Embodied Energy and

Heating and Cooling Energy

Associated with Timbercrete

In Australian Housing

This report has been prepared on behalf of **ELECTRONIC BLUEPRINT** by:

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Embodied Energy and Heating and Cooling Energy Associated with Timbercrete in Australian Housing

Background
The BCA Vol 2 (Building Code of Australia Volume 2) sets out the performance requirements for energy saving in housing, and some DTS (deemed-to-satisfy) construction details. Both the performance requirements and the DTS provisions are based on minimising heating and cooling energy, and do not give requirements for minimising the embodied energy used to manufacture the building components.

Scope
This paper provides estimates of the embodied energy used to manufacture Timbercrete wall systems, and compares it to a selected benchmark (clay masonry veneer), commonly used in Australian housing. From this data, the savings in embodied energy to change from the benchmark system to Timbercrete can be calculated, and this information can be expressed as a percentage of the heating and cooling energy over the life of the house.

Form of Construction
Timbercrete is often constructed as single-leaf masonry with large roof overhangs. However, if Timbercrete walls are designed in accordance with BCA Volume 2 Part 3.12 Deemed-to-Satisfy energy provisions or NSW BASIX provisions, the use of a veneer system could be preferable to single leaf. For this reason, both Timbercrete single leaf walls and Timbercrete veneer walls have been analysed in this report.

Limitations
This is a preliminary study based on a limited amount of information, and should be augmented by a more comprehensive study. It does not consider credits for reuse of materials during the final demolition. Nor does it include painting and maintenance of non-face-brick components.

Analysis

- Table 1 shows the embodied energy of various masonry systems, including clay masonry veneer, Timbercrete single leaf and Timbercrete veneer. Embodied energy values are expressed as MJ/m^2 of wall area.

- Table 2 shows the embodied energy saving to change construction from clay brick veneer to Timbercrete single leaf or Timbercrete veneer.

Conclusions

- Table 1 shows that the embodied energies of Timbercrete single leaf and Timbercrete veneer are both less than the selected benchmark construction, clay masonry veneer.

- Table 2 shows that a change construction from the clay brick veneer benchmark to Timbercrete can lead to savings in embodied energy up to 6% of the target operational 5 Star heating and cooling energy expended over the life of the building.

Table 1 - Embodied Energy of Various Masonry Systems			
Climate Zone	Embodied Energy MJ/m^2 wall		
	Clay Masonry Veneer	Timbercrete Single Leaf	Timbercrete Veneer
1 Hot humid warm winter	689	510	272
2 Warm humid summer, mild winter	689	510	272
3 Hot dry summer, warm winter	689	510	272
4 Hot dry, cool winter	689	510	272
5 Warm temperate	689	510	272
6 Mild temperate	689	510	272
7 Cool temperate	689	510	272
8 Alpine area	713	566	295

Notes:
1. The insulation of all systems is in accordance with the BCA-2006 Volume 2 requirements and the corresponding Deemed-to-Satisfy details.
2. Tabulated values are the sum of the embodied energies of the principal components making up the wall.

Table 2 - Embodied Energy Saving to Change Construction From Clay Brick Veneer To Timbercrete Single Leaf or Timbercrete Veneer

Climate Zone	5 Star Heating & Cooling Energy (MJ/m^2 wall over life)	Embodied Energy Reduction if Construction is Changed from Clay Masonry Veneer to Timbercrete			
		MJ/m^2 wall		% of Heating & Cooling Energy wall over life)	
		Timbercrete Single Leaf	Timbercrete Veneer	Timbercrete Single Leaf	Timbercrete Veneer
1 Hot humid warm winter	24,624	-179	-418	**-1%**	**-2%**
2 Warm humid summer, mild winter	6,926	-179	-418	**-3%**	**-6%**
3 Hot dry summer, warm winter	10,004	-179	-418	**-2%**	**-4%**
4 Hot dry, cool winter	12,697	-179	-418	**-1%**	**-3%**
5 Warm temperate	8,465	-179	-418	**-2%**	**-5%**
6 Mild temperate	14,236	-179	-418	**-1%**	**-3%**
7 Cool temperate	19,238	-179	-418	**-1%**	**-2%**
8 Alpine area	16,545	-147	-418	**-1%**	**-3%**

Notes:
The insulation of all systems is in accordance with the Draft BCA-2006 Volume 2 requirements and the corresponding Deemed-to-Satisfy details.

Appendix 1
Methodology

The methodology employed herein is as follows.

