Energy and Low Income Tropical Housing

CPD: SUSTAINABLE CONSTRUCTION

ENERGY ANALYSIS OF BUILDINGS & BUILDING MATERIALS

TANZANIA

Thursday 15th January 2015

gaia group

NHBRA TANZANIA www.nhbra.go.tz

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Energy and Low Income Tropical Housing

Thursday 15th: Embodied Energy 2.

Calculations:

- **Embodied energy in Various building materials**
- **Embodied energy in different wall constructions**
- **Variations**

Primary Energy

- Energy found in nature in raw fuels
- It has not been subjected to any conversion or transformation process.
- It can be non-renewable (fossil fuels) or renewable

Embodied Energy

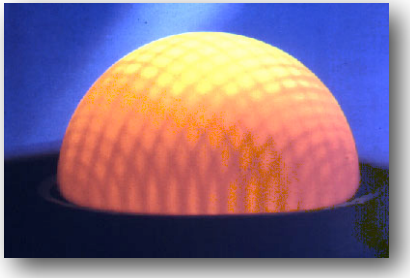
Everything we use has embodied energy

Embodied Energy

- Is sum of all the energy required to produce any goods or services
- It is treated as if that energy was incorporated or 'embodied' in the product.
- Allows comparison between products independent of the source of the energy ....which may be renewable (clean) or non-renewable (fossil fuel)
- It is measured in MegaJoules



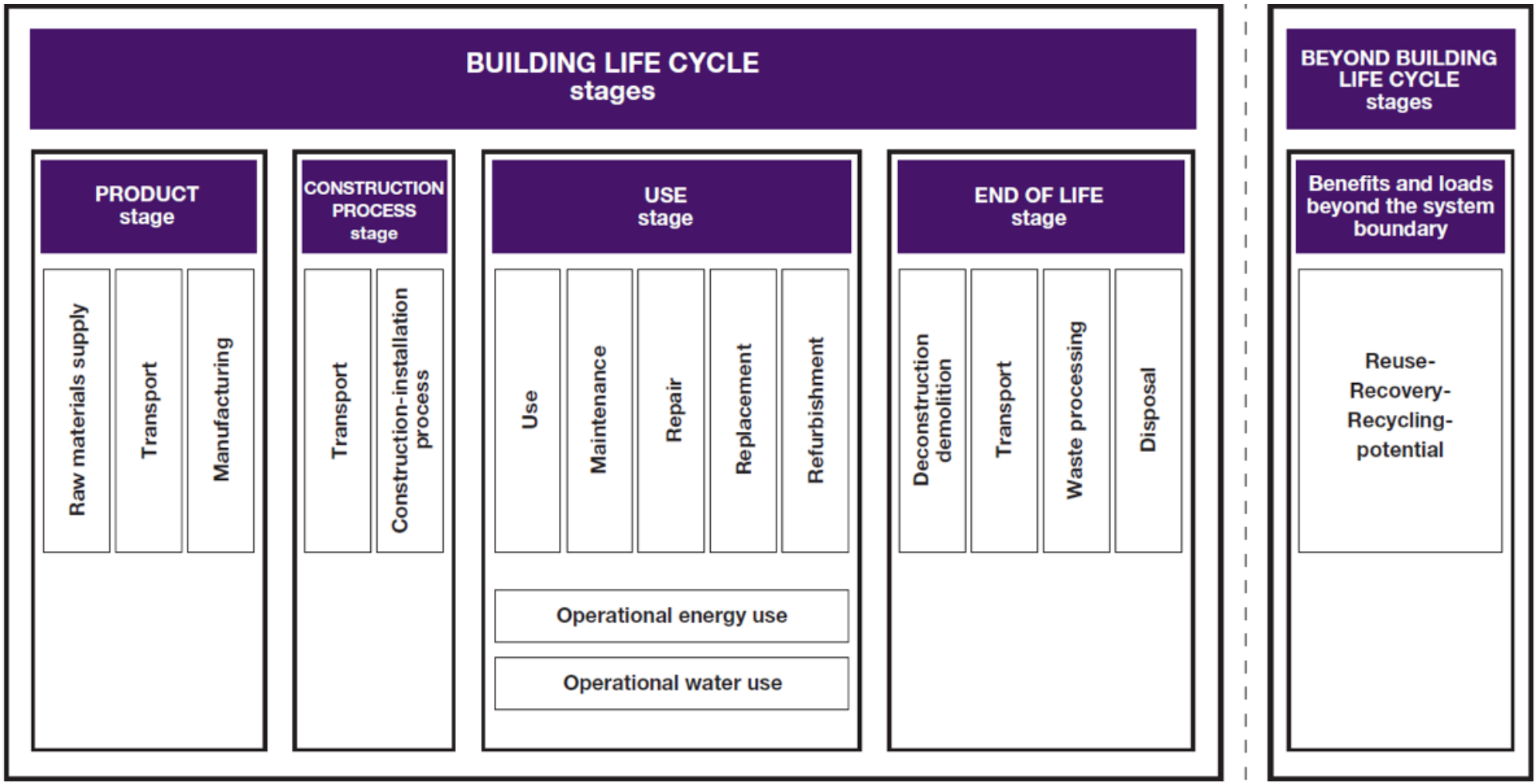




IT DOES NOT INCLUDE HUMAN ENERGY!

Embodied Energy in buildings

Occurs throughout the building life



Embodied Energy in buildings

- It includes the energy taken to get raw goods such as plants, stone, sand or aggregate

Embodied Energy in buildings

- and it includes the energy taken to move these raw goods to a factory

Embodied Energy in buildings

- and it includes the energy taken to manufacture or transform these into a product

Embodied Energy in buildings

- and it includes the energy taken to move these products to where they are needed

Embodied Energy in buildings

- and it includes the energy taken to operate the building

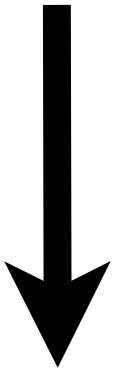
Embodied Energy in buildings

- and it includes the energy taken to maintain or repair them - for example paints, mortars, polish

