

Introduction

Slide 1 *“Treat the Earth well. It was not given to you by your parents; it was loaned to you by your children”*

Good afternoon and thanks to Timber Queensland for the invite to present a paper that I hope will increase your knowledge of broader sustainability concepts. I would like to open with this Kenyan proverb that I feel succinctly captures the intergenerational concept of sustainability.

My presentation will consider sustainability in the built environment and examine how the intelligent use of timber may lead to improved sustainability outcomes by the consideration of the embodied energy of building materials.

Sustainability – How Does Timber Stack Up?

Whilst this design may provide the ultimate in sustainable construction, it may not be practical in QLD. So how does timber stack up? Timber provides numerous sustainability benefits, including;

- The ability to sequester and store CO₂,
- Providing diverse habitats and biodiversity,
- The ability to re-use and recycle materials,
- Providing a low embodied energy building material, the focus of this presentation.

What is Embodied Energy?

Slide 4 One method of measuring the sustainability of building materials is to consider the embodied energy contained within the products, or the amount of energy that has accumulated in a building material during the stages of production. Embodied energy represents 20 to 50 times the annual operation energy of most Australian residential, commercial, institutional and educational buildings¹ and it has been estimated 18 million trees grown to maturity are required to offset the annual embodied greenhouse impacts in the construction industry alone².

Why is understanding the embodied energy of materials important? Building materials are responsible for approximately 2% of total Australian greenhouse emissions and comprise approximately 10% of the overall greenhouse impacts of buildings³. Building approval data provided by the Australian Bureau of Statistics (ABS) records approvals for single detached Class 1A dwellings rose from 105

¹ Treloar G, Fay R, Building Materials Selection – Greenhouse Strategies, 2005 p.1,

² Scoping Study to Investigate Measures for Improving the Environmental Sustainability of Building Materials, 2006 p.56

³ Australian Greenhouse Office 2006, p.xiv

298 in 2005-06 to 109 350 in 2007-08, an increase of 4.77% per annum⁴. Acting in concert with increased dwelling approvals is the increase in average dwelling size. As noted, 'The average area of new dwellings has increased markedly – by 40% in the 20 years to 2003 – from 166m² to 241m² for separate houses and 110m² to 163m² for multi units'⁵. In fact, it was recently noted in the Australian Financial Review that; 'Australia has the largest average house size in the world' (*We want to be alone*, p. 29, AFR, June 24-25 2010).

As increased dwelling sizes leads to negative environmental externalities, so to can increased regulations generate unintended consequences.

Examining the 2010 BCA energy efficiency requirements⁶, it is seen that as the energy efficiency requirements of buildings increases, so proportionally does the ratio of embodied energy. This may be demonstrated with the 2010 BCA amendments, where increasing the minimum insulation to a maximum R 5.1 increased the embodied energy to 60.2 MJ/m² whereas the existing R2.7 bulk fibreglass batts had an embodied energy of 32.2 MJ/m². To place this in perspective this increase represents an additional 6748 MJ (1.4 tonnes of CO₂ emissions) of embodied energy for the average house, meaning the energy payback period (meaning the time it takes for the energy savings created by the increased insulation to overtake the embodied energy) is 2.5 years⁷ (the payback period does not include increased wall insulation, larger studs to accommodate the bulk insulation etc).

Returning to the question of sustainability as expressed by embodied energy, it may be beneficial to compare a range of timber products against some other common building materials to obtain a comparative ranking of sustainability. The following values have been calculated by the University of Bath (UK) Inventory of Carbon and Energy (ICE) program⁸ and provide a convenient metric of sustainability values;

Product	Embodied Energy
Concrete (no steel)	1.11 (MJ/kg)
Concrete Block	0.81 (MJ/kg) or 9.23 MJ per Block

⁴ Australian Bureau Statistics 2009, p.18,

⁵ Scoping Study to Investigate Measures for Improving the Environmental Sustainability of Building Materials, 2006 p.22

⁶ Australian Building Codes Board, *Building Code of Australia*, Volume 2, (2010)

⁷ Calculation based on the following assumptions: 241m² dwelling, all ceiling insulation assumed bulk, straight linear interpolation to obtain embodied energy value of insulation, difference in insulation embodied energy values multiplies by area to achieve total values, total value divided by 11 MJ/m² difference between 5 & 6 star rating to obtain payback period.

