GBCSL Presentation, Colombo

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Sustainable Buildings and Green Buildings

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Sustainable Buildings

- Introduction
- Principles of sustainable developments
  - Sustainable constructions
  - Sustainable buildings
    - Green buildings
      - Carbon neutral buildings
        - » Energy efficient buildings
        - » Healthy buildings

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Presentation objectives

- To gain some understanding of what a "sustainable building" is.
- To gain an appreciation of the challenges of achieving sustainable buildings in urban contexts.
- To be aware of building rating tools.

Environmental impacts of buildings

Resource Extraction → Material Manufacturing → Construction → Service → Demolition & Recycling

- 50 % of all global resources are used in construction,
- 50 % of energy is used for construction,
- 45 % of energy is used to HVAC systems,
- 40 % of water is used for sanitation and other purposes,
- 60 % of main agricultural land has been lost to,
- 70 % of timber is used (Edwards & Hyett 2002).

In Victoria, commercial buildings accounts for 12% of total GHG emissions and this is expected to increase by 100% by 2010

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"This earth and its vegetation is yours.
But they should be protected not only for your benefit but also for the benefit of future generations. …"

Mahindra Chintana

(Source: National Council for Sustainable Development, 2009, National Action Plan for Haritha Lanka Programme, Presidential Secretariat, Colombo 01.)

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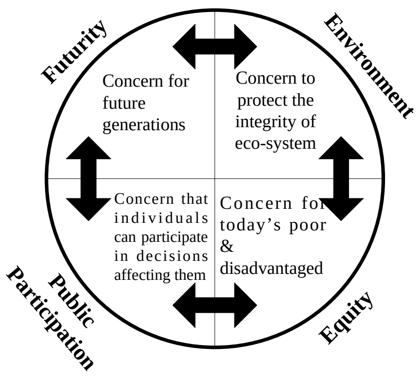
Principles of development



Source: Cooper 1997

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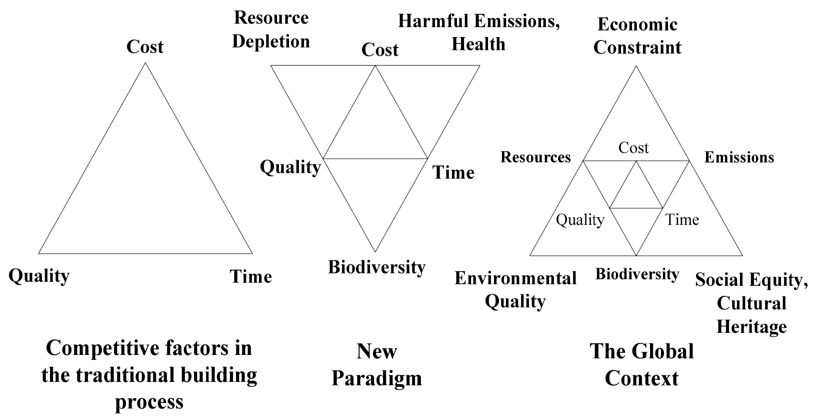
Evolution of sustainable construction



Source: Bourdeau 1999

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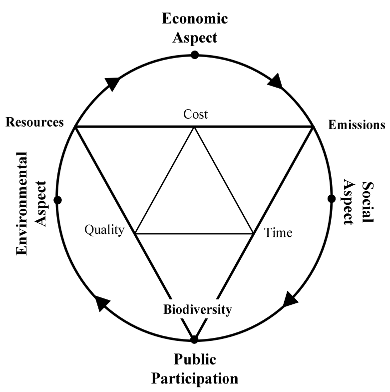
Framework of sustainable construction

A framework has been proposed considering the four aspects of sustainable construction (Lu Aye & Mirza 2006)