For a range of common Australian house building components in each Climate Zone:

1. From published data, determine the embodied energy per unit mass of common building components.

2. Determine the mass and embodied energy of each selected component and its most common alternatives
   - Timbercrete single leaf wall
   - Timbercrete veneer wall
   - Clay brick veneer wall (benchmark construction)

3. Determine the embodied energy difference, to change to the principal component from the benchmark form of construction.

4. Using the ABCB Protocol energy software, determine the target heating and cooling energy consumption for each relevant location. [1]

5. Compare the embodied energy difference (to change from the principal component to the alternative form of construction) to target 5 star heating and cooling energy consumption.[2] [3]

[1] A more sophisticated approach is to analyse each house design using conforming software (e.g. AccuRATE). However the approach used in this paper is considered to be more appropriate for comparing embodied energies, since most houses will suffer various limitations of site orientation, shading etc. and will probably only "just" achieve the required energy consumption defined in the ABCB Protocol. The means of achieving the required energy consumption may involve details that have little or nothing to do with the choice between the principal building component and the alternative.

[2] The "savings" are expressed as a percentage of the Heating and Cooling energy calculated using the ABCB Protocol for House Energy Rating Software Version 2006.1.

[3] The calculated values for embodied energy are considered to be very low proportions of heating and cooling energy. Total life-cycle energy of a house is much higher (7 to 8 times higher) than the heating and cooling energy. [3] If embodied energy saving were treated as a proportion of total life-cycle energy rather than of heating and cooling energy, the proportions would go from very small to insignificant. This suggests that there are far more significant savings in energy and greenhouse gas emissions to be made through controlling house operational energy (appliances etc) than by attempting to control embodied energy of the building fabric.

Appendix 2
Embodied energy per unit mass of common building components

The embodied energy of particular building materials depends in part on the country of origin and the process involved in manufacture. There are many sources of information on embodied energy of materials, some of which are available on the Internet.

The following have been chosen for use in this report.

Estimated Embodied Energy of Common Building Components			
Material	Approximate density kg/m^3	Embodied Energy [1] MJ/kg	**Embodied Energy MJ/ m^3**
Timbercrete blocks	1,000	1.9 [Note 3]	**1,900**
Brick (clay)	1,700	2.5 [Note 1, 2]	**4,250**
Tile (clay)	1,920	2.5	**4,800**
Tile (concrete)	1,920	0.8	**4.800**
Concrete block	2,180	0.9	**1,960**
Concrete (ready-mix 17.5 MPa)	2,400	1.0	**2,400**
Plasterboard	880	6.1	**5,368**
Kiln dried, dressed timber	510	2.5	**1280**
Aluminium	2,680	191.0	**512,000**
Galvanised steel	7,850	34.8	**273,000**
Fibreglass Insulation	18	30.3	**550**
Cellulose Insulation	29	3.3	**100**
Cellulose Insulation	29	3.3	**100**
Wool (recycled) Insulation		14.6	
Polyester Insulation		53.7	
1. Source: ATLA News Newsletter Issue 7 No 4 November 1998 (Except Timbercrete value)			

Notes

1. For consistency of comparisons, the values of embodied energy per unit mass of common building components have all been drawn from a common source. This is considered to be the most appropriate approach, notwithstanding that the use of energy in the manufacture of products varies from plant to plant.

2. The energy of manufacture of a “typical” eastern Australian brick plant may be higher, up to 2.9 MJ/kg bricks.

3. The Timbercrete embodied energy is determined in the following way.
   Published embodied energy of concrete blocks 0.9 MJ/kg
   Average density of concrete blocks 2,180 kg/m^3
   Average density of Timbercrete blocks 1,000 kg/m^3
   Composition of Timbercrete is 17% portland cement by weight (slightly more rich than concrete blocks, but employs no curing process)
   Calculated embodied energy of Timbercrete blocks
   = 0.9 x 2,100 / 1,000
   = 1.9 MJ/kg

Appendix 2
Embodied Energy in Timbercrete

This appendix sets out the embodied energy considerations of the components of Timbercrete.

Recycled Waste
Timbercrete is made from predominately a waste product, timber waste such as sawdust and or wood chip is the main ingredient. (Other cellulous/organic product can be substituted.) Timbercrete uses some of the large amounts of sawmill waste from plantation timbers and turn it into walls (bricks) of various types. No old forest waste is considered.

