

# Life Cycle Assessment of Brick and Timber House and Effects on Climate Change in Malaysia

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## ABSTRACT

Environment education is an important issue not only from the origination stage but also from the value of sustain it for now and for next generations. From the 1990s, the importance of environment conserve becomes understood for conservation effort in many areas. Among all activity, building construction industry played the principal roles in improving the environment, therefore attempt to mitigate effects from building constructions to environment. Sustainable development needs a method to evaluate and compare the environmental effect of human activity on any economic for various products. Environmental impacts include emission into the environment and utilization of resources as well as other inventions such as land use to build new products. The materials consist of brick and timber house with different roof materials. This study review the extraction of raw materials until the erected of building on the site. The objectives show that how much this construction can effect on climate change and human toxicity by building construction. The aim of this article is introducing the most friendly environment material for building construction and result shows wood building is the preferable solution.

**KEYWORD:** Life cycle assessment, human toxicity, climate change mitigation

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## 1. INTRODUCTION

Life cycle assessment (LCA) is a quite new method for evaluating and assessing the environmental impact of products or services across their life-span. LCA can assess only on manufacturing phase of product or only end of life that depends on the boundary of the study. According the previous studies building sector contribute almost 20% to 30 % of greenhouse gas emissions and more than 50 % are coming from residential sector (Mark Levine et al). For evaluate the product over their life cycle and for approve needs to have a standard organization. The International Standards Organization (ISO) sets the world-wide standard 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. The approach used to evaluate in this study is using of SIMAPRO which already have defined under ISO. The result of life cycle assessment can help the decision maker for interpreting the results; therefore make a more informed decision. A decision trend move to choose more sustainable and friendlier material or process. Decision maker by wise decision can significantly protect plant from hazard emissions.

The study, undertaken by UTM University, is a true cradle to grave analysis, which used ISO 14044 compliant LCA methodology to compare environmental indicators of two different construction material by same structures.

The remainder of this research is organized as follows: section I has related to the introduction and explaining the problem of project. In section II, expand and describe the Literature review, In section III, explain the Impact assessment methods and goal of this study, Finally, in section VII represent and interpretation of result that specifically concentrate on human toxicity, non-renewable energy and co2 emission.

The goal of this research is to characterize the main LC processes (extraction of material from nature, manufacturing of material, transport material to site and erected) assessing two alternative exterior and interior walls (material of both are same) for the same house to identify environmentally preferable solutions. This research can help decision-maker to choose the most sustainable material for housing.

## 2. LITERATURE REVIEW

Kanghee Lee (2009) studied about Life Cycle Assessment Program for building in South Korea. Kanghee presents foundations for the development of a Life Cycle Assessment (LCA) program for buildings, focusing on their energy consumption and carbon dioxide emission levels, with a comparison of domestically and foreign designed programs. Oscar.o.r et al (2010) studied to compare two different building in two different countries. First

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one is in Spain as a developed country, and another one is in Colombia as a country under development. Results show that the use phase in the Pamplona house (Colombia) represents a lower percentage for all impacts in the total than in the Barcelona house (Spain).

Dongwei Yu et al (2011) studied residential bamboo building in china and survey of carbon emission. The result showed that bamboo in comparison to brick-concrete building has required less energy and emits less carbon dioxide to the environment. This study indicates that bamboo which is a local material in some part of china is a more environmental friendly product. T. Ramesh et al (2012) studied about the life cycle of three different envelope of building material in India. The house had studied with conventional (fired clay) and alternative wall materials (hollow concrete, soil cement, fly ash and aerated concrete) under varying thickness of wall, and insulation (expanded polystyrene) on the wall and roof. Study suggests that alternative wall materials alone (without insulation) reduce LCE demand of the building by 1.5–5%.

