

Identification Characteristic of Energy Efficient Timber House



Febriane Paulina Makalew, Rilya Rumbayan, and Novatus Senduk

Abstract The energy efficient house principle is to minimize the use of energy for household and daily activity. Timber house is the potential in saving energy due to its characteristics. Effort in saving energy for the building has been done, such as the use of supporting energy save including solar panel and design house to circulate air and heat in a passive house. The aim of this paper is to identify the potential of energy efficient in a timber house and it's characteristic. The methodology used is survey data on traditional timber houses in Woloan village, North Sulawesi. The result shows that there is limited implementation of energy efficient timber houses in Woloan village. The characteristic of energy efficient timber house is construction on floor, wall, roof and opening with treatment to safe energy passively and the use of the solar panel. There is potential in improving the quality of timber houses to be energy efficient buildings. The use of solar panels for timber houses based on order has been recognized, although the construction is conducted by the solar panel company. Moreover, the construction and lay out of the house is dominant by natural ventilation and adequate opening for natural light. There is a need for further research to evaluate the amount of energy efficient in a different type of timber house as well as the mixed construction of timber and other construction material.

Keywords Timber house · Energy efficient · Passive house · Solar panel

1 Introduction

The material of timber has been used for many constructions including house construction. Timber has been acknowledged as safer energy material due to its characteristics. The characteristic of timber is a good thermal insulator. Wood is a material that cannot transfer heat therefore the internal house does not receive heat from outside. Timber house can be found in many areas including in North Sulawesi, Indonesia. The traditional house of Minahasa, one of the ethnic in North

F. P. Makalew (✉) · R. Rumbayan · N. Senduk
Manado State Polytechnic, Manado, North Sulawesi Indonesia, Indonesia
e-mail: febrianne.makalew@sipil.polimdo.ac.id

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Sulawesi, is dominant using timber for construction material. In designing energy efficient buildings, the use of wood as the main material for timber houses give an impact on indoor temperature to be more comfortable for people. However, there is a need to considered other parts of house construction. The use of material glass on the window of timber house for the purpose of increasing natural light on the other hand can increase the temperature of the internal house. The characteristic of glass is transparent and as the best transmission of heat.

The concept of energy efficient building has been widespread with many terms. The consideration of environment quality is an approach for better building construction such as green building, environmentally friendly construction and passive house. GBCI [1] for example, established criteria for the green building including energy efficiency and conservation which consist of electricity, passive design analysis, artificial lighting, thermal condition, heat reduction, energy efficient home appliances and renewable energy sources. In terms of material resource and cycle, environmentally friendly material and certified wood are criteria that need to consider (ibid). For indoor health and comfort the criteria including fresh air circulation and natural light. Azizah et al. [2], evaluate the standard of greenhouse to a number of dwelling in the urban area. The standard green house of selected dwelling with vary functions can be improved through the use of renewable energy and lighting device. Using the standard ASHRAE (American Society of Heating, Refrigeration, Air conditioning Engineering), the timber house in the coastal and hill area is measured [3]. The timber house in the coastal area is more comfortable than the coastal area based on AMV value.

A passive house is one of the house designs types to improve the quality of energy efficient houses. The concept of a passive house is started in 1983 in Germany and has been developed ever since in many countries [4]. A good ventilation system in the passive house should overcome more than 75% heat in the house which is lower 90% than the conventionally built house (ibid). Therefore, the design for energy efficient timber houses should implement the concept of the passive house through house construction and material (ibid). The standard of a passive house is based on the use of energy at a low level [5]. The criteria for the assessment of a passive house is including heating, cooling, air tightness and renewable primary energy (ibid). Whilst the criteria for building components are including insulation on the ground, exterior and interior and construction of window and ventilation (ibid). In terms of renewable energy, the type used for passive houses such as solar panel system, the PV system and renewable energy plants (ibid).

Considering the advantage in applied passive house concept, [6] evaluate the development in using the passive house as a system in recently and future. Such a system has been used by the client and industry in which the regulation is the second leading (ibid). The implementation of a passive house could be improved by adequate information, skilled and stakeholder involvement. However, the process of reaching the optimum benefit of the passive house should be followed with good quality control. The climate change has led to research on passive house evaluation in which the majority house fails to circulate the heat in the peak temperature [7]. Problems found in the ventilation system that is inadequate. The passive house in the

rural area helps the community to live with energy efficient dwelling and in a comfort area (ibid). However, a passive house system can be failed if the daily activity has not followed the rule of its system (ibid).

