



## Evaluation of the Cost of Residential Buildings with Environmentally Friendly Concepts



Ni Kadek Sri Ebtha Yuni<sup>a</sup>  
I Wayan Sudiasa<sup>b</sup>  
I Komang Sudiarta<sup>c</sup>  
Putu Eny Suhardiyani<sup>d</sup>  
I Putu Widyarsana<sup>e</sup>  
I Ketut Sutapa<sup>f</sup>

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### Abstract

The initial stages of construction implementation begin with planning, implementation, and operation. Each stage of the project must be with a green or environmentally friendly concept. Eco-friendly planning in residential buildings starts from the use of building materials, energy-efficient design concepts, and economical development costs. In addition, the construction of houses must also pay attention to health, such as ventilation, garbage disposal, and the provision of green environments for plants. The costs analyzed in this study refer to environmentally friendly concepts that can be applied to the construction of residential houses. Residential buildings in urban areas generally have narrow land, so the 1st-floor building built is with an area of 36 m<sup>2</sup>, 45 m<sup>2</sup>, or 60 m<sup>2</sup>. The object of research, in this case, is building housing built by developers in general. As for the results of field observations, environmentally friendly concepts that can be used are land arrangement, energy saving, healthy homes, and the use of environmentally friendly materials. Design modifications from existing conditions are the addition of a more lost, glass-block, the use of red brick, mild steel, and modification of water taps. The purpose of the modification is to use electrical energy and water and run the concept of a healthy home. From the modified design, the construction cost for a 36 m<sup>2</sup> type house building is IDR 148,000,000 without tax. The monthly operational costs incurred are IDR 652,916.

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### Corresponding author:

Ni Kadek Sri Ebtha Yuni,

Civil Engineering Department, Politeknik Negeri Bali, Badung, Indonesia.

Email address: [ebthayuni@pnb.ac.id](mailto:ebthayuni@pnb.ac.id)

<sup>a</sup> Civil Engineering Department, Politeknik Negeri Bali, Badung, Indonesia

<sup>b</sup> Civil Engineering Department, Politeknik Negeri Bali, Badung, Indonesia

<sup>c</sup> Civil Engineering Department, Politeknik Negeri Bali, Badung, Indonesia

<sup>d</sup> Departmen of Information System, IT Stikom Bali, Denpasar, Indonesia

<sup>e</sup> Departmen of Information System, IT Stikom Bali, Denpasar, Indonesia

<sup>f</sup> Civil Engineering Department, Politeknik Negeri Bali, Badung, Indonesia

## 1 Introduction

Human needs for housing as primary needs cannot be underestimated. Currently, most residential houses are built only focusing on aspects of beauty without considering the environmental and climatic conditions at the location of the planned residence to be built (Simbolon & Nasution, 2017). The concept of environmentally friendly building or green building concept is the creation of construction from the stage of planning, implementing and using construction products that are environmentally friendly, efficient in the use of energy and resources, and low cost, and pay attention to the health, comfort of its residents who all adhere to sustainable principles (Yebra et al., 2004; Manzini & Vezzoli, 2003). Green buildings must also start with land use that is following the urban spatial layout and is a designated area. In addition, Green Building also pays attention to the level of operation of its maintenance operations. The benefits of Green Building Development include environmental benefits, economic benefits, and social benefits. Each region has building regulations that must be obeyed such as the Basic Building Coefficient (KDB), Building Floor Coefficient (KLB), Building Commensurate Line (GSB), and Green Open Space (RTH) (Karuniastuti, 2016). To achieve this, passive design can be carried out with natural ventilation methods and natural lighting applied to building design. The minimum area of natural ventilation in a room is 10% of the floor area of the room. From the results of the analysis obtained the best building orientation facing east-west, for the best opening orientation facing north and south, in this direction the sunlight shines steadily throughout the day (Synnefa et al., 2007; Gustavsson & Joelsson, 2010). To overcome high solar radiation, in the area around the building was planted vegeasi with shady and soothing tree species. As for giving a cold effect to the room, the appropriate opening/window type from the analysis results is a pivot-type window to maximize the entry of wind in the space. To overcome high humidity conditions, a bottom vent is made right under the window, then on the adapt that has a flat plane ventilated to remove hot air in the space between the roof and ceiling. To provide natural coolness to the building, a distance is made between the building and the existing building so that the wind can move freely in the building area (Simbolon & Nasution, 2017). Material selection is an important aspect of environmentally friendly development (Syahriyah, 2017).

The application of environmentally friendly buildings is usually referred to as green construction, which is at the planning stage seen in several construction designs that received awards as energy-efficient building designs, namely building systems designed to reduce electricity consumption for lighting and air conditioning (Imran, 2018). Apart from building planning, the approach that needs to be done includes human behaviour itself as occupants/users, regulation of building problems and their environment, engineering form and space, use of alternative energy, use of building materials and others (Ningsar & Erdiono, 2012).