Helena Monteiro et al (2012) studied about a building with seven alternative exterior walls. The aim is to identify environmentally preferable solutions for environment meanwhile this study accomplished by three different methods. Compare methods revealed that any significant effect on results from choosing method. The methods that have used in this study are following: CED (cumulative energy demand), CML 2001 and Eco-indicator'99. The results show that the most significant LC process depends on the operational pattern assumed. Regarding the assessment of the exterior wall alternatives, the results indicate the wood-wall is the preferable solution.

Dongwei et al (2011) studied about energy use and carbon emission over the life cycle of bamboo structure prototype in china. This research proved bamboo in comparison with brick-concrete building has a less energy use and also released less carbon dioxide emission. Therefore, bamboo is more environment friendly material in china market. The results indicate that there is a potential to reduce 11.0% (18.5%) of the embodied energy (carbon) for the use of recycled-content building materials and 51.3% (69.2%) for the recycling of construction and demolition waste, respectively. Adalberth (1997) proposed a methodology to account for the LC energy of buildings from cradle to grave and applied it to three Swedish single-family houses in 1991 and 1992. The base of this project the previous studies only concentrates on energy use by building and not survey all life cycle of a building such as manufacturing, renovation and waste. Among other results, Adalberth concluded that the building use phase requires 85% of the total LC energy while construction materials amount to 15%.

### 3. IMPACT ASSESSMENT METHODS

Life Cycle Assessment (LCA) has standardized by the International Standardization organization (ISO) in the 14040 series (ISO. International Standardization Organization, 2006). The four steps of this Methodology defined as: goal and scope definition, inventory Analysis, impact assessment and interpretation.

LCA has a different four stages which comprises of goal and scope, inventory analyses, impact assessment and interpretation of the result. The major stages in an LCA study are the raw material acquisition, materials manufacture, production, use/reuse/maintenance, and waste management. The system boundaries, assumptions, and conventions to be addressed in each stage has presented. The system boundary of this study includes the raw accusation, manufacturing, transport of material to the site. This study evaluated only walls and roof and not foundation system.

The house construction phase includes the material production and assembly in manufacturing such as built the wall panels and roof component and then transports it to the site work. The building materials have accounted in terms of mass (walls, roof, floor, windows and glass) for both timber and brick in this study.

IMPACT 2002+ is a life cycle impact assessment (LCIA) method which proposes a feasible implementation of a combined midpoint/damage approach, linking all types of life cycle inventory result via 14 midpoint categories to four damage categories. For IMPACT 2002+, new concepts and methods have developed, especially for the comparative assessment of human toxicity and ecotoxicity

The previous study has been accomplished by different methods such as (Eco-indicator'99, CML 2001 and CED (cumulative energy demand) which all represent the result for endpoint of life cycle. IMPACT 2002+ is almost new method for accomplish the life cycle assessment.

The scientific contributions of this paper are: 1) represent the most environmental friendly material for residential building. 2) Compare the two different materials of building by midpoint life cycle impact assessment. 3) Compare the human toxicity, non-renewable energy and co2 emission on brick and timber building.

Table 1 material of buildings

Building components	Area (m <sup>2</sup> )	Material layers	Thickness (m)	Total weight (kg)
Wall	168	Brick	0.100	46500
Wall	168	Timber	0.200	23436
Brick mortar		Cement		1674
wood for roof	85			2650
gypsum	78	Gypsum	0.01	647
Bitumen sealing	85		0.010	510
Window	12	Glass	0.020	300
Paint	168			33
Nail for wood		Iron		33.6

Life cycle assessment has described under boundaries which mean what sequence of building operation has calculated. In this study boundaries is containing start of extraction raw material transfer it to the site and manufacturing and then transfer the materials to the site has considered. The phase of demolished is not in this boundary. Table 1 shows the quantity of each material that has used in buildings. The case study has three bedrooms, living room, and kitchen and apparently washes room (figure 1). The case study is including three bedroom, kitchen, dining room and living room and also total floor area of about 78 m<sup>2</sup>.

