



## TECHNICAL NOTE #30

### LCA: Environmental impacts of clay bricks in South Africa

Management Summary and consolidation report of the LCA study  
“Life Cycle Assessment of clay brick walling in South Africa”

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This study was undertaken by The Clay Brick Association of South Africa representing brick makers who participated and contributed to the development of the study.



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## INTRODUCTION

Peter Drucker famously quoted, “what gets measured, gets managed”. By examining an activity we are forced to pay attention to it. By producing relevant and accurate measurements we can identify where improvements are possible, and then track progress against the original benchmark.

It was with this intention that the Clay Brick Association of Southern Africa embarked on a 3-year project to complete South Africa’s first industry-wide Life Cycle Assessment (LCA) for clay brick products.

The study analyses the full lifecycle of clay brick:

- Raw material extraction and clay brick production
- Construction including transport to site
- The operational life of the building, with the focus on heating and cooling energy and maintenance.
- Building end-of-life, disposal, recycling and reuse.
- Social Life Cycle Assessment within the context of sustainable development

The study was performed using specific production data from 86 out of the 102 clay brick production sites in South Africa which are members of the CBA. It is estimated that this covers about 95% of the South African national production.

The analysis was conducted in accordance with the ISO 14040 and 14044 standards with an external review in order to aim at the highest quality standards. The results were summarized by the University of Pretoria, in an extensive report tailored for environmental experts which describes the detailed methodology, data basis and all the assumptions used in the study.

The LCA was conducted by the University of Pretoria and co-funded by the National Research Foundation. The successful conclusion of the in-depth research study is a significant achievement for the Energy Efficient Clay Brick Project (EECB), an initiative funded by the Swiss Agency for Development and Cooperation (SDC) and implemented in South Africa by Swisscontact.

In order to facilitate the dissemination of the findings of the LCA amongst CBA members and construction industry stakeholders Swisscontact contracted Quantis, in collaboration with the University of Pretoria, to extract the most relevant results from the primary reports and consolidate these into a detailed and user-friendly summary which is available on the CBA website.



## KEY FINDINGS

### Average production of 1kg of clay brick in South Africa

- 3.46MJ of fossil energy
- 0.27 kg of CO<sub>2</sub>-equivalent emissions

### Annual sector total

- 33.5 billion MJs of non-renewable energy consumed
- 2.6 million tons CO<sub>2</sub> equivalent emissions

With respect to brick manufacturing, the main environmental impacts relate to the mining, production and burning of coal, which is the raw material used for combustion during firing. Because South Africa relies on coal burning technology for the generation of electricity, changing to electric kiln technologies would not reduce environmental impact.

## BENEFITS FOR THE CONSTRUCTION INDUSTRY

The full LCA will allow architects to accurately calculate the lifetime environmental impact of using clay brick in a building, compared against other construction materials. Access to accurate data will make it easier to design “green” buildings that are naturally energy efficient.

Due to the long life expectancy of brick, the environmental impact of clay brick production is conceptually spread over 50 years. In environmental terms, electricity saved during the operations phase of a building far outweighs energy used during production.

This makes clay brick an attractive option for both environmentally-conscious architects and cost-conscious property owners.

## CUTTING CO<sub>2</sub> EMISSIONS IN BRICK-MAKING

Even though environmental impacts from production are not dominant in the overall lifecycle, the clay brick sector is committed optimizing production processes.

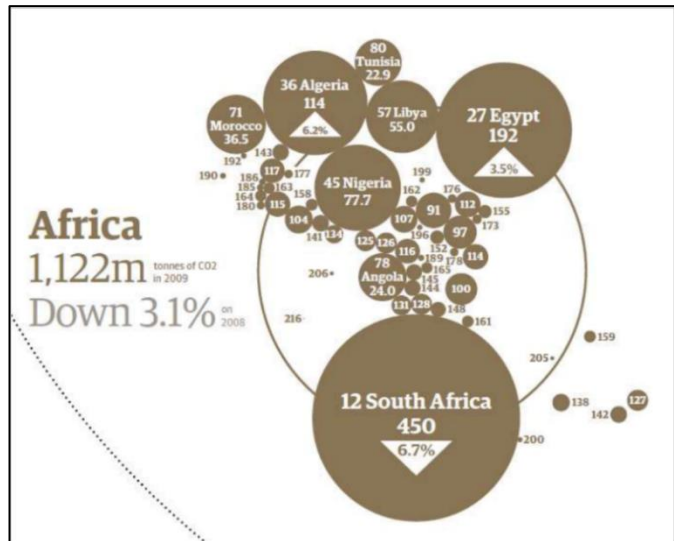
The LCA findings from the extraction and production stage provide a direct benefit for CBA members who now have access to accurate and locally-relevant statistics on energy efficiency, emissions, strengths and challenges across a broad range of brickmaking technologies.

