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# Energy Efficiency Analysis of Green Building in the Construction of Anutapura Hospital Building, Palu, Indonesia

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***Abstract***
*The Anutapura Palu Hospital Reconstruction Project was designed to implement the Green Building principle which aims for the efficiency of energy used. This study was conducted to determine what factors affect the target of fulfilling the green building energy efficiency performance criteria and how the implementation of the green building energy efficiency performance criteria is carried out. The analysis method used refers to government regulations and direct observation of the research object. The results of the study indicate that there are 7 (seven) aspects that affect the energy efficiency performance criteria with a total of 46 points, but in the Anutapura Palu Hospital Reconstruction Project only 26 points can be achieved. The implementation of the energy efficiency performance criteria is influenced by several things, including the habits of building users, limited human resources for building managers and poor maintenance. The implementation of energy efficiency performance criteria is greatly influenced by non-technical factors such as user habits, limited human resources and lack of equipment maintenance*

***Keywords:*** *Green Building, Energy, Efficiency, Hospital*

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## I. INTRODUCTION

Buildings in general consume 40 percent of the electrical energy produced and contribute around 30 percent of carbon dioxide emissions .[1], [2]This condition is because almost 90 (ninety) percent of human life is spent in buildings that directly require energy resources[3], [4] to regulate indoor air conditions and lighting energy sources, utilization of water resources, material resources and other energy resources so that buildings have an important role in maintaining the balance of nature conservation[5].

Palu City experienced a disaster on September 28, 2018, resulting in damage to existing infrastructure. The AMC (Anutapura Medical Center) building of Anutapura Hospital was one of the buildings that was severely damaged and had to be reconstructed. With the vision of Build Back Better in handling Rehabilitation and Reconstruction after the Central Sulawesi disaster, the reconstruction of the AMC (Anutapura Medical Center) building of Anutapura Hospital Palu as one of the vital buildings of health service facilities was designed to be a building that meets the technical standards of building reliability by implementing the principles of green building construction[6], [7] that can save consumption of energy resources, water and improve the quality of air in a comfortable room.[8]

Definition of Building is a physical structure that is the result of a construction process [7], [9], permanently located in its place, with some or all of its parts above ground, in the ground, or above water. Buildings are designed for various public functions or private use functions, such as office functions, health services, residences, religious activities, businesses, social activities, culture or other special activities [10].

BGH (Green Building) is a building that meets the Building Technical Standards and shows measurable performance in saving energy, water, and other resources (PUPR Regulation No. 21 of 2021 Chapter 1.2). This is achieved through the application of BGH principles in accordance with its function and classification at each stage of its implementation.

BGH Technical Standards are the criteria that must be met to realize BGH performance at the programming, technical planning, construction implementation, utilization, and demolition stages [11]. Building Construction Implementation is a development activity that includes technical planning and construction implementation, as well as utilization, Conservation, and Demolition activities [12].

According to the Big Indonesian Dictionary, Criteria is a measure that is the basis for assessing or determining something, while Performance is something that is achieved [13], so that the Green Building Performance Criteria is a measure that is the basis for assessing what must be achieved in implementing Green Buildings [14].

Factors influencing the implementation of green building energy efficiency [15], [16], Energy consumption in buildings can be influenced by several things, including technical and non-technical factor [9], [17], [18] s. Technical factors that influence the achievement of energy efficiency in the implementation of green buildings include:

- Building façade
- Types of materials used in building construction
- Ventilation system
- Air conditioning system
- Lighting system
- In-building transportation system
- Electrical system

Apart from technical factor [16], [19]s, efforts to make energy consumption efficient in buildings are also influenced by non-technical factors, including: Lack of maintenance of building equipment such as air conditioning equipment, lighting system equipment, transportation equipment in the building and other equipment. Habits of building users, both residents and visitors. Inappropriate use of equipment in building construction [20], [21].

Green Building Assessment CriteriaReferring to the Regulation of the Minister of Public Housing and People's Settlements of the Republic of Indonesia Number 21 of 2021, the Efficiency Criteria is very important because in the total number of points available in the implementation of green buildings, there are 46 significant points out of a total of 165 points or 27.88 percent [22], [23].