Carbon Trap
Sawdust (sawmill waste) is typically used to produced fertiliser or it is used in horse stables and the like. It is also burnt; all such uses produce carbon gases as the product breaks down. This in turn adds to global warming through the green house effect. On the other hand Timbercrete is a carbon trap because the timber is preserved in a cement/sand/clay tomb.

Other Ingredients
A smaller portion of unwashed sand is incorporated.

Binders
A small portion of portland cement binder (17%) is typically used.

No Kiln Firing
Timbercrete does not involve the use of any kilns or drying tunnels.

Energy use during manufacturing
To manufacture enough Timbercrete blocks for 1m^2 of single skin wall, a one HP electric motor runs for approximately 5 minutes. In some of our larger Timbercrete factories a 24HP Kanga Loader is run for 2 minutes to load the hopper. The process is totally hand made with machine usage kept to an absolute minimum.

Energy to attain raw materials
All Timbercrete factories are located in satellite cities and towns, these factories supply bricks and blocks to their respective local areas. Therefore the average time to access our sawdust sand and cement is approximately 1 hour. One 75 m^3 truck will deliver enough sawmill wast to produce 681m^2 of wall area One 20 ton load of sand will deliver enough material for 222m^2 of wall area One truck load of cement will deliver enough material for 864m^2 of wall area.

Energy to Deliver Finished Product.
One truck (carting 18 pallets) supplies enough block for 149m^2 of wall area. The time in transit is typically between 15 minutes and 2 hours (one way) which reflects the fact Timbercrete has a network of small businesses close to customers and so avoid the long hauls associated with other masonry products

Life Span
Timbercrete longevity is the same as any other non reinforced concrete product, with an expected life span well in excess of the design life of the building. As per other concrete products sealing or rendering increases its longevity.

No Acid Cleaning
Timbercrete dwellings do not require cleaning with acidic chemicals.

Appendix 3
Typical Relationship between Net Area of External Wall and Floor Area of Habitable Rooms

The values tabulated ibelow are the prescribed limits on energy consumption for the total of heating and cooling per unit floor area of habitable room. This area is different from the net area of external wall (which incorporates the wall embodied energy).

The relationship between net area of external wall and floor area of habitable rooms depends on the building dimensions, window and door areas, proportion of habitable to non-habitable rooms and height of sub-floor. The relationship could also vary a little depending on whether the house is one or two storey, although this effect is minor provided suitable adjustment to the other inputs is made.

The following calculations determine a typical relationship between net area of external wall and floor area of habitable rooms, and will be used in subsequent calculations.

Typical Relationship Between Net Area of External Wall and Floor Area of Habitable Rooms		
Length	15.0	m
Width	10.0	m
Floor to ceiling height	2.4	m
Subfloor height	0.3	m
Total wall height	2.7	m
Proportion habitable floor	15%	
Windows & door area (Including jambs, sill etc)	36	m^2
Internal gross wall area (including windows & doors)	120	m^2
(Windows + doors) / Wall	30%	
Net external wall area (based on total wall height)	99	m^2
Habitable floor area	128	m^2
Net external wall area / Habitable floor area	77%	

Appendix 4
Target 5 Star Heating and Cooling Energy Consumption

Target Heating and Cooling Energy to Achieve 5 Star Performance
MJ/m² based on <u>Habitable Floor</u> Area

Zone	Representative City		5 Star Annual Energy Limit MJ/m²	5 Star Lifetime Energy Limit MJ/m²
1 Hot humid warm winter	Darwin	1	320	19,200
2 Warm humid summer, mild winter	Brisbane	10	90	5,400
3 Hot dry summer, warm winter	Alice Springs	6	130	7,800
4 Hot dry, cool winter	Tamworth	14	165	9,900
5 Warm temperate	Sydney (East)	17	110	6,600
6 Mild temperate	Melbourne	21	185	11,100
7 Cool temperate	Hobart	25	250	15,000
8 Alpine area	Alpine	26	215	12,900

Notes

1. Annual energy limit from ABCB Protocol Building Energy Analysis Software Version 2005.1 May 2005.

2. The energy consumption values are total of heating and cooling per unit <u>floor</u> area of <u>habitable</u> rooms.

3. Lifetime energy limit is based on 60 years building life.

Target Heating and Cooling Energy to Achieve 3 or 5 Star Performance
MJ/m² based on <u>Net External Wall</u> Area