- Environmental
- Economics
- Social
- Public Participation



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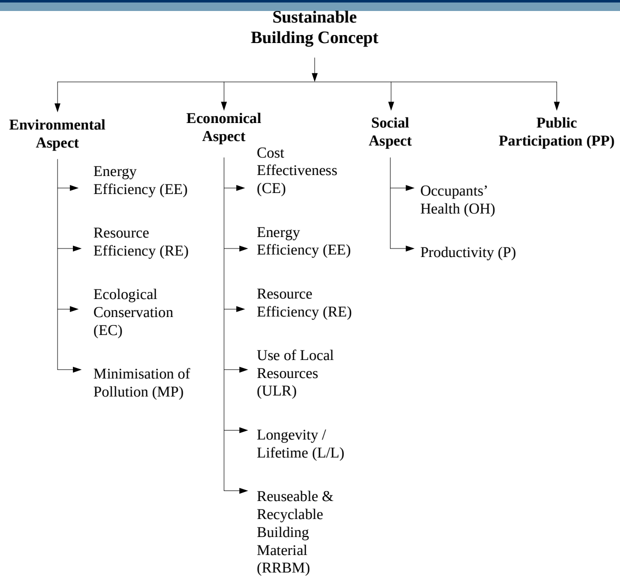

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Review of definitions & concepts

Definition/Concept	E A	S A	Ec A	PP
Duijvestein 1993	x	x	X	x
Kibert 1994	✓	✓	X	x
Huovila 1998	✓	✓	X	x
Bourdeau 1998	✓	✓	✓	x
Kunszt 1998	✓	✓	X	x
Bologna et. al. 1998	✓	✓	x	x
Anom 1998	✓	✓	x	x
Lanting 1998	✓	✓	✓	x
Suler 1998	✓	✓	x	x
Smerdon et. al. 1998	✓	✓	x	x

Definition/Concept	E A	S A	Ec A	PP
Landman 1999	✓	✓	✓	x
SBC 2000	✓	✓	✓	x
Guy & Farmer 2001	x	x	x	x
Yashiro 2001	✓	✓	x	x
GBC 2002	✓	✓	✓	x
CS/DPD 2002	✓	✓	✓	x
Glicksman 2003	✓	✓	x	x
Kibert 2005	✓	x	x	x
OEA 2005	✓	✓	✓	x
John 2005	✓	✓	✓	x

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Review of assessment tools

Tool	E A	S A	Ec A	PP
GB Tool	✓	✓	x	x
BASIX	✓	x	x	x
BREEAM	✓	x	x	x
BEES	✓	x	✓	x
ENVEST	✓	x	✓	x
LISA	✓	x	x	x
LEED	✓	✓	x	x

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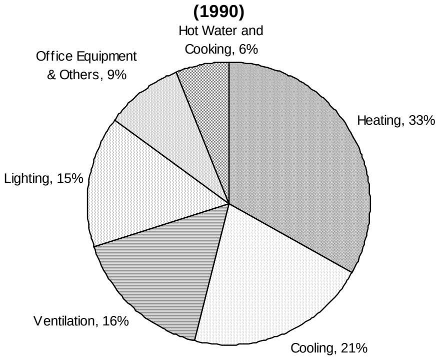
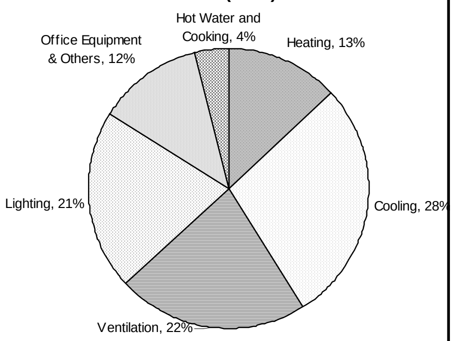
Energy use & GHG emissions in Australia

Commercial Building Energy Share by End-use (1990)



Commercial Building GHG Emissions Share by End-use (1990)



Source: Australian Greenhouse Office 1999

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Full life cycle of buildings

- Resource extraction
- Manufacturing of construction materials
- Materials transport
- Construction
- In service use
- Refurbishment, recycling, disposal

Life cycle GHG emissions inventory

Throughout the life cycle stages energy and materials are used and solid, liquid and gaseous residues are emitted which need to be quantified in each stage (Table 1).

