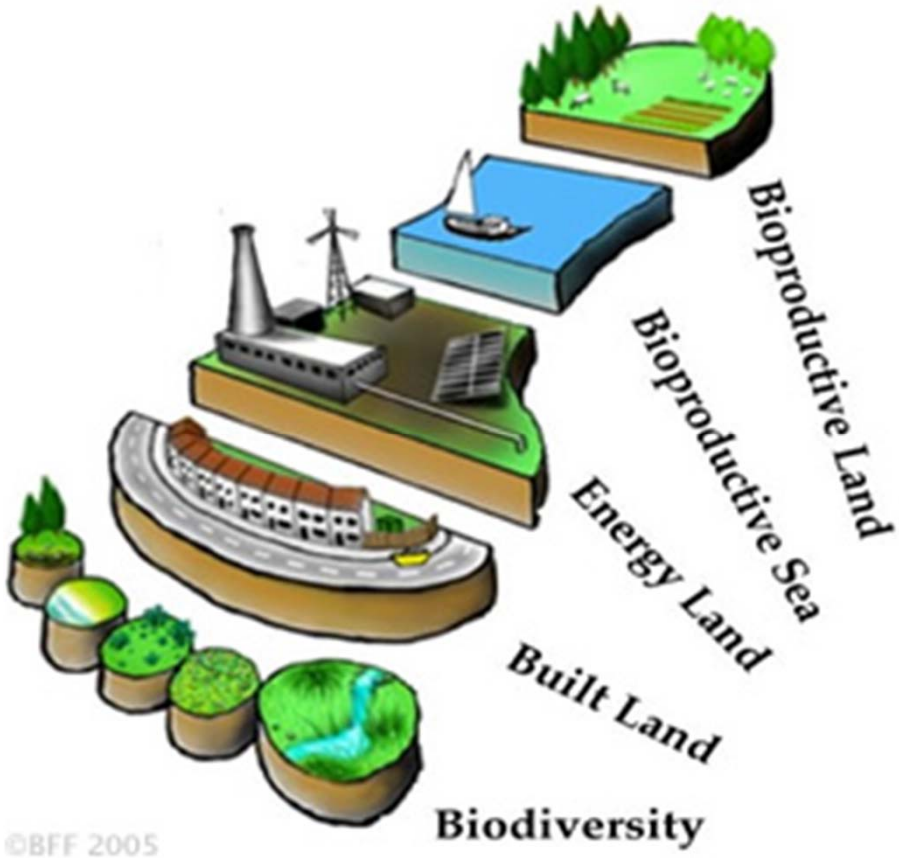
Human needs and development

Supply

Waste

Supporting ecosystems and resource base





Carbon footprint of a building and its components

- Materials manufacturing
- Materials transport
- Demolition wastes transport
- Demolition wastes treatment

- Building construction
- Building operation
- Building renovation
- De-construction