## II. RESEARCH METHODS

Collection techniques in this study are divided into two, namely primary data collection techniques such as conducting field surveys around the research location of the AMC Building, Anutapura Hospital, Palu and conducting interviews with related parties, the data of which will then be collected and analyzed, and secondary data collection techniques, namely by collecting data from related agencies which aim to determine the parameters that will be used in this study, especially in the process of data analysis and processing.[24], [25]

Research Instruments, according, a research instrument is a data collection tool used to measure and assess natural and social phenomena that are observed. In this study, the process of collecting and processing data carried out by researchers used several methods. instruments which include the following:

- Green Building Performance Rating Tools
- Dialux software for analyzing lighting
- Autocad software functions to analyze technical planning data.
- Energy efficiency calculation worksheet

Green building performance analysis techniques on energy efficiency criteria.

- Collecting primary data and secondary research data
- Conducting technical data analysis for AMC building planning
- Conducting analysis of each Green Building performance parameter with supporting documents on energy efficiency criteria.

Referring to the Regulation of the Minister of Public Housing and People's Settlements of the Republic of Indonesia Number 21 of 2021, the Efficiency Criteria is something that is very important because in the total number of points available in the implementation of green buildings, there are points that...

OTTV Calculation
OTTV Equation:

$$OTTV=\alpha\ [U_w.\ (1-WWR).\ T_{dek}] +U_f.\ WWR.\ \Delta T+SC.\ WWR.\ SF$$

OTTV entire outer wall:

$$OTTV= ((A_{o1}.\ OTTV_1) + (A_{o2}.\ OTTV_2) +\cdots (A_{oi}.\ OTTV_i))/ (A_{o1}+A_{o2}+\cdots+A_{oi})$$

Information:

A_o : Facade wall area (m 2)

α : Absorbance of solar radiation
U_w : Massive wall thermal transmittance (W/m 2.K)
U_f : Thermal transmittance penetration (W/m 2. K)
WWR : Ratio of window area (A_f) to facade area (A_w) at a specified orientation)
T_dek : Equivalent temperature difference (K)
SF : Solar radiation factor (W/m 2)
SC : Shading coefficient of the fenestration system
ΔT : Difference in temperature between the outside and inside of the building
RTTV Calculation

*RTTV* = Through Massive Walls + Conduction Through Enetration + Radiation through penetration
RTTV= (α [A_r. U_r. T dek] +A_s. U_f. ΔT+A_s. SC. SF)/A_o

Information:
A_o : Facade wall area (m 2)
A_r : Area of non-transparent roof (m 2)
A_s : Skylight area (m 2)
U_r : Massive wall thermal transmittance (W/m 2. K)
U_s : Thermal transmittance of fenestration (skylight) (W / m2.K)
SF : 400 (Based on SNI6389:2020)

significant as many as 46 points from a total of 165 points or 27.88 percent

## III. RESULTS AND DISCUSSION

Buildings in general consume 40 percent of the electrical energy produced and contribute around 30 percent of carbon dioxide emissions .[1], [2]This condition is because almost 90 (ninety) percent of human life is spent in buildings that directly require energy resources[3], [4] to regulate indoor air conditions and lighting energy sources, utilization of water resources, material resources and other energy resources so that buildings have an important role in maintaining the balance of nature conservation[5].

The assessment of green building performance criteria refers to PUPR Regulation Number 21 of 2021 which is further described in the technical instructions for assessment in the Circular of the Minister of PUPR No. 2 of 2022. There are 7 (seven) green building performance criteria that must be assessed, but in this study, the analysis of the performance criteria assessment carried out was limited to the criteria for energy efficiency with the analysis results in accordance with the following table 1

Observation Results on the Implementation of Green Building Energy Efficiency Performance Criteria Building envelope.The AMC building of Anutapura Hospital has engineered the building envelope using lightweight brick or hebel wall materials and dark blue panasap glass materials which aim to reduce the heat energy from the sun entering the building.In addition, the width of the window openings in the building is designed to be as efficient as possible to maintain the entry of natural light and minimize the incoming temperature.

Ventilation System, in rooms that are not air conditioned (no air conditioning installed), engineering is carried out by installing mechanical ventilation to maintain comfortable air exchange in the room and maintain a comfortable temperature.