Table 1. Matrix of environmental concern

Life-cycle stage	Environmental concern				
	Material Choice	Energy use	Solid residues	Liquid residues	Gaseous residues
Resource extraction	1, 1	1, 2	1, 3	1, 4	1, 5
Manufacturing of construction materials	2, 1	2, 2	2, 3	2, 4	2, 5
Materials transport	3, 1	3, 2	3, 3	3, 4	3, 5
In service use	4, 1	4, 2	4, 3	4, 4	4, 5
Refurbishment, recycling, disposal	5, 1	5, 2	5, 3	5, 4	5, 5

Life cycle GHG emissions

- Embodied greenhouse gas emission
- Transport greenhouse gas emission
- Operational greenhouse gas emissions
- Disposal greenhouse gas emissions

Table 2. Matrix of greenhouse gas emission sources

Life-cycle stage	Energy use	Solid Residues	Liquid residues	Gaseous Residues
Resource extraction	E	E	E	E
Manufacturing of construction materials	E	E	E	E
Materials transport	T	T	T	T
In service use	O	O	O	O
Refurbishment, recycling, disposal	D	D	D	D

E = embodied, T = transport, O = operational, D = disposal

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Annual life cycle GHG emissions

$$LCGHG = \frac{G_E}{L} + \frac{G_T}{L} + G_O + \frac{G_D}{L}$$

Where

L = service life of the construction (yr),

G_E = embodied GHG emission (kg $CO_{2\text{-}e}$),

G_T = transport GHG emission (kg $CO_{2\text{-}e}$),

G_O = operational GHG emission (kg $CO_{2\text{-}e}$/yr), and

G_D = disposal GHG emission (kg $CO_{2\text{-}e}$).

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Embodied GHG emissions

$$G_E = \sum (a_i M_i)$$

Where

a_i = embodied greenhouse emission per unit of each material (kg CO_{2-e}/kg), this is also known as carbon dioxide intensity ratio (CDIR) MacMath & Fisk (2000) and

M_i = mass of each material (kg).

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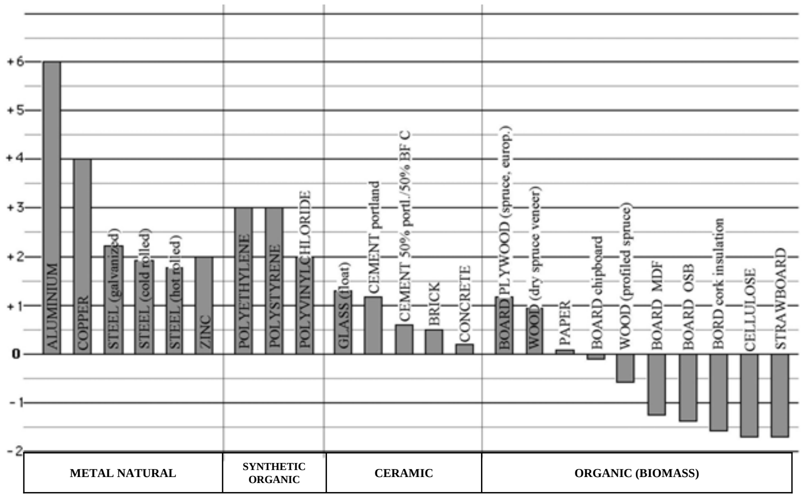
CDIRs (kg CO_{2-e}/kg) of materials



Source: MacMath & Fisk 2000

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Transport GHG emission

$$G_T = \sum (b_i D_i M_i)$$

Where

b_i = transport greenhouse gas emission per distance per unit mass of each material (kg $CO_{2\text{-}e}$/km per kg),

D_i = distance of transport (km), and

M_i = mass of each material (kg).

Operational GHG emissions

$$G_O = \sum (c_j E_j) + \sum (G_r)$$

Where

c_j = full fuel cycle emission factor of each type of energy used (kg $CO_{2\text{-}e}$/MJ),

E_j = annual operational primary energy consumption (MJ/yr), and

G_r = annual greenhouse gas emissions from solid, liquid and gaseous residues from operation (kg $CO_{2\text{-}e}$/yr).