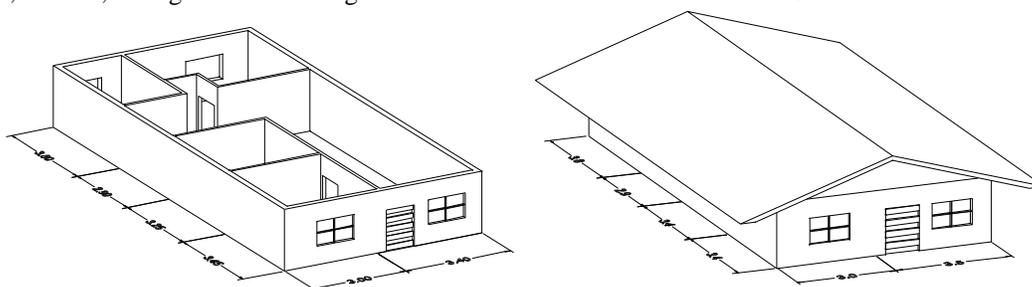


Figure 1 architectural model of single family house

#### 4. RESULTS AND DISCUSSION

Table 2 shows the result of emission from the beginning step of extraction or raw material to transfer it to manufacturing and then transfer the brick to timber to the site for erected the building. This table shows the quantity of emission release to the environment for 100 years and from this point can estimate which material is more environmental friendly.

##### 4.1 Impact 2002

The first aim of this study is the survey the human toxicity forms both material. Human toxicity here represent from the sum of Carcinogens and Non-Carcinogens. Human toxicity can define as the state or quality of being poisonous or capable of causing harm to exposed humans in a long term. Because from building activity, some emission released to the environment that remain in the air and can cause damage on human health.

Table 2 characterization result of Impact 2002

Impact 2002	Unit	Brick	Timber
Carcinogens	KgC2h3cl eq	56.9	6.28
Non-Carcinogens	KgC2h3cl eq	48.2	31.5
Respiratory inorganics	Kg PM2.5eq	5.64	1.01
Ionizing radiation	Bq c-14 eq	1.20E5	1.04E4
Ozone layer depletion	Kg CFC-11eq	0.0009	0.0001
Respiratory organics	Kg c2H4 eq	4.53	.45
Aquatic ecotoxicity	Kg TEG water	1.3E5	1.6E5
Terrestrial ecotoxicity	Kg TEG soil	4.9E4	2.9E4
Terrestrial acid/Nutri	Kg SO2 eq	143	31
Land occupation	M2 org .arabel	39.1	6.34
Aquatic acidification	Kg SO2 eq	32	5.71
Aquatic eutrophication	Kg PO4-lim	1	.412
Global warming	Kg CO2 eq	1.2E4	877
Non-renewable energy	MJ primary	1.3E5	1.2E4
Mineral extraction	MJ surplus	16.8	15.4

Figure 2 shows the result of comparison and indicated that brick has a more damage on human health by its life cycle. The types of toxicities where substances may cause lethality to the entire body, lethality to specific organs, major/minor damage, or cause cancer. These are globally accepted definitions of what toxicity is. Anything falling outside of the definition cannot be classified as that type of toxicant. The amount of emission from brick construction is 105.1 Kg and for timber are 37.78. As a result of this part can apparently find the timber as more sustainable material because of less damage emission on human toxicity.