Air Conditioning System, to maintain comfortable indoor temperatures, the air conditioning in the AMC building of Anutapura Hospital is designed using a VRV type cassette AC with a temperature output of 25 0 C + 1 and a relative indoor humidity of 60% + 10.

The air conditioning equipment used does not comply with SNI 6390:2020 as regulated in PUPR Ministerial Regulation No. 20 of 2021 to achieve the energy efficiency criteria points for green buildings.

Lighting system settings in the AMC building of Anutapura Hospital The artificial lighting system in the room does not yet have maximum power and is in accordance with SNI 6197:2020 but maximizes lighting output in accordance with SNI 6197:2020. In the AMC building, Anutapura Hospital also made efforts to make energy efficient for lighting by placing one switch in a room smaller than 30 m2. The AMC building of Anutapura Hospital does not install occupant sensors/lighting controllers in rooms with certain functions as required in SNI 6197:2020

For natural lighting, the AMC building has not implemented separate lamp grouping for areas that do not receive natural light and has not used a light intensity sensor (lux) that can regulate the lighting according to the standard lighting level.Transportation System in Building, to support user mobility in the AMC building, Anutapura Hospital does not use escalators but uses 6 (six) elevator units that are divided into 2 (two) units for

patient lifts, 2 (two) units for visitor lifts and 2 (two) units for service lifts. Although in its design it does not calculate lift traffic analysis according to SNI 03-6573-2001, the type of lift that uses Variable Voltage Variable Frequency (VVVF) technology and uses slow motion or on/off automatic technology.

Electrical System,the source of electrical energy utilizes the electricity supply from the State Electricity Company (PLN) with a backup supply from a diesel-fueled generator and has not utilized renewable sources of electrical energy.In the AMC building of Anutapura Hospital, electrical loads are grouped and each has a kWh meter, and an electrical energy submeter is available for the main power source greater than 100kVa and also separates each installation such as separate air conditioning installations with lighting installations and health equipment installations.

**Table 1**. building energy efficiency performance criteria points.

| No | BGH Energy Efficiency Performance Criteria | Value Acquisition | | |
|---|---|---|---|---|
| | | Value available | Percentage | Value Achieved |
| 1 | Building Envelope | 9 | 19.57% | 9 |
| 2 | Ventilation System | 3 | 6.52% | 3 |
| 3 | Air Conditioning System | 7 | 15.22% | 2 |
| 4 | Lighting System | 12 | 26.09% | 2 |
| 5 | Transportation System in Building | 3 | 6.52% | 2 |
| 6 | Energy Efficiency Calculation | 5 | 10.87% | 3 |
| 7 | Electrical System | 7 | 15.22% | 5 |
| | Total Value | 46 | 100.00% | 9 |

Taking into account the targeted BGH (Green Building) ranking target and analysis of the fulfillment of criteria for each BGH Performance Criteria, here we present a summary of the criteria & values proposed for:

Table 2 BGH Performance Fulfillment Targets for Each Criteria

| BGH PERFORMANCE CRITERIA | | VALUE OBTAINMENT | | |
|---|---|---|---|---|
| | | Available Values | Values Taken | Percentage |
| [ BGH A ] | SITE MANAGEMENT | 38 | 15 | 39.47% |
| [ BGH A ] | ENERGY USE EFFICIENCY | 46 | 26 | 56.52% |
| [ BGH C ] | EFFICIENCY OF WATER USE | 22 | 18 | 81.82% |
| [ BGH D ] | INDOOR AIR QUALITY | 19 | 8 | 42.11% |
| [ BGH E ] | ENVIRONMENTALLY FRIENDLY MATERIALS | 21 | 13 | 61.90% |
| [ BGH F ] | WASTE MANAGEMENT | 7 | 5 | 71.43% |

| | | | | |
|---|---|---|---|---|
| [ BGH G ] | WASTE WATER MANAGEMENT | 12 | 8 | 66.67% |
| | Total Maximum Overall Value | **165** | **93** | 56.36% |

