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Thermal Comfort Level Analysis to Support Energy Efficiency Based on Building Information Modeling (BIM) (Case Study of Fajar University Postgraduate Building)

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ABSTRACT

Indonesia faces significant challenges regarding energy consumption in the building sector, which continues to rise alongside urbanization and economic growth. Energy use in commercial buildings, particularly office and educational facilities, significantly contributes to the national total energy consumption, with HVAC (Heating, Ventilation, and Air Conditioning) systems being a major component of building energy consumption. By modeling HVAC systems, natural lighting, and thermal insulation, Building Information Modeling (BIM) can help optimize energy usage and reduce operational costs in buildings. However, despite the proven benefits of BIM in energy analysis and thermal comfort, challenges remain in its implementation. Many construction projects still rely on traditional methods that are less effective in integrating data and analysis. Additionally, a lack of understanding about BIM usage among construction professionals also hinders the achievement of optimal energy efficiency.

Keywords: thermal, energy efficiency, building information modelling, BIM.

INTRODUCTION

Thermal comfort in buildings is one of the important aspects that affect the quality of life of its occupants. In this modern era, with increasing awareness of energy efficiency and environmental sustainability, it is important to integrate thermal comfort analysis into the building planning and design process. The application of Building Information Modeling (BIM) technology is an effective solution to achieve this goal. BIM allows designers to create detailed digital models, so they can simulate and analyze the building's thermal performance before construction is carried out.

Thermal comfort is not only related to air temperature, but also to humidity, wind speed, and the interaction between users and the building environment. Therefore, a comprehensive analysis of thermal comfort levels can help in designing buildings that are not only comfortable but also energy efficient. The Building Information Modeling (BIM)-based approach has developed rapidly as an innovative solution for modeling and simulating the thermal aspects and energy efficiency of buildings. Through BIM, architects and engineers can create thermal comfort simulations from the design stage, making it easier to analyze critical parameters that affect comfort and energy efficiency [1], [2]. BIM allows building professionals to accurately identify and improve building designs before construction begins, thus reducing errors and achieving energy optimization more easily.

Previous studies have shown that the use of BIM in building design can reduce energy use in air conditioning systems by up to 30% or more by making design adjustments to elements such as room layout, openings, and the type of materials used [2], [3]. The application of BIM in thermal comfort analysis provides significant benefits. By using BIM software, designers can simulate thermal conditions in real time, identify areas that need improvement, and evaluate various design options that can improve energy efficiency [4]-[7].

However, the majority of BIM-based research on thermal comfort and energy efficiency still focuses on buildings in subtropical and temperate climates, where weather conditions are generally more moderate. The results of these studies are not necessarily relevant to buildings in humid tropical areas such as Makassar, which have high temperatures and significant humidity throughout the year [8]-[10]. This climate condition creates a high demand for cooling energy to maintain thermal comfort, especially in educational buildings such as lecture halls, which have different energy usage characteristics compared to office or residential buildings [11]-[13]. In Indonesia, research on thermal comfort in educational buildings is still minimal, especially those integrating BIM-based approaches. In addition, research related to educational buildings in tropical climates often only includes simple observations or statistical models in analyzing thermal comfort, without utilizing the potential of BIM technology for detailed simulation. Studies that combine thermal comfort analysis and energy efficiency with BIM in educational buildings in humid tropical areas are still rare in the academic literature. This research gap indicates the need for further exploration of how BIM can be used to model, monitor, and improve thermal comfort in humid tropical buildings, so that it can provide effective design recommendations and simulations [14]-[18].

This study aims to fill this gap by analyzing the level of thermal comfort in the Fajar University Postgraduate Building, located in Makassar, using a BIM-based approach. This building was chosen as a case study because it functions as an intensive lecture hall, so it has high thermal comfort needs. The BIM-based approach in this study will allow analysis of thermal comfort conditions in various design and energy management scenarios, as well as provide an overview of the thermal behavior of buildings in humid tropical climates [19]-[21].

RESEARCH METHOD

This research methodology aims to analyze the level of thermal comfort in buildings using the Building Information Modeling (BIM) approach. This study is expected to provide insight into how building design can be optimized to improve thermal comfort while supporting energy efficiency [22]-[25].

Research Design

This study uses qualitative and quantitative descriptive methods.