Embodied Energy in buildings

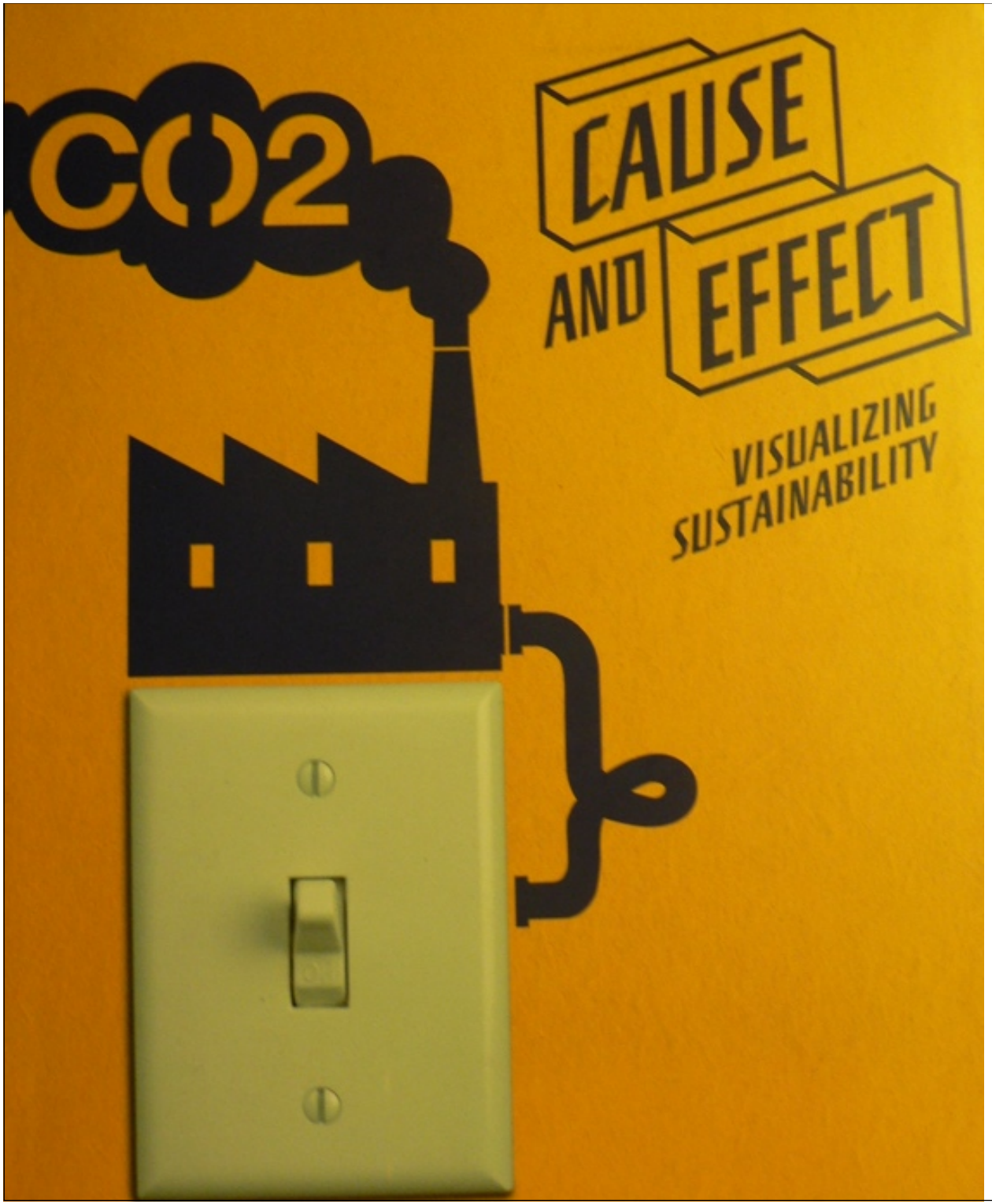
- and it includes the energy taken to demolish and dispose of them

The embodied energy can be identified and quantified at each stage



and can then be used to plan an effective reduction strategy.

But... it’s about more than energy



Because different forms of energy have different embodied pollution

Non-renewable (fossil fuel) Energy

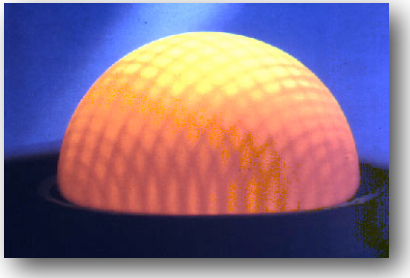
Renewable (Clean) Energy

Consequences

- Using energy creates pollution
- But some energy creates more pollution:-
  - non-renewable (fossil fuel) energy releases carbon dioxide when burned
  - renewable (clean) energy does not
- Carbon dioxide contributes to climate change
- We call this pollution **embodied carbon**