⁸ Hammond, G & Jones, C, Inventory of Carbon & Energy Version 1.6a, Sustainable Energy Research Team, Department of Mechanical Engineering University of Bath UK

Cement	4.6 (MJ/kg)
Single Face Brick	8.21 (MJ/kg) or 23 MJ per Brick
Sawn softwood	7.4 (MJ/kg)
Sawn Hardwood	7.8 (MJ/kg)
LVL Timber	9.5 (MJ/kg)
Plywood	15 (MJ/kg)
Structural Steel (Bar and Rod)	36.4 (MJ/kg)
Aluminium	155 (MJ/kg)

As demonstrated, timber has relatively low embodied energy values, although both concrete and brick are lower per unit value. This however must be viewed with caution as there is much greater mass in concrete construction than timber. Considering a 200m² floor area based upon a 100mm slab or 19mm softwood floor we can see;

25 MPa Reinforced Concrete (no beams) = 20m³ x 2400kg/m³ x 2.12 MJ/kg =
101760 MJ

Softwood Flooring and Sub frame (Hyspan bearers and Hyjoist joists)

Flooring 3.8m³ x 700kg/m³ x 7.4 MJ/kg = 19684 MJ
Bearers 80lm x 7kg/m x 9.5 MJ/kg = 5320MJ
Joists 440lm x 2.9kg/m x 9.5 MJ/kg = 12122MJ
Total = **37126MJ**

As established, the timber flooring system has less than half the embodied energy than the concrete floor.

To further demonstrate how material selection affects total embodied energy values⁹, a detached dwelling was modelled using a computer thermal simulation rating tool¹⁰ and embodied energy system values published in Part 5.2 of the 'Your Home Technical Manual.'

Two common construction methodologies were modelled, high and low thermal mass. Both examples achieved at least the minimum acceptable (BCA 2009) 5 star energy rating.

The high thermal mass building comprised the following elements;

- Cavity masonry external walls,
- Masonry internal walls,
- Concrete slab on ground,
- Tile roof.

⁹ *Your Home Technical Manual – Material Use 5.2 Embodied Energy*

¹⁰ Solar logic - BERs Pro available online at <http://www.solarlogic.com.au/>

- All other elements (roof trusses, glazing, doors the same as low thermal mass)

Element	Material	Area M ²	Embodied energy MJ/m ²	Total embodied energy MJ
External walls	Cavity Brick	78.8	860	67768
Internal walls	Cavity Brick	45.6	430	19608
Floor	Concrete	105	645	67725
Roof	Tile	105	251	26355
Roof insulation	R 2 Batts	105	32.2	3381
Wall insulation	N/A			
				184837

The low thermal mass building comprised the following elements;

- Fibre cement, timber frame external walls,
- Plasterboard, timber frame internal walls,
- Elevated timber floor,
- Sheet steel, truss roof,
- R3 bulk insulation in the ceiling,
- Aircell insulation in the walls/floor

Element	Material	Area M ²	Embodied energy MJ/m ²	Total embodied energy
External walls	Fibre Cement	78.8	169	13317
Internal walls	plasterboard	45.6	245	11172
Floor	Timber	105	293	30765
Roof	Sheet steel	105	330	34650
Roof insulation	R 3 Batts	105	42	4410
Wall insulation	Aircell	78.8	220	17336
Floor insulation	Aircell	105	220	23100

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This modelling demonstrates that the low thermal mass building has 27.1% less embodied energy than the high thermal mass building, but still satisfies the minimum BCA energy efficiency requirements.

To further emphasise the significance of informed material selection, if we consider the emission differences between low and high thermal mass buildings we see that;

1. Low thermal mass construction resulted in an average saving of 50087 M/J of embodied energy consumption per house,
2. If just 10% of the annual new housing stock was constructed using low thermal mass, this would result in a saving of 547 million MJ of energy, or
3. 4.7 million Trees planted annually to off-set the emissions generated by the material selection, or the equivalent of removing 24000 cars from our roads each year¹¹

Conclusion

The current election campaign has moved the question of sustainability to prominence, with projections of Australia's population reaching 36 million by 2050 with associated infrastructure and housing demands.

One commonly ascribed solution is to move to higher density housing, a construction type that generally necessitates masonry and concrete construction to satisfy BCA fire and sound transmission requirements. Far from providing a sustainability panacea, high density housing may lead to negative environmental externalities, with a 2005 study (Myors et al. 2005) finding 'high rise development in Sydney had higher greenhouse gas emissions per person than detached dwellings or townhouses/villas. These findings were attributed to factors such as;

- Frequent specification and inclusion of air-conditioning, spa baths, swimming pools and luxury appliances¹²,
- Operational energy use in multi-storey construction is exacerbated by the use of elevators and centralised mechanical ventilation in high rise

¹¹ Based on 1.5 – 2.0lt petrol car traveling 20,000km per year producing .21280 kg/co2 per km.
Source – 2009 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting

¹² Australian Conservation Foundation, 2007, p.10

- construction with energy consumption increased due to common areas such as lifts, corridors and pools¹³,
- The floor area of multi-units has increased in the 20 years to 2003, from an average of 110m² to 163 m², with occupant densities reducing to 2.6 persons per household¹⁴,
 - As previously demonstrated, high mass masonry construction has a higher embodied energy compared to light weight construction (such as timber)

These comments do not seek to deny the reality that high density dwellings will form a central part of future sustainable construction options; however the environmental negatives associated with this type of dwelling make it vital that when builders, designers and consumers have options in material selection (such as detached dwellings and duplexes) that consideration is given to sustainable, low embodied energy materials such as timber.

Thank you

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¹³ Myers et al, 2005 in Wright, 2007, p.3

¹⁴ Australian Greenhouse Office as reported in the Scoping Study, 2006, p22

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