## 2 Materials and Methods

The research began with conducting a field study, to find out the design of houses that are currently being built. Field studies are carried out in the form of collecting data on the existing condition of house buildings that have been built. Data collection is carried out in the form of structured interviews with residents of the house, as well as conducting documentation photographs. Furthermore, designing the design of the house refers to the Regulation of the Minister of Environment Year 2010 and the principle of eco-architecture using the Autocad program (PERMEN LH No. 12 Tahun 2010). Briefly The research steps: (1) Field studies to determine existing conditions, (2) Secondary data collection, (3) Designing house designs referring to the 2010 Minister of Environment Regulation and eco-architecture principles, (4) Calculating construction costs and operational costs. The analysis used in this study is qualitative and quantitative analysis. Qualitative analysis was used to determine environmentally friendly design following the 2010 Regulation of the Minister of Environment and eco-architectural principles. Eco-friendly design is also in line with the principles of healthy homes and environmentally friendly materials. Following the Joint Decree of the Minister of Home Affairs, the Minister of Public Works and the State Minister of Public Housing Article 23 regarding the structure of components and building materials must have requirements (PUPR, 2018): The use of building materials for cheap construction may consist of local or other building materials whose strength meets technical requirements. Today's environmentally friendly building materials are needed to maintain future generations which are the goal of reducing energy consumption, emissions or garbage or waste to create a comfortable earth. The placement of the building varies in layout concerning the orientation of the sun which is also affected by lighting (Prayoga et al., 2018). The selection of materials, the combination of several types of materials and the right design can produce energy-efficient buildings (Budhyowati & Kembuan, 2021).

### 3 Results and Discussions

#### 3.1 Existing conditions of the building

This residential building is built on land with an area between 70 m<sup>2</sup> to 100 m<sup>2</sup>, with a building area of 36 m<sup>2</sup> and 45 m<sup>2</sup>. This study focused on buildings with a land area of 70 m<sup>2</sup> and a building area of 36 m<sup>2</sup>. The specifications are coral foundations, reinforced concrete structures, light steel roof frames, concrete tiles, adobe walls, plaster, aci, paint, ceramics, fabrication doors, gypsum, and a carport.



Figure 1. Existing building view

#### 3.2 Selection of environmentally friendly concepts

Based on the results of field observations, environmentally friendly concepts that can be applied are:

a. Arrangement and use of the land following its designation

The arrangement here is a building placement that must be effective because the existing land is narrow. In addition, the arrangement of this land also considers the placement of a holy place for Hindu owners. The arrangement of the building must also pay attention to harmony with nature through the provision of open space. This open space can be planted with grass, or trees that can reduce air pollution. Through the provision of green space, it is expected to support the availability of the Green Terbuka Space (RTH) Area (Dwiyanto, 2009). Currently, residential land is increasingly limited, so many innovations are made in making green open spaces. An alternative that can be done is to use the fence as a place to put potted plants and use roof shoulders to plant plants. The use of fences and roofs as a place to plant green plants can function to absorb solar heat and reduce pollution as well as produce oxygen and air conditioning (Tyrväinen et al., 2014; Kyzas & Deliyanni, 2015).



Figure 2. The green environment in residential areas

b. Saving of energy resources (electricity and water)

Energy saving in this study is reducing electricity and water use. Saving electricity is carried out by paying attention to the design of door and window openings, ventilation used for air circulation and lighting (Castleton et al., 2010; Mohsen & Akash, 2001). In existing conditions, the house buildings built in Kutuh Village mostly lack air circulation and lighting. Such as lack of ventilation and the height of the building between the floor and the ceiling is low. In addition to through doors and windows and ventilation, the use of garden lights from solar panels is also useful for lighting on the event day. The use of solar panels in residential homes can be used for garden lighting or roads.



Figure 3. Modified building design

In the above design, the concept of lighting is obtained through the south, west and east directions. In the morning Light can enter through the east in the kitchen room, and bedroom, so there is no need to turn on a lot of lights. On the kitchen wall installed glass block and concrete luster, so that light and air can enter naturally. This building consists of 2 entrances and each room is equipped with articulated windows, with luster on top. This condition during the day can reduce the use of lights and air conditioning. In the bathroom,

glass block and concrete luster are installed for air and lighting. To save water is done by using a tap that uses a tap that only releases water in a certain volume.

c. Improved health and comfort

A house with the concept of blending with the environment will be very good for maximum acquisition of sunlight and fresh air. This can be done by providing space for plants and open areas before designing the spaces in the house. Sanitation arrangements must also be considered in building environmentally friendly houses. In the research environment, clean water sources came from PDAM (Regional Drinking Water Company). Meanwhile, for dirty water, it is necessary to plan the drain. Dirty water is distinguished into:

- 1) Rainwater drains
- 2) Open, located under the roof channel and must be able to drain rainwater into the environmental rainwater channel with a slope of at least 2%.
- 3) The drains used for bathing and washing open and flow into environmental channels.
- 4) Dirty water channels from closed latrines are channelled to cubluks or septic tanks and then the liquid has flowed into infiltration or filtration wells which can then be discharged into existing water bodies (rivers and others).
- 5) Garbage must be disposed of in its place because if disposed of carelessly it can damage the environment, and clog waterways that can cause flooding. In addition, it can be sorted by sorting organic and inorganic waste, after which waste processing is carried out as needed. In each house, 2 trash cans have been provided, and later this waste will be distributed to the landfill every 2 times a week by appointed officers.

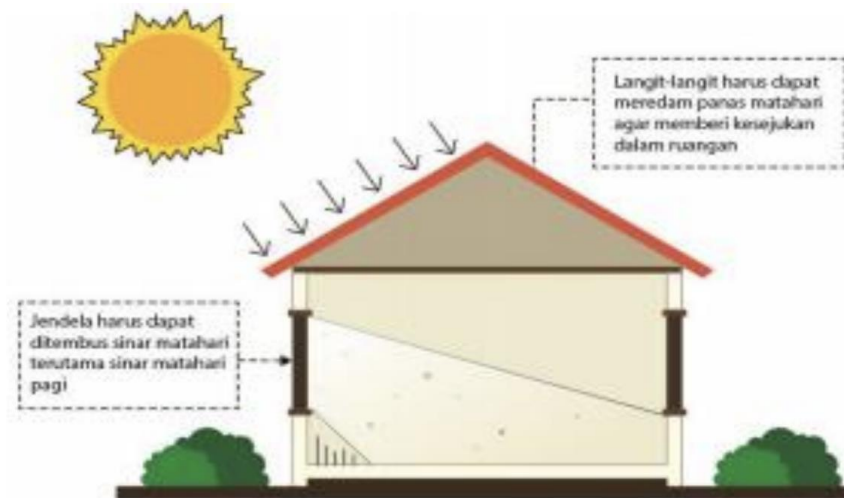


Figure 4. Sunlight circulation

d. Selection of materials that are environmentally friendly and have a long life cycle

Residential materials that can be modified as part of the selection of environmentally friendly materials are:

- 1) The use of brick material as a wall covering is replaced with brick material. This is with the aim that the conditions inside the house remain cool even though it is hot outside considering the Kutuh area is a limestone hill. The ability of bricks to absorb heat is the focus of the selection of environmentally friendly materials. In addition, if applied using exposed bricks, the building does not need to be finished with plaster, aci and paint. In addition to natural bricks, other wall covering materials that can be used are fabricated bricks (lightweight bricks) that have the characteristics of fire resistance, are strong against high pressure, low water absorption, soundproof, and absorb solar heat significantly.
- 2) The use of mild steel and aluminium for the main building frame and roof began to be carried out as a substitute for wood material. The circulation of the issue of illegal logging due to uncontrolled logging of forests has placed wooden buildings that began to decrease as a form of concern for the preservation of the earth. Mild steel can be selected based on several levels of quality depending on the raw material. Steel roofs and building frames have the advantages of being stronger, anti-rust, anti-porous, anti-termite,

- flexible, easy to install, and lighter so that they do not burden construction and foundations, and can be installed with architectural design calculations and civil engineering calculations.
- 3) The use of solid wood materials such as frames, door leaves and furniture is replaced by using modified engineering wood. As the name suggests, this material is a combination of scrap wood with plastic and other materials. Together with other materials, these scrap pieces of wood are pressed and glued together until they glue firmly. When compared to wood, this material is certainly more sustainable. Maintenance is also easier than real wood care. Wood composites are made to overcome weaknesses in wood such as being easily eaten by termites and fungi. This composite material is claimed to be more resistant to weather and has almost the same strength as some types of real wood.
  - 4) The use of scaffolding from bamboo or ribs is replaced by renting steel scaffolding so that it does not cause waste.
  - 5) Ceramic floor covering with a size of 40 x 40 cm in the entire room. Ceramic fragments can be installed on the kitchen wall that is installed randomly and neatly.

### 3.3 Construction cost planning

Cost Budget Plan Recapitulation Building price recapitulation is part of the calculation of the building cost budget plan which serves to recap the results of the unit price analysis calculation so that it is easy to read and understand (Uğur & Leblebici, 2018; Baloi & Price, 2003). Before making a recapitulation of building prices, the price of each work item is first calculated. Based on the design with the adopted concept, the construction cost is further calculated (Sutapa et al., 2022).

