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Optimizing Energy Use in Traditional House *Bantayo Poboide* Using Sefaira Simulation

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ABSTRACT
This study aims to determine the optimization of energy use in *Bantayo Poboide*, a traditional house in Gorontalo, Indonesia, which in term of architecture, has been constructed considering the tropical condition of Indonesia. The method used is optimization using softscape and hardscape with Sefaira simulation. Before optimization, the overall energy use is 163 kWh/m^2/yr, with cooling energy reaches 712964 kWh/yr. The simulation improved the energy use, by applying shade in softscape and hardscape, with percentage reduction of 50% from each side of the building. The cooling energy lessens up to 109809 kWh/yr as well as improvement in well lit, over lit, and under lit, to reach the EUI of the building up to 79 kWh/m^2/yr.

Keywords: Energy use optimization, EUI optimization, Bantayo Poboide, Sefaira simulation.

1. INTRODUCTION

"*Arsitektur Nusantara*" or archipelago architecture is a concept of local-based architecture in Indonesia considering its tropical condition. The concept of the building is proven over the years is the solution to the problem of climate tropics that occurred in the area of the archipelago. Limboto City, for example, is humid; temperature averagely 18°C - 28°C with high sun intensity and humidity. One of the goals in designing by using Architecture Tropical is making room to save the use of energy in buildings [1].

Reducing energy use can be achieved through a variety of methods, such as understanding the building typology, the facade of the building that responds to sunlight, the area that can provide a microclimate, the use of energy-saving technology, a hairdressing room, and the use of materials, among others. Thus, the traditional house is constructed to quite large and has wooden construction which is known locally as *Bantayo Poboide*.

To reduce the use of energy can be done by several means, including processing of forms typology of the building, the facade of the building that responds to light the sun, the area that can provide a climate Micro, the use of technology saving energy, a hairdressing room, use of materials and other others can be arranged to give the influence to reduce energy use. One of the

buildings with very large energy use of the house, so it needs to pay more attention to a design [2].

There are several researchers publishing the results of their studies on thermal performance and thermal comfort in several traditional housing types in Indonesia. Among them are studied by Sangkertadi and Tungka [3], Harimu [4], Fitriaty et al. [5], Juhana [6], Riyanto [7]. All of which resulted in the conclusion that resembles, in which time during the day is always there the situation is not comfortable in a few hours, especially in the summer heat (dry). Factor the gusts of wind in the body becomes important for efforts to increase a sense of comfort thermal in the area temperate tropical humid, through its role to support the process of evaporation of sweat humans [8]. Designing a building is always necessary considerations, among other needs of space, comfort room, the wishes of the owner of the building, and response to the environment. Placement of the building can create comfort are desirable. Based on the writings Lippsmeier contained meaning, that the placement of the building is "right", likely to acquire the temperature of the air which is low to some degree, compared to when placing "not right" [9]. Placement of the building in question includes: placement of the sun, the placement of the wind, the adjustment of the building houses regarding the shape plans and construction, as well as the selection of materials that are appropriate [10]. In addition to the

need to note also the orientation of the building which encourages their chances of system ventilation cross.

The design of the house of traditional archipelago using the approach of the concept of the wisdom of the local archipelago as the contribution from humans to optimize the use of the thermal that exist in the building. Optimizing thermal usage will reduce usage and operational costs in buildings. Then by reducing costs, it also increases user productivity in it so that it can become a healthy work environment.

The transfer of heat to the buildings in the area tropics, especially that applying the system of passive and rely on the system of ventilation naturally, in addition to depending on the type of material sheathing of the building, also depends on the discharge vent. The modes of heat transfer through conduction, convection, and radiation also apply. Use of the material timber on elements of walls can reduce the "thermal mass" (the process of conduction) compared with the use of materials of concrete or brick, so that when the night the day is no release of heat from the wall into the room. As some of the data results of the study more, that "time lag" storage of heat on a board of wood for wall home wood is for about 1.6 hours [11].

2. METHODS

Performance-Based Design (PBD) is a design of a building that considers the performance of the building. PBD is a process that is repeated, by way of judging in the sustainability of how the performance of a building, what that became a factor performance of the building, and how to affect the performance of the building to achieve the goal that much better.

