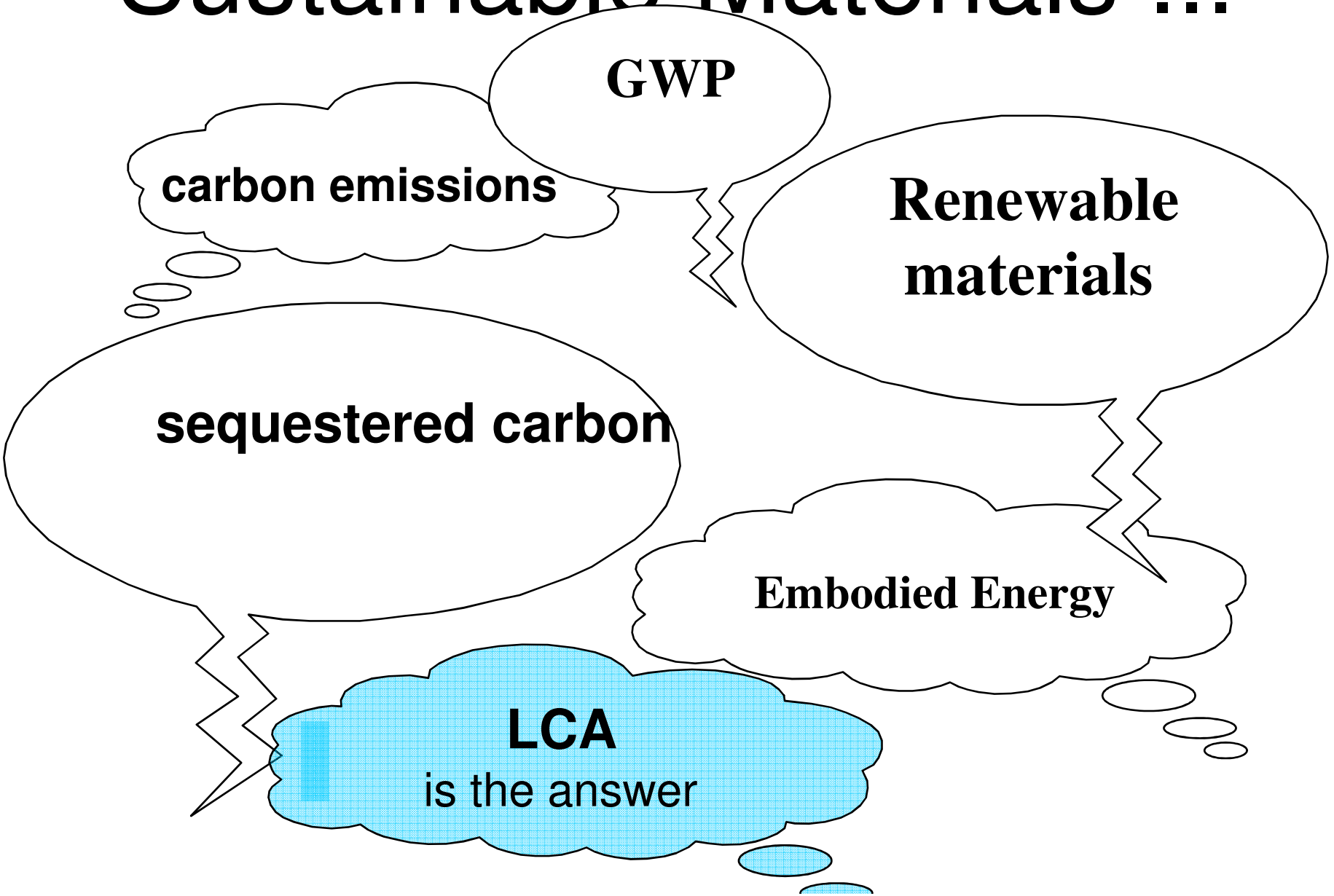
Low Carbon Design & Construction

Prof. Kevin McCartney, UCC
Cork Centre for Architectural Education

Energy Cork

Breakfast Briefing April 2016

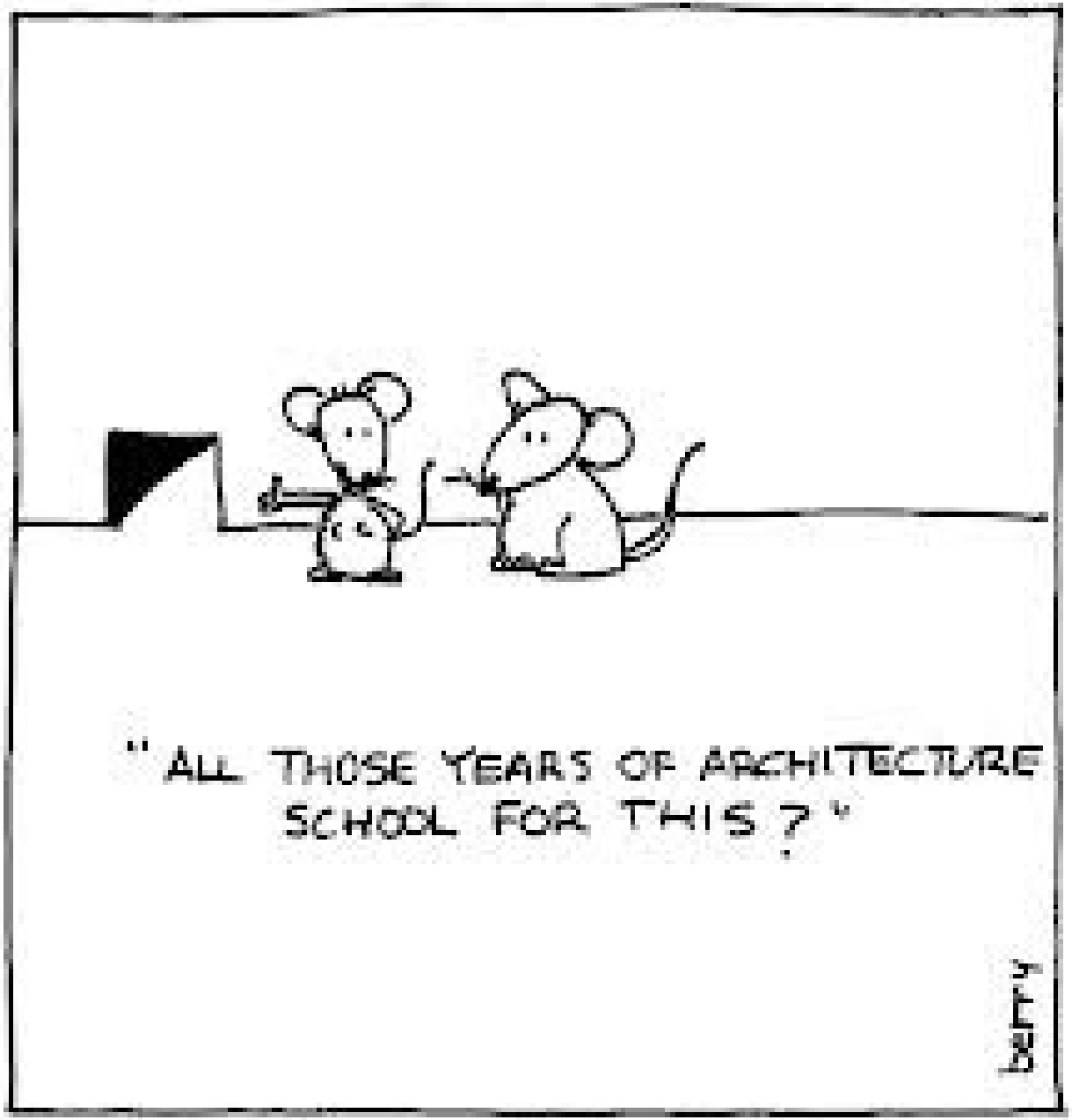
Sustainable Materials ...



Life Cycle Assessment (LCA)

"Designers are not qualified to properly assess and understand the full implication of LCA"

Anderson, Shiers, Steele, (2009) *The Green Guide to Specification"*
IHS BRE Press


"ALL THOSE YEARS OF ARCHITECTURE SCHOOL FOR THIS?"
barry

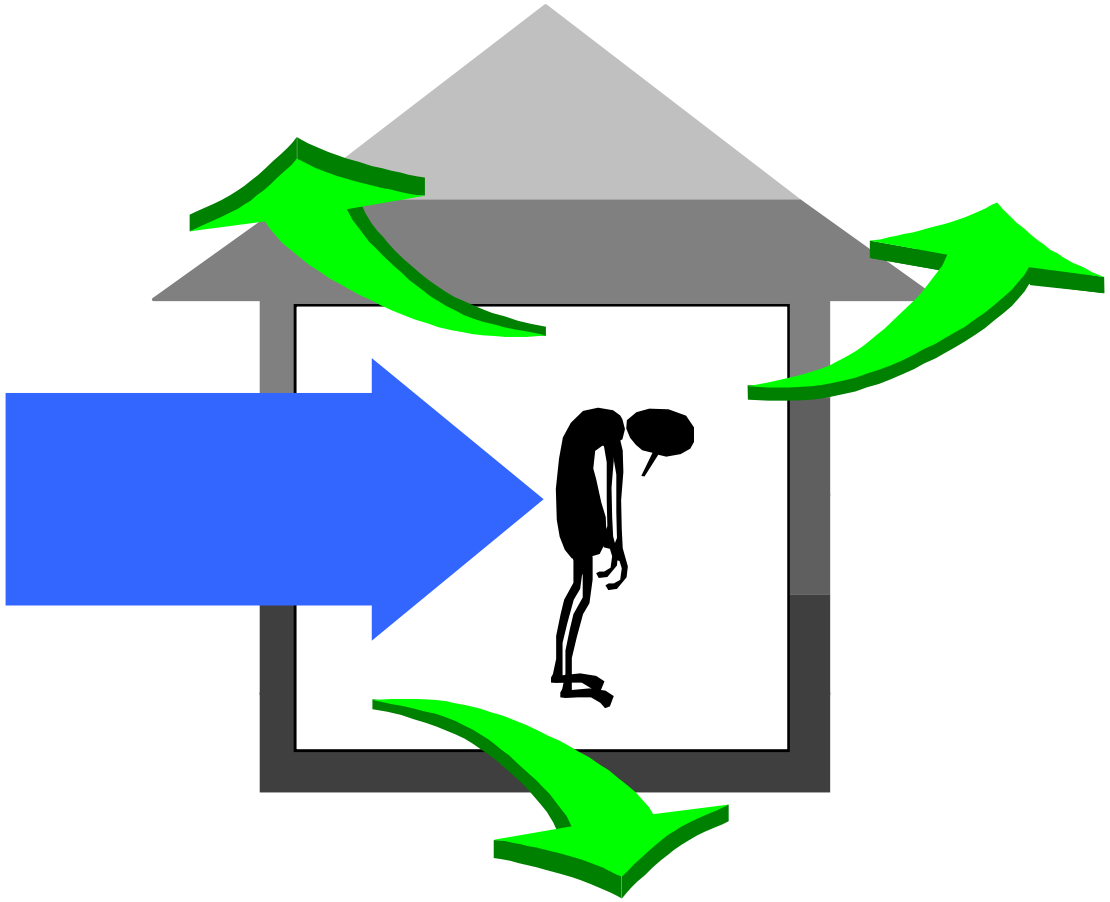
Principles of low carbon design

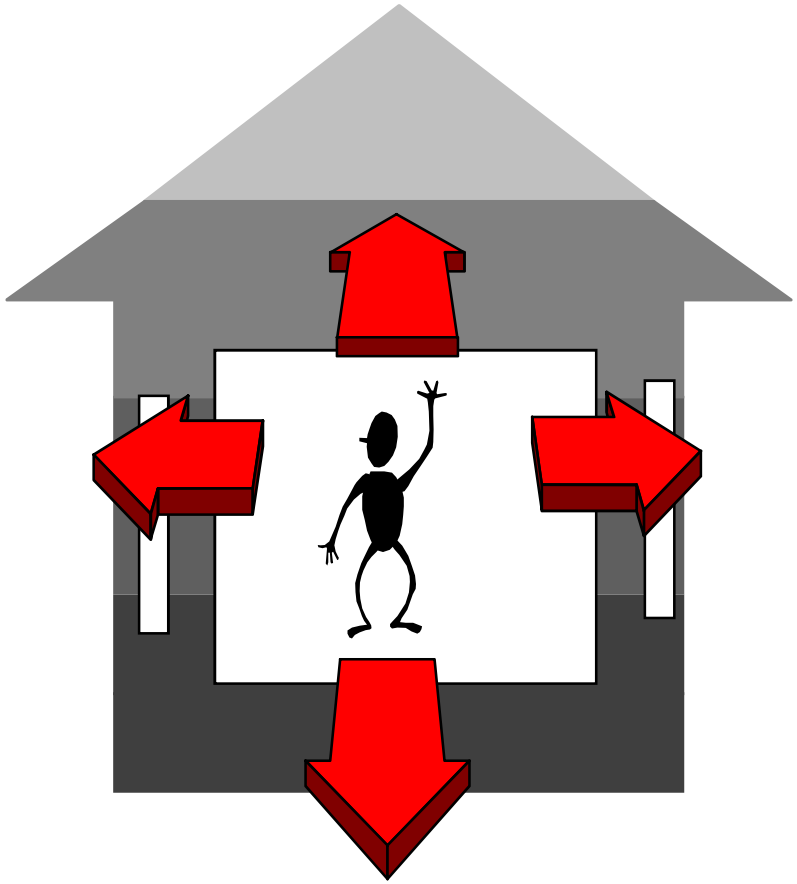
- ?
- ?
- ?
- ?
- ?