Table 1  
Development cost budget details

No	Job Description	Total Price
1	Preparatory Work	IDR 1.420.000
2	Earthworks and sand works	IDR 4.000.000
3	Foundation Work	IDR 8.200.000
4	Concrete Works	IDR 9.500.000
5	Wall Work	IDR 30.300.000
6	Roof Work	IDR 24.000.000
7	Floor and Wall Ceiling Work	IDR 16.300.000
8	Sills Work	IDR 22.800.000
9	Electrical Works	IDR 5.000.000
10	Sanitair Works	IDR 14.500.000
11	Painting work	IDR 8.500.000
12	Carport work	IDR 3.480.000
	Total (without VAT)	IDR 148.000.000

Simple residential building with type 36 m<sup>2</sup>, has a scope of structural, architectural, and MEP work. The unit price analysis used in this study refers to the field analysis of developer contractors. Based on the results of the analysis of the calculation of development costs according to the adopted design, a total cost of IDR 148,000,000 without VAT was obtained.

### 3.4 Operational cost planning

The operational costs of residential houses sometimes suck up quite a lot of household finances which can make residents confused about handling them. Routine expenses for electricity, water, and telecommunications are often out of account due to wasteful use. The house model determines the amount of operational costs, one-story houses are more efficient in operational and maintenance costs compared to two-story houses. Interior design that is modelled with lighting games will also require greater operational and maintenance costs. However, we cannot limit people from building houses on more than one floor or limit them to choosing a simple house model because it depends on the tastes and financial condition of the owner, but how to arrange a residential house to effectively use



energy, water, and others. In addition, not a few residents want to save money but do not have an effective strategy to reduce household operational costs. Therefore, this paper will discuss various strategies to reduce operational costs and routine housing shopping. In addition, operational costs can be reduced (Syamsidarti & Rahim, 2017). In this study, what is included in building operational costs are house maintenance costs, electricity and water costs, garbage collection costs, and community dues. The cost details are as follows:

1. Home Maintenance Costs

Building maintenance is usually carried out for a long time, for example, 1 year after the building is occupied. For residential houses maintenance is carried out on wall paint items, water taps, lamps, and garden maintenance. The assumption in this study is that maintenance is carried out within 1 year.

Table 2  
Home maintenance costs

No	Job Description	Volume	Unit	Unit Price (IDR)	Total (IDR)
1	Exterior wall paint repair	25	m2	55.000	1.375.000
2	Replacement of kitchen and bathroom faucets	2	set	50.000	100.000
3	Replacement lamp	6	nos	50.000	300.000
4	Garden maintenance	1	Ls	300.000	300.000
	Total				2.075.000

The total cost of this maintenance is calculated for 1 year. So if converted per month to IDR 172,917

a) Electricity Cost

Electricity in residential houses in existing conditions in 1 month is IDR 400,000, with facilities of 1 AC that are turned on for an average of 18 hours, 1 refrigerator unit, 1 dispenser unit, 1 washing machine unit, 1 TV, iron 4 times a month, 6 pieces of 15-watt lamps. Through a modified design with the addition of loster, and garden lights with a solar-cell system, electricity costs are obtained assuming the air conditioner is used at night from 18.00 to 06.00 for 12 hours. Because there is already a loster, the lamp is expected not to always be turned on, only when necessary. With this condition, it is expected to save electricity costs by 50% so that electricity costs become IDR 200,000 every month.

b) Water Cost

In existing conditions, the average monthly water cost is IDR 200,000 which is used for bathing, washing clothes, cooking, watering plants, and filling water reservoirs. This condition is a little difficult to save because no area can be used to collect rainwater. Savings can be made by choosing a water faucet that dispenses water in a diffuse manner, rather than centrally. With this modification, the assumption can be saved by 10% so that it becomes IDR 180,000 every month.

c) Garbage Collection Fees and Dues

The amount of waste costs has been determined following BUMDES regulations, which is IDR 50,000 every month. Likewise, the contribution value has been set at IDR 100,000 every month.

Table 3  
Residential operating costs

No	Description	Cost
1	Home maintenance	172.917
2	Electricity	200.000
3	Water	180.000
4	Garbage Collection Fees and Dues	100.000
	Total	652.916

Based on the results of the analysis, it was found that the operational cost of buildings designed using environmentally friendly concepts in one month was IDR 652,916.

## 4 Conclusion

Based on the environmentally friendly design chosen are (a) Arrangement and use of land, (b) Saving energy resources (electricity and water), (c) Improving health and comfort, (d) Selection of materials that are environmentally friendly and have a long life cycle. Construction costs IDR 148,000,000 without VAT, and operational costs IDR 652,916.

### *Conflict of interest statement*

The authors declared that they have no competing interests.

### *Statement of authorship*

The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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