

A total Life Cycle Assessment

of clay bricks, mortar and Australian homes
the **new methodology** for comparing building materials

Total Life Cycle Assessment overview

To understand and mitigate the environmental impact of building and occupying houses, Think Brick Australia has used an international best practice total Life Cycle Assessment (LCA) methodology to accurately compare the advantages and disadvantages of different building materials.

The peer reviewed outcome provides a more realistic view of building construction impact on the environment which will inform better...

- ... policy development by government;
- ... planning by architects, designers and builders; and
- ... consumer awareness of the environmental impact caused by building and living in a home.

The research is unique for its depth and breadth of analysis; it not only assesses the impact of a single brick and square metre of brick wall, but also includes the emissions from a lived-in house to present a single-figure view of the carbon dioxide emitted from the manufacture, construction and use of Australian homes.

Think Brick Australia considers that this methodology is the only appropriate methodology for comparative LCAs and legislation that targets emission reductions in the building materials sector. Its design recognises that all building materials are different and that the advantages and disadvantages of both heavy and lightweight construction need to be fairly balanced across all four stages of a building's lifecycle.

Research questions

- 1 What are the greenhouse gas impacts of a clay brick over its lifetime?
- 2 What are the major sources of greenhouse gas emissions in a typical Australian home?
- 3 What are the major sources of greenhouse gas emissions in typical Australian homes (excluding non-HVAC energy consumption)?
- 4 How do clay brick homes compare to timber weatherboard as an external cladding?

Key terminology

Life Cycle Assessment (LCA)

A Life Cycle Assessment measures the environmental impact of products by analysing all the inputs (ie raw materials, water, energy) and outputs (ie the end product, waste, emissions) of manufacture, transport, use and maintenance of the product, and its disposal.

ISO 14040/14044

The International Standards Organisation (ISO) sets world-wide standards for many activities, including life cycle assessment. Although not all LCAs have to follow these standards, it is necessary to do so before publishing any comparative results.

SBE

Single Brick Equivalent is a common unit of measurement across the clay brick industry for a brick. An SBE has the dimensions of 230x110x76mm and for the purposes of this study weighs 3kgs.

Embodied energy and emissions

Embodied energy refers to the energy used to manufacture or construct a product. Until recently embodied energy was used as an easy to communicate indicator, but it is not sufficient to convey the environmental impact given the increased use of renewable energy and other forms of emissions

reduction. As such *embodied emissions* is a more accurate representation of the climate change impact.

CO₂-e

Carbon dioxide equivalents. There are six greenhouse gases that contribute to climate change which are all normalised to the value and impact of carbon dioxide.

HVAC

Heating, Ventilation & Air Conditioning.

Operational energy

Operational energy includes all the energy used to power our homes. It includes energy for heating, cooling, lighting, appliances and hot water.

Cradle to gate

Cradle to gate measures the environmental impact of a product from the extraction of its raw materials until it leaves the 'gate' of the manufacturing facility. It does not include the transport to the construction site.

Cradle to grave

Cradle to grave measures the environmental impact of a product from the extraction of its raw materials until the product is disposed (ie to landfill). This does include the transport to the construction site.

Thermal modelling

The energy consumed by heating and cooling a house is predicted using thermal modelling software. It uses a set of behavioural assumptions and the precise construction methods to give an indication of the energy efficiency of a house.