‘OPERATIONAL’ energy

Loss of heat through building fabric requires a balancing input of heat to maintain occupant comfort. This requires fuel combustion causing CO2 emissions.

Reduce Operational Energy

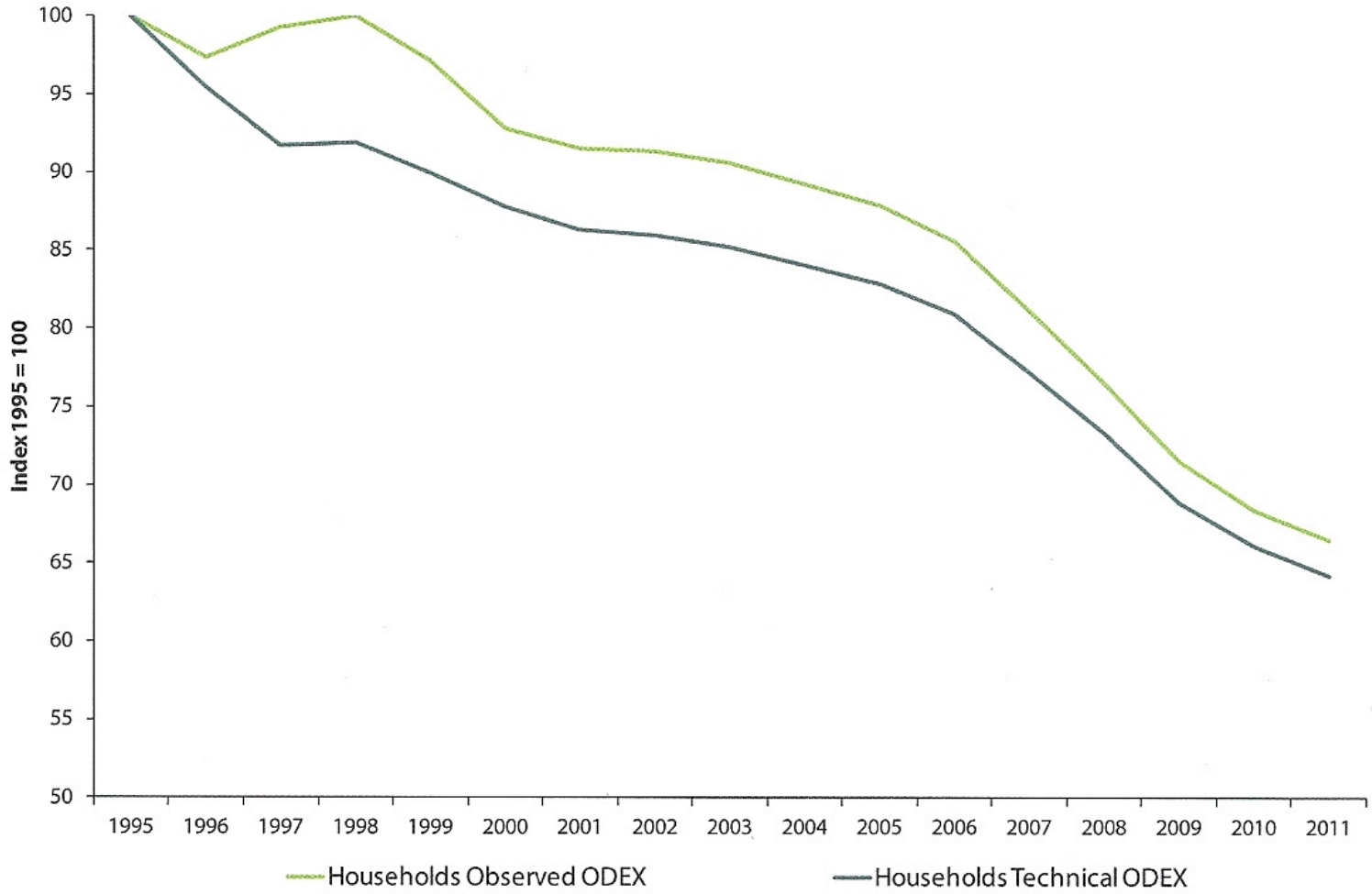




Cut uncontrolled ventilation heat loss & cut fabric heat loss

Energy efficiency in Irish dwellings improved by 2.5% per year from 1995-2011

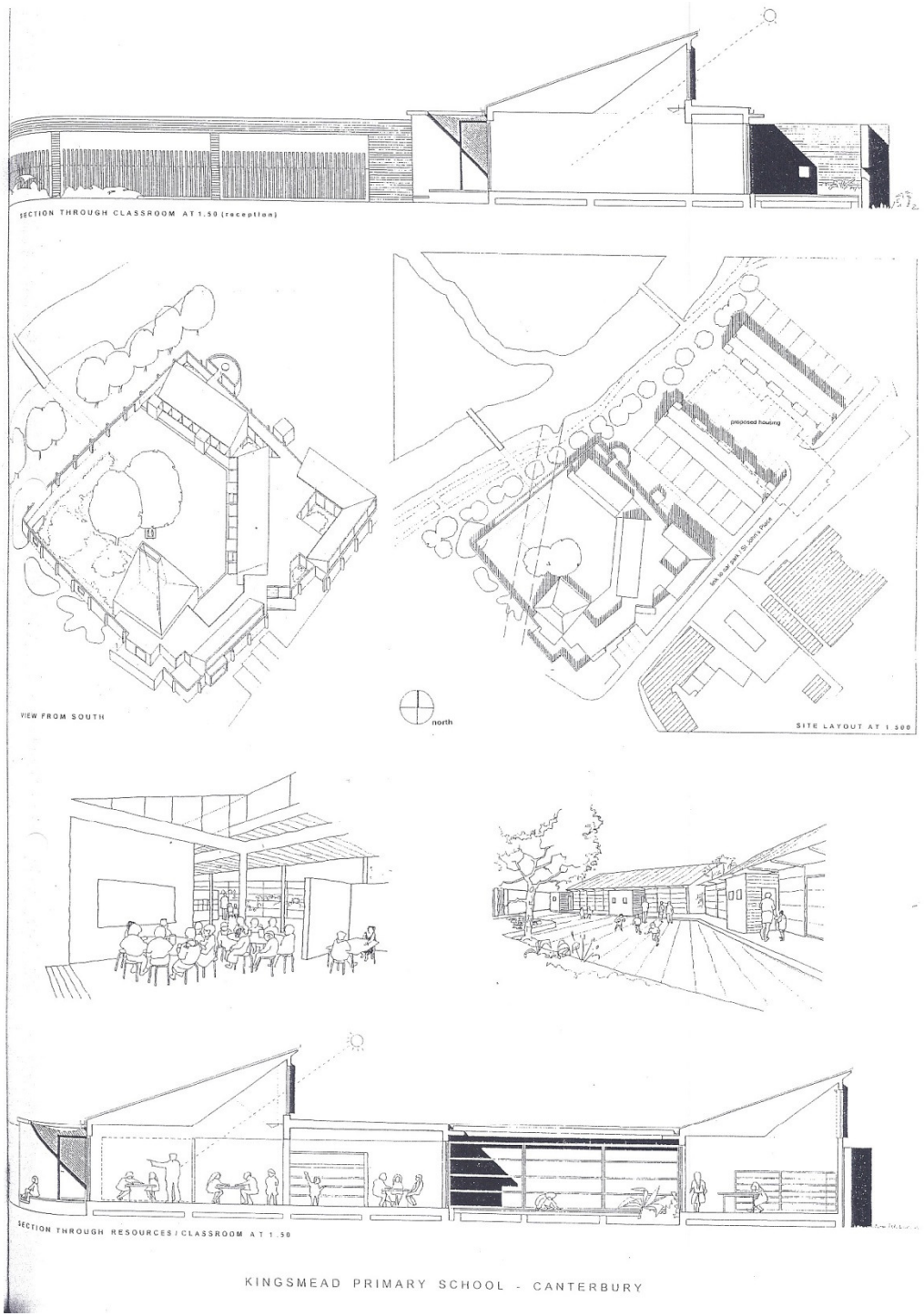
Figure 73 *Household ODEX 1995 - 2011*



Source: Energy in Ireland 1990-2011, 2012 Report SEAI, p80

Principles of Low Carbon Design

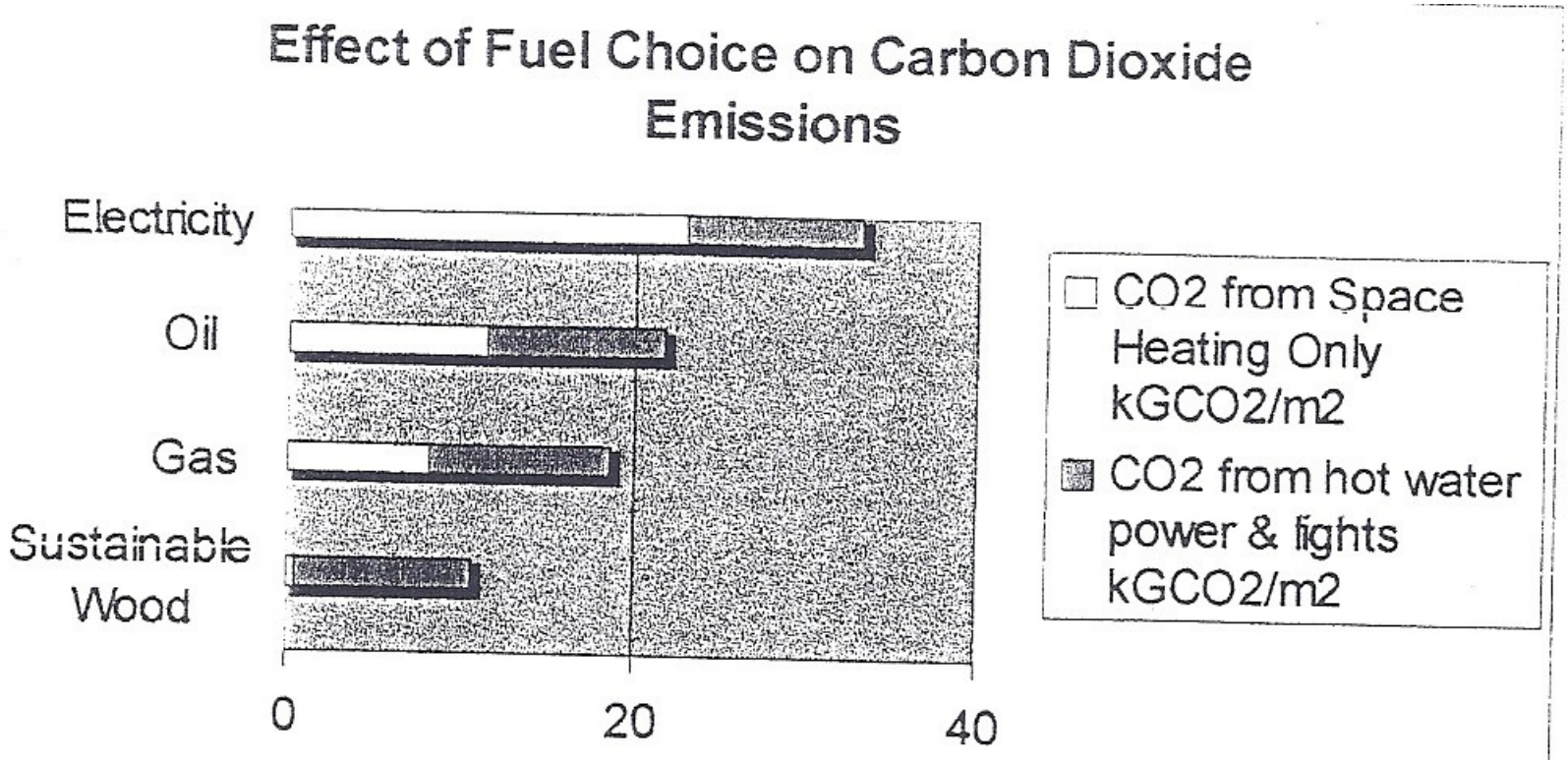
1. Minimise fuel demand



Kingsmead Primary School Canterbury

Sir Colin Stansfield Smith, John Pardy, Kevin McCartney

Joint Winner, RIBA International Competition for 2001
Sustainable School Design,



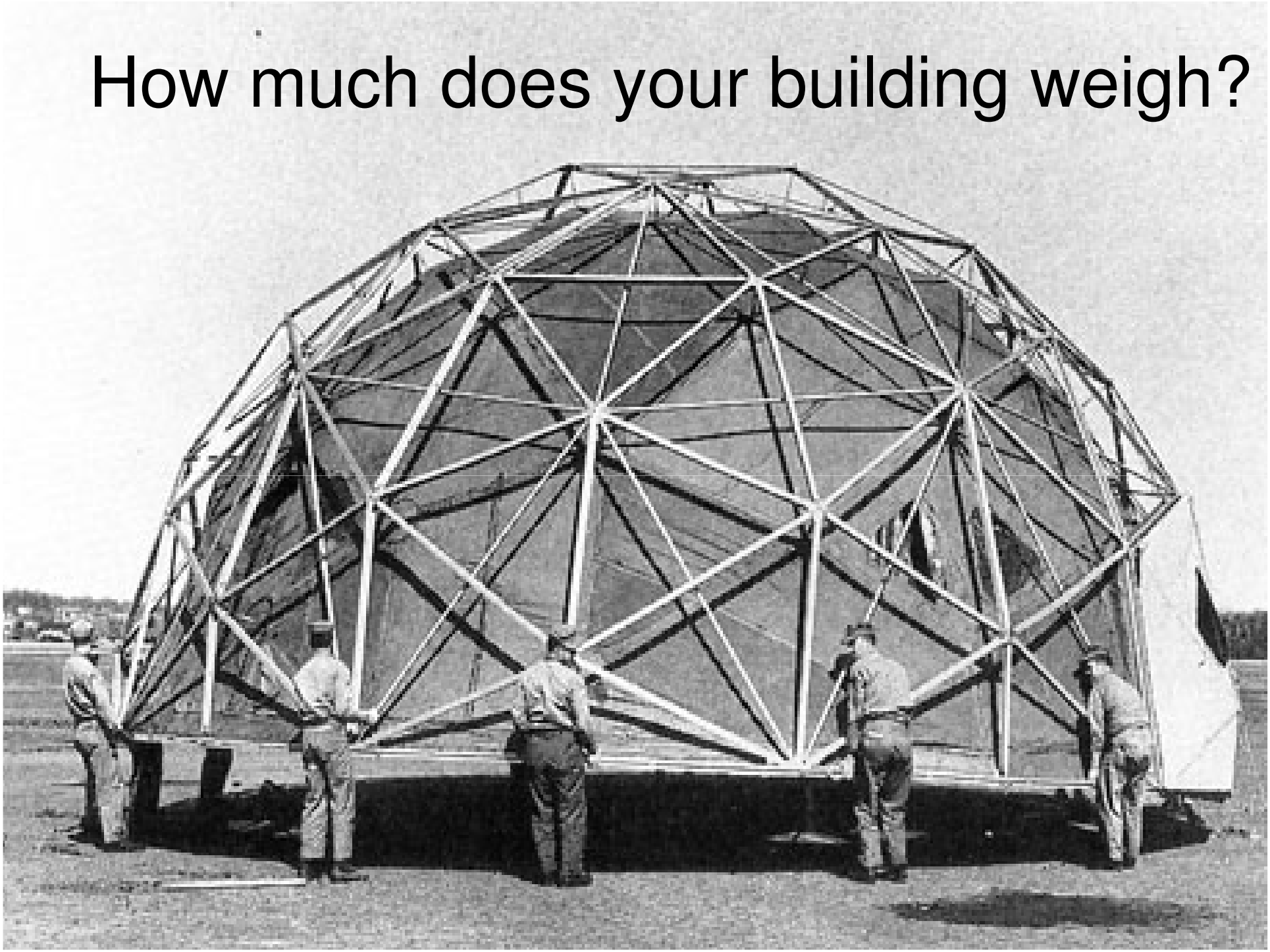