Different type of timber house has been developed from traditional to modern house. Moreover, the house also creates energy efficient house whether it's naturally constructed such as for a traditional house or adding energy efficient devices such as for a modern house. The traditional timber construction of Kaili ethnic in Central Sulawesi Indonesia for example, is evaluated as an energy efficient house [8]. The energy efficient can be seen in the construction of houses including roof, floor, window, ventilation, wall and vegetation (ibid). Interestingly, the floor board use for the house has a gap that allows air circulation to the indoor building and creates a comfort room (ibid). Traditional house multi-storey is focusing on the part of the building, material, construction system, opening and ornament [9].

The design and construction of timber houses have been developed to protect the environment from degradation. The implementation of the solar panel to block based construction for a residential house in western China is aimed to protect the environment in a rural area [10]. The system is divided into three categories including solar energy, green technology and standard. For the solar energy category, the block is including passive and active solar energy (ibid). Result suggests that the house in the rural area should face the solar path and living area on the opposite site to block the heat movement (ibid). This type of house is not just energy efficient but also environmentally friendly due to its design and function. Moreover, Lazarevica et al. [11] create an innovation system on multi-storey wood-frame. The part of the building is a building frame with the material of wood. Emphasis on its components, building materials, construction systems, ornaments, opening's treatment, environment, and its spatial organization (ibid). The recent development on frame timber house has led to prefabrication house structure with 3D analysis of modular built in [12]. The type of house is multi-storey and multifamily building.

Furthermore, the development of construction material in a creative way has been done to support the timber house in achieving energy efficient buildings. Part of building construction material as main or supporting material help reduce the indoor heat and safe more energy. The use of wood as a building material is to reduce carbon emission [13]. This is to encourage the use of wood as construction material in an innovative way (ibid). Lianto [14], using material glass for the window can give adequate light for the indoor house as well as the impact on the increasing of room temperature. The type of glass should be properly chosen to avoid excessive heat to the indoor house such as RayBan glass and adding material to the surface using plastic film (ibid).

The criteria of energy efficient houses also vary from the stages of construction preparation to the treatment approach. Natural wood house stages are started from log cutting to waste treatment as life cycle assessment [15]. The life cycle CO₂ emission with natural material is lower than another source which is including energy consumption from the household (ibid). In terms of aspects that support energy efficient building Baboli et al. [16] evaluate that the design of houses considering a moderate climate with orientation based on maximum natural light and available

courtyard. Moreover, design an environmentally friendly house is a mixed approach to interior and exterior treatment [17]. Such treatment is related to air circulation and light intake including building orientation, vegetation, type of window and roof (ibid).

Therefore, identify the characteristic of energy efficient for timber houses could help in creating and developing an optimum design and construction of the house.

2 Design and Construction of Timber House

In designing a timber house, the approach for the concept should be established since the beginning of the process. Energy efficient building approach supports a good quality of the environment. The occupant of the timber house could get benefit from their daily activity including low spending on energy needs as well as having a comfortable room. With the creativity of the designer in considering occupant needs, the building design is attractive as well as energy efficient is achieved. The construction of timber houses originally follows the principle of building strength and characteristic of wood as the main material.

Timber house design and construction has been developed in considering the characteristic of location including weather and geography local condition, the material available, man power resource and local culture. The development of traditional timber houses to a modern timber house can be found in many places including Tomohon city and Woloan village. The timber house traditionally was only one floor placed in the high level around 3 m-high from the ground. The house is supported by a structural column made by the high quality of wood. The foundation was made by the original stone.

Traditional timber house in Minahasa, North Sulawesi has been built by the ancestor since the beginning of the tribe community. A number of original timber houses can be found in North Sulawesi such as in Tomohon city and Woloan village. This area is an old area for traditional culture and house. The characteristic of traditional timber house is as shown in Table 1.

The example of a traditional timber house can be seen in the Fig. 1.

From Fig. 1, there are differences between traditional timber houses and modern timber houses. The original timber house is made of wood for all parts of the building construction. The main difference can be seen in the building structure where the column on the first floor uses high quality of wood. Traditional timber house only has a floor plan on the second floor. The first storey is an open plan design with stairs as access to the second floor. Traditionally this design aims to protect the occupant from a wild animal therefore there is no room for activity on the first floor. The example of a timber house in Fig. 1a is one of the original houses left in the area. The area is the city of Tomohon known as having a number of original traditional timber houses.