Factors influencing the target of fulfilling the green building criteria in the AMC Anutapura Hospital Building Development project for energy efficiency criteria in the assessment of energy efficiency performance criteria at the technical planning stage, there are 7 (seven) aspects that affect the target achievement of the points obtained. Of the 7 aspects, there are 46 points available, while the points claimed are 26 points, there is a difference of 20 points that should still be claimed. Some criteria that are not claimed against the available points include:

**Table 2.** Assessment Of Energy Efficiency Performance Criteria

| Benchmarks | Performance criteria | | Value available | Value in claim | Reason |
|---|---|---|---|---|---|
| | Air Conditioning System Criteria | | | | |
| Benchmarks | 3b | kW/TR or COP of air conditioning equipment in accordance with SNI 6390:2020 or the latest edition.<br>*Notes:*<br>If the building is planned not to use an air conditioning system, it will get full marks. | 5 | 0 | Air conditioning equipment in AMC buildings requires special specifications so that the specified kW/TR is not met. |
| | | | | | |
| | 2. Lighting System Criteria | | | | |
| Benchmarks | 4a1 | The artificial lighting system for the room is planned to have maximum power and lighting levels in accordance with SNI 6197:2020 or the latest edition. | 2 | 0 | The lights used in the AMC building do not yet use lights that have the power according to SNI 6197:2020 |
| | 4a3 | Use of occupancy sensors/lighting controllers in spaces with specific functions as required in SNI 6197:2020 or the latest edition | 2 | 0 | The use of sensors can increase the cost of building AMC construction so this point is not claimed. |
| | 4b1 | Areas that receive natural lighting according to standards have separate lamp groups from areas that do not receive natural light. | 4 | 0 | The rooms in the AMC building do not separate artificial lighting and natural lighting. |
| | 4b2 | Areas that receive natural lighting according to standards are equipped with light intensity sensors (lux) that can regulate the lighting according to the standard lighting level. | | | The use of lux meter sensors can increase the cost of building AMC buildings so this point is not claimed. |
| | | | | | |
| Benchmarks | Criteria for indoor transportation systems | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | 5a | Lift traffic analysis calculations according to SNI 03-6573-2001 or the latest edition. | 1 | 0 | The use of lifts in the AMC building does not meet the traffic analysis standards according to existing SNI |
| | | | | | |
| Benchmarks | 7. Electrical system criteria | | | | |
| | 7c | There are plans to utilize electrical energy sources from renewable energy sources. | 2 | 0 | In the AMC building construction project, electrical energy from renewable sources is not used. |

Implementation of green building energy efficiency criteria for the AMC building of Anutapura Hospital.The implementation of the green building energy efficiency criteria in the AMC building of Anutapura Hospital is expected to be achieved optimally, but there are still several non-technical obstacles that cause the expected energy efficiency not to be achieved, including Ventilation System, the comfort of temperature and air exchange in a room with mechanical ventilation is disturbed by the habit of building users who smoke in the room, such as smoking on the emergency stairs and other places.

Air Conditioning System, the reduced achievement of energy efficiency in air conditioning criteria is caused by the habits of building users who do not turn off the AC in rooms that are not used at certain times and the lack of routine maintenance from building managers for existing air conditioning equipment.

Lighting system, he habit of building managers and users of not turning off the lights when the room is no longer in use at certain times can reduce the achievement of energy efficiency in green buildings. Electrical system In the AMC building, Anutapura Hospital uses Building Automation system technology which is expected to help monitor and manage several existing electrical equipment, but the limited human resources available to manage it have resulted in the target of achieving energy efficiency being reduced.

## IV. CONCLUSION

There are 7 factors that affect the target of achieving the performance criteria for green building energy efficiency that must be assessed with a total of 46 points available with the highest point in the lighting system aspect of 12 points or 26.09 percent. In the AMC Building Development project of Anutapura Hospital, 26 points or 56.52 percent of the available points were obtained so that there were still 20 points that were not achieved, this was because several other points were not met and one of the causes was the increase in construction costs if they had to be met while the project contract value had been determined. The implementation of the performance criteria for green building efficiency in the AMC building of Anutapura Hospital is still not optimal due to non-technical factors such as limited human resources for building managers for the operation and maintenance of existing equipment and the habits of building users who do not understand the purpose of green building energy efficiency.

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