Wood chip boilers were specified for Kingsmead school. This reduced CO_2 emissions by as much as 68% compared with electric heating, and by 42% compared with high efficency GAS boilers (McCartney, 2001)

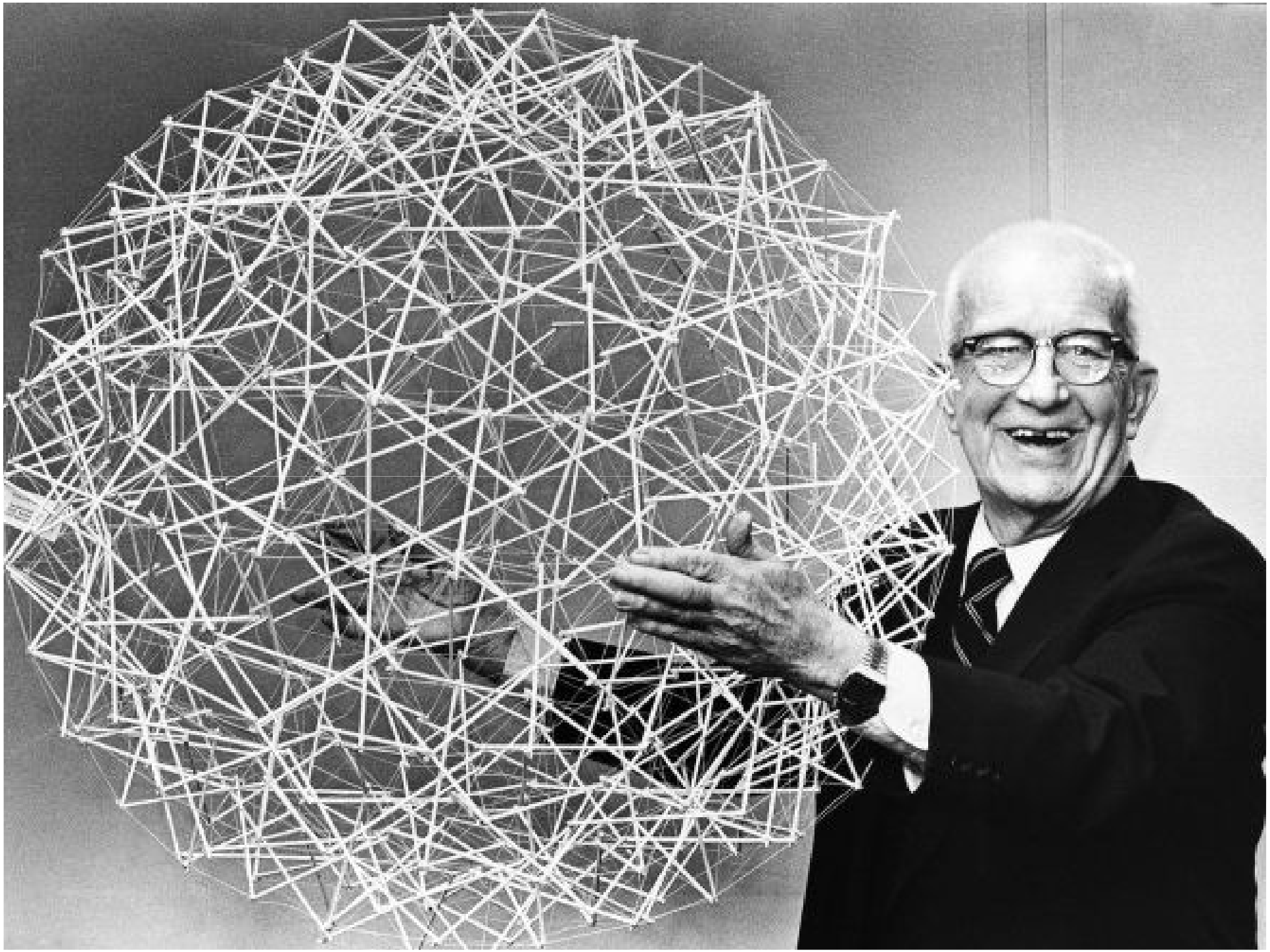
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient

How much does your building weigh?

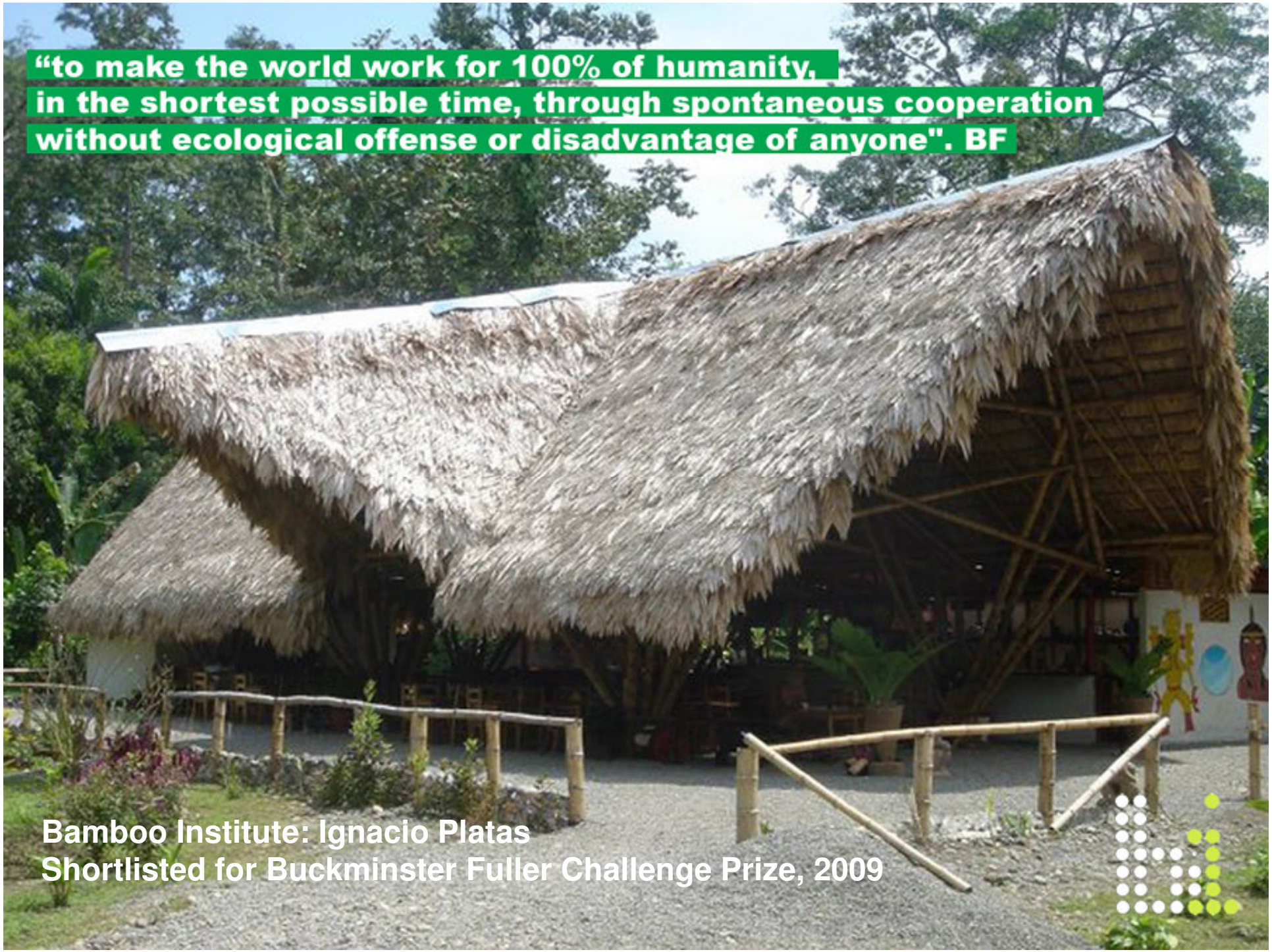
How much does your building weigh?



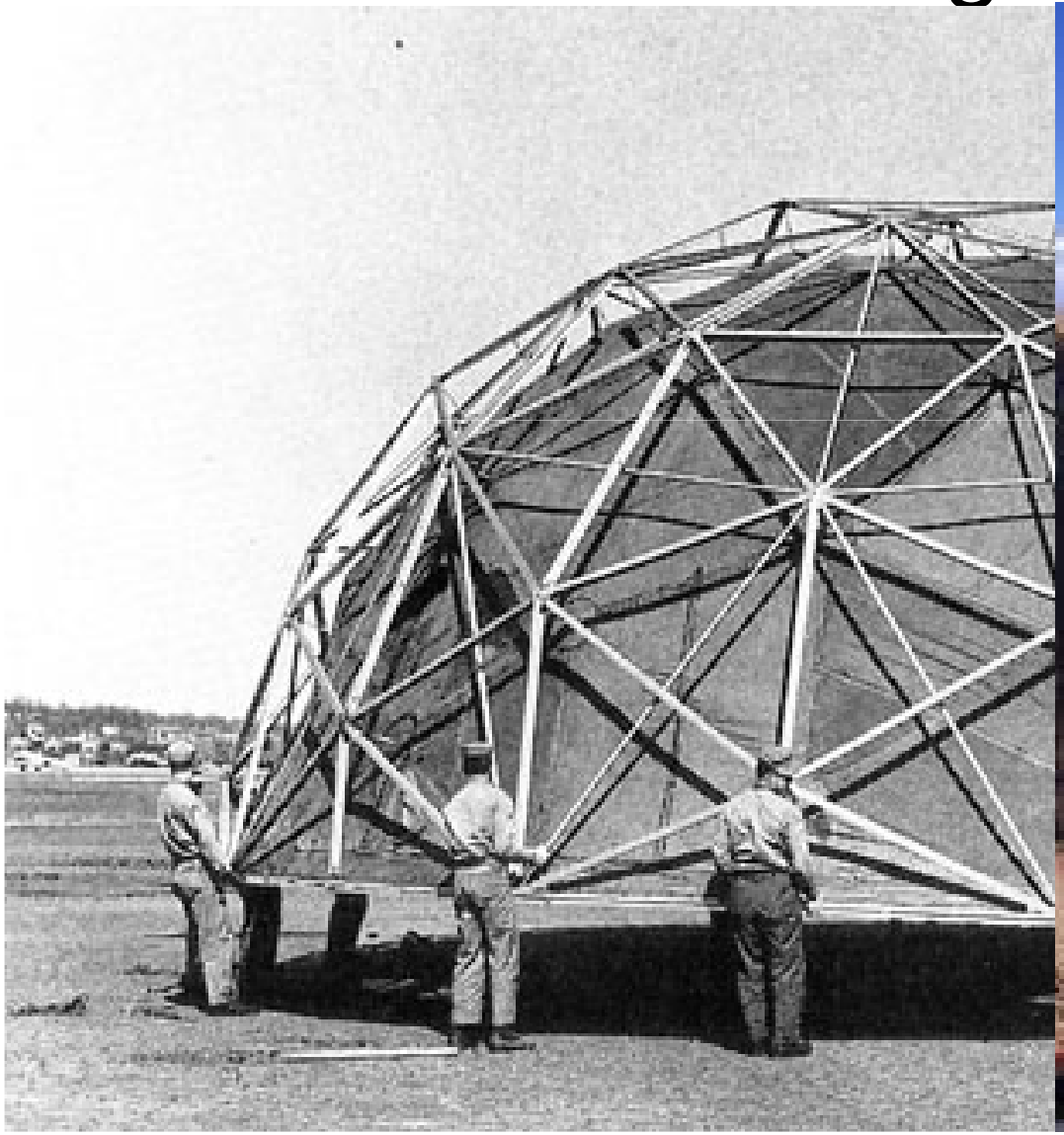


Ohio Institute of Historic Structures

Buckminster Fuller proposal for a city-scale dome providing controlled micro-climate


“to make the world work for 100% of humanity,
in the shortest possible time, through spontaneous cooperation
without ecological offense or disadvantage of anyone". BF
Bamboo Institute: Ignacio Platas
Shortlisted for Buckminster Fuller Challenge Prize, 2009

How much does your building weigh?