Qualitative Descriptive Approach

1. Objectives
   a. Understand the factors that influence thermal comfort in buildings from the user's perspective.
   b. Collect in-depth information about occupant experiences related to thermal comfort.
2. Data Collection Methods
   a. Interviews: Conducting interviews with building occupants to gain insight into their perceptions of thermal comfort.
   b. Observations: Observing the building’s thermal conditions across time and weather conditions, and how occupants interact with the space.
   c. Case Studies: Analyzing several buildings that use BIM and how the approach improves thermal comfort.
3. Data Analysis
   a. Using thematic analysis to identify patterns and themes that emerge from interviews and observations.
   b. Comparing user experiences with BIM-generated designs to identify gaps or strengths.
4. Expected Outcomes:
   a. Deeper understanding of how building design and aspects affect thermal comfort.
   b. Recommendations for building design improvements based on user feedback.

Quantitative Descriptive Approach

1. Objectives

A quantitative descriptive approach to the analysis of thermal comfort levels in the context of Building Information Modeling (BIM) using Archicad can be done through several steps. The quantitative descriptive method aims to provide an accurate and systematic picture of thermal comfort. This study focuses on collecting numerical data that describes current conditions, without intervening or manipulating the research object.

2. Data Collection Method

a. Climate Data: Collect local climate data such as temperature, humidity, wind speed. In Archicad 27 software, this data can be downloaded in real time from the WEP (Weather Event Prediction) Map site.

b. Building Characteristics: Determine building design parameters such as orientation, door and window sizes, types of building materials, and the HVAC system used.

3. Data Analysis

a. Descriptive Statistics: Using descriptive statistical analysis to interpret data obtained from field measurements and simulations. The measurement results are compared with applicable thermal comfort standards, such as SNI or ASHRAE.

b. Simulation Evaluation: The results of the Archicad simulation should be evaluated to see the comparison between the existing conditions and the simulation results in terms of thermal comfort.

4. Quantitative Descriptive Analysis

After getting the results of the simulation:

a. Make a statistical summary of the PMV/PPD data across different rooms/building sections.

b. Analyze the average PMV/PPD values based on time of day/year to see the comfort trend.

5. Quantitative Descriptive Analysis

Use graphs or charts to show the distribution of PMV/PPD values across rooms or sections in the model. For example, a bar graph shows a comparison of the comfort levels of each room based on a certain time of year.

6. Drawing Conclusions and Design Recommendations

Based on the results of the analysis:

a. Identify which areas do not meet the thermal comfort standards according to local regulations, namely [26].

b. Provide recommendations for redesign if needed, for example replacing certain materials to be more energetically efficient.

By using both approaches, the analysis of the thermal comfort level of buildings based on BIM can provide a holistic understanding. The qualitative approach will offer in-depth insights into the user experience, while the quantitative approach will provide measurable data to support more efficient design decisions. This combination is ideal for designing buildings that are not only comfortable for their occupants but also efficient in energy use.

Research Location and Time

This research was conducted in September - November 2024 which included literature studies, data collection, data processing, data analysis using Archicad software to the preparation of research results reports. The location of the research is the Postgraduate Building of Fajar University (Unifa), Jl. Prof. Abdurrahman Basalamah No.101, Karampuang, Panakkukang District, Makassar City, South Sulawesi [27]. The geographical conditions of the city of Makassar are located between 119 ° 25 'E and 5 ° 8' S (sulselprov.go.id). Administratively, the city of Makassar consists of 15 sub-districts with an area of 175.77 km².

Measuring Thermal Comfort of Buildings Using BIM with Archicad Software.27

Measuring thermal comfort in buildings using Building Information Modeling (BIM) involves several steps integrated with simulation technology and data analysis. Here are the ways that can be done:

Initial Data Collection

In supporting this research, there are stages that are carried out, namely the collection of primary data, secondary data, and data processing using BIM Archicad.27 software, then entering data analysis, discussion and drawing conclusions.

a. Primary Data

The primary data in this study includes several things, namely;

1. Building Data:

a. Room Dimensions: Size and volume of the room to be analyzed.

b. Building Materials: Types of materials used on walls, roofs, and floors, which affect thermal insulation.
c. Building Orientation: The direction of the building to the sun, which affects sunlight exposure and indoor temperature.

2. Weather Data:
Data is obtained from the nearest weather station, including outside temperature, humidity, wind speed, and solar radiation. Including the expected minimum and maximum temperatures. This data is usually in EPW (Energy Plus Weather) format for use in the analysis. Data is obtained by downloading from EPW Map.