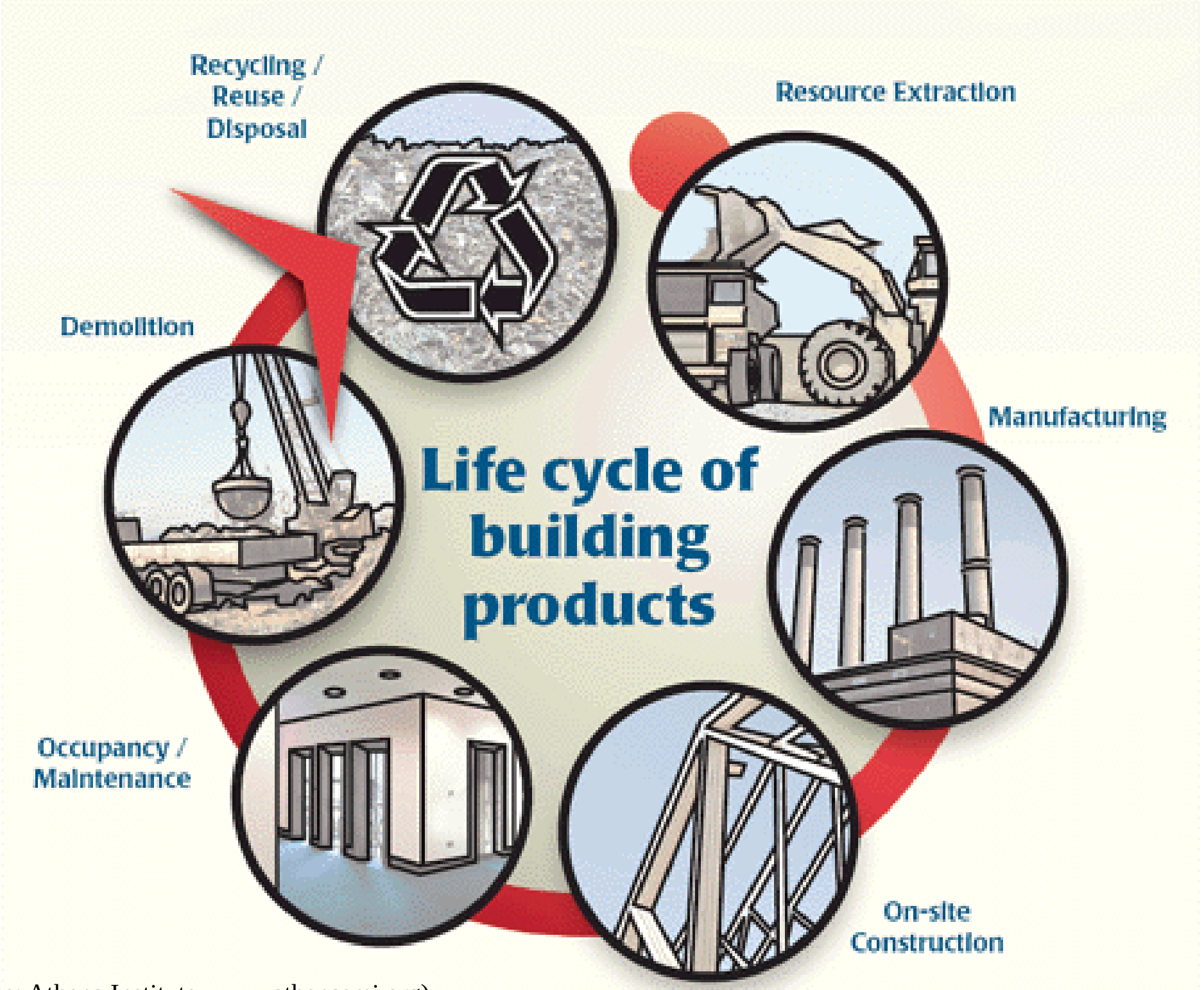
- Electricity consumption
- On-site fuel consumption
- On-site waste water treatment
- On-site solid wastes treatment
- Industrial processes housed in the building

Assess Carbon Footprints

- International standards for carbon footprint calculation and analysis
  - ISO 14040: Life Cycle Assessment - Principles and Framework
  - BSI: PAS 2050 - Specification for the Assessment of Life-Cycle GHG Emissions of Goods/Services
  - WRI/WBCSD: Greenhouse Gas Protocol
  - IPCC: 2006 Guidelines for National Greenhouse Gas Inventories