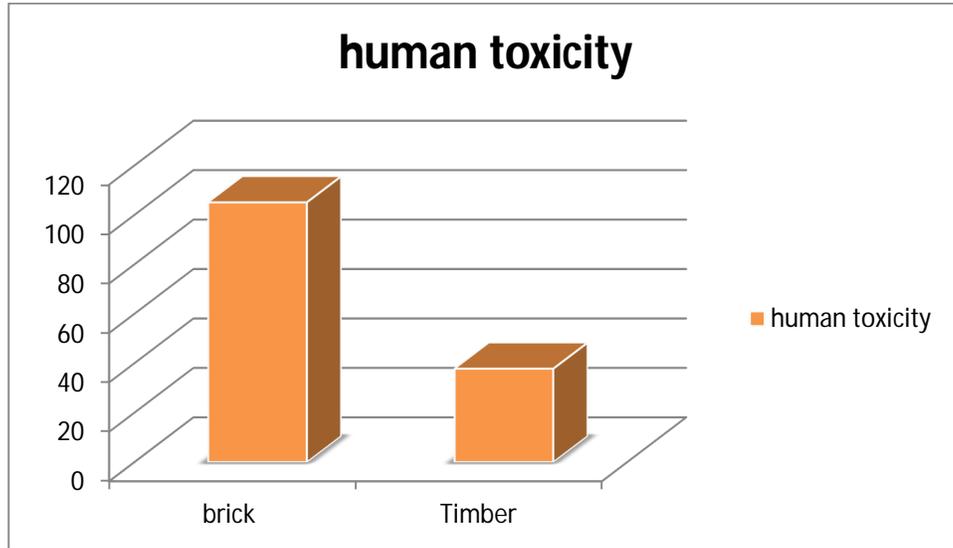


Figure 2 comparison of human toxicity

Another topic that discuss here is Non-renewable energy. A non-renewable resource also known as a finite resource is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human timeframes. An example is carbon-based, organically-derived fuel. To choose a building material as much as that specific material is renewable energy that called as more sustainable. Here to compare between timber house and brick house form figure 3 indicated that timber is more environmental friendly material. However by cutting tree it might deforest happen but by replant the tree can renew this source and keep it for the next generations. MJ primary is the unit to describe the Non-renewable energy in the life cycle study.  $1.3E5$  MJ primary for brick and  $1.2E4$  MJ primary represent as timber materials. Figure 3 shows that a profound difference between the two buildings on usage of non-renewable energy. This non-renewable resource has been consider in this study to show and proof that cutting trees might lead to deforest, but there is no panic if replant other trees. Eventually, not only wood material is a sustainable choice for construction versus brick but also there is no panic about losing trees.