The use of coal in brick-making accounts for most carbon emissions and pollutants like SO<sub>2</sub> and nitrous oxides. Switching brick-makers to technologies proven to be more energy efficient will reduce South Africa’s total CO<sub>2</sub> emissions and improve air quality. The CBA plans to periodically update the LCA to assess the sector’s progress in addressing environmental hot spots.

## ENVIRONMENTAL ASSESSMENT OF CLAY BRICK PRODUCTION IN SA

South Africa is the largest CO<sub>2</sub> emitter in Africa and the 12<sup>th</sup> largest in the world. The building sector is known to be a major source of greenhouse gas emissions – with about 40% of the emissions caused by the production of building products including clay bricks (Milford, 2009).

While many building products make environmental claims, few of these are based on internationally, scientifically-recognised methodologies. The CBA wanted to make sure that any environmental claims it makes are backed by strong scientific evidence.



CO<sub>2</sub> emissions in Africa (McCormick & Scruton, 2012).

Because global warming, human health and damages to the ecosystem can cause serious impacts on our society, it was decided to extend the study beyond a detailed assessment of the CO<sub>2</sub> emissions, but to take a holistic approach that would look at all major environmental aspects.

### TOTAL EMISSIONS - PRODUCTION PHASE

Overall, considering the weighted average of all considered production sites and technologies, the production of 1 kg of average clay brick in South Africa can be associated with the emission of 0.27 kg of CO<sub>2</sub>-equivalents (meaning that not only the effect of CO<sub>2</sub>, but also the one of other substances like methane, for example, is considered). Based on the yearly production considered in this study, this leads to a total of 2.6 million tons CO<sub>2</sub> equivalents emitted per year.

### LCA METHODOLOGY - PRODUCTION PHASE

#### DATA COLLECTION

At the core of the study “Life cycle assessment of clay brick walling in South Africa” lies a detailed data collection. Particularly, to assess the environmental impacts from the production of clay bricks, operational data from 86 manufacturing sites was collected.

It detailed the types and amounts of input materials used (e.g. clay, coal, etc.), energy vectors (e.g. natural gas, electricity), the typical transport distances needed to transport all the materials to the production sites as well as the transport services needed within the production sites for the manufacturing of the bricks and the typical production processes in use.

The data collected covers about 95% of the bricks produced in South Africa. It details resources flows into each of the typical production steps of clay bricks manufacturing:

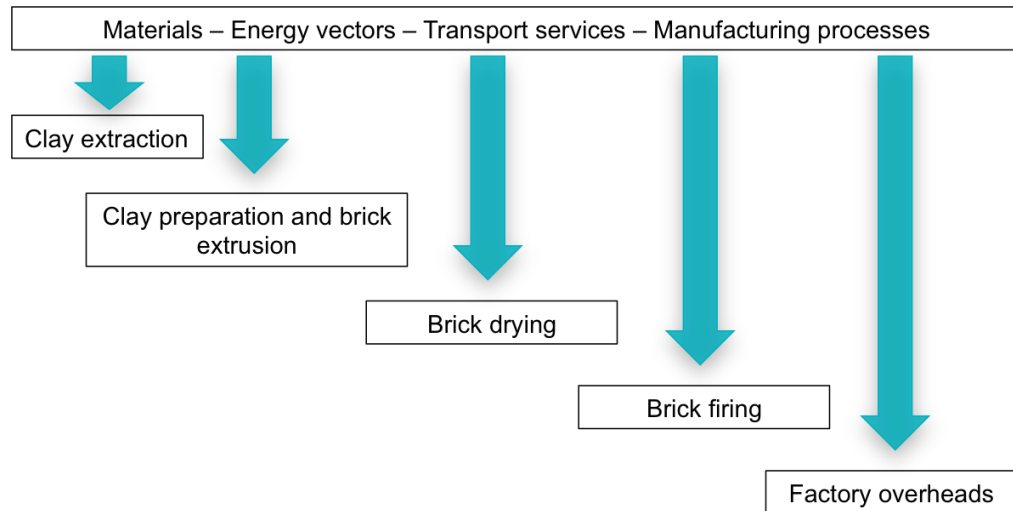


Figure 1: Main steps in clay brick production.