1. Research, method and design

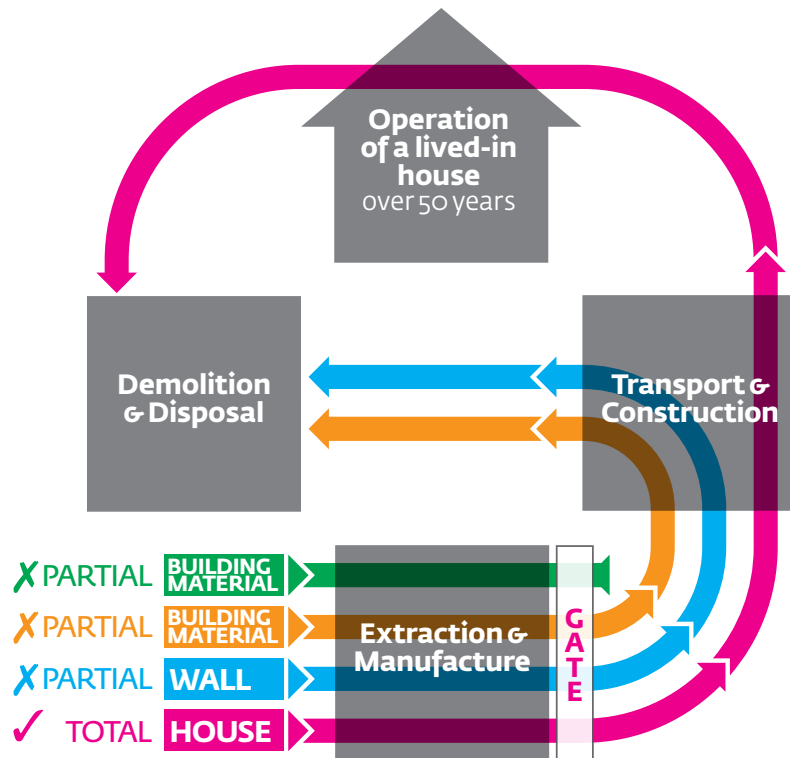


Figure 1

A total Life Cycle Assessment: LCA paths and life cycle stages

Figure 1 colour-codes and depicts four different types of LCAs that can be undertaken:

- › The building material (a single brick) – cradle to gate (Green)
- › The building material (a single brick) – cradle to grave (Orange)
- › A square metre of brick wall – cradle to grave (Blue)
- › A built and lived-in house over a lifetime of 50 years – cradle to grave (Pink)

While for many products the current cradle to gate and cradle to grave LCAs (as demonstrated in figure 1 by green, orange and blue) are sufficient to make like-with-like comparisons, for building materials only the total LCA represented in pink is accurate.

Think Brick Australia undertook a Kyoto Protocol and ISO 14040 fully compliant and peer reviewed total Life Cycle Assessment combining both embodied and operational energy emissions.

An LCA attempts to quantify the environmental impacts of products across their entire life cycle based on all the inputs to, and outputs from, each life cycle stage of that product.

This study examined the emissions from (1) a single brick, (2) a square metre of brick wall, and (3) a built and lived-in house over a lifetime of 50 years.

The cradle to gate (green), and cradle to grave (orange or blue) LCAs in figure 1 are the most common methodologies used to determine the impacts of building products. Unfortunately these are not accurate comparisons because they omit a significant source of emissions and do not recognise that different building materials influence the total emissions created by a house in different ways.

To overcome this limitation, Think Brick Australia has used an international best practice total LCA methodology that includes the operational emissions created by a family of four people living in different locations (Brisbane, Newcastle and Melbourne).

The modelling was completed in Design Builder which considers all forms of operational energy as compared to AccuRate which only considers Heating, Ventilation & Air Conditioning (HVAC).

The findings from the study are presented as a single-figure view of carbon dioxide in alignment with Australia's carbon policy objective to reduce carbon emissions by 60 per cent by 2050.

The results presented in this study are based on a number of realistic models of typical Australian homes. As with any model, however, different assumptions will lead to different outcomes.

“All assumptions made are precautionary; they are intended to determine the worst case scenario for brick as a construction material in residential housing. This being the case, we find that, over an assumed 50 year life of the building, brick performed no worse than other building materials. When a longer life span was assumed, brick often presented as a marginally preferred material.”

Energetics 2009

2. Findings

The LCA confirmed that for a deemed-to-satisfy 5-star house, operational energy emissions are the largest sources of greenhouse gas emissions over a 50 year building life.

What are the greenhouse gas impacts of a clay brick over its lifetime?

	1 SBE	1m ² Wall Assembly
Cradle to gate	0.61 kg CO ₂ -e	NA
Cradle to grave	0.70 kg CO ₂ -e	40 kg CO ₂ -e

Figure 2

Figure 2 demonstrates that a single brick assessed using cradle to gate LCA (shown in green) creates 0.61kg of CO₂-e over its life cycle. That same brick, when transport and disposal in landfill is considered (cradle to grave, shown in orange), creates an additional 0.09kg of CO₂-e. By comparison, a square metre of single layer brick wall (with the addition of mortar) creates 40kg of CO₂-e (shown in blue).

What are the major sources of greenhouse gas emissions in a typical Australian home?

Using the total life cycle assessment depicted in figure 1, a typical Australian home as modelled (and regardless of external walling material) creates approximately 89 per cent of its emissions over 50 years from the operational energy used to power the appliances, hot water, lighting and HVAC.

Only 11 per cent of emissions come from the building materials and construction process (figure 3).

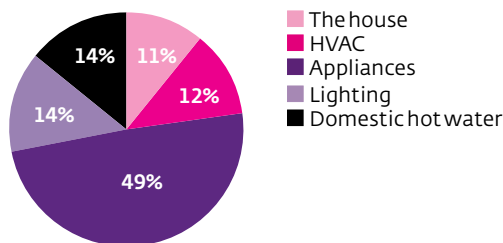


Figure 3

What are the major sources of greenhouse gas emissions in typical Australian homes (excluding non-HVAC energy consumption)?

Figure 4 uses the total life cycle assessment but removes sources of operational energy consumption not influenced by the walling materials.

Without the operational energy from appliances, lighting or hot water the emissions from the building materials and HVAC energy consumption are more easily examined (11 and 12 per cent in figure 3 respectively).