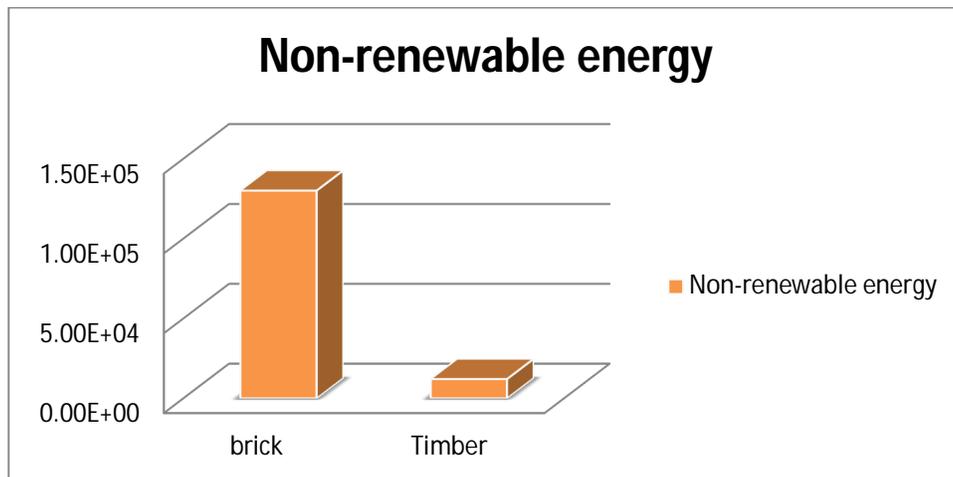


Figure 3 comparison of non-renewable resource usage

The third and last aim of this study is assessing the effect of above mentioned construction on global warming. Global warming, by definition, means the earth is getting warmer. This also means that sea levels are beginning to rise, because of the expansion of water and because of the melting of glacial ice and the ice caps. This in turn will have a serious effect on coastal areas and may mean the displacement of entire populations in areas like Bangladesh and some of the Pacific Islands. When pollution builds up in Earth's atmosphere, it cannot escape. Heat from the sun shines through the pollution (greenhouse gases) and the greenhouse gases act almost like a greenhouse, trapping heat. So as more greenhouse gases build up, more heat is trapped in Earth's atmosphere, therefore causing Earth to heat up and causing Global Warming. Figure 4 shows the global warming effect of two materials during the manufacturing production phase. Emission from brick is 1.2E4 Kg CO<sub>2</sub> and for timber is lower about 877 Kg CO<sub>2</sub>. Eventually, for Global warming also timber is a better choice than brick and can be environmentally solution.

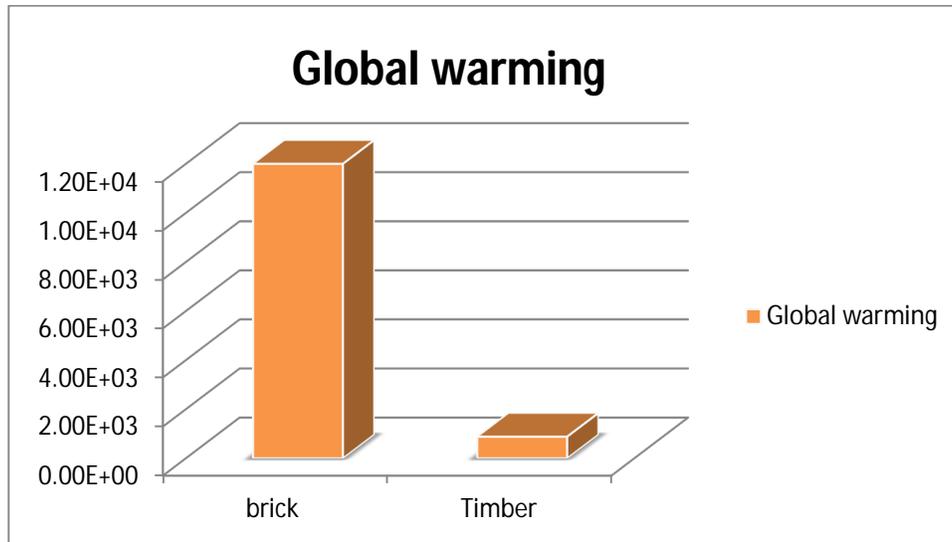


Figure 4 comparison of Global warming emission

Global warming as defined by the United Nations' Intergovernmental Panel on Climate Change (IPCC) is the rise in the average temperature of the Earth that has been happening since the beginning of the Industrial Revolution. The scientific consensus is that global warming is happening, and it is being caused by anthropogenic means, that it, it has caused by man's actions, especially those that add to the greenhouse gases in the atmosphere. Man does this by the burning of fossil fuels (coal, oil and natural gas) and by deforestation. Combustion of fossil fuels releases long-stored carbon dioxide into the atmosphere, and deforestation has removed the carbon sinks of the immense forests that used to absorb and store carbon. Lastly timber building has less emission as GHG (greenhouse gas) to the environment than brick material; therefore timber is a better choice.

### 5. Conclusions

The results show houses that incorporate most timber in their construction have lower emissions of global warming gases, lower levels of resource depletion, and have less energy embodied in their total manufacturing phase. The increased use of timber is also correlated to greater land and water use, which is to be anticipated for a forestry product, therefore need to plane tree based on any tree given cut. The aim of this study is to review two buildings materials by the same structure and also reveal which type of building consumes more energy and have more greenhouse gas (GHG) emissions. In conclusion, timber building shows less environmental impact during the production, manufacturing and transportation to site thus that is the best choice for construction than brick.

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