The study differentiates between six brick manufacturing techniques, which are defined by how the bricks are fired in different types of kilns. The kilns considered in the report are:

- Clamp kiln
- Tunnel kiln
- Transverse Arch kiln (TVA)
- Hoffman kiln
- Vertical Shaft Brick kiln (VSBK)
- Zigzag kiln

By distinguishing between the various brick production technologies and the various production steps, the study allows members to analyse the strengths and challenges of each production path and to identify areas of optimization.

The study furthermore analyses the impacts coming from the building’s construction, operational and disposal phases including energy consumed for heating and cooling, and the impacts from the dismantling and disposal of materials after demolition.

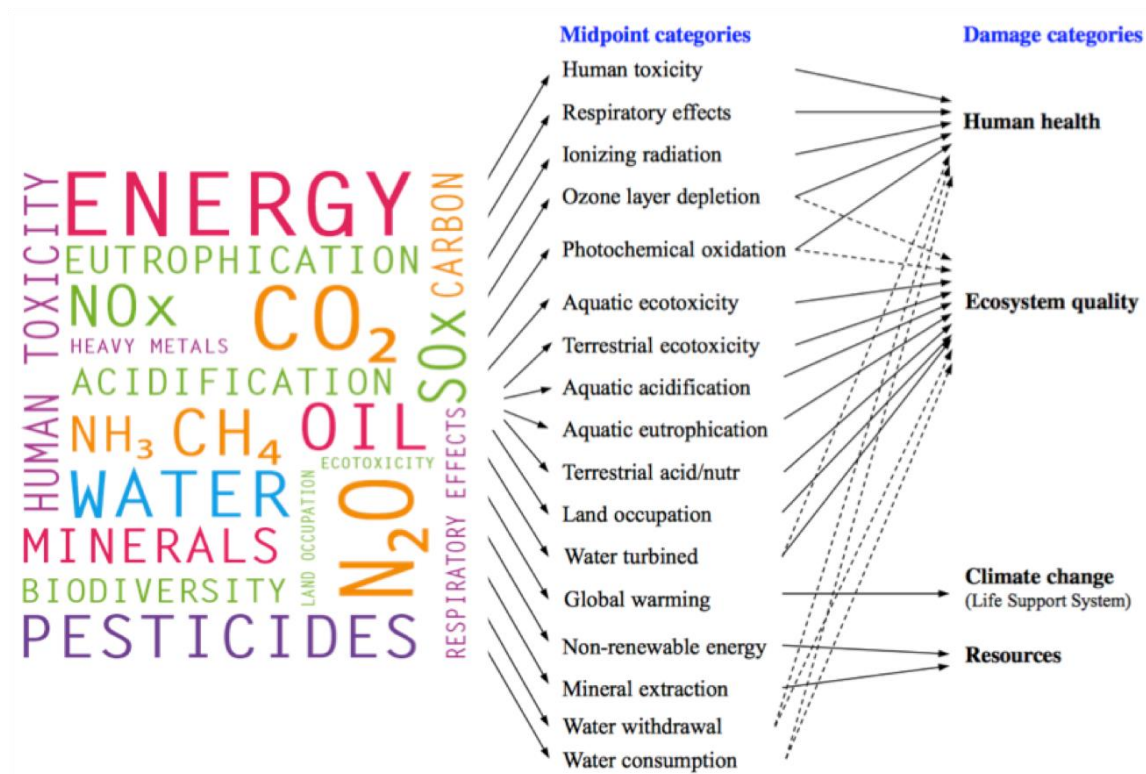
For the assessment of the electricity used for heating and cooling in the building during the operational phase, simulations were performed as summarised in the report “A thermal performance comparison between six wall construction methods frequently used in South Africa” (Vosloo, Harris, Holm, von Rooyen, & Rice, 2015). The building in and disposal phase were modelled through data sourced from literature.

In addition to data collected from clay brick producers and from official literature, data on the environmental impacts of processes like the production of coal or the combustion of natural gas, was taken from the environmental database EcoInvent.