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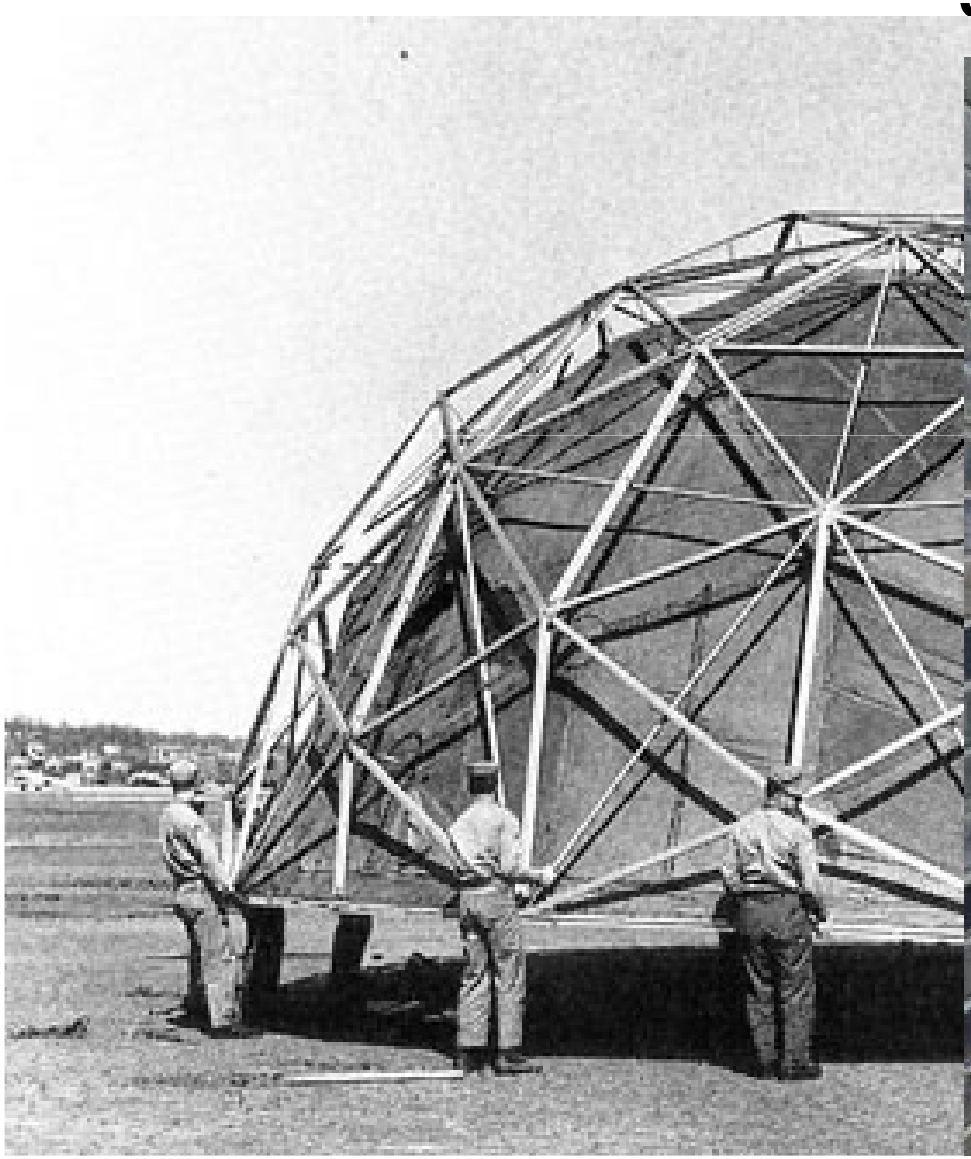
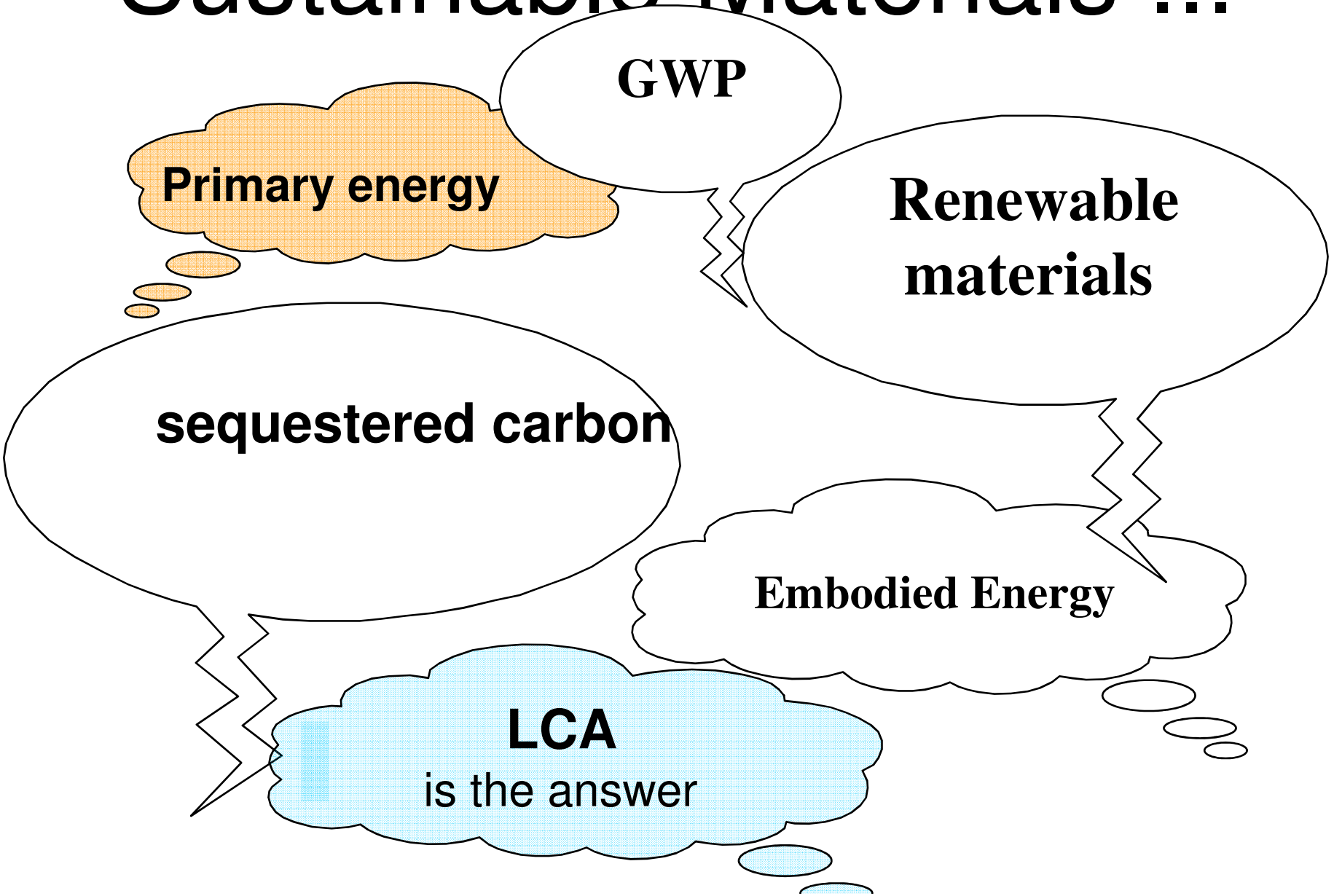


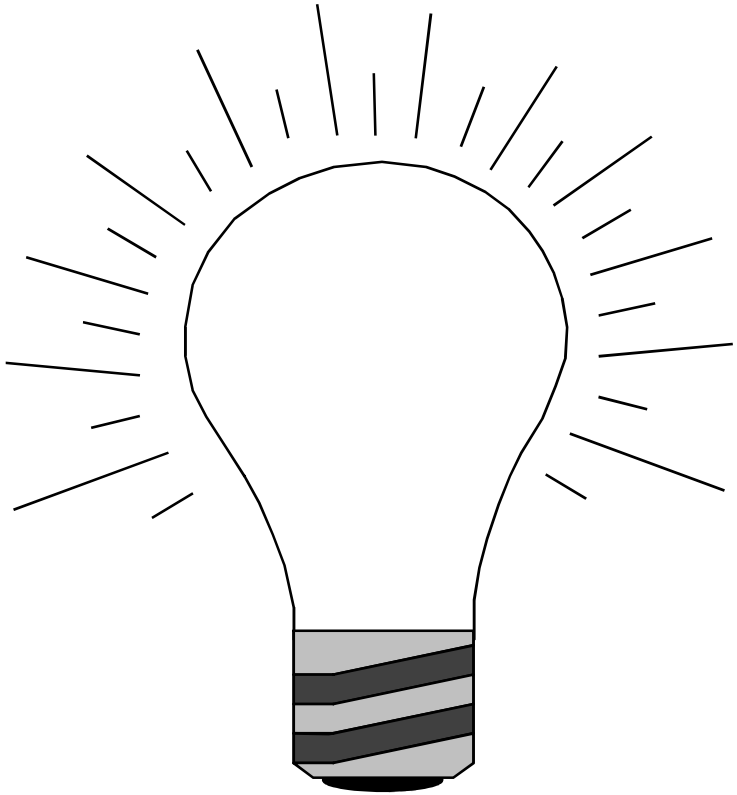
Casa López/Lujano
by Oficina 3 Estudio de Arquitectura

Principles of Low Carbon Design

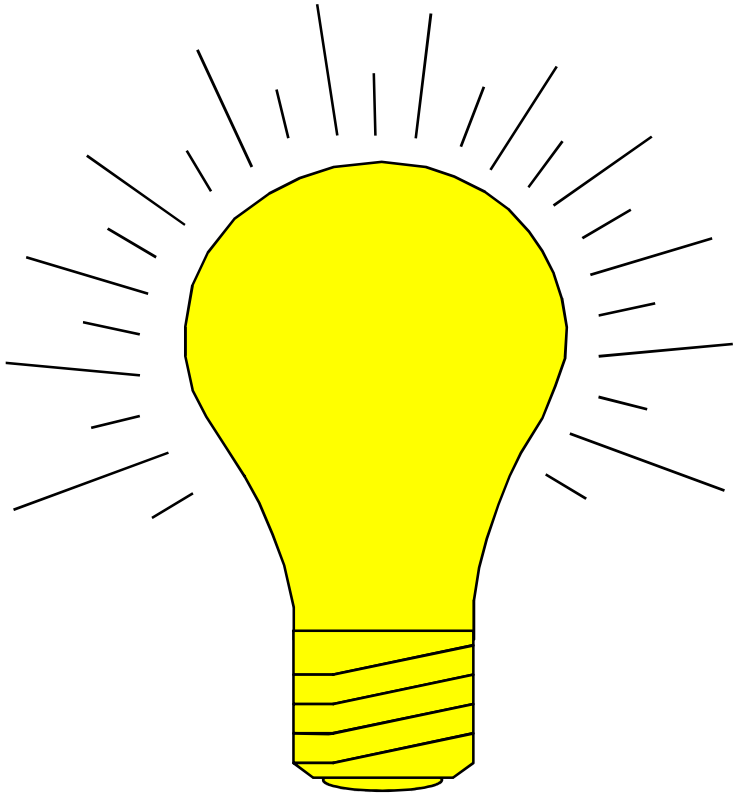
1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability

Sustainable Materials ...