From this it can be seen that the brick wall only represents approximately five per cent of the emissions in a typical Australian home.

Although there are differences between building materials, the study shows that over 50 years they produce minimal differences in the climate change impact. Furthermore this highlights that reducing HVAC energy consumption delivers the most significant emission reductions, and that lowering embodied emissions in all parts of the house will have a more substantial impact than exclusive focus on the external cladding.

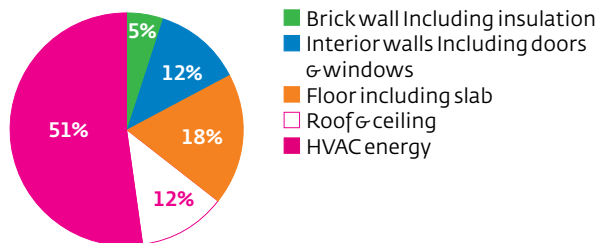


Figure 4

How do clay brick homes compare to timber weatherboard as an external cladding?

Tonnes CO ₂ -e	Insulated brick veneer	Insulated weatherboard	Insulated double brick
House Plan A	67.4	64.4	75.9
House Plan B	63.5	60.3	69.7

Figure 5

Figures 5 & 6 compare the differences between a partial cradle to grave LCA and the total LCA used in this study (as represented by the blue and pink paths in figure 1). While figure 5 only assesses the emissions from three of the four life cycle stages, figure 6 shows typical results from all four stages over 50 years.

In the figure 6 examples shown, there are no discernable differences in carbon impact between the brick veneer and weatherboard houses. Furthermore, the higher energy efficiency of the double brick house in Newcastle has reduced total emissions below the equivalent brick veneer and weatherboard houses. The Newcastle results can be broadly transferred to Eastern Sydney, Adelaide and Perth.

While the study has highlighted that every case needs to be considered on its own merits, the examples do suggest that lower embodied emissions do not necessarily mean lower carbon impacts, and that the benefits of increased energy efficiency can offset higher embodied emissions.

Comparison of total emissions over 50 years

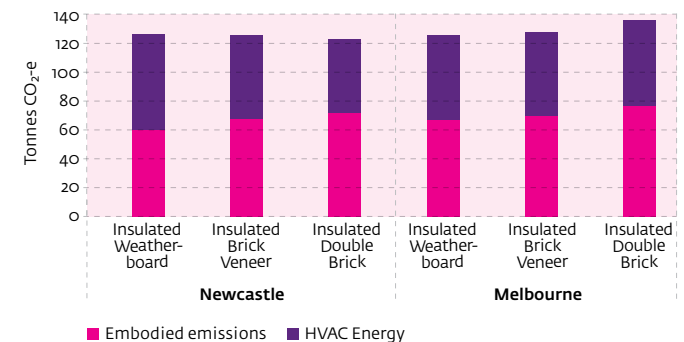


Figure 6

3. Conclusions

- › **Improving the design and operation of a house is currently the best way to significantly reduce greenhouse gas emissions**
- › **The walling material(s) have very little impact on the overall greenhouse gas emissions caused by a house**
- › **Comparing building materials requires measuring the four stages of a building's total life cycle (fig 1)**
- › **The embodied emissions of a typical Australian house represent only 11 per cent of the total emissions over a 50-year life cycle, regardless of walling materials**

This study demonstrates that the external walling material alone cannot substantially reduce the house's emissions. Rather, emission reductions are achieved by using a total life cycle analysis and understanding how all parts of the house contribute to its total emissions.

In particular this study has highlighted that analysis of emissions based only on the manufacture of building materials and/or the construction of a house does not capture the breadth of information required to properly develop public policy.

The best way to capture this information is to use the total life cycle analysis methodology described in figure 1.

The largest limitation of this methodology is the thermal modelling process. Work is already underway by governments and academics to resolve these issues, and once complete, it will be possible to develop a standard Australian LCA methodology to complement current and future carbon policies.

About Think Brick Australia

Think Brick Australia represents Australia's clay brick and paver manufacturers. It conducts research on behalf of the industry relevant to the use and manufacture of clay brick and pavers.

Think Brick Australia commissioned Energetics to undertake this research on behalf of the Australian clay brick manufacturing industry to support two key areas of activity:

- › The development of Life Cycle Indicators (LCI) for CSIRO and the Australian Life Cycle Assessment Society's (ALCAS) AusLCI project
- › To understand the impact of carbon policies on the clay brick industry

For more information

- › Download and comment on the full report: blog.thinkbrick.com.au/sustainability/lca
- › Read and comment on the new LCA methodology: blog.thinkbrick.com.au/sustainability/lca-methodology
- › Read and comment on key issues identified: blog.thinkbrick.com.au/sustainability/lca-issues
- › Visit thinkbrick.com.au for more information and design ideas with clay bricks