## IMPACT ASSESSMENT METHODOLOGY – PRODUCTION PHASE

The methodology chosen for the study is Life Cycle Assessment (LCA), an internationally and scientifically recognised approach that quantifies the environmental impacts of products, systems or services by analysing the emissions produced and the resources consumed during their production, building use and the end-of-life phase. Once the emissions produced and the resources consumed over the life cycle of a product are known, it is then possible to use so called impact assessment methods to quantify the damages produced with respect to specific environmental aspects.

The impact assessment method considered in the study is Impact 2002+ (Humbert, De Schryver, Bengoa, Margni, & Jolliet, 2014). However, while in the full LCA report “Life cycle assessment of clay brick walling in South Africa” the results were presented looking at the midpoint categories (and, therefore looking at quite a large variety of different indicators) in this consolidation report the analysis will focus on the Damage Categories of the Impact 2002+ methodology Human Health, Ecosystem quality, Climate change and Resources, which are obtained by bringing together all Midpoint Indicators focusing on one of these specific environmental aspects, thereby simplifying the interpretation of the results.



**The detailed Lifecycle Assessment study and related documents are available from the Clay Brick Association of South Africa.**

## LCA RESEARCH FINDINGS – PRODUCTION PHASE

The results are shown for the six technologies during the production of 1 kg of finished brick.

### HUMAN HEALTH

Human Health” describes potential damage to the human body caused by substances emitted. Impacts during clay preparation originate from the emissions at coal mines during extraction. During firing, damaging emissions are sulphur dioxide, nitrogen oxides, Dioxin 2,3,7,8 Tetrachlorodibenzo-p, particulates and ammonia.

### ECOSYSTEM QUALITY

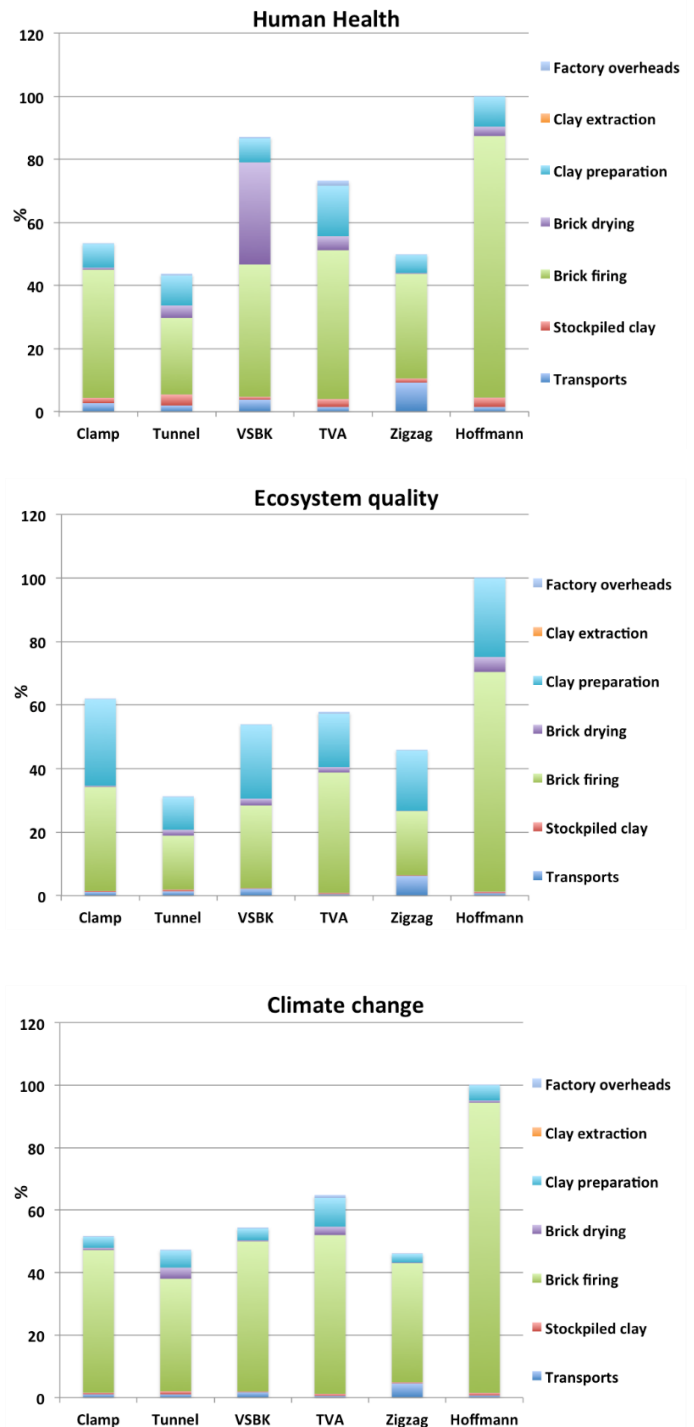
Ecosystem quality” describes damages caused to the ecosystem in terms of the number of species which might be affected due to emissions or induced land transformations.