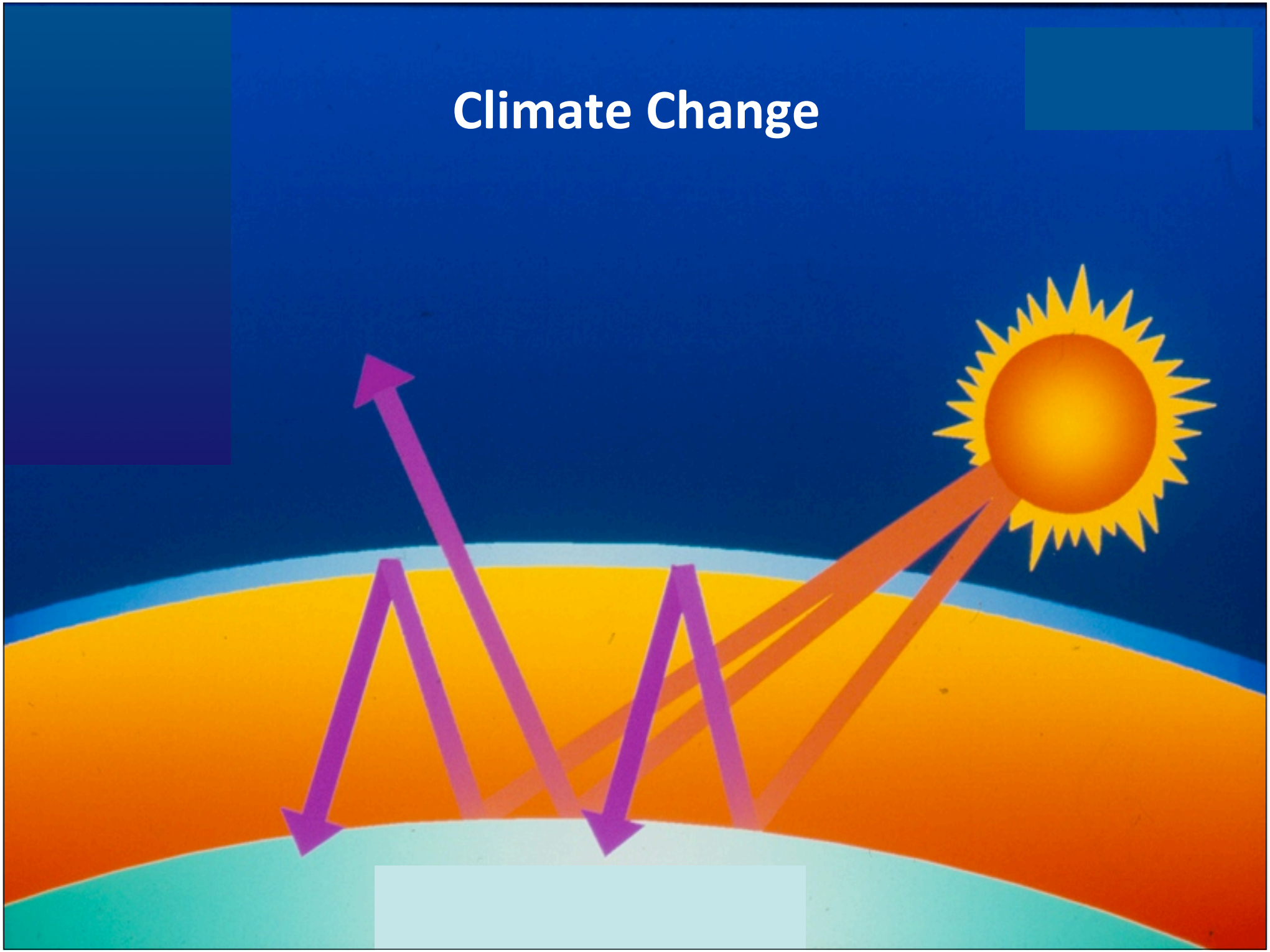


Embodied Carbon ($kgCO_2/kg$)

- The energy used by buildings creates carbon emissions throughout a building life cycle

- due to energy consumption and chemical processes during extraction, manufacture, transportation, assembly, replacement and deconstruction of construction materials or products.
- Embodied carbon is usually expressed in kg of CO_2 per kg of product or material.

Climate Change



Global Warming Potential - GWP (kgCO2e)

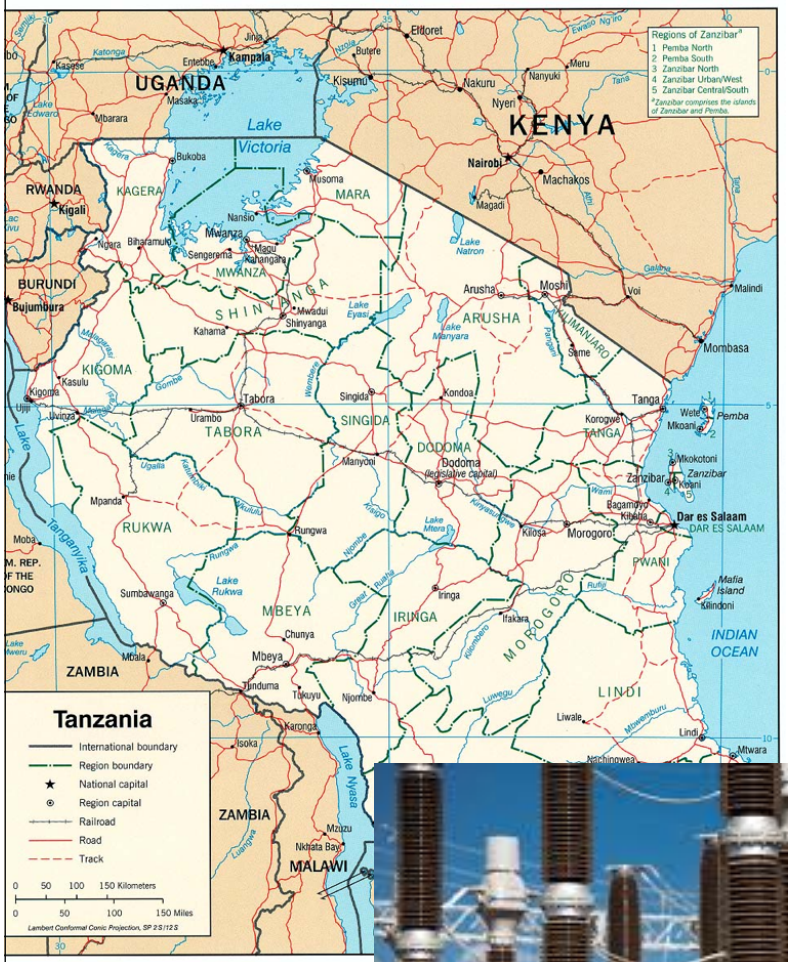
- A measure of the relative impact of a gas on global warming.

Table 1 Global warming potentials (GWP) of greenhouse gases

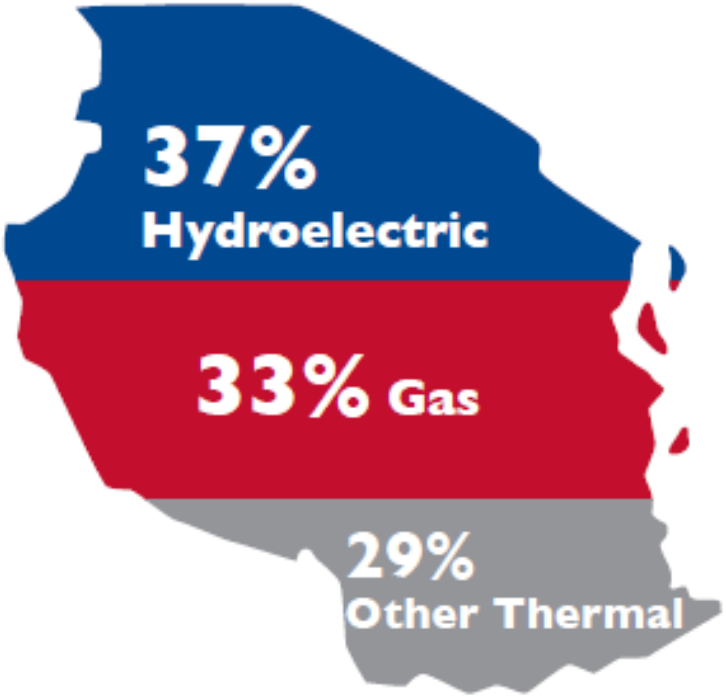
Greenhouse gas	GWP over 100 years	Typical sources
Carbon dioxide (CO_2)	1	Energy combustion, biochemical reactions
Methane (CH_4)	25	Decomposition
Nitrous oxide (N_2O)	298	Fertilizers, car emissions, manufacturing
Sulfur hexafluoride (SF_6)	22,800	Switch gears, substations
Perfluorocarbon (PFC)	7,390–12,200	Aluminium smelting
Hydrofluorocarbon (HFC)	124–14,800	Refrigerants, industrial gases

Based on *Climate Change 2007: The Physical Science Basis*. Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Table 2.14. Cambridge University Press.

