australbricks

Background Paper

Taking the Long View: Embodied Energy & Life Cycle Analysis

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Summary

This paper examines the concept of embodied energy in building materials and its place in the context of energy consumed (and consequential greenhouse gases emitted) over the lifetime of an average house, a process known as life cycle analysis.

Recent Australian research has highlighted the dominance of utilisation energy in the total energy consumed over a building's lifetime.

Therefore it is important to select building materials and systems that can contribute to reducing utilisation energy.

Materials with high thermal mass, such as clay bricks, have the potential to reduce the need to artificially heat and cool a building when used in combination with passive design techniques.

Clay bricks also have a long life, are highly durable and require virtually no maintenance thus ensuring their environmental impact is low for the life of a building.

The embodied energy inherent in bricks is an investment that can provide substantial savings in energy and greenhouse gas emissions over the life of a building.

THINK BRICK AUSTRALIA

Austral Bricks is a member of Think Brick Australia (formerly the Clay Brick and Paver Institute), the Australian authority on bricks, brickwork and segmental clay paving.

HIA GreenSmart®

Austral Bricks is a GreenSmart Partner, a program sponsored by the Housing Industry Association to promote environmental performance in Australia's building industry

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Build in Brick • It's Only Natural

Introduction

Building design is one way in which we directly impact on the earth's resources. Our choice of building products will have an effect not only on today's resources but also on those of the future. It is therefore important to consider products that are 'green' for the long-term.

Significant emphasis is placed on the embodied energy of building products as it is a relatively easy number to quantify and comprehend. However, it is far more relevant to consider the energy associated with a product, not just in manufacture but over its total life cycle.

What is embodied energy?

The embodied energy in a building is that energy consumed by the processes associated with its production, from the acquisition of raw materials to product delivery including their manufacture into a useable product, transportation at each stage, and the administrative functions associated with these steps.

Embodied energy in building products

All manufactured products have an embodied energy component. This chart, adapted from a CSIRO publication[1], shows that bricks are low on the scale of embodied energy in building materials.

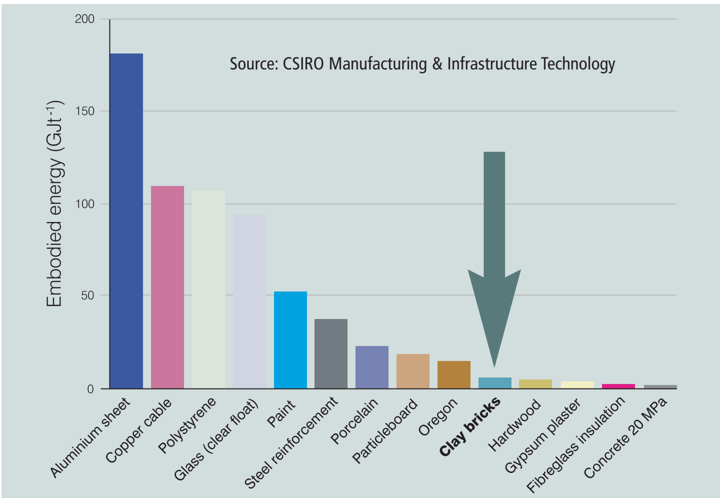

Figure 1 – Embodied energy levels of common building materials.

Particleboard, steel reinforcement, paint, glass and polystyrene all have higher levels of embodied energy than clay bricks. Concrete, hardwood and plaster have marginally lower levels.

These figures are based on weight. The embodied energy proportions change when material usage is considered on area. Heavyweight walling systems can use as much as 50 percent more embodied energy per square metre than lightweight walling systems. However, heavy walls add mass which is a unique and critical component of passive building design.

Investing in embodied energy

The embodied energy inherent in bricks should be considered an investment that can lead to long-term energy savings in two ways:

- Brickwork's thermal mass reduces the need for artificial heating and cooling when used in combination with passive design principles.
- Bricks have a long life and high level of durability, are colourfast and all but maintenance free. These qualities all but eliminate the need to invest further embodied energy.

This is recognised by the Australian Greenhouse Office which states that the "single most important factor in reducing the impact of embodied energy is to design long life, durable and adaptable buildings."[2]

The CSIRO supports this basic position: "In choosing between alternative building materials or products on the basis of embodied energy, not only the initial materials should be considered but also the materials consumed over the life of the building during maintenance, repair and replacement."[1]

Industry-recognised expert Bill Lawson gave the following appraisal[3] of the clay building products industry:[3]

• Raw material availability	very good
• Minimal environmental impact	good
• Embodied energy efficiency	very good
• Product lifespan	excellent
• Freedom from maintenance	excellent
• Potential for product reuse	fair
• Material recyclability	good

Although there is a strong correlation between the level of embodied energy and the production of greenhouse gases, production processes using natural gas produce substantially lower levels of greenhouse gases than those using electricity (for comparable energy levels). Almost all bricks are fired using natural gas.