The largest contributions in clay preparation derive from Aluminium emissions occurring in the coal mine. Similarly, Aluminium emissions are also a key contributor during firing due the use of coal as internal fuel.

### CLIMATE CHANGE

Climate change” considers the effect of all emissions that contribute to global warming.

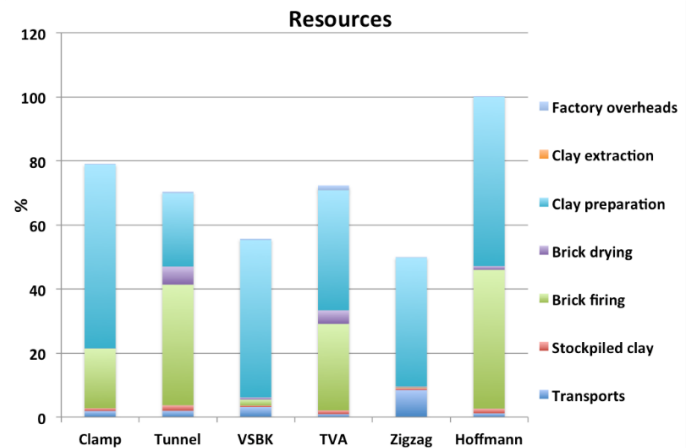
The main contributing process is firing and the dominating cause is the fossil CO<sub>2</sub> emissions coming from the combustion of the coal; both, the one added to the kiln as well as the one mixed to the clay during preparation.



## RESOURCES

Resources” estimates the consumption of non-renewable resources.

The main impacts are caused by the addition of coal to the clay mixture as this depletes the reserves of coals. Similarly, the use of non-renewable fossil fuels in the firing steps (mostly coal or gas) leads to other relevant contributions.



## OBSERVATIONS ON TECHNOLOGY

Based on the operational values, it is possible to assess trends in the figures above by comparing the different production technologies. The study has a broad geographic coverage of about 83% of manufacturers. Production data is across one year (2012 and 2013), and related to the production of 9 611 million kgs of fired bricks, or 3 494 million standard bricks.

For some of the technologies (particularly TVA, Hoffman, VSBK and Zigzag) the results are based on a limited number of factories and can be influenced by Individual factory characteristics.

Some trends become clear by reviewing the input of coal, both as internal and firing fuel for each technology.

<i>Grams coal per kg fired brick</i>	<b>Clamp</b>	<b>Tunnel</b>	<b>TVA</b>	<b>Hoffman</b>	<b>VSBK</b>	<b>Zigzag</b>
Coal mixed as internal fuel during PREPARATION	95.81	26.42	42.39	83.58	80.01	66.36
Coal added as external fuel during FIRING	32.91	13.03	41.09	76.35	2.50	0.00
<b>Total</b>	<b>128.73</b>	<b>39.44</b>	<b>83.48</b>	<b>159.93</b>	<b>82.51</b>	<b>66.36</b>

Table 1: Coal input in the clay preparation and firing step (measured as grams of coal per kg fired brick).

- The Tunnel kiln performs well in the indicators Human health, Ecosystem quality and Climate change thanks to the smaller amounts of coal used as internal and external fuel. It does not perform as well with respect to Resources due to other fossil fuels (oil and gas) used in addition to coal.

- The Hoffmann kiln always performs worse than the other methods as this technology requires the highest amount of coal, both in terms of internal fuel during clay preparation as well as external fuel during the firing step.
- The VSBK route has very small impacts in the Resource indicator when it comes to the firing step – thanks to the fairly low amount of coal used as additional fuel, but performs worse in other steps and indicators due to rather high amount of coal mixed as internal fuel.
- The Zigzag kiln performs well due to the absence of additional fossil fuels in the firing step.