- E.g., Methane has a global warming potential of 25
  - 1 kg of Methane has the same impact on climate change as 25 kg of CO_2
  - 1 kg of Methane counts as 25 kg of CO_2 equivalent emissions or CO_{2e}



Current Generation Input Mix



18%
Access to electricity

1,501 MW
Current installed capacity

7%
Rural access to electricity

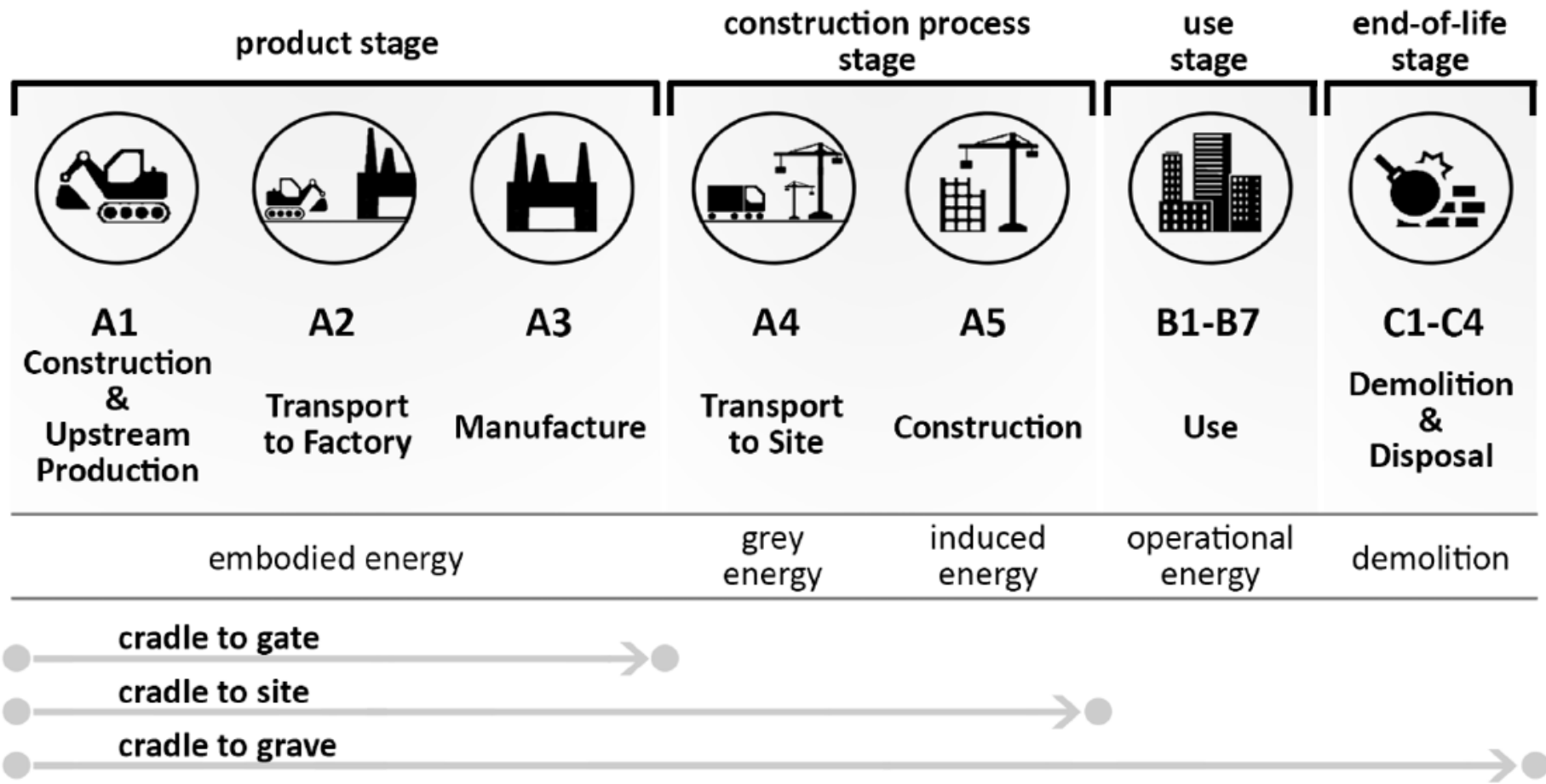
17¢
Average tariff rate

Sources: World Bank Databank, 2010; TANESCO Operations Report, 2013; EWURA website; National Bureau of Statistics, 2011

Embodied energy of grid electricity depends on the mix of fuels

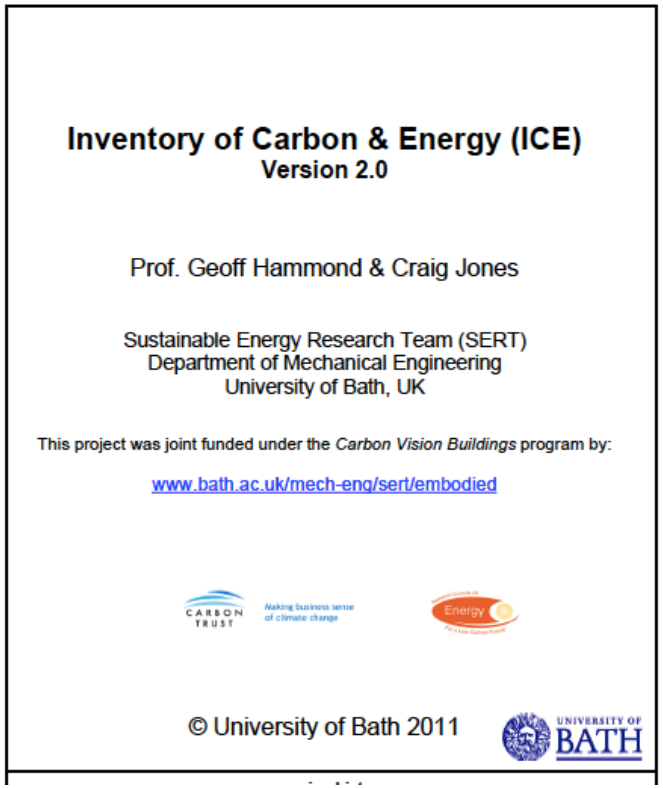
Resources


RICS QS & Construction Standards IP 32/2012
RICS Professional Information, UK
Methodology to calculate embodied carbon of materials
1st edition, information paper
RICS
the mark of property professionalism worldwide
rics.org/standards


product stage
construction process stage
use stage
end-of-life stage
A1
Construction & Upstream Production
A2
Transport to Factory
A3
Manufacture
A4
Transport to Site
A5
Construction
B1-B7
Use
C1-C4
Demolition & Disposal
embodied energy
grey energy
induced energy
operational energy
demolition
cradle to gate
cradle to site
cradle to grave

Handout

- Generic data base
- produced by University of Bath
- Supplied by manufacture
- Average values for materials
- Global sources
- Range of studies
- Cradle to gate
- Non-specific



Inventory of Carbon & Energy (ICE)
Version 2.0

Prof. Geoff Hammond & Craig Jones

Sustainable Energy Research Team (SERT)
Department of Mechanical Engineering
University of Bath, UK

This project was joint funded under the *Carbon Vision Buildings* program by:

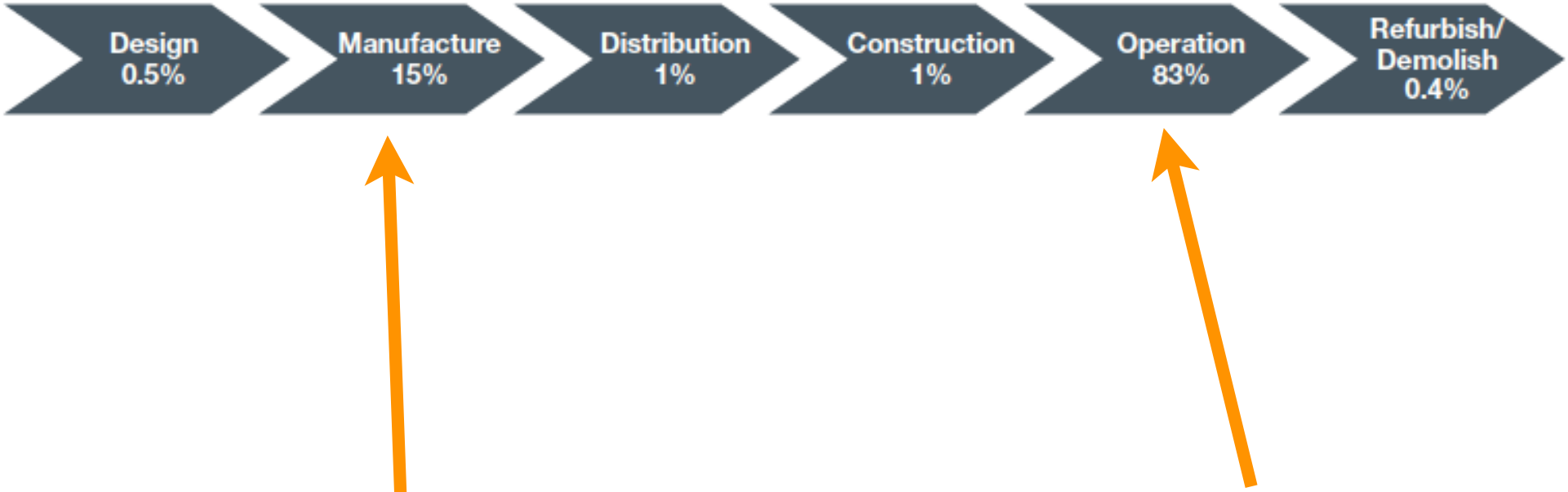
www.bath.ac.uk/mech-eng/sert/embodied

stages

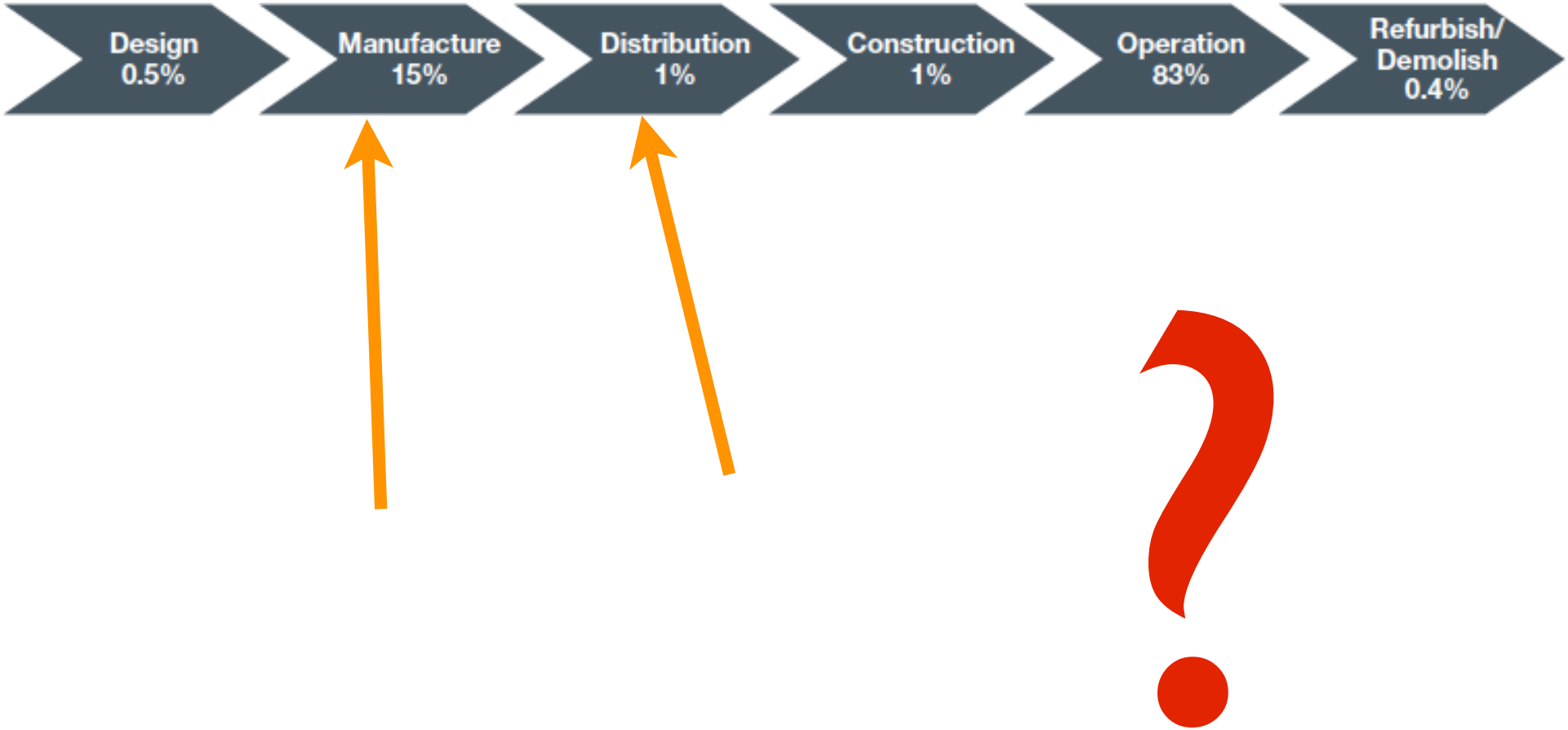
Materials or product manufacture cradle-to-gate emissions are those associated with the production of construction products/ materials.

- The emissions arise from the energy used in
  - ✦extracting materials,
  - ✦refining them (i.e. primary manufacture),
  - ✦transporting &
  - ✦ processing them to produce a finished product (i.e. secondary manufacture).