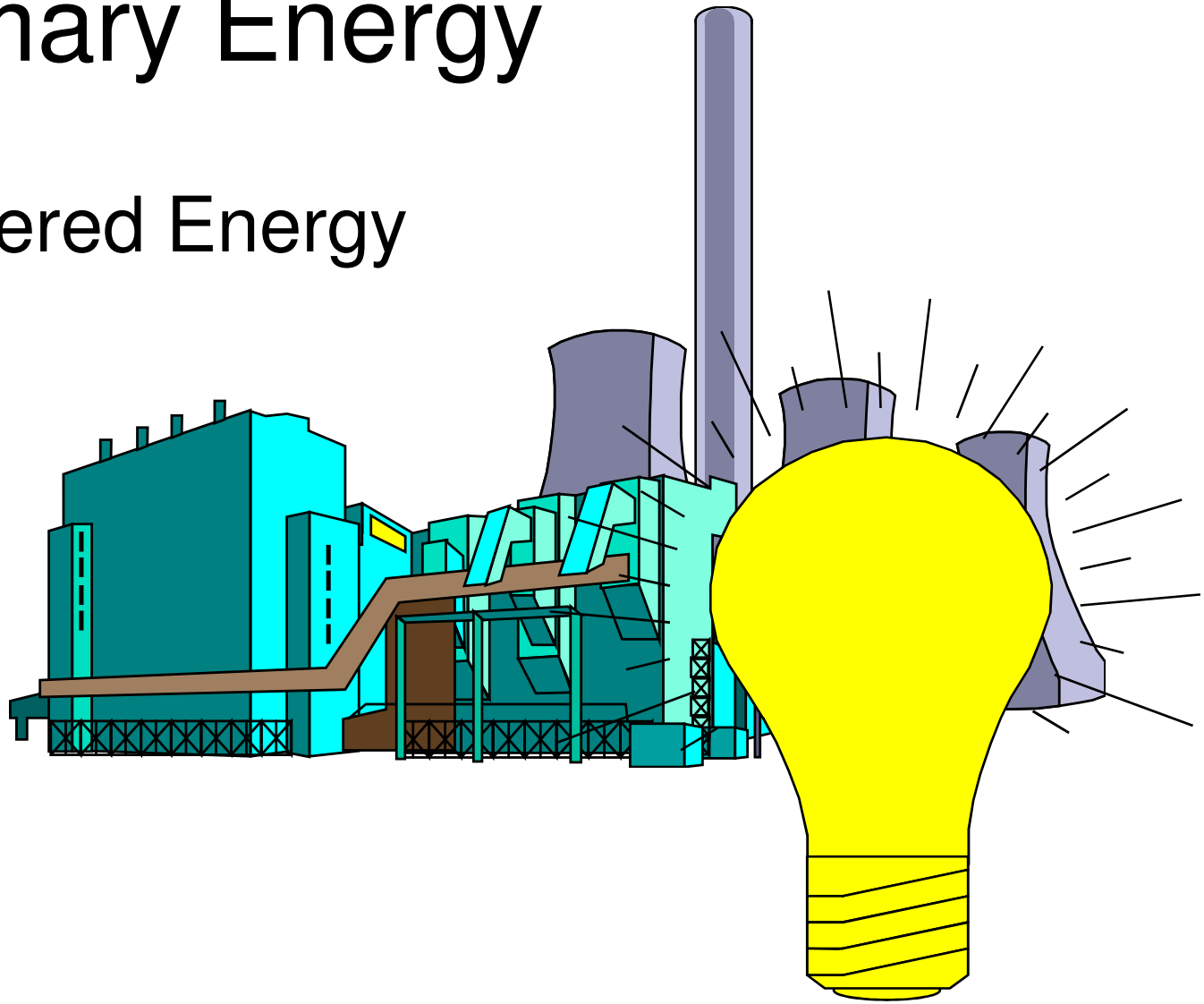


Delivered Energy



Primary Energy

Delivered Energy



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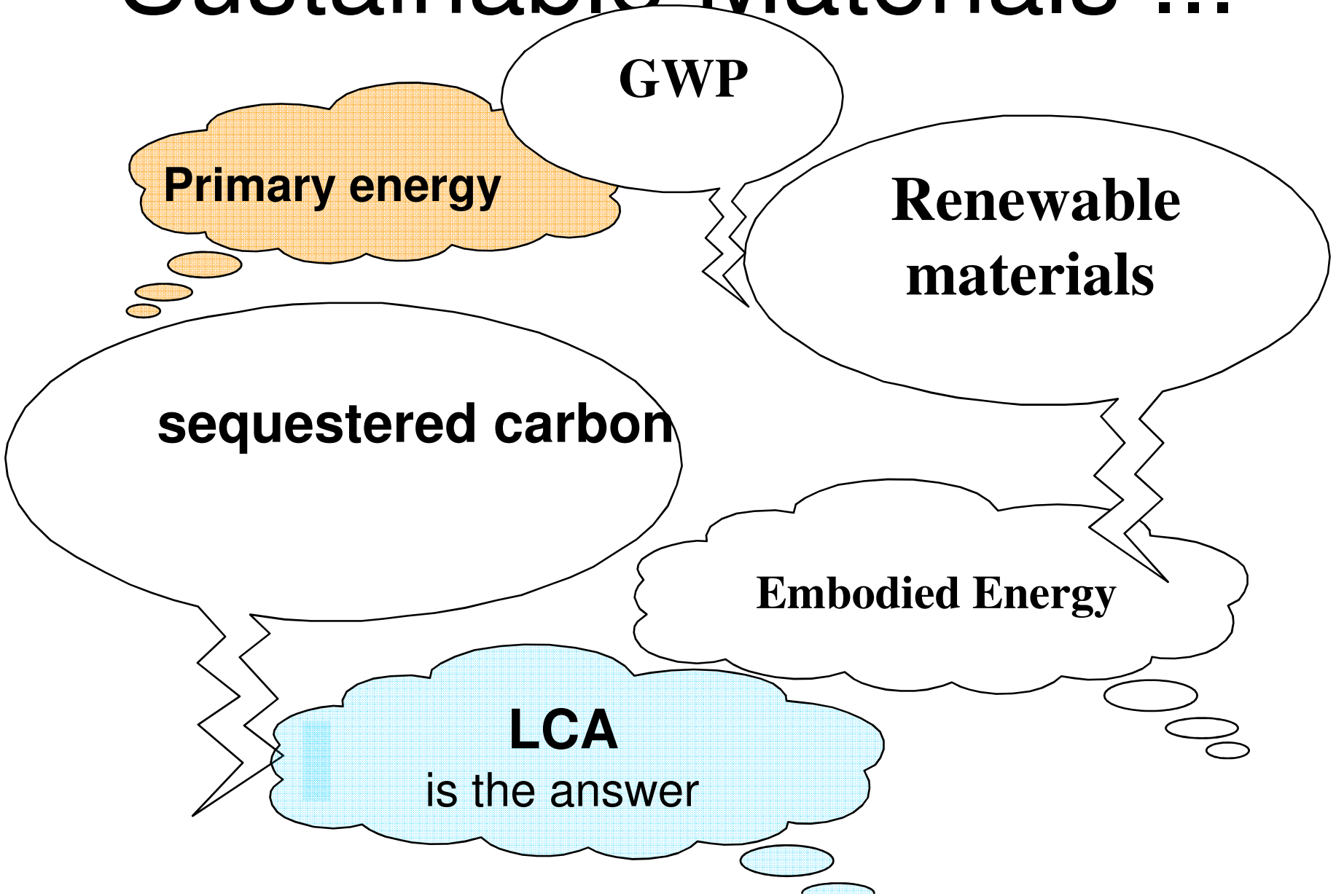
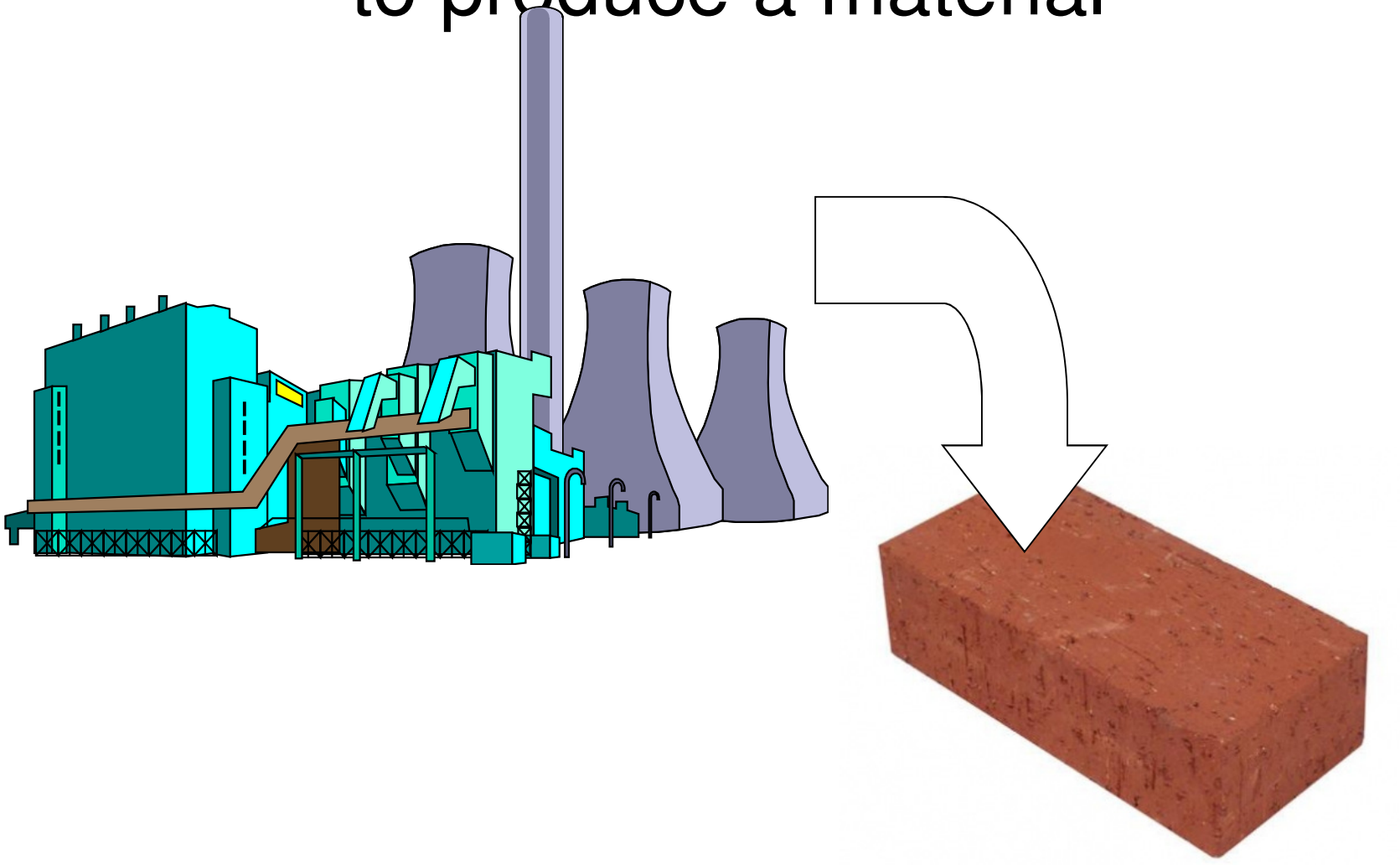
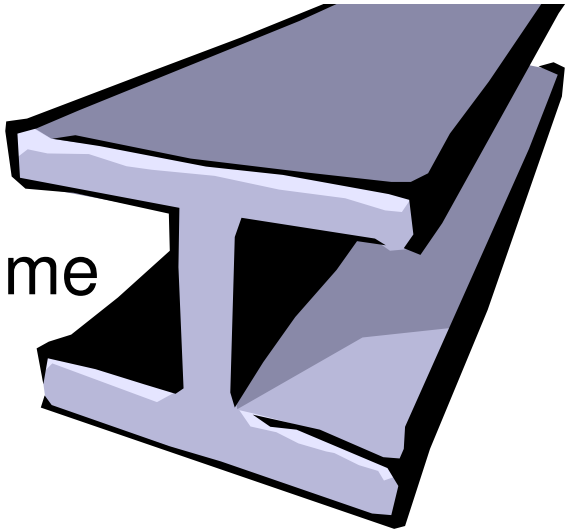


Embodied Energy (EE)

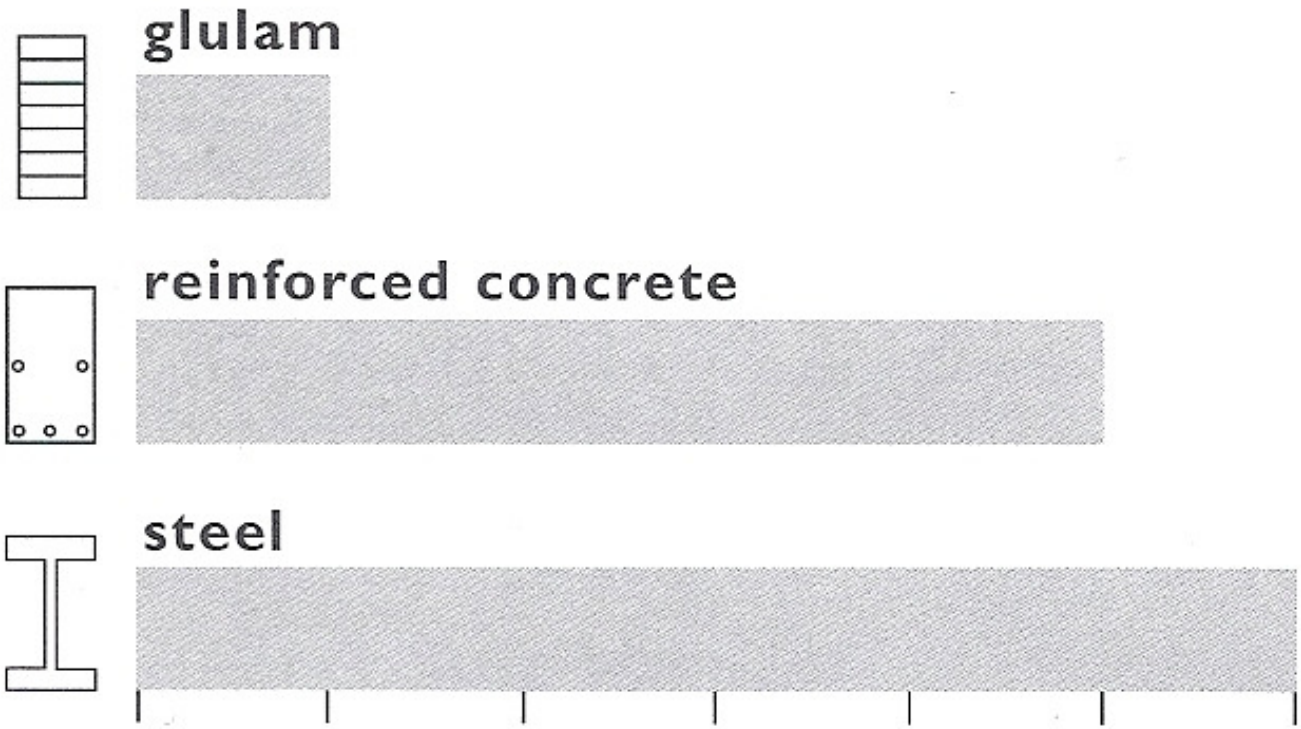
The total primary energy required to produce a material