So, in general, focusing only on the enhancement of the firing efficiency might not lead to a reduction of the overall impacts if a high amount of coal used as internal fuel is required. Both amounts must be reduced.

To achieve an overall reduction of the environmental impacts of brick production, both, the amount of coal used as internal fuel as well as the amount of fossil fuels used during the firing step have to be reduced. The overall contribution of coal impacts are summarised in Figure 2. This graph shows for each technology the relative coal contribution in each indicator, both, in terms of coal input and its combustion emissions, as opposed to all other causes (for example other materials or energy inputs – in blue). As discussed above, for most technologies coal impacts are the dominant contributors in all indicators. One of the main exceptions is the Tunnel route which is the one with the smallest coal input.

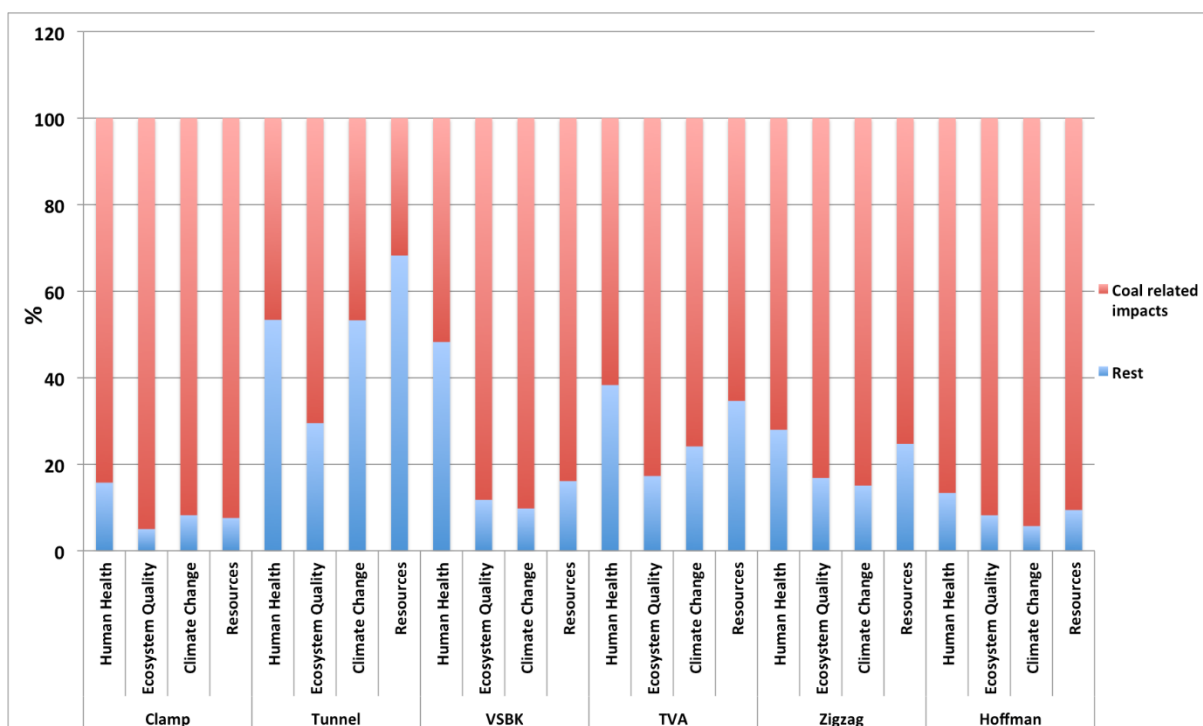


Figure 2: Relative coal contribution for each technology and indicator.