3. Thermal Comfort Parameters:
Operative Temperature (To): Temperature considered comfortable for occupants, usually measured in a certain range according to standards such as [26].

4. HVAC (Heating, Ventilation and Air Conditioning) System
a. System Specification: Details about the heating, ventilation and air conditioning systems used.
b. Operation Schedule: Space usage schedule to estimate cooling and heating loads based on occupant activity.

5. Energy Simulation Data
a. Energy Evaluation: Use of the energy evaluation feature in Archicad to analyze energy use from cooling and lighting systems.
b. 3D Modeling: Creation of a three-dimensional model to simulate the interaction between all of the above elements in the context of the building environment.

b. Secondary Data
a. Interviews: Conducting interviews with building occupants to gain insight into their perceptions of thermal comfort.
b. Observation: Observing the thermal conditions of the building at various times and weather conditions, as well as how occupants interact with the space.
c. Case Study: Analyzing several buildings using BIM and how the approach improves thermal comfort.

Modeling with BIM Archicad.27

a. Project Preparation
a. New Project Setup: Start by creating a new project, setting the appropriate units of measurement, scale, and coordinate system.
b. Basic Data Import: If there is topographic data or basic drawings (such as CAD), the user can import them to facilitate element placement.

b. 3D Model Creation
a. Initial Plan: The process begins with the creation of a basic plan of the building using 2D drawing tools.
b. Vertical Extrusion: Once the plan is complete, the user can extrude the walls upwards to form the building volume and generate a 3D image.

c. Model Detailing
Material & Texture Usage: Applying materials to the surface of building elements. The choice of material type greatly influences the thermal performance of a building.

d. Energy Analysis and Simulation
Conducting an energy performance analysis that helps evaluate the building's thermal performance and energy efficiency based on the design that has been made [28]-[31].

Design Recommendations

Design Intervention: Based on the results of the analysis, carry out design interventions if necessary. This can include changing materials, increasing ventilation, or adding insulated walls on the outside or inside of the building to achieve thermal comfort.

This research methodology is designed to provide a comprehensive understanding of the level of thermal comfort in buildings, as well as how BIM technology can be used to support energy efficiency. With this systematic approach, it is expected to provide a significant contribution to the design of more comfortable and sustainable buildings.

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RESULTS AND DISCUSSION

Thermal Comfort Measurement Results

Building Modeling

To conduct an analysis of the level of thermal comfort in the Postgraduate Building of Fajar University, on the third floor which functions as a lecturer and staff room and a lecture room, the building that is the object of the research must first be re-modeled virtually with the Archicad 27 software. The physical data of the object to be modeled is taken through careful field measurements and observations with the aim that the resulting model approaches the actual form and specifications. The following are the results of re-modeling the research object using Archicad 27 software:

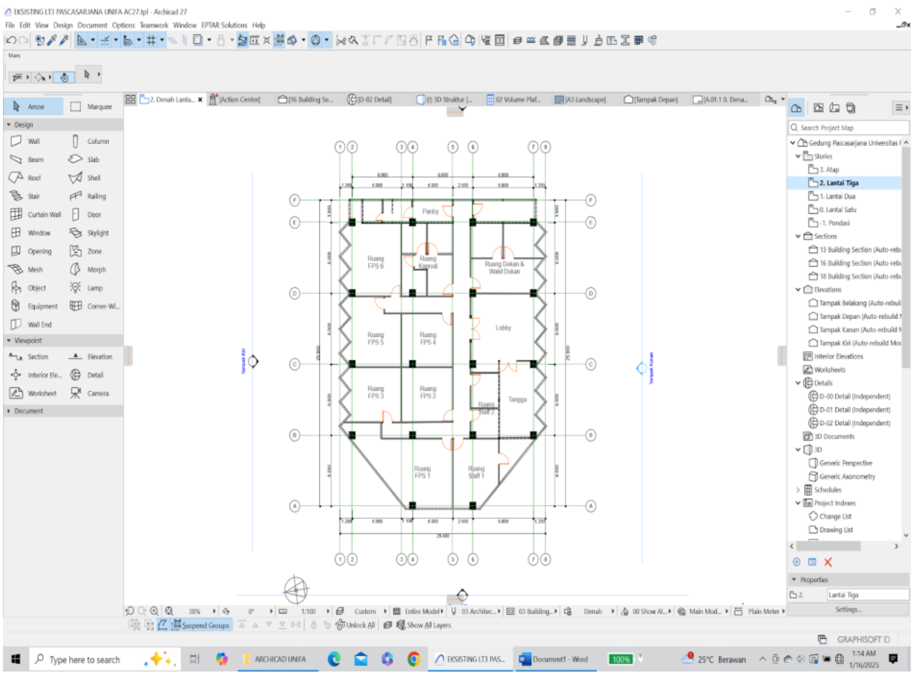

Figure 1. Primary Data of 2D Floor Plan of 3rd Floor of Fajar University Postgraduate Building Source: Simulation with Archicad software 27, 2025

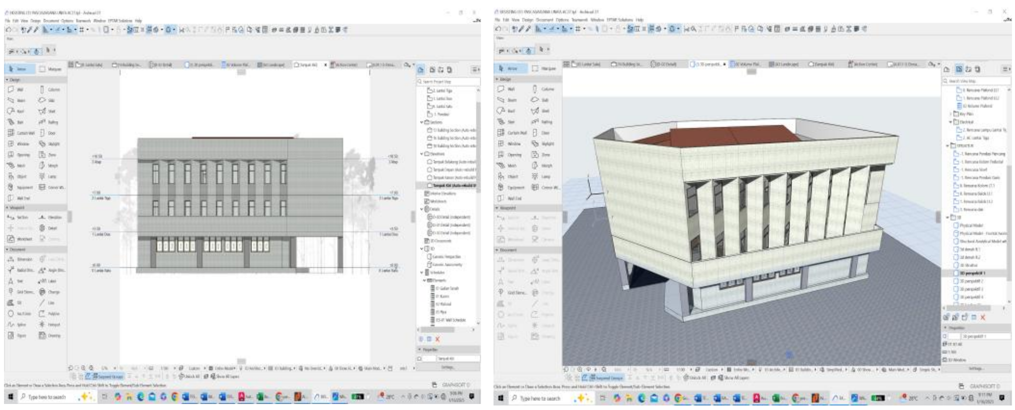

Figure 2. Primary Data of 3D View of Fajar University Postgraduate Building Source: Simulation with Archicad software 27, 2025

Building Data

The results of the remodeling of the 3rd Floor of the Fajar University Postgraduate Building have the following main attribute data:

General Project Data		
Project Name:	Gedung Pascasarjana Un...	
City Location:		
Latitude:	5° S	
Longitude:	119° E	
Altitude:	0.00	m
Climate Data Source:	IDN_SL_Ma...0_TMYx.epw	
Evaluation Date:	1/14/2025 10:44 AM	
Building Geometry Data		
Gross Floor Area:	**454.62**	m²
Treated Floor Area:	**428.08**	m²
External Envelope Area:	**371.04**	m²
Ventilated Volume:	**1411.52**	m³
Glazing Ratio:	**2**	%
Building Shell Performance Data		
Infiltration at 50Pa:	**1.13**	ACH

Heat Transfer Coefficients	U value	[W/m²K]
Building Shell Average:	**2.29**	
Floors:	--	
External:	**1.64 - 2.65**	
Underground:	--	
Openings:	**3.07 - 3.13**	
Specific Annual Values		
Net Heating Energy:	**0.00**	kWh/m²a
Net Cooling Energy:	**22.27**	kWh/m²a
Total Net Energy:	**22.27**	kWh/m²a
Energy Consumption:	**45.54**	kWh/m²a
Fuel Consumption:	**30.89**	kWh/m²a
Primary Energy:	**122.56**	kWh/m²a
Fuel Cost:	**52494.59**	GBP/m²a
CO_2 Emission:	**6.67**	kg/m²a
Degree Days		
Heating (HDD):	**0.00**	
Cooling (CDD):	**6148.35**	

Figure 3. Primary Data of Fajar University Postgraduate Building Source: Simulation with Archicad Software 27, 2025

a. The area of the 3rd floor is 454.62m² and the volume of the room is 1411.42 m³.

Thermal Block	Zones Assigned	Operation Profile	Gross Floor Area m²	Volume m³
001 Lobby Area	1	Circulation and tra...	42.61	133.89
002 Ruang Dekan+Wakil Dekan	1	Personal office	42.11	