Sefaira is a Performance-Based Design application, a plugin extension with the SketchUp/Revit modeling application which functions to analyze and simulate the level of energy use of buildings through analysis of building envelopes and building forms. Before conducting a building analysis, it is important to select the type of building that will be used as the object of study.

The advantage of Sefaira is the use of an application that is quite easy and simple. Using Sefaira by using an internet connection is enough to prepare the building design and its zoning so that the data can be read by Sefaira. Interest sefaira is to create a model of conceptual, with the shape of the geometry that is simple with the intent to carry out the analysis of energy effectively. Sefaira reads the geometry concept to be analyzed, with a simple representative so that it provides an overview of thermal transmittance.

The location of the study object is planned in the Limboto District, Gorontalo District" Gorontalo Province, Indonesia, to be precise in the Limboto city

center area. The total area of the site which is the concept of a cultural park area of 5000 m², the surroundings is in the district central office area. For site conditions, have tree vegetation as shade trees to reduce solar radiation that leads to the north side of the building.

Figure 1 Front view of *Bantayo Poboide*.

3. FINDINGS AND DISCUSSION

3.1. Energy Analysis

Table 1 shows the energy use as a result of energy use projection by electronic per meter square (Equipment Dominated), amount of energy used in the building (EUI), percentage of light enters the building (Mostly Lit), and energy use of cooling system on parts of building that caused energy released and energy needed because of exposure to sun rays, the leak of the building, and the conduction of the glass element.

Table 1. Existing condition

Indicator (Unit)	Existing Condition
Total Area Floor (m²)	2,264
Energy Use Intensity/EUI (kWh/m²/yr)	162
Equipment Dominated (kWh/yr)	
Heating:	0
Cooling :	159193
Lighting :	46993
Equipment :	117482
Fans :	428929
Pumps	0

EUI in Table 2 shows that the overall energy used is 162kWh/m²/yr, while based on Sefaira guideline, the energy use in the office or public buildings is up to 79 kWh /m²/yr. Hence, about 83 kWh/m²/yr amount of energy needs to be trimmed. Based on Table 2, the amount of energy that dominates is in equipment at 117482 kWh/yr, followed by cooling at 46993 kWh/yr. This means the value is greater than the energy used for

Lighting and Fans. Reduce the amount of glass on the facade, offer shading, or vary the coefficient of the window to achieve good window performance are alternatives to reducing the burden on the cooling system.

Table 2. Energy audit results with **Sefaira**. The superscript signs described as: "G" is gains, "L" is losses, "C" is cooling, "H" is heating

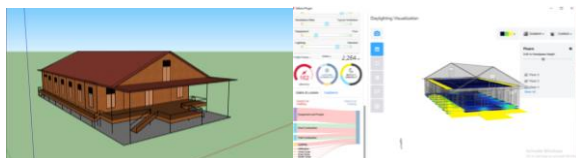| Indicator (Unit)	Value
Mostly Lit (%)	
Under Lit :	53
Well Lit :	21
Over Lit :	27
East Solar (kWh/yr)	2748 [G] 0 [L]
West Solar (kWh/yr)	3456 [GC]
North Solar (kWh/yr)	779 [GC]
South Solar (kWh/yr)	1296 [G] 0 [L]
Glazing Conduction (kWh/yr)	2398 [G] 470 [L]
Wall Conduction (kWh/yr)	28767 [L] 42870 [G]
Roof Conduction (kWh/yr)	53435 [L] 72060 [G]
Floor Conduction (kWh/yr)	1645 [L] 888 [G]
Infiltration (kWh/yr)	9620 [L] 3 [G]
HVAC Cooling (kWh/yr)	359,313 [L] 84,319 [G]

Figure 2 Existing simulation.