The evaluation for the traditional timber house can be divided into different aspects including the type of material, construction, quality of the material. In terms of the type of material used, the traditional house originally uses wood for the whole

Table 1 Characteristic of energy efficient timber house

No.	Part of house construction	Characteristic
1	Foundation	Material stone Place on the ground Develop into concrete with stone and concrete
2	Column	Material wood High quality of wood for structure The first floor developed into reinforcing concrete Second floor high quality of wood
3	Beam	Material wood High quality of wood for construction
4	Wall	Material wood Type of board with 30 cm wide Developed into “lammersering” smaller type of board with 10 cm wide
5	Ceiling	Material wood Type of board with 30 cm wide Developed into “lammersering” smaller type of board with 10 cm wide and gypsum
6	Roof frame	Material wood Developed into light steel
7	Roof cover	Material palm fiber, zinc board Developed into tile roof and concrete
8	Window	Material wood and glass for opening Wood for frame Developed into the glass for thermal protection For frame developed into light steel material
9	Door	Material wood for frame and opening



a



b

Fig. 1 The example of the traditional timber house. **a** Traditional house. **b** Modern timber house

construction and structure. Moreover, for the roof cover material, the original material use is made of sago palm leaves or Rumbia. The development of the traditional house is the change of material used such as the use of zinc board for the roof covered. The level of the traditional building is placed on the high area around 1.5–3 m height. For kitchen and bathroom, originally placed at the backyard separate from the main building.

The modern timber house is varied in terms of design and construction. The example in Fig. 1b is a developed timber house from traditional house design. The floor plan is available for first and second floor building. The first floor made of concrete and brick. The structure is reinforced concrete and the wall is constructed by red brick. The wall plastering with mixed cement and sand and finishing with painting. The function of the first floor is mostly similar to the second floor such as bedroom and living room. For certain function such as kitchen, is placed on the first floor. The bathroom mostly placed on the first floor while some have placed on the second floor with concrete as a construction material.

The concept of the passive house can be implemented in a timber house can be seen in Fig. 2. The main criteria are air circulation and treatment for the construction.

The implementation of the passive house concept can be applied to a different type of timber house. The window needs to be constructed with a wood frame and for opening is using the type of glass with protection from the exceed heat of the sun. Cross ventilation is important in circulating air from room to room. Good quality of window and ventilation construction help to create a comfort room with comfort temperature for the occupant. An additional device such as solar panel and thermal insulation support the energy efficient house. Solar panel contributes to the energy provided by getting energy power from the sun. Thermal insulation is placed in the wall is to protect the room from the heat from outside. The material for building construction should be chosen carefully as some material can increase the temperature of the room.



Fig. 2 Implementation concept of the passive house to timber house

3 Characteristic of Energy Efficient Timber House

The characteristic of energy efficient timber house based on a literature review and preliminary survey can be seen in Table 2.

The type of timber house in Woloan village can be seen in Table 3.

The variation of timber house is caused by the change in occupant needs, development of material and devices. The wood board, for example, has been used originally for the window opening. The change of wood board for opening on the window to the material of glass is to increase the quality of the light in the room. The change of the first floor from an open plan to a floor plan with a number of rooms is considering the need for a place for vary activities of the occupant. This changing should not decrease the quality of air circulation as well as the use of energy. The design for mezzanine in the two storeys of house support the air circulation vertically.




Based on data, the majority timber house in Woloan Village has not fully considered the use of energy efficient construction. The evaluation of energy efficient timber house can be seen in Table 4.

From the sample of a timber house, the design and construction for saving energy in a natural way are implemented due to available opening with glass material and a cross circulation system of air ventilation. The general type of floor plan with cross ventilation and window design in the house is the principle of a passive house. The passive house is a type of design in which the building control its temperature to be comforted for human due to the construction and floor plan create a space that protects the over heat from outside. With this process and supported by cross air circulation and adequate light, the energy used for light and air condition is low.