Zone	Representative City		5 Star Annual Energy Limit MJ/m²	5 Star Lifetime Energy Limit MJ/m²
1 Hot humid warm winter	Darwin	1	410	24,624
2 Warm humid summer, mild winter	Brisbane	10	115	6,926
3 Hot dry summer, warm winter	Alice Springs	6	167	10,004
4 Hot dry, cool winter	Tamworth	14	212	12,697
5 Warm temperate	Sydney (East)	17	141	8,465
6 Mild temperate	Melbourne	21	237	14,236
7 Cool temperate	Hobart	25	321	19,238
8 Alpine area	Alpine	26	276	16,545

Notes

1. Annual energy limit from ABCB Protocol for Building Energy Analysis Software Version 2005.1 May 2005.

2. The energy consumption values are total of heating and cooling per unit <u>net external wall</u> area of <u>habitable</u> rooms.

3. Lifetime energy limit is based on 60 years building life.

Sustainability Statement

Organisation making the statement	**Timbercrete Pty Ltd**
Details of Organisation ABN, Address, Phone, Email, Web	ABN 50349159373 2628 Bells Line of Road, Bilpin NSW 2758, AUSTRALIA Phone +612 4657 1149, 04 2767 1149 Email - peter@timbercrete.com.au Web - www.timbercrete.com.au
Nominated Product(s)	The nominated products are: **Timbercrete 190 mm single leaf walls**, consisting of 405 x 155 x 190 mm (nominal dimensions) solid Timbercrete blocks, set in 1:0:5 mortar with methyl cellulose water thickener, with horizontal metal straps at every second course, and incorporating bulk insulation nominated in BCA Volume 2 Part 3.12. **Timbercrete 90 mm veneer walls**, consisting of 290 x 90 x 90 mm (nominal dimensions) solid Timbercrete blocks, set in 1:0:5 mortar with methyl cellulose water thickener, with horizontal metal straps at every second course, supported by 70 mm MGP10 timber stud wall, with 10 mm plasterboard lining and incorporating bulk insulation nominated in BCA Volume 2 Part 3.12.
Sustainability Statement(s)	Timbercrete 190 mm single leaf walls and Timbercrete 90 mm veneer walls have lower embodied energy than commonly available alternatives.
Definition of "commonly used alternatives"	The "commonly used alternatives" referred to in this statement are: **Clay masonry veneer walls**, consisting of 230 x 76 x 110 mm extruded clay bricks, set in 1:1:6 mortar, supported by 70 mm MGP10 timber stud wall, with 10 mm plasterboard lining and incorporating bulk insulation nominated in BCA Volume 2 Part 3.12.
Basis of Statement(s)	Desk research, set out in: R.K. Johnston, *Embodied Energy and Heating and Cooling Energy Associated with Timbercrete In Australian Housing*, ELECTRONIC BLUEPRINT, D06111001-1, 10/1106, provides estimates of the embodied energy used to manufacture Timbercrete wall systems, and compares it to a selected benchmark (clay masonry veneer), commonly used in Australian housing. From this data, the savings in embodied energy to change from the benchmark system to Timbercrete can be calculated, and this information can be expressed as a percentage of the heating and cooling energy over the life of the house.
Relevant Certificates etc	**Report** R.K. Johnston, *Embodied Energy and Heating and Cooling Energy Associated with Timbercrete In Australian Housing*, ELECTRONIC BLUEPRINT, D06111001-1, 10/1106
Declaration	I hereby certify that the Sustainability Statements detailed above, together with the nominated supporting information are accurate and a true representation of the nominated product(s).
Person making the Declaration Name and Position	Peter Collier Managing Director
Signature	
Date of Declaration	

Concrete Recipe for 1m3 at 20mpa

Cement = 250 kg or (200kg + 70kg Fly ash)
Crushed Gravel (20mm) = 730kg
Crushed Gravel (10mm) = 315kg
Course Sand = 245kg
Fine Sand = 665kg

Mortar Calculation

Mortar mix B.
10 litres cement (13kg)
10 litres lime
30 litres fatty brick sand
30 litres corse washed sand
This mix produces 50 litres of mortar mud.

Mortar m3 per std 200mm wide cobble stone block.
(.400mm + .180mm)= .580x .190x .018mm = .0019836 x 1000 = **1.98 litres**

1.98 litres x 13.22 (Blocks per M2) = 26.1 Litres per of mortar per M2 of wall area

2 litres of mortar per block at a 18mm thick mortar joint.

Therefore the above mortar will lay approximately **25.2 Blocks with a 18mm mortar bed,**

Mortar dry density = 1.62 to 1.77 kg/litre