3.2. Mitigation Strategy

Mitigation is dependent on the elements of the building that have a significant impact on the building's performance, and accepted only the least damaging strategy. Table 3 shows the elements of the building and the acceptable strategies to increase the performance of the building. The following are design recommendations for buildings that have been analyzed.
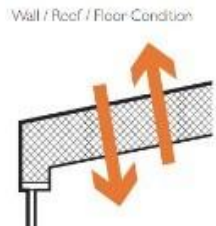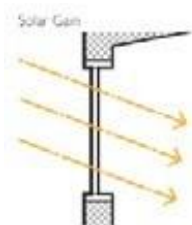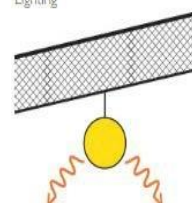
Table 3. Design strategy
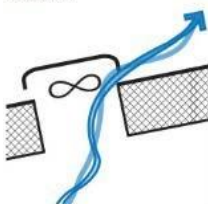
Building Aspects	Design Recommendations
Wall / Roof / Floor Condition	• Reduce (the shape of the building should be denser, smaller, and simpler) • Increase level insulation (change the R-Value or U-Factor)
Glazing Conduction	• Reduce the opening wide area • Improve the material and opening insulation
Solar Gain	• reduce opening area openings that facing the sun • Add shading • Increase the glass layer setting (reduce the solar heat gain coefficient)
Lighting	• Establish lighting that is efficient (reduce lighting power density) • Consider lighting daylight with light control with a passive design

Table 4. Synthesis of design recommendations

Ventilation	Reduce the ventilation ratio (if appropriate, the ventilation ratio is determined from code requirements especially from the direction of the sun's radiation
Glass (AVG)	• Reduce the aperture area (especially on the facade exposed to the sun) • Adding shade or shading in the form of vegetation

This synthesis will then be applied to Gorontalo traditional buildings based on the recommendations given. It should be noted that not all recommendations can be applied; this is because the adjustment of the design to the resulting analysis will affect the application of recommendations in buildings.

3.3. Result of Simulation

In Figure 3, visible changes occur in the mass of the building. There is a shade on each side of the building. Application of 3-meter wide is intended to reduce the radiation that is exposed through the window.

Besides, the adjustment of the application of shade on the side of the building is influenced by the duration of the sun. In Table burden of energy is borne by the building through the West and East high compared with the North and the South. However, on the side of the North and the South is the side that is affected by the direct rays of the sun in at 10 AM until 2 PM. This is the peak highs of radiation the sun so that the application of shade on the building is done on each side.

Figure 3 Visible changes occur in the mass of the building.

Table 5. Variable analysis of buildings in Sefaira (with changes)

Indicator (Unit)	Energy Standards	Change in Energy Standards
HVAC Type	VAV – Return Air Package (System 5/6)	VAV – Return Air Package (System 5/6)
Baseline	ASHRAE 90.1 – 2013	ASHRAE 90.1 – 2013
ASHRAE Climate Zone	2	2
Wall Insulation	0.73	0.10

Indicator (Unit)	Energy Standards	Change in Energy Standards
W/(m²K)		
Floor Insulation W/(m²K)	0.63	0.10
Roof Insulation (W/(m²K))	0.25	0.10
Glazing U- Factor (W/(m²K))	2.28	0.10
Visible Light Transmittance (%)	42	100
Solar Heat Gain Coefficient (SHGC)	0.25	0.21
Infiltration Rate (m³/m²h)	7.2	1
Ventilation Rate (L/S)	15	0
Equipment (W/m²)	24.9	15
Lighting (W/m²)	10.1	6.5

Table 6 shows the comparison of the energy standard values used as a reference for analyzing energy use in buildings. The HVAC Type, Baseline, and ASHRAE Climate Zone did not change. This is because these indicators have become an application reference so it is not recommended to make changes. However, in addition to the above indicators, changes were made to provide analysis results that could reduce energy use. These indicators relate to the use of materials and material specifications that will be applied to buildings
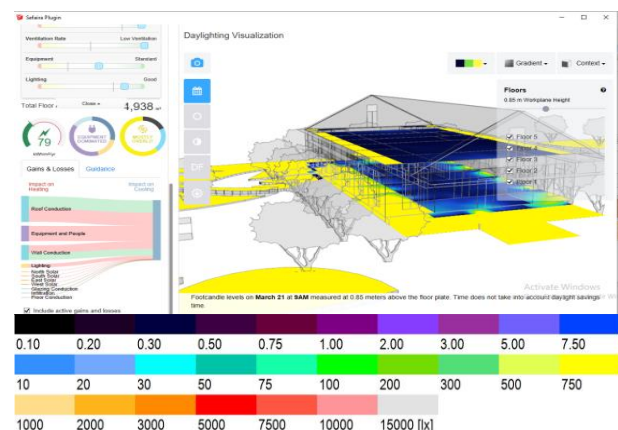

Figure 4 Details of shade on building.