- **Non- Renewable Material**
  - Finite: extracted once
    or developed over a long period of time
    e.g. stone, minerals, steel



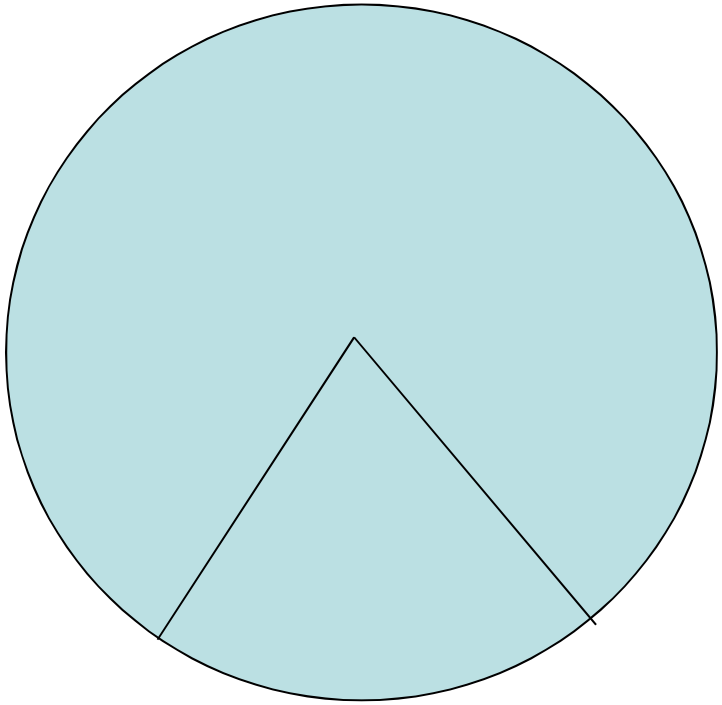
- **Renewable Material**
  - One Kilogram of dried timber can contain
    1.8 Kilograms of $C0_2$eq/kg stored as Carbon
    or a negative GWP -1.8 Kg$C0_2$eq/kg [5]
  - Sustainability depends on consumption not exceeding regeneration
  - Sustainable production can have benefits to the wider ecosystem
  - Procure responsibly from sustainable sources



Comparison of Embodied Energy in glulam timber, concrete and steel beams of the same strength.
Steel has 6 times more Embodied Energy than glulam timber.

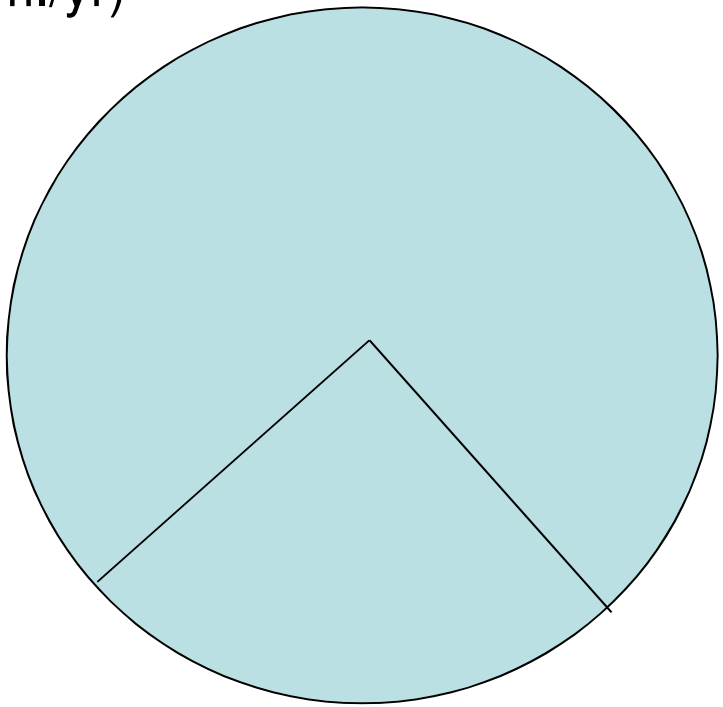
Graph:. Culture of Timber, McCartney, 1995. Data: Baird & Chan, 1983, NZ.

FABRIC ROLE IN EE AND GWP
222 sq. m. low operational energy home
(42 kWh/sq.m./yr)



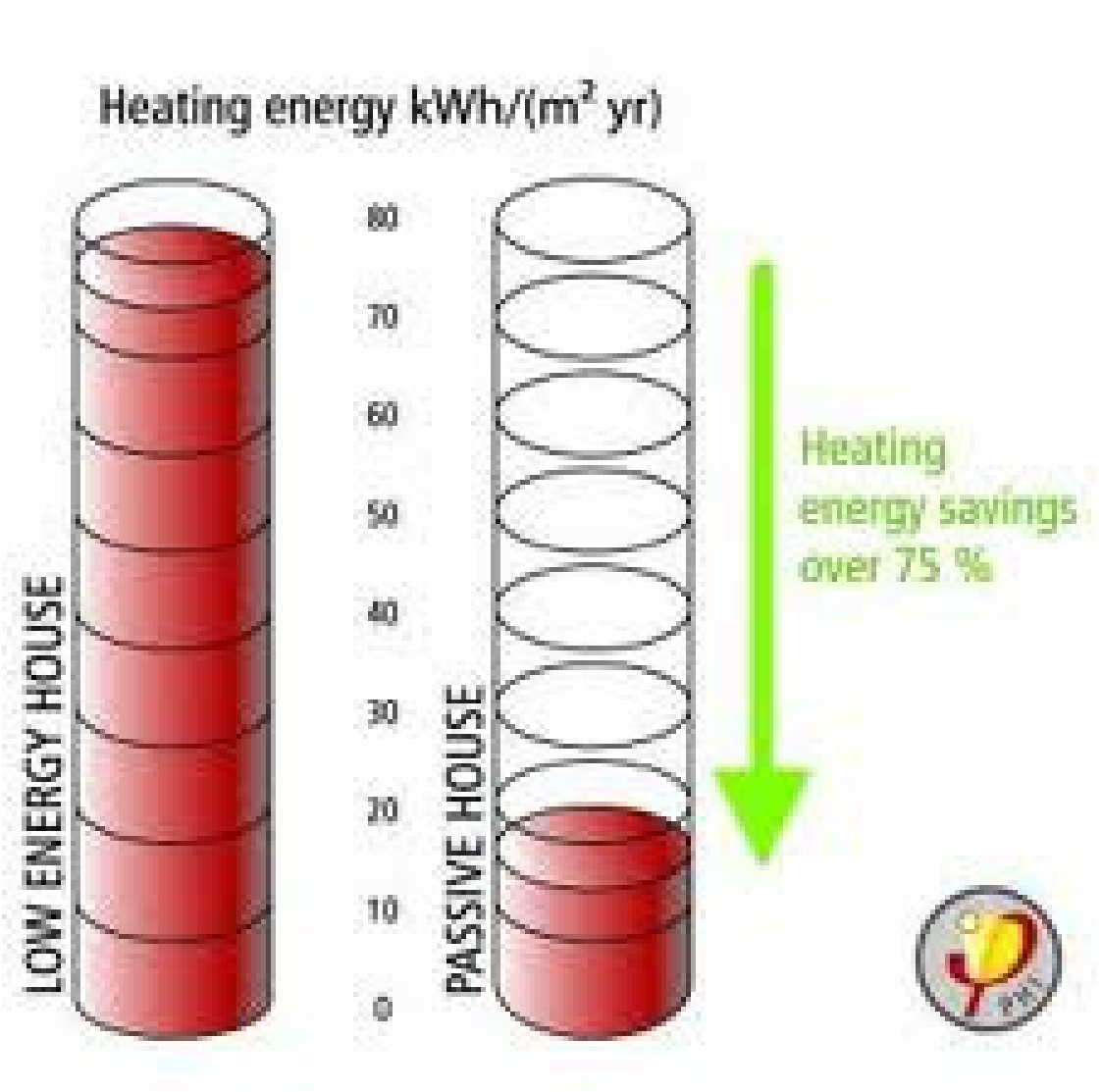
Fabric responsible for 30%

of Total Embodied Energy

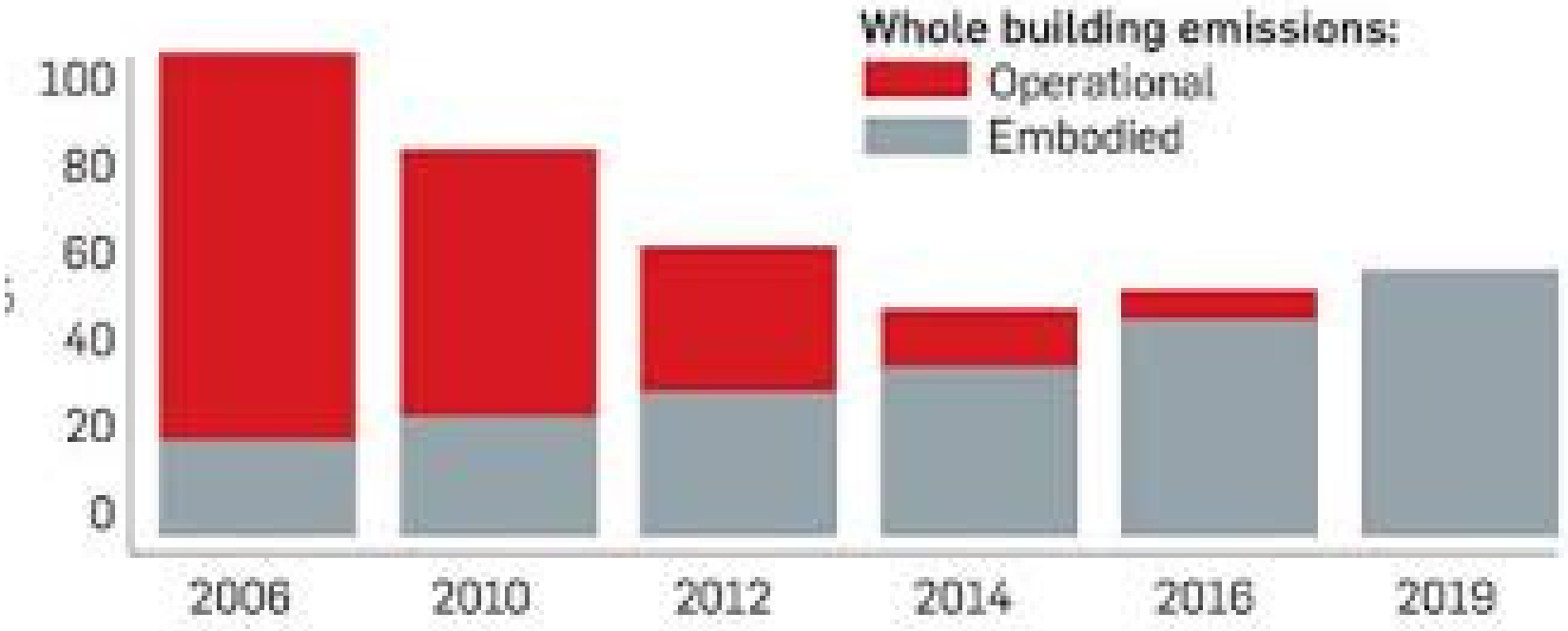


Fabric responsible for 41% of Global Warming Potential GWP

Bribian, Uson, Scarpellini (2009) Life Cycle Assessment in Buildings, Buildings & Environment 44(12)


Heating energy kWh/(m² yr)
80
70
60
50
40
30
20
10
0
LOW ENERGY HOUSE
PASSIVE HOUSE
Heating
energy savings
over 75 %