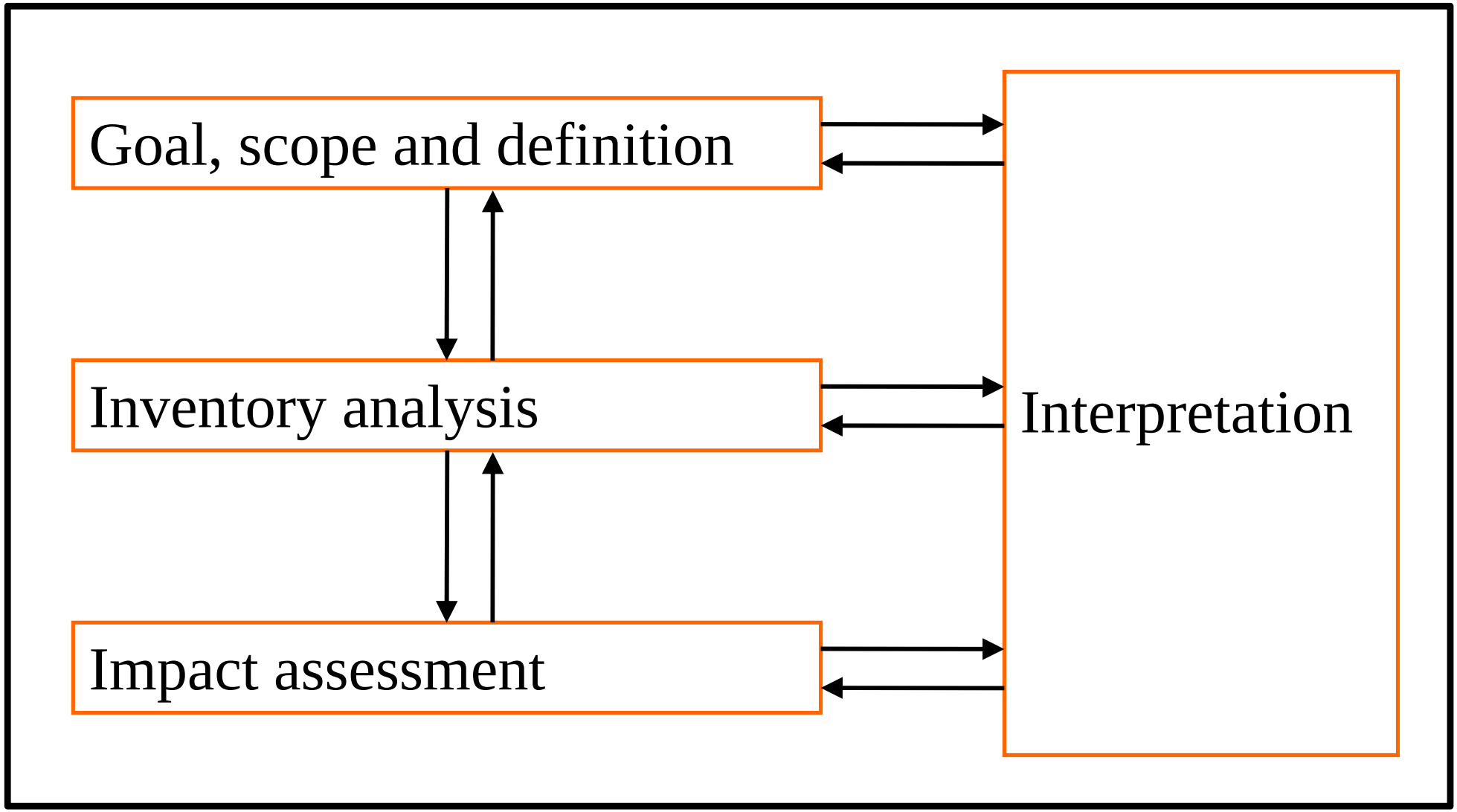
Cradle-to-Grave

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



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

Life cycle assessment framework



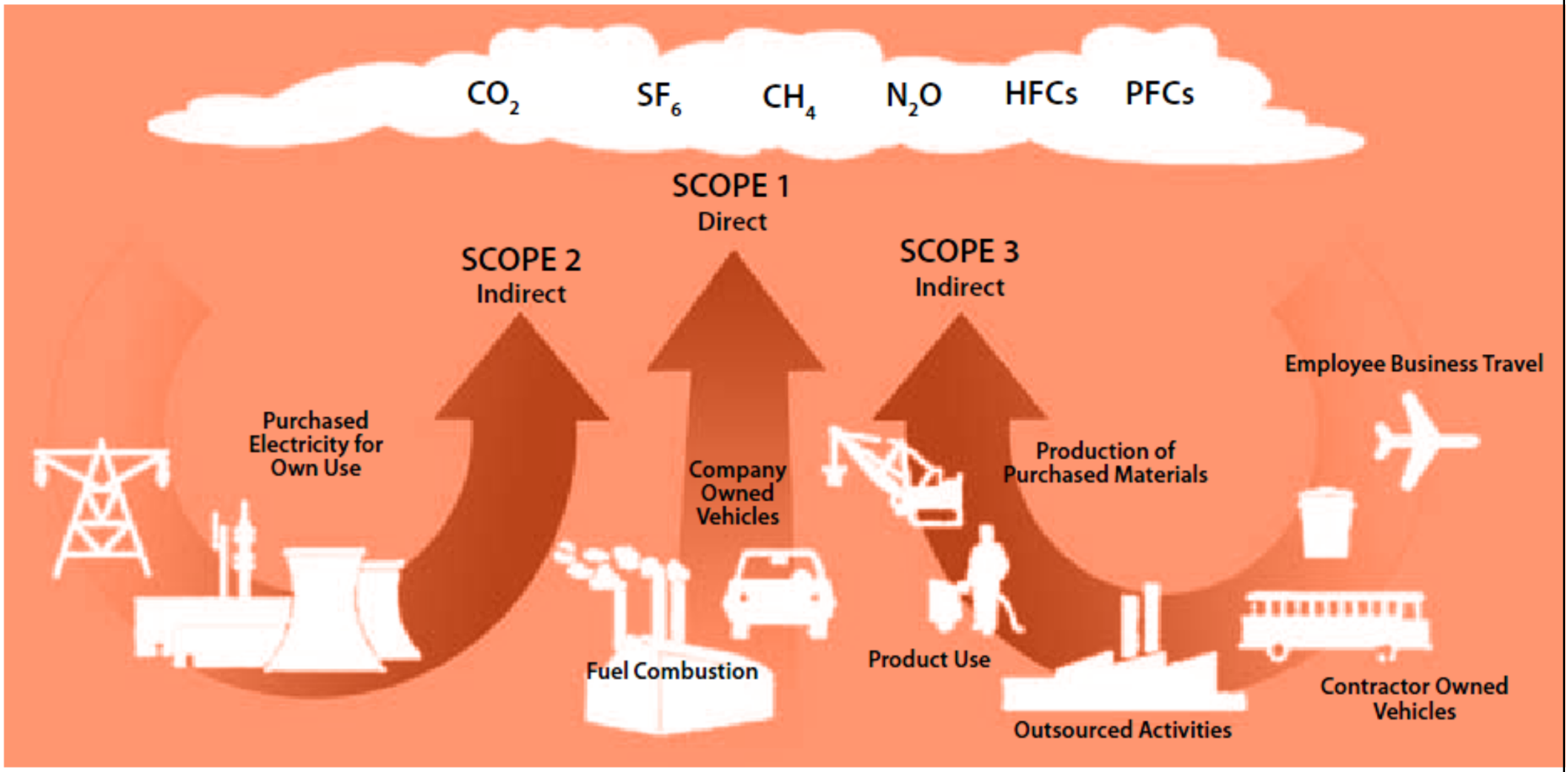
(Source: US-EPA)

Assess Carbon Footprints

- HK's carbon audit guidelines for buildings to report on greenhouse gas emissions focus on:
  - Physical boundaries (site boundaries of building)
  - Operational boundaries (to identify and classify the activities to determine the scope)
    - Scope 1 – direct emissions and removals
    - Scope 2 – energy indirect emissions
    - Scope 3 – other indirect emissions
  - Reporting period (usually one year)
  - Collecting data and information to quantify the greenhouse gas performance

Carbon Audit碳審計
綠色機構 Green Partner

Scope of greenhouse gas (GHG) emissions



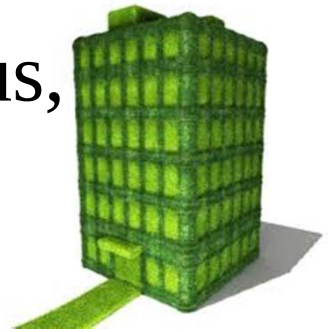
(Source: UNEP Sustainable Buildings and Climate Initiative, www.unepsbci.org)