Table 2 Characteristic of energy efficient timber house

No.	Characteristic	Source
1	Floor construction	[8], traditional Minahasa house
2	Wall construction with insulation	[5]
3	Roof construction	[17]
4	Material use	[9, 11, 13]
5	Supporting appliance and device	[2, 5]
6	Spatial and orientation	[11]
7	Low energy	[10]
8	Natural light, opening	[9, 16]
9	Standard of energy use	[3]
10	Pass certified of saving energy	[1, 5]
11	Environment consideration	[10, 17]

Table 3 Type of timber house

No.	Type	Characteristic
1	Timber house one storey 	New house prefabrication
2	Timber house two storey	New house prefabrication
3	Timber house two storey not full 	New house prefabrication
4	Timber house two storey not full	Old traditional Minahasa house First floor open plan for multi-function
5	Timber house two storey full	Old house
6	Timber house two storey with mezzanine 	New house prefabrication
7	Mixed timber and concrete house	New house The first floor is concrete The second floor is timber
8	Mixed timber and concrete house	Used house The first floor is concrete The second floor is timber

Moreover, the design for the type of two-storey timber house has been developed into a variety of the second floor from a full floor plan similar to the first floor to half floor plan. This design supports natural air circulation floor to floor as well as the distribution of light.

In the design of the passive house, the development of timber construction has not included insulation on the wall and the floor. While the use of a solar panel is limited.

Table 4 Evaluation of energy efficient based on the type of timber house

No.	Type of timber house	Evaluation energy efficient	Natural light	Natural air	Material
1	Traditional timber house	No adding of solar panel	Natural light from opening window glass	Natural air circulation from ventilation with cross type	Material old timber with majority damage due to less maintenance
2	New prefabrication timber house	Adding solar panel with construction by solar panel company	Natural light from opening window glass	Natural air circulation from ventilation with cross type	New timber with vary quality Jati wood and Nantu wood
3	Mixed house of timber and concrete	Electricity power from the national electricity company	Natural light from opening window glass	Natural air circulation from ventilation with cross type	Vary the type of wood for construction First floor with concrete Second floor with timber

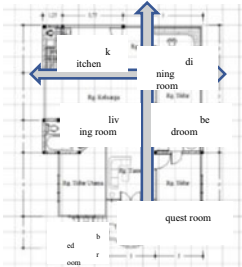
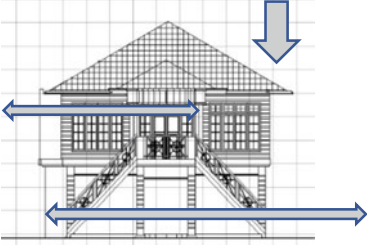
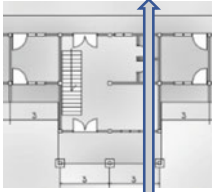

The implementation for timber house to be more energy efficient by using the less additional device and more design on timber construction to adjust the temperature of the house itself, it's crucial to be considered.

The implementation of energy efficient timber houses can be applied by design the floor plan of a timber house with cross air circulation and natural light area. Energy efficient timber houses in a traditional timber house and modern timber house from the sample houses show a different level of implementation. The design for energy timber houses can be seen in Table 5.

4 Conclusion

In conclusion, the characteristic of energy efficient timber houses based on literature study and field study are basically considered air circulation, natural light, material use, additional devices and energy use. The concept of energy efficient houses is developed widely based on consideration of environment impact including green house and passive house. Timber house is using wood as the main material which is a thermal insulator. Wood is an energy efficient material. The use of the material other than wood needs to acknowledge the effect of increasing heat due to the character of material such as glass for the window. The passive house as a concept for energy efficient houses can be applied in a timber house. The main approach is the air need to have good circulation such as the type of cross ventilation. Moreover, the use of insulation on the wall helps to protect the room from excessive heat. Timber house

Table 5 Design for energy efficient timber house

No.	Type of house	Potential energy efficient timber house
1	<p>Traditional timber house The floor plan should have cross ventilation horizontally and vertically if possible</p>  <p>Floor plan</p>	<p>Improve opening and ventilation Construct insulation on the wall Using solar panel Using glass with surface protection</p>  <p>Front view</p>
2	<p>Modern timber house The floor plan should have cross ventilation</p>  <p>Floor plan</p>	<p>Improve opening and ventilation Construct insulation on the wall Using solar panel Using glass with surface protection</p>  <p>Front view</p>

is an example of an energy efficient house. Types of timber houses are vary based on the number of storeys, material use and time of construction. Timber house has been developed from original traditional house to other types including, one storey timber house, full two-storey timber house, half full two storeys of a timber house, two storey timber houses with mezzanine and mixed timber and concrete house. The concept of energy efficient house such as a passive house, need to be maintained and have good quality control. A number of changes recently including weather conditions should be balanced with the improvement of control and standard.

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