By continually improving manufacturing processes and principles, Austral Bricks aims to reduce the embodied energy content of its products and further improve upon this environmental assessment.

Refer to Austral Bricks publication *Beyond Lifetimes* for further information on sustainability.

The case for life cycle analysis (LCA)

As the authorities quoted previously acknowledge, the level of energy embodied in a product is just the beginning of the energy consumption story. Significant amounts of energy (and consequent greenhouse gas emissions) are consumed in maintaining a building over its long lifespan. Even greater amounts of energy are consumed in living in a house, a process known as utilisation energy.

Life cycle analysis (or life cycle assessment) takes the long view on energy consumption, placing the embodied energy into a context of the extended maintenance and utilisation of a building.

LCA examines the total environmental impact of a material or product through every step of its life – from obtaining raw materials (for example, through mining or logging), through manufacture, transport, their use in the home, and ultimate disposal or recycling.

The analysis may also consider a range of environmental impacts such as resource depletion, energy and water use, greenhouse emissions and waste generation.

The ability of a material to be reused or recycled has the potential to reduce the impact of embodied energy.

An Australian life cycle analysis

A life cycle study of a typical project home has been conducted by the Centre for Sustainable Technology at The University of Newcastle[4]. The computer modelling was based on a small project home in the Sydney climate zone. The study encompassed all stages of the life of the house, including:

- building material production, transportation and construction
- appliances and fit-out of the home
- the energy associated with living in the home (utilisation energy), including cooking, lighting, heating and cooling
- building repairs and maintenance
- the end-of-life aspects of building decommissioning

The researchers found that over the lifecycle "utilisation energy had the greatest environmental impact" and was found to account for "more than 90% of energy consumption and greenhouse gas emissions". This is shown clearly in the following charts adapted from their report.

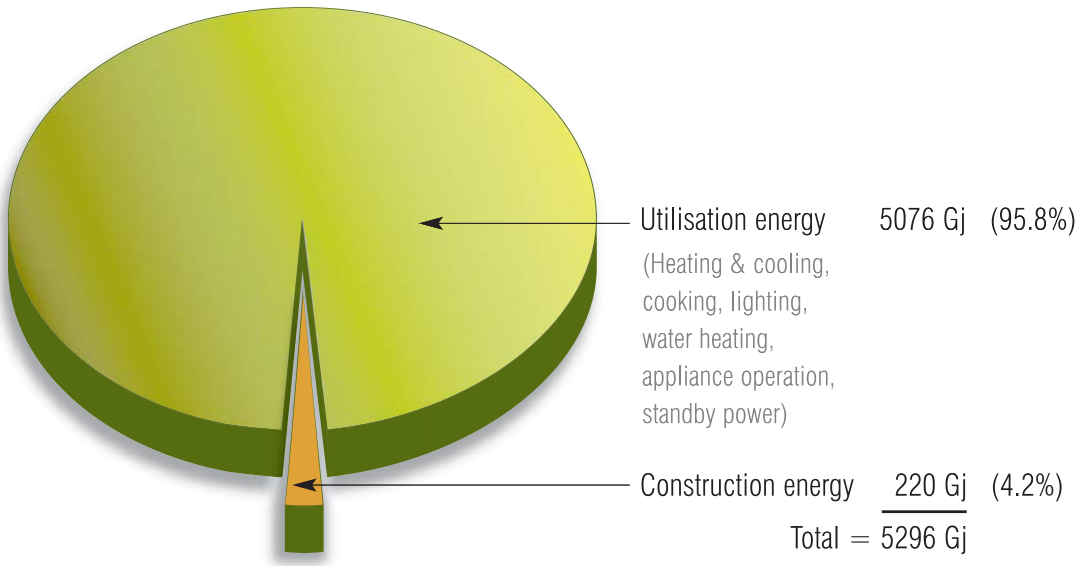

Figure 2 – Construction and utilisation energy (Gj) consumed over the 50-year life of a typical brick veneer house

Everyday living has by far the greatest environmental impact. The combined heating and cooling components also noticeably outweigh the construction energy use. Therefore, consideration should be given to building materials that will enable the heating and cooling energy to be reduced. This is becoming increasingly important as we grow ever more reliant on artificial heating and cooling.

The thermal performance of a house directly impacts upon the extent to which it is heated and cooled. The researchers found that "the materials of construction have only a very small impact on the overall resource energy and greenhouse gas emissions," representing just five percent of total energy usage. This number will vary from building to building, but it is important to realise the impact that building utilisation has on energy use. Therefore, to consider just the embodied energy of building materials would be to fail to assess a building's total environmental impact.