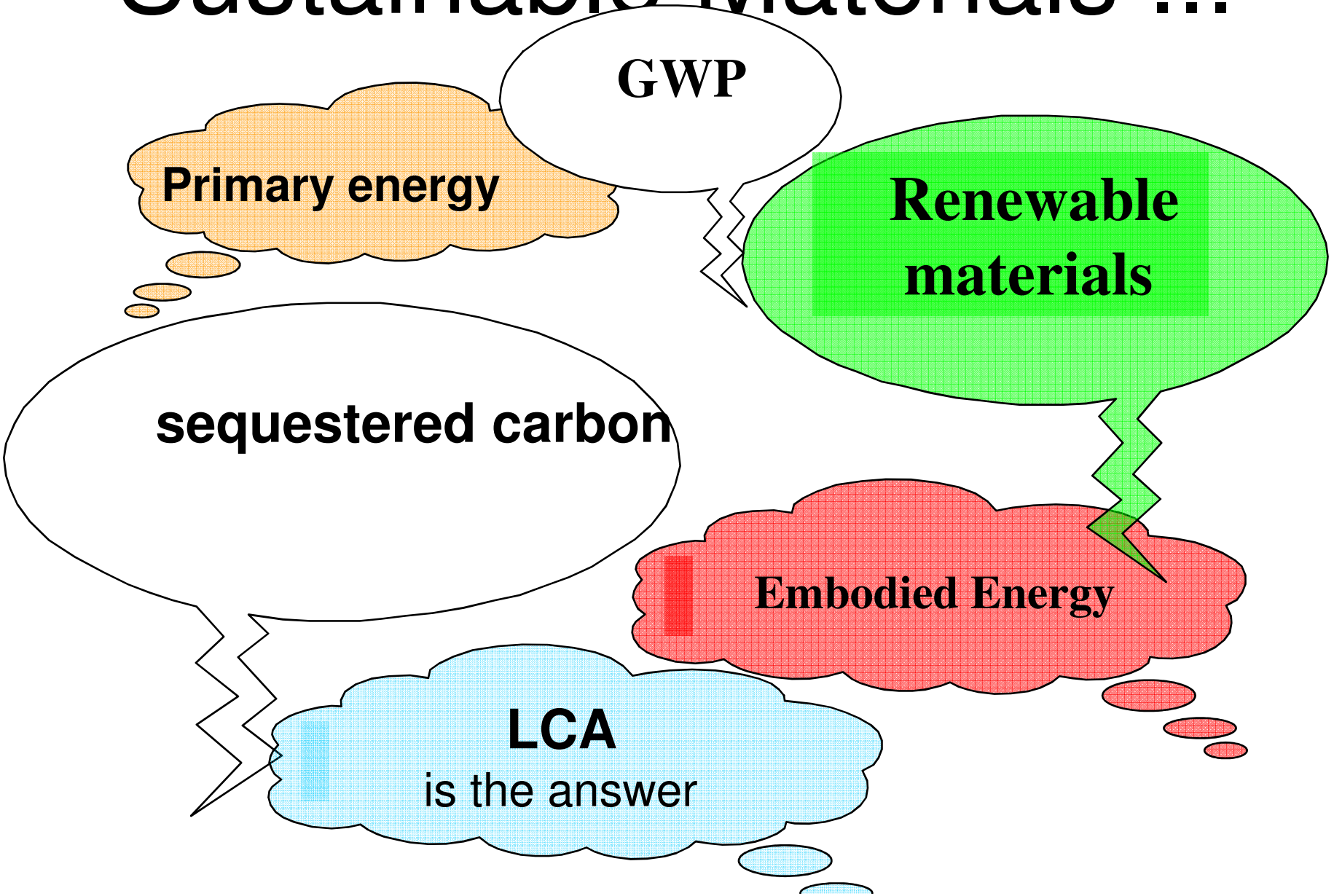
Embodied energy will be dominant contributor to carbon emissions



PBA's graph shows that embodied rather than operational carbon will soon become the dominant factor in reducing new buildings' carbon footprints. New building regulations in 2016 will enforce the need for all new homes to be zero carbon from that date - with non-residential to follow by 2019.

Building Design 1/5/2013

Sustainable Materials ...



RENEWABLE VERSUS NON RENEWABLE BUILDING FABRIC

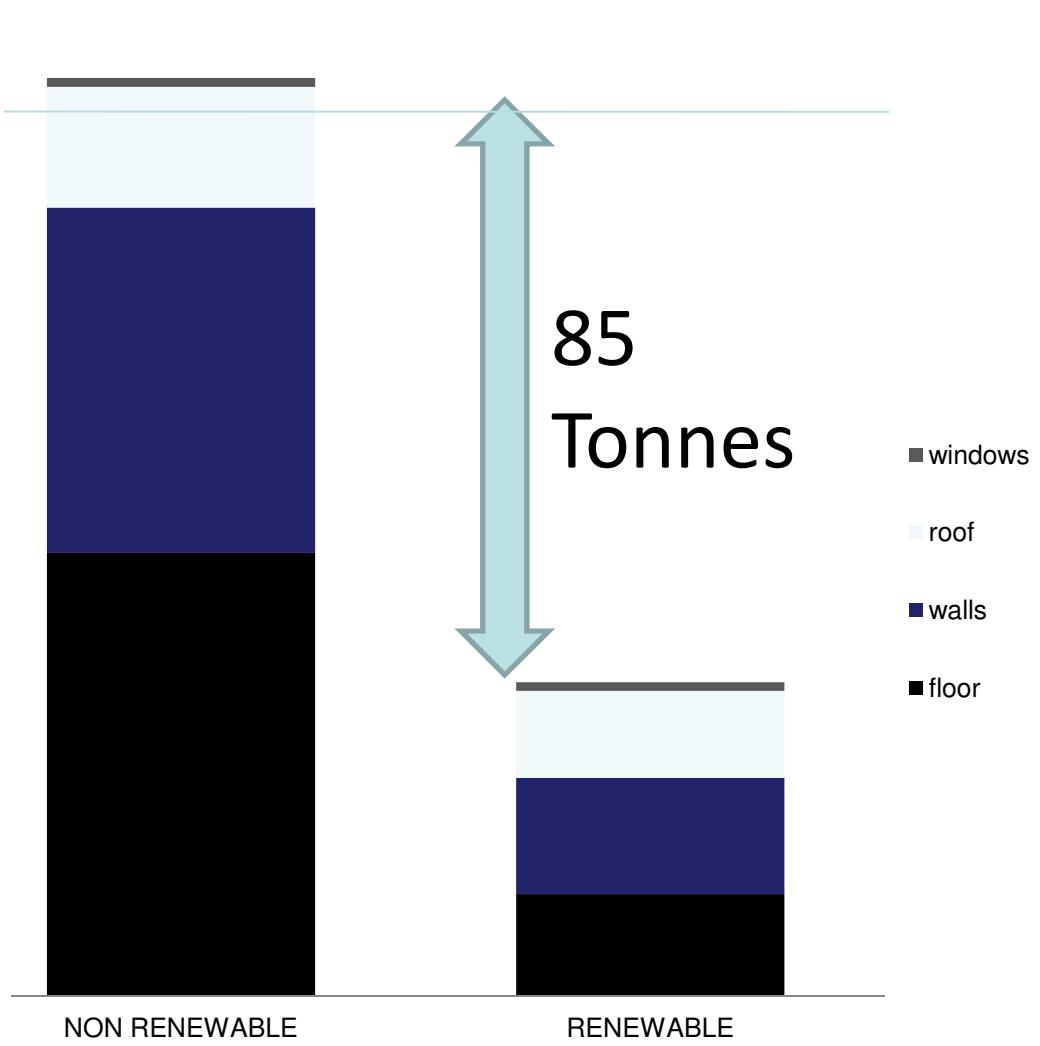
A COMPARATIVE STUDY ON THE EFFECT OF MATERIAL CHOICE
ON THE EMBODIED ENERGY AND GLOBAL WARMING POTENTIAL
OF LOW ENERGY BUILDINGS (2011)

by

Minka McInerney & Simon Tucker

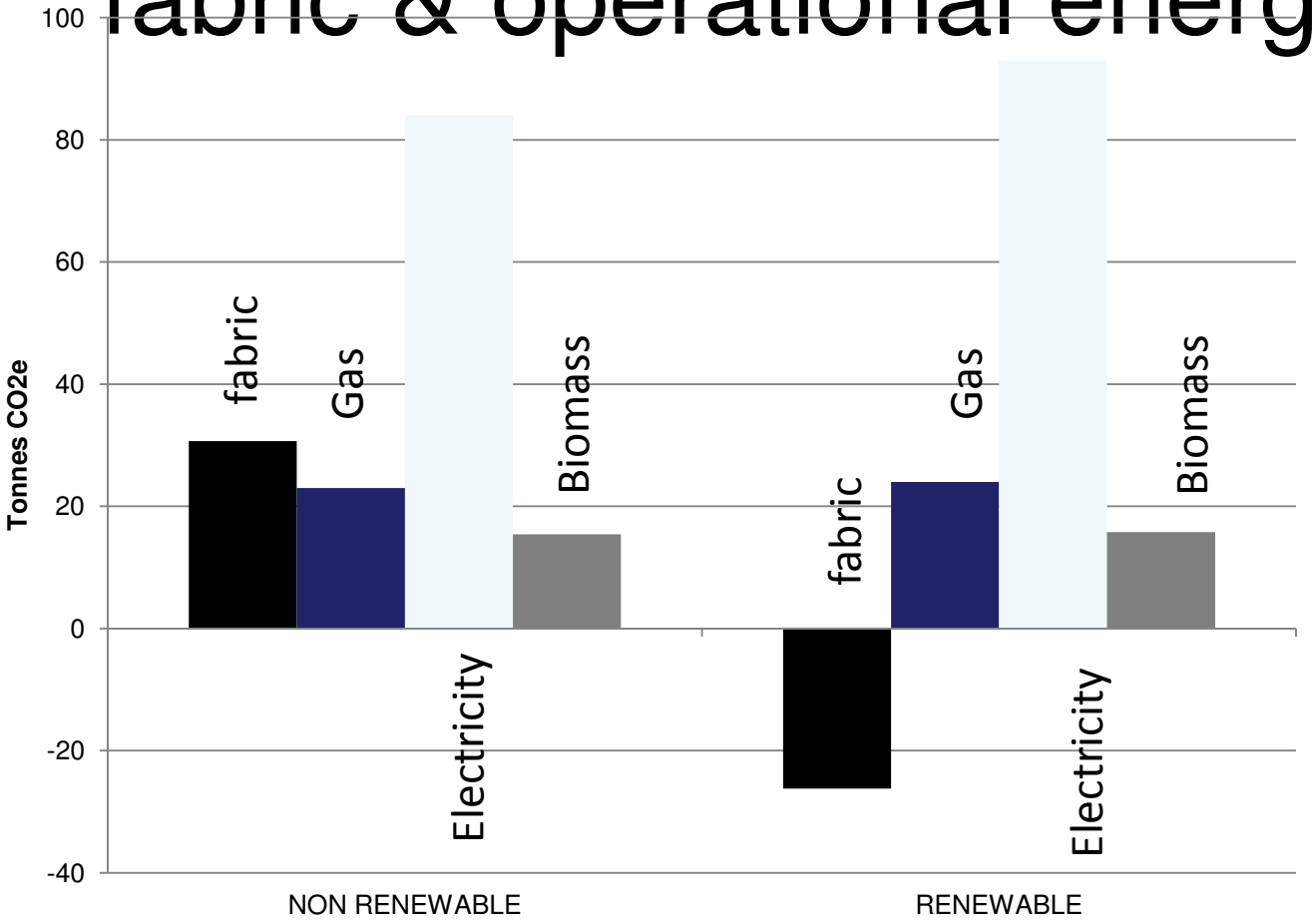
Weight Comparison

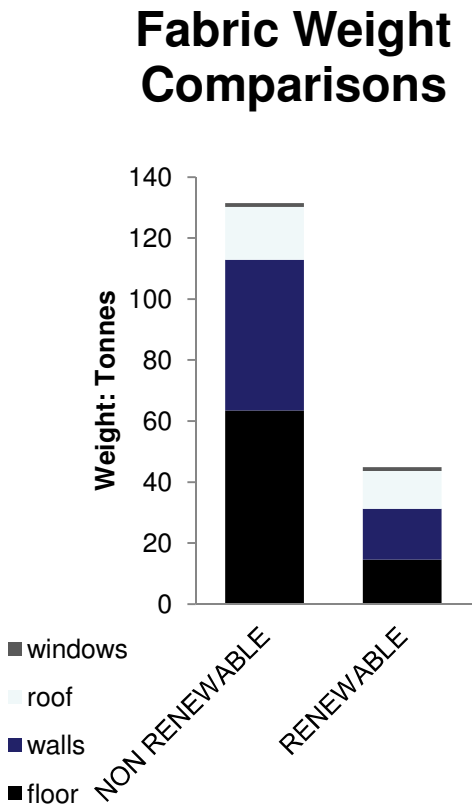
How much does your building weigh?