Table 6. Comparison of the energy standard values used as a reference for analyzing energy use in buildings

Indicator (Unit)	Initial Value	Value Change	Information
Total Area Floor (m²)	19.240	22.851	-
Energy Use Intensity/EUI (kWh/m²/yr)	126	79	Decrease
Equipment Dominated (kWh/yr)			
Cooling :	712964	109809	
Lighting :	399461	66636	Increase
Equipment :	998652	154800	
Fans :	308259	57860	
Mostly Lit (%)			
Under Lit :	53	18	
Well Lit :	21	20	Increase
Over Lit :	27	62	
East Solar (kWh/yr)	2748 ^{G} / 0 ^{L}	1798 ^{G} / 0 ^{L}	Decrease
West Solar (kWh/yr)	3456 ^{G} / 0 ^{L}	2341 ^{G} / 0 ^{L}	Decrease
North Solar (kWh/yr)	779 ^{G} / 0 ^{L}	585 ^{G} / 0 ^{L}	Decrease
South Solar (kWh/yr)	1296 ^{G} / 0 ^{L}	897 ^{G} / 0 ^{L}	Decrease
Glazing Conduction (kWh/yr)	2398 ^{G} / 470 ^{L}	377 ^{L} / 1979 ^{G}	Decrease
Wall Conduction (kWh/yr)	28767 ^{L} / 42870 ^{G}	131.142 ^{L} / 142.473 ^{G}	Increase
Roof Conduction (kWh/yr)	53435 ^{L} / 72060 ^{G}	228.367 ^{L} / 250.351 ^{G}	Decrease
Floor Conduction (kWh/yr)	1645 ^{L} / 888 ^{G}	60 ^{L} / 243 ^{G}	Increase
Infiltration (kWh/yr)	9620 ^{L} / 3 ^{G}	9 ^{L} / 4672 ^{G}	Increase
VAC Heating (kWh/yr)	359.313 ^{L} / 84.319 ^{G}	754.894 ^{L} / 360.225 ^{G}	Increase

The after being analyzed, the resulting data in Table 5 shows a significant change. The EUI generated by the building reaches 79 kWh/m2/yr, significantly reduced from the previous analysis of 163 kWh/m2/yr. The change in the Total Area Floor is due to the application of shade on the side of the building and the addition of the garden landscape. The use of energy loads on cooling has experienced a good change, reduced to reach 109809 kWh / yr from the previous 712964 kWh / yr.

The application of shade in the form of soft scape and hardscape has benefits that affect energy use in buildings. Direct sun exposure is resisted by shade. Radiation that should go through the windows directly can be resisted by the shade and absorbed by the surrounding trees, reducing the effects of radiation. Based on the data in Table 5, well-lit in the building area decreased from 21% to 20%, Over lit increased from 27% to 62%, under-lit decreased by 53% from 18%. So that the light that enters the building is a greater percentage. For each side of the building, it succeeded in reducing the energy load from applying shade and changing the indicator value on the application. Percentage reduction of 50% from each side of the building. All of this is of course the basis so that the EUI of this building can reach 79 kWh/m²/yr from the energy use limit set at 79 kWh/m2/yr.

4. CONCLUSION

The results of the simulation showed that before doing the optimization, the energy that is used as a whole amounted to 162 kWh/m2/yr. Having conducted the optimization of the form of the application of shade in the form of soft scape and hardscape has benefits that affect the use of energy in buildings. Percentage reduction of 50% from each side of the building. All of this must be the basis of so EUI building it can reach 79 kWh/m2/yr of limits the use of energy is set at 79 kWh/m2/yr.

Changes in layout and building materials affect the level of thermal radiation in the building. In the context of saving energy, the passive design must be responsive to the climate. Several cases of the traditional ancestral houses of the archipelago have works that are adaptive to the changes in their surroundings. For example, our ancestors already understood the concept of air movement. The movement of air and the architectural side is the basis for the development of the local archipelago house design concept. As a nation that has a history and relies on science, technology, norm and values, we should be able to protect the legacy of our ancestors that has proven their ability to adapt to the climate of the archipelago. Therefore, collaborative research is needed in the development of Indonesian homes following our identity by the times.

ACKNOWLEDGMENTS

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