It is important to note that passive solar design principles were not used in this project home. If a building was designed with passive solar principles, the energy savings brought about by using materials with thermal mass could significantly offset the embodied energy of the material. Therefore, a relatively small initial investment in the embodied energy of the building materials may lead to a significant reduction in the energy used over the building's life.

Refer to Austral Bricks publication *Energy Efficient Homes* for further information on the principles of energy efficient house design.

Conclusions

A 'whole-of-life' approach is essential when considering embodied energy and life cycle analysis. Research has shown that the energy consumed in day-to-day living is by the far the largest contributor to a building's energy use. Therefore it is especially important to choose materials that have the potential to reduce the energy consumed over the life of the building. The thermal mass inherent in clay bricks is an essential component of passive design, a proven technique that can reduce the energy used to artificially heat and cool a home. Therefore the embodied energy in bricks is a once-off investment that has the potential to provide substantial savings in energy use and greenhouse gas emissions now and into the future. The durability and long-life of bricks also reduces the long-term environmental impact of a home.

Appendix: Embodied energy in perspective

It is essential to recognise that the energy embodied in bricks is minor by comparison to that consumed in everyday living. Instituting simple household changes can result in savings in greenhouse gas emissions that far the exceed greenhouse gas emissions generated as a result of the manufacture of a house-load of bricks.

For example, a brick veneer house built on passive design principles will reduce or even eliminate the use of air-conditioning. The energy saved by reducing the use of an air-conditioner by just one-third over 10 years will offset the entire energy embodied in the bricks of a typical brick veneer house (see Tables A1 and A3).

Greater reductions in the use of an air-conditioner – or its total elimination – will further reduce the overall environmental impact of the house.

Legend:

CO_2-e = carbon dioxide equivalent, the internationally recognised measure of greenhouse gas emissions

GHGE = greenhouse gas emissions

Table A1 – Greenhouse gas emissions associated with the embodied energy of the bricks in typical Australian brick houses (CO_2-e)[4]

	GHGE (tonnes)
Brick veneer (8000 bricks)	5.1
Cavity brick (22,000 bricks)	14.1

Table A2 – Greenhouse gas emissions resulting from the energy consumption of typical Australian household (CO2-e)[5]

	GHGE per year (tonnes)	GHGE over 50 years (average house lifetime) (tonnes)
Household energy consumption[2]	8.0	400.0
Operation of car	6.0	300.0

Table A3 – Sources of potential reductions in greenhouse gas emissions in typical Australian households (CO_2-e)[5]

	GHGE (tonnes)		
	Per year	**Over 10 years (product lifetime)**	**Over 50 years (house lifetime)**
Changing one 100W incandescent light globe to a 20W compact fluorescent	0.13		6.5
Changing from an electric hot water to a gas hot water system	3.0		150.0
Installing a AAA-rated water efficient showerhead (connected to electric hot water service)	0.5		25.0
Reducing yearly electricity bill by $120	1.0		50.0
Reducing car use by 10km a day	1.3		65.0
Upgrading from the least efficient to the most efficient refrigerator		10.0	
Operation of a 2 star air-conditioner[6]		18.0	
Operation of a 4 star air-conditioner[6]		15.0	

Table A4 – Greenhouse gas emissions resulting from common activities (CO_2-e)[5]

	Associated GHGE (tonnes)
Return flight to Europe (per person)[7]	10.0
345 litres of petrol	1.0

References

1 *Embodied Energy*, CSIRO Manufacturing and Infrastructure Technology, www.cmit.csiro.au/brochures/tech/embodied/

2 *Your Home Technical Manual*, section 3.1, Australian Greenhouse Office, www.greenhouse.gov.au/yourhome/technical/index.htm

3 Lawson, B, *Building Materials, Energy and the Environment: Towards Ecologically Sustainable Development*, Royal Australian Institute of Architects, Canberra, 1996

4 *LCA Fact Sheet*, Centre for Sustainable Technology, The University of Newcastle, www.cbpi.com.au/resources/general/lca_fact_sheet.pdf

5 Unless otherwise noted, all greenhouse gas emission information in these tables is sourced from *Global Warming Cool It!*, Australian Greenhouse Office, www.greenhouse.gov.au/gwci/

6 *Information Paper: The Impact of Residential Air-conditioning on the Western Australian Electricity System*, Western Australian Office of Energy, www.energy.wa.gov.au/cproot/603/2759/air conditioning paper.pdf

7 Grigg, A, 'Business Gets What Government Neglects: The Right Climate for Hot Money', *Australian Financial Review*, 17 June 2006 (view at www.yesusyd.org.au/modules/news/article.php?storyid=9)