UK Context


Design
0.5%
Manufacture
15%
Distribution
1%
Construction
1%
Operation
83%
Refurbish/
Demolish
0.4%

Tanzania Context



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WORKSHOP

Calculations

Compare Embodied Energy of

MBEKI Concrete Block

&

NHBRA Interlocking Brick

% difference

Embodied energy case study

Item	MATERIAL TYPE	VOLUME	DENSITY	WEIGHT	EMBODIED ENERGY INTENSITY	TOTAL EMBODIED ENERGY (MJ)	EMBODIED CARBON	TOTAL EMBODIED CARBON
		m3	Kg/m3	KG	(MJ/KG)	MJ	(kgCO2/Kg)	(KGCO2)
		from manufacturer	from manufacturer	calculate	from data sheet	WEIGHT X EE	from data sheet	WEIGHT x EC

Compare Embodied Energy of

MBEKI Concrete Tile

&

NHBRA Tile

% difference


Keep
Challenging

Embodied energy case study

Item	MATERIAL TYPE	VOLUME	DENSITY	WEIGHT	EMBODIED ENERGY INTENSITY	TOTAL EMBODIED ENERGY (MJ)	EMBODIED CARBON	TOTAL EMBODIED CARBON
		m3	Kg/m3	KG	(MJ/KG)	MJ	(kgCO2/Kg)	(KGCO2)
		from manufacturer	from manufacturer	calculate	from data sheet	WEIGHT X EE	from data sheet	WEIGHT x EC

Compare Embodied Energy of MBEKI Concrete Tile Roof/m^2 & NHBRA Tile Roof/m^2

Embodied energy case study

Item	MATERIAL TYPE	VOLUME	DENSITY	WEIGHT	EMBODIED ENERGY INTENSITY	TOTAL EMBODIED ENERGY (MJ)	EMBODIED CARBON	TOTAL EMBODIED CARBON
		m3	Kg/m3	KG	(MJ/KG)	MJ	(kgCO2/Kg)	(KGCO2)
		from manufacturer	from manufacturer	calculate	from data sheet	WEIGHT X EE	from data sheet	WEIGHT x EC

Compare Embodied Energy of

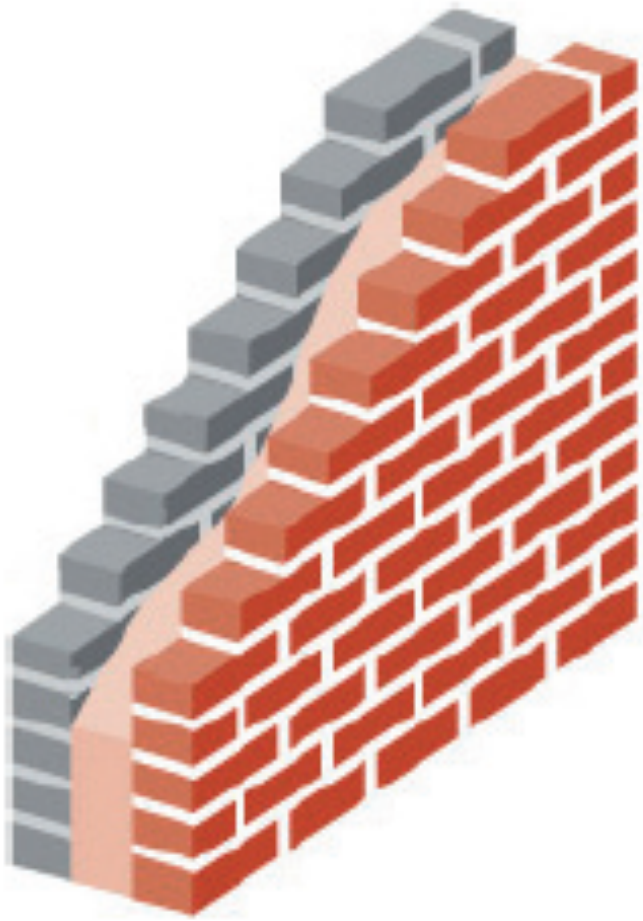
MBEKI Concrete Block House Wall

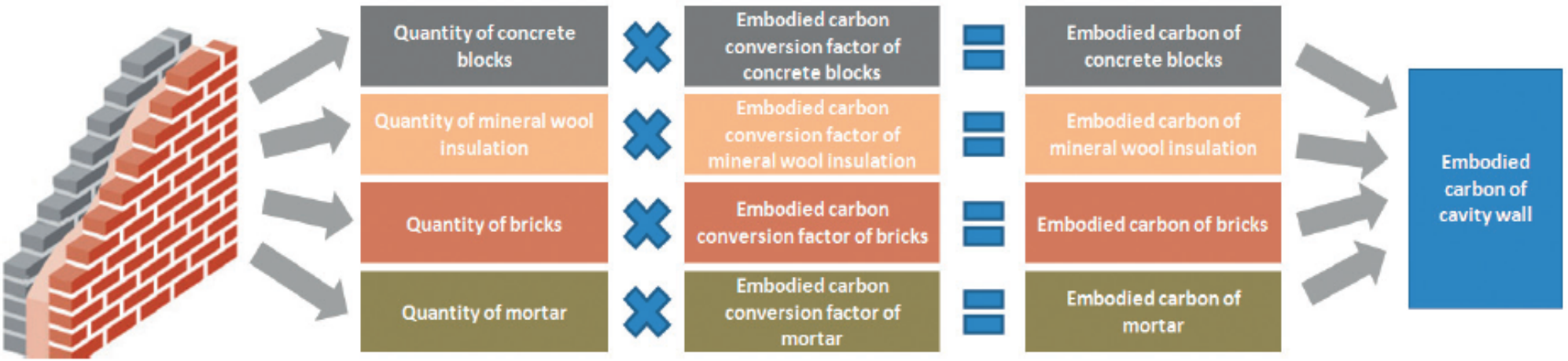
&

NHBRA Brick House Wall

> inclusive of internal and external finishes

Consider a cavity Wall





Break into component parts

Establish quantities and types of materials source

Establish embodied carbon for each part ($kgCO_2/kg$)

Multiply

Summate

Embodied energy case study

Item	MATERIAL TYPE	VOLUME	DENSITY	WEIGHT	EMBODIED ENERGY INTENSITY	TOTAL EMBODIED ENERGY (MJ)	EMBODIED CARBON	TOTAL EMBODIED CARBON
		m3	Kg/m3	KG	(MJ/KG)	MJ	(kgCO2/Kg)	(KGCO2)
		from manufacturer	from manufacturer	calculate	from data sheet	WEIGHT X EE	from data sheet	WEIGHT x EC

Next

- Add a timber frame opening of $1m^2$
- Add Glass
- Add Burglar bars
- Change frame to aluminium

Key Issues

- Understand the local context
- What do we need to know to help us make good decisions?
- How much is manufacture/operational/transport/construction/disposal?
- Which areas need most attention?
- Identify the highest impacts (carbon hotspots) or low hanging fruit.
- Calculating absolutes may not be necessary!
- Is it heavy or dense or highly processed ----steel, concrete, aluminium?

  ★ ee/ec may be high
- Is it local sourced?..