Global Warming Potential Comparison

fabric & operational energy 25 yrs

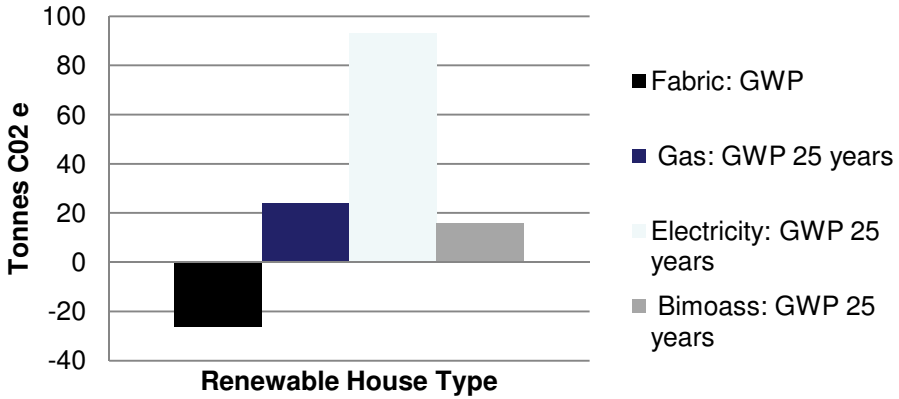




Renewable fabric implication

Total GWP Fabric	**Total GWP Fuel over 25 Years of operation ($TC0_2e$)**		**Equivalent operational (years)**
-26 $TC0_2e$	Gas	24	28
	Electricity	93	7.5
	Biomass	16	41

Renewable Comparison GWP: Fabric & Operational demand

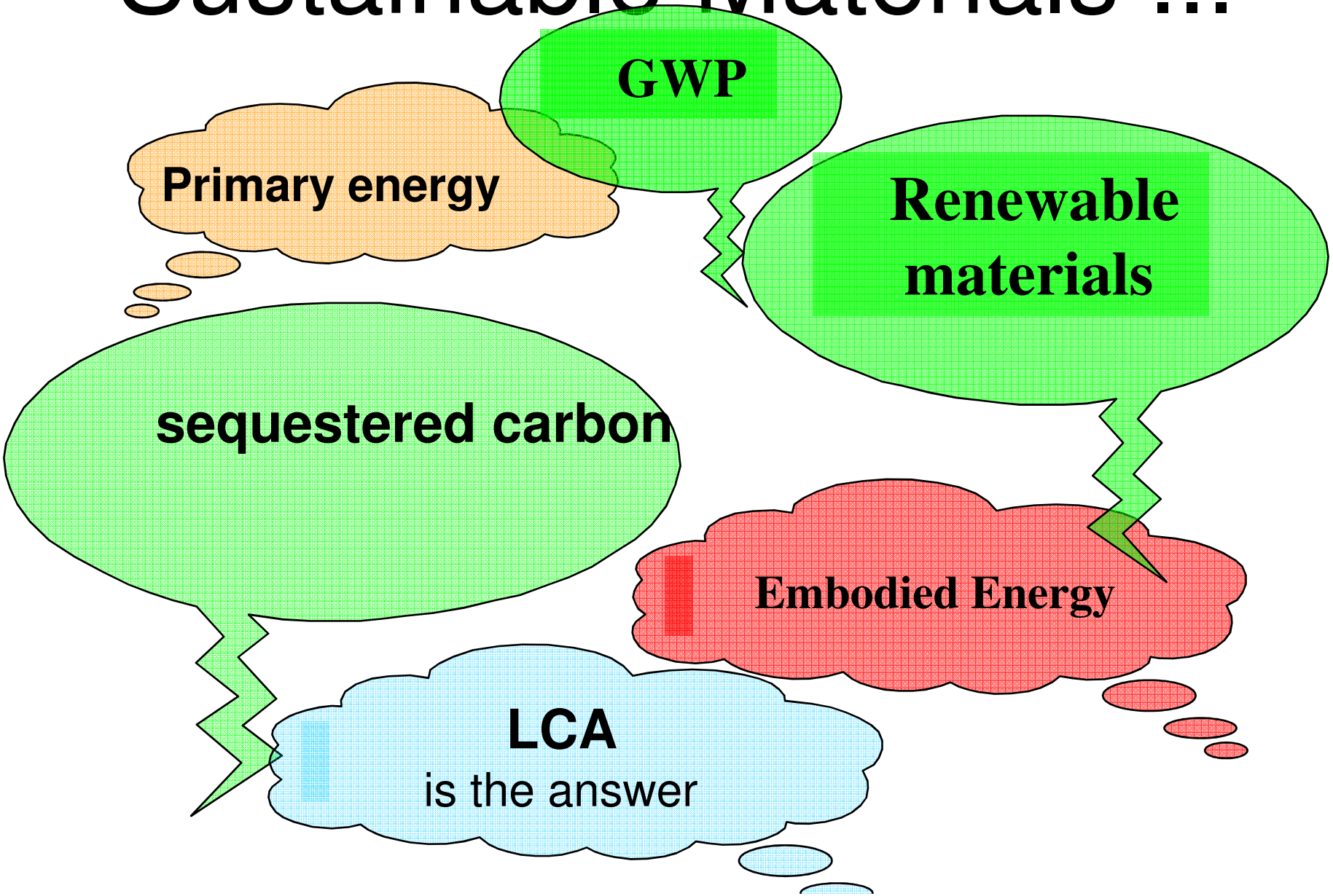


"Zero Carbon Design?"

Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability
4. Select low embodied energy materials

Sustainable Materials ...



Global Warming Potential (GWP)

The metric adopted by the IPCC to assess Green House Gases

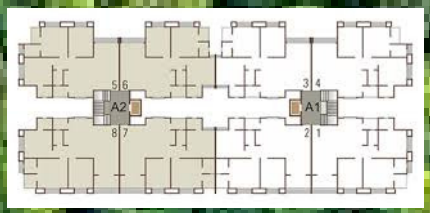
- **Embodied Carbon:** positive GWP of material production – a function of energy generation
- **Sequestered Carbon:** negative GWP of the Carbon stored in plant based renewable materials

Carbon Dioxide Absorption

1 square metre of forest
can absorb 1 kg/year

ECOLOGICAL FOOTPRINT

buildings require a forest area 40-80 times their floor area to absorb its CO_2 emissions from operating energy



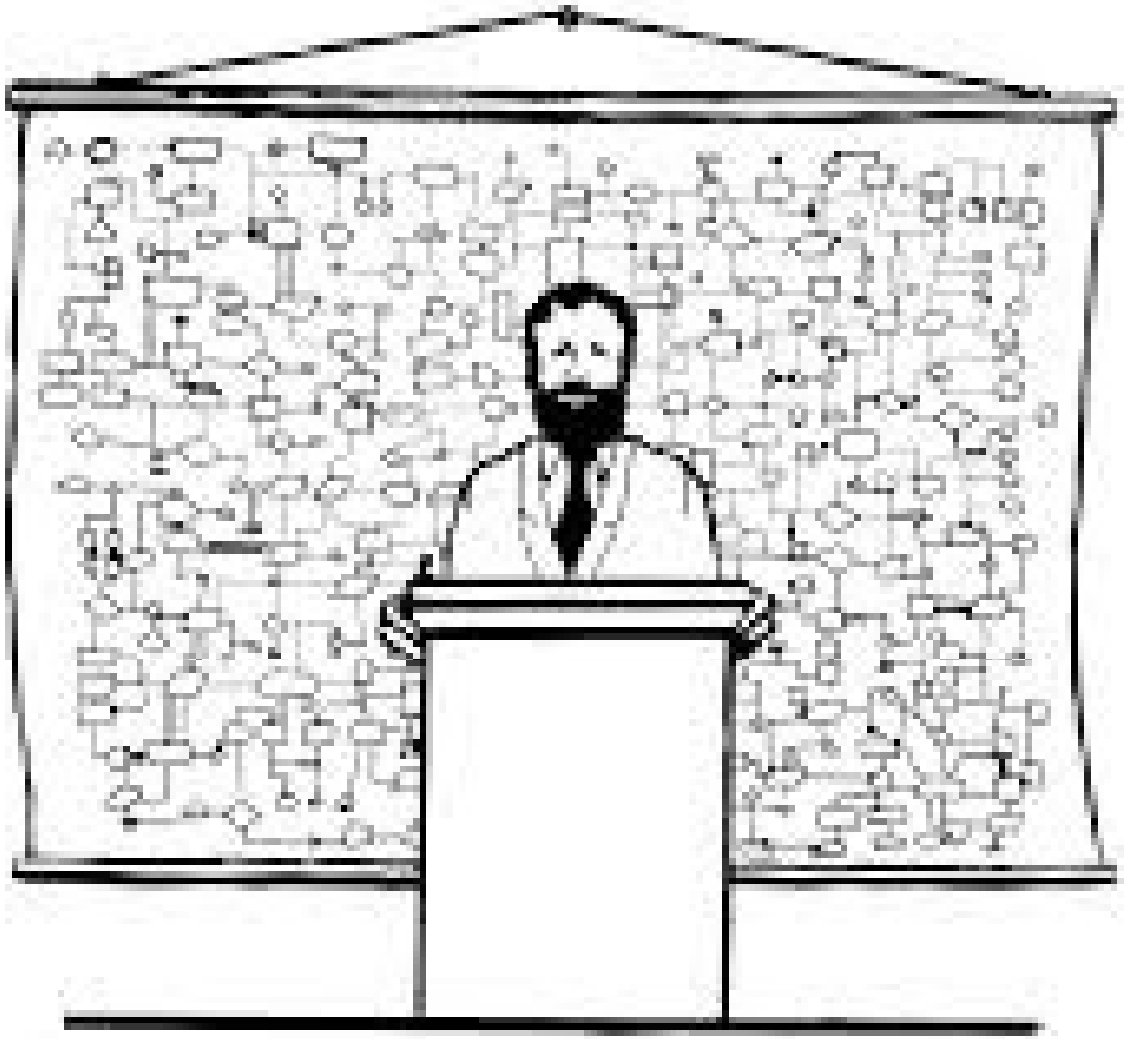
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability
4. Select low embodied energy materials
5. Select materials which sequester carbon

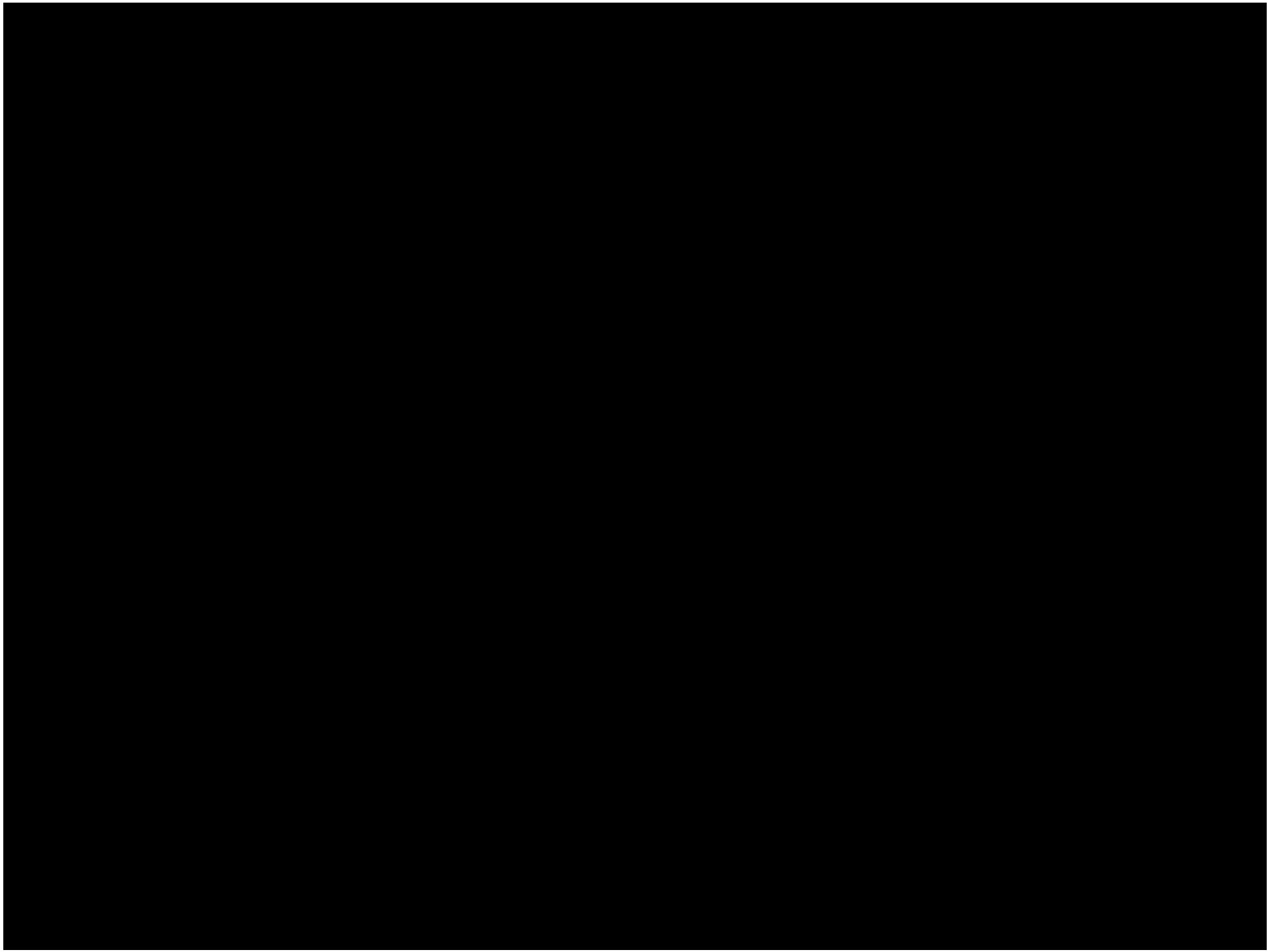
Designers Role

(Minka McInerney & Simon Tucker)

- Potential of Carbon Sequestration in building materials should not be ignored
- EE & GWP become very significant in low energy design
- Low operational energy design lends itself to simple LCA such as EE & GWP i.e. easy to calculate fabric quantities in tandem with U-value calculations
- Designers should become familiar with Construction material inventories & seek Environmental Product Declarations (EPD)
- Design for dematerialization[(3)] & durability
- Source renewable materials sustainably



“Now that you have an overview of the system, we’re ready for a little more detail”



- As the operational carbon of buildings is reduced following the more stringent requirements of Approved Document L, embodied carbon is moving higher up the agenda when it comes to making decisions about the best way to reduce a building's overall carbon footprint.
- PBA's graph (below) shows that embodied rather than operational carbon will soon become the dominant factor in reducing new buildings' carbon footprints, especially with the introduction of the new building regulations in 2016. These have been dubbed "zero carbon" because the regulations will enforce the need for all new homes to be zero carbon from that date - with non-residential to follow by 2019.
- "It is likely that embodied carbon reductions will be permitted as an 'allowable solution' in the 'zero carbon' building regulations 2016, and presently these are increasingly being accepted by local authorities as a trade-off against uneconomic renewables targets," says Dr Kelly, adding that embodied carbon is also being given more attention in the current draft of Breeam assessments.

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http://www.bdonline.co.uk/where-the-embodied-is-buried/5054003.article
Pamela Buxton, Building Design,1 May 2013