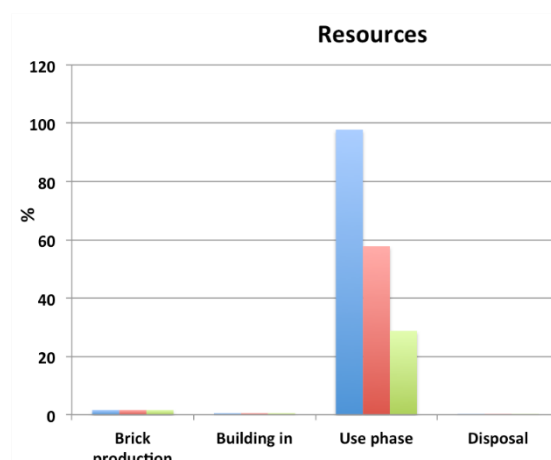
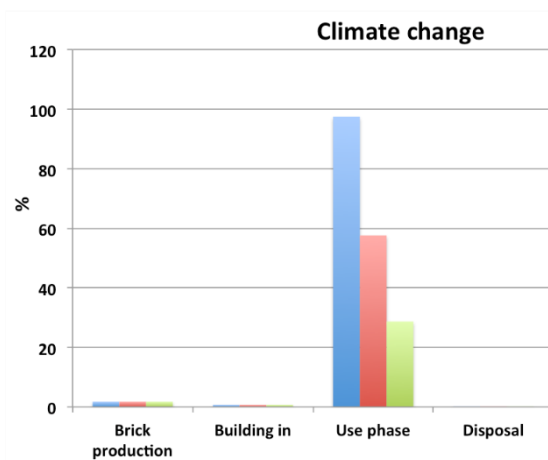
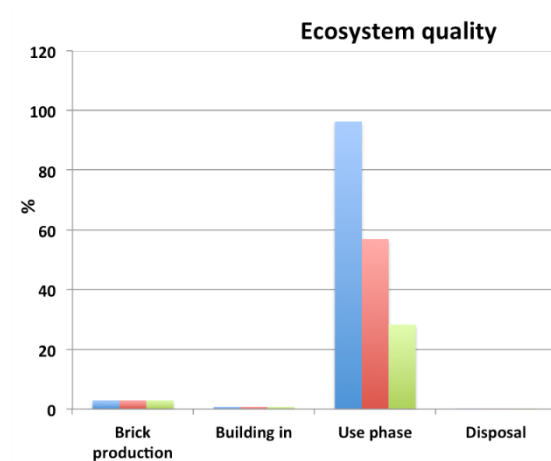
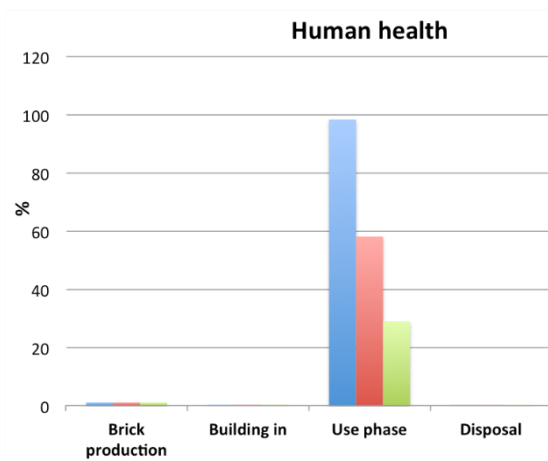
## ELECTRICITY USE

Finally, the contribution on the overall impacts from the use of electricity during the production process was also analysed. Electricity used in the production process leads to appreciable impacts in all technologies and particularly for the Tunnel and TVA, where contributions of around 15% to 30% can be observed.

## FULL LIFECYCLE ANALYSIS

The full LCA assesses the combined impacts of clay brick production, the delivery and placing of brick during construction of a building, the operation or use phase (i.e. electricity needed for heating and cooling of the building) and final demolition and disposal.

- **Blue:** 220mm wall in Climate Zone 6
- **Red:** 280mm cavity wall in Climate Zone 5
- **Green:** 280mm insulated cavity wall in Climate Zone 1



*Impacts from the production of the electricity required in the manufacturing process (in red) as opposed to the ones coming from all other processes or inputs involved (in blue).*



All indicators show the same trend: when looking at the entire life cycle of a brick wall, the results are completely dominated by the use phase meaning the impacts deriving from the production of the electricity used for the heating and cooling of the building. All other life cycle steps including the production of the bricks show minor almost negligible impacts.

The main reasons for this trend are two-fold.

1. Being largely based on coal technology, South African electricity is characterised by high impacts in all indicators.
2. Due to their long life expectancy, the impacts coming from the bricks production are conceptually spread over 50 years whereas the ones from the electricity production for the use phase accumulate over 50 years.

Since brick production has a negligible impact it can be concluded that in environmental terms building structures that lead to electricity savings in the use or operations phase represent the more favourable solution. The advantages become even more relevant for those climatic zones that are characterised by larger electricity consumptions for heating and cooling.

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### For further information:

The Clay Brick Association of South Africa

Website: [www.claybrick.org](http://www.claybrick.org)