Operational energy use in buildings

Table 3. Matrix of energy used in office buildings

Category \ Primary fuels used	Coal	Oil	Gas
Heating	1, 1	1, 2	1, 3
Cooling	2, 1	2, 2	2, 3
Ventilation	3, 1	3, 2	3, 3
Lighting	4, 1	4, 2	4, 3
Hot water	5, 1	5, 2	5, 3
Cooking	6, 1	6, 2	6, 3
Equipment and others	7, 1	7, 2	7, 3

Disposal GHG emission

$$G_D = \sum \left(d_k M_k \right)$$

Where

d_k = disposal greenhouse gas emission per unit of each material (kg $CO_{2\text{-}e}$/kg), and

M_k = mass of each material (kg).

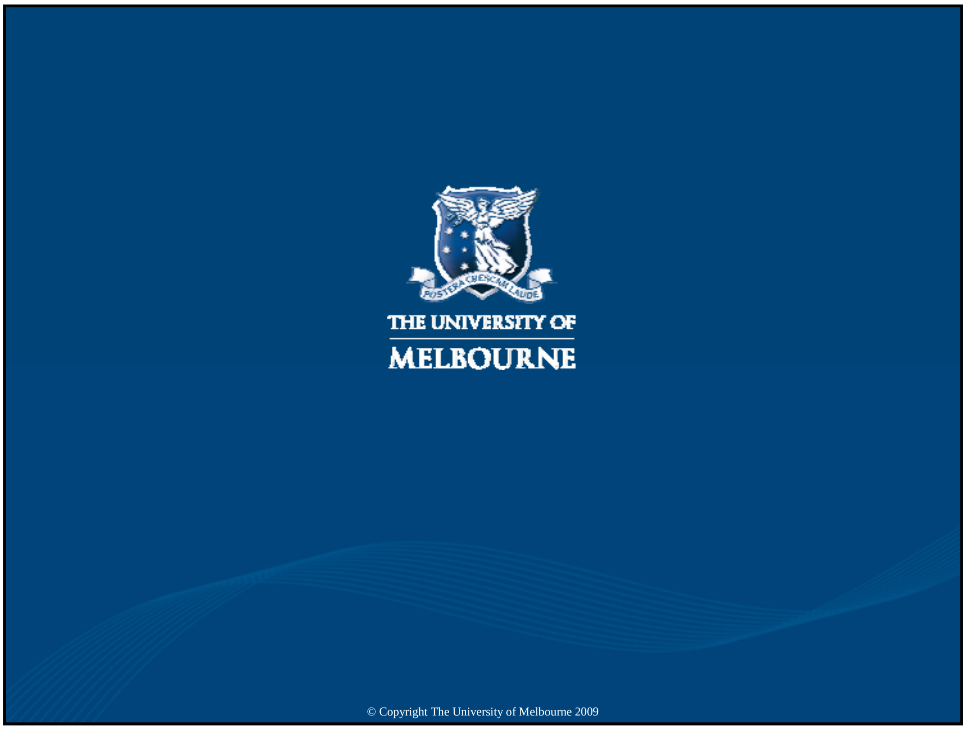
Depending on the end of life recycling or disposal method used net greenhouse gas emission could be positive or negative.

Discussion

- Extension in service life of the building will reduce the GHG emissions
- To reduce the transport GHG gas emission local materials, should be used.
- The long term average annual operational delivered energy consumption (coal, oil & gas) can be estimated by using a building energy simulation tool in conjunction with weather data
- The disposal greenhouse gas factor may be positive or negative. If the residual material (waste) is used as an energy source the value is negative (i.e. net saving in GHG emission).

Conclusions

- Lack of general consensus on the meaning of "sustainable building"
- Lack of integrated approach to assess the sustainability of buildings
- A framework for quantifying annual life cycle greenhouse emissions of building and construction has been presented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