Table 3: Different carbon reduction approaches

Strictly zero carbon	No carbon is emitted within Scopes 1 and 2; neither balancing nor offsets are allowed.
Net zero carbon	All carbon emissions within emissions Scope 1 are eliminated, and emissions within Scope 2 are balanced through export of low or zero carbon goods, internal or external sequestration, or import substitution of Scope 3 emissions.
Carbon neutral	Any and all emissions for which the building is responsible under Scopes 1 and 2 can be managed through the purchase of offsets from third parties that lie outside the building's boundaries.
Low carbon	Emissions under Scopes 1, 2 and 3 are reduced compared to a baseline. The reduction level is often not clearly specified.

Discussions

- Suitable candidates of ZCB
  - Medium- to high-rise buildings and high operating loads are quite difficult
  - Low-rise residential buildings is more feasible
- Green building sustainability assessments
  - Current assessment schemes (e.g. BEAM Plus, BREEAM and LEED) focus primarily on operational carbon
  - Use carbon footprints to measure sustainability



Discussions

- Carbon footprint is an effective *carbon accounting method* for facilitating GHG trade-offs and optimisation in buildings
  - Implement life cycle thinking into building planning and design
- Composite indicators including environmental, social, and economic footprints can also be developed

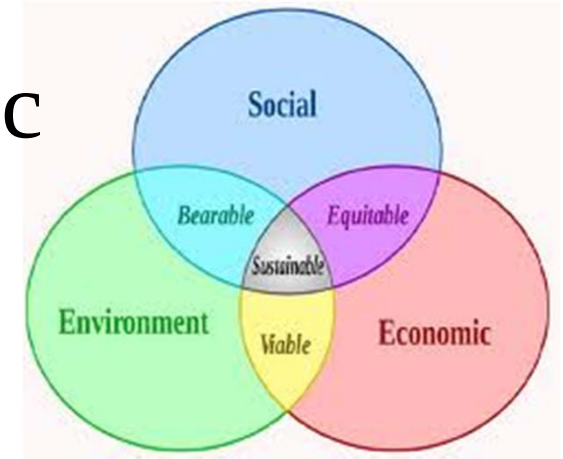


Table 4: Design strategies for ZCB

- At the outset, the building project should take into account building energy efficiency and use of renewable energy
- Select the appropriate building site; allow opportunity to apply renewable energy and to reduce transportation and food production needs
- Optimise passive design strategies to protect the natural and comfortable environment in order to reduce energy demand
- Conserve water and reduce the demand for hot water
- Appropriately select materials in order to reduce the environmental impacts
- Reduce energy use in all aspects of the building operation
- Consider building energy efficiency first before introducing renewable energy offsets

Hong Kong Situation

- Urban density
  - The land and space available for housing the population are very limited
  - HK has highly efficient mass transit and public transportation systems
  - Comprehensive urban planning and efficient high-performance building design are needed
  - Integrate sustainable transportation strategy, urban form and typology

Hong Kong Situation

- Community sustainability
  - High population densities and compact buildings
    - Can provide opportunities for using larger scale community based energy systems and cost-effective energy and utility supply arrangements
    - District cooling system, waste-to-energy recovery approach, centralised solar thermal or other renewable energy systems, and community based greening and water recycling programmes
  - A ‘zero carbon’ community

Conclusions

- ZCB/ZEB will lead the transition into low-carbon societies
- A clear ZCB definition and effective assessment methods are urgently needed

- Use carbon footprints as indicators to measure sustainability and for assessing ZCB
  - More work is needed to develop reliable data and information for footprint or sustainability assessment

THANK YOU
謝 謝

Zero carbon
Zero energy
Zero waste
Zero-carbon transport
Zero-carbon energy
Zero-carbon home
Zero-carbon city

我完全自給自足