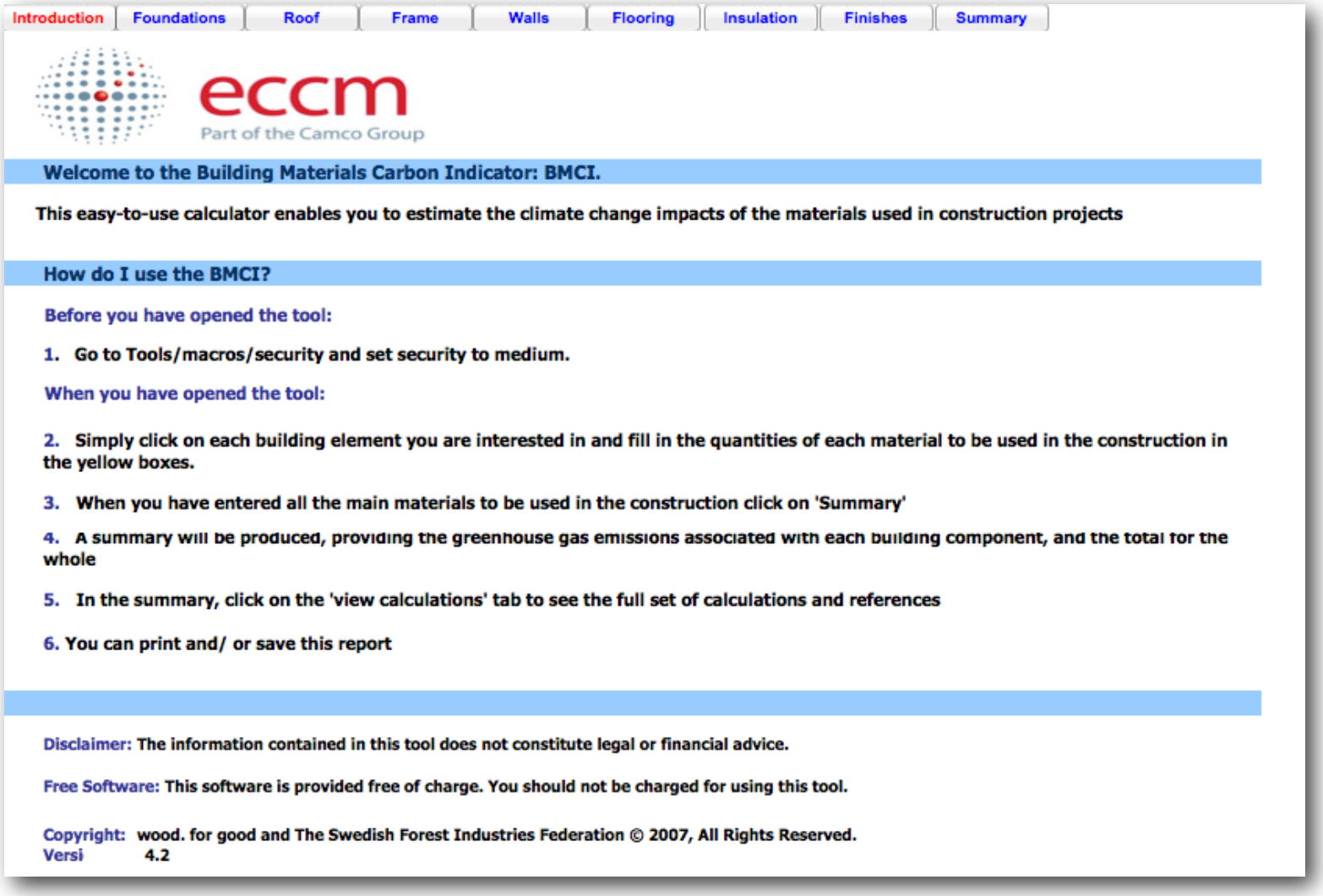
  ★ then travel component may be low

Design interventions

- Is it possible to use less material?
- Is it possible to change material to a low carbon alternative?
- DO NOT FORGET WASTAGE!
- DO NOT FORGET TOXICITY!
- Is it possible to design for recycling?
- Is it possible to design for re-use?
- Is it possible to use products with high recycled content, e.g. cement replacement materials such as GGBS (ground granulated blast furnace slag) or PFA (pulverised fuel ash)?
- Is it possible to use low carbon design details, e.g. exposed concrete ceilings; aerated block work?
- Is it possible to design to the site? i.e reduce amount of soil movement?

ECCM Calculator

- useful to get some quick comparison
- not to be relied upon



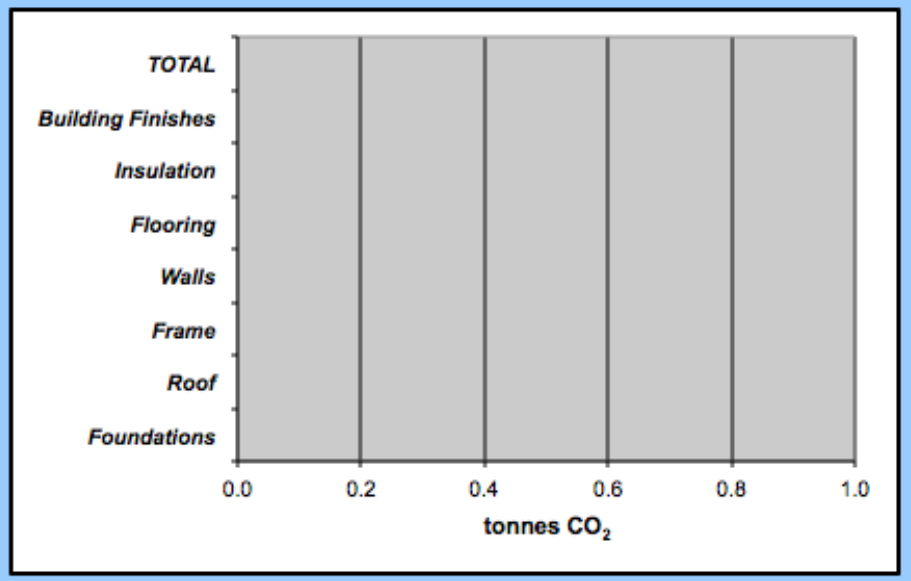
ECCM Calculator

Introduction | Foundations | Roof | Frame | Walls | Flooring | Insulation | Finishes | Summary

FOUNDATION MATERIALS

TYPE	MATERIAL	QUANTITY	UNITS
Concrete	1. Pouring Concrete	0	tonnes
	2. Reinforced Concrete	0	tonnes
	3. Concrete Block	0	m3
	4. Aerated Concrete	0	m3
Wood	1. Joists	0	tonnes
Gravel	1. Gravel	0	m3
Steel	1. Steel	0	tonnes

Current CO_2e emissions: 0.0 tCO_2e



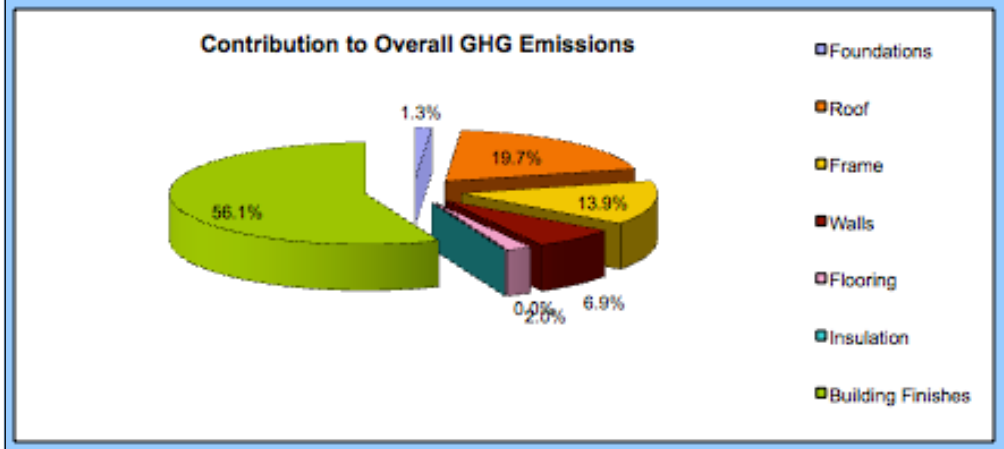
ECCM Calculator

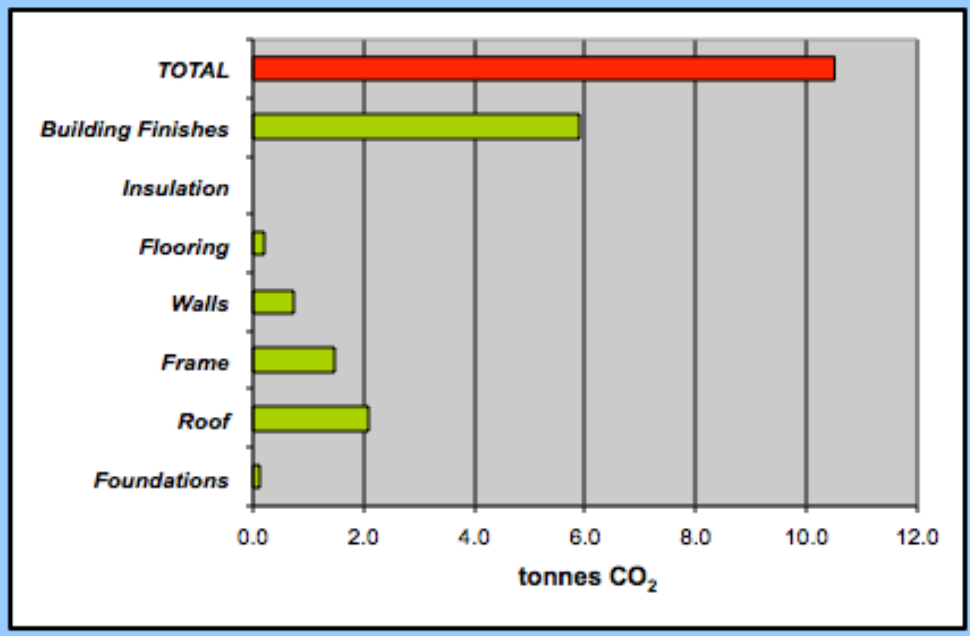
Introduction | Foundations | Roof | Frame | Walls | Flooring | Insulation | Finishes | Summary

REPORT

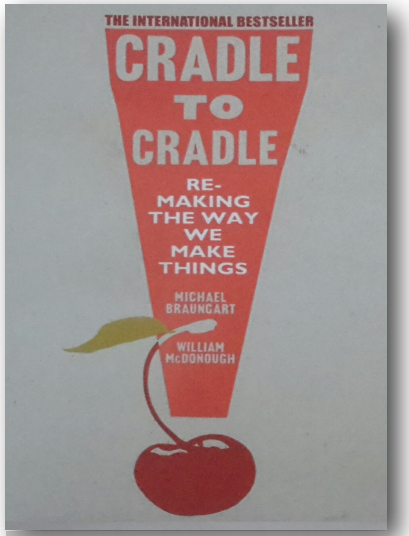
Summary

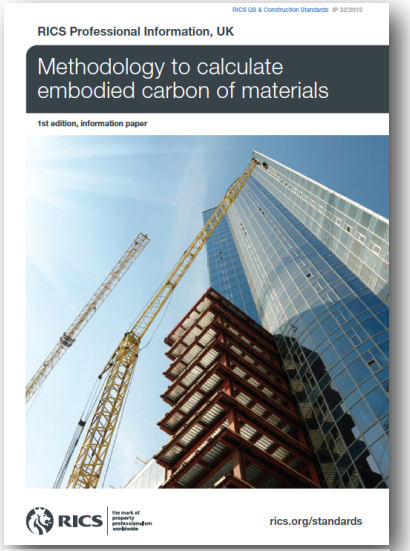
ELEMENT	tonnes CO_2
Foundations	0.1
Roof	2.1
Frame	1.5
Walls	0.7
Flooring	0.2
Insulation	0.0
Building Finishes	5.9
TOTAL	10.5

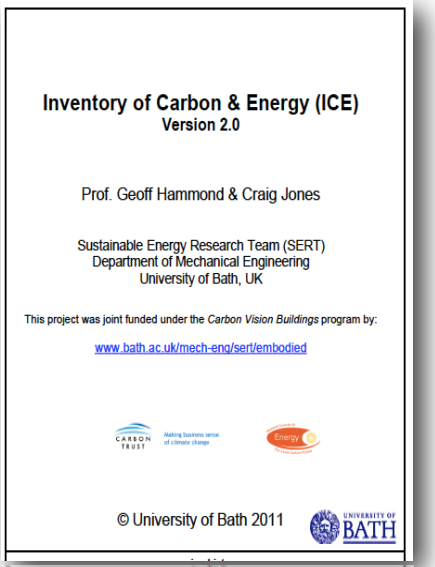


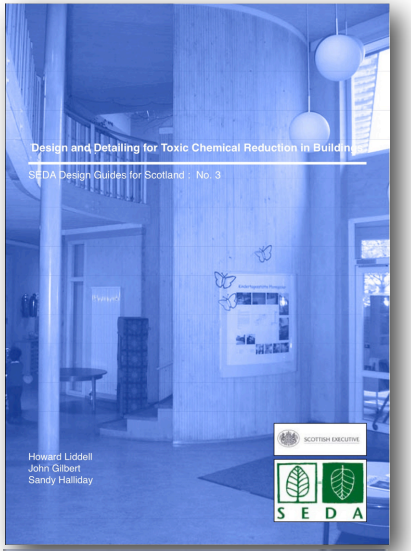


View Calculations









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Circular Economy

Download ICE data base from here

ICE Database

Download ECCM's building materials carbon indicator - updates

ECCM calculator

Energy and Low Income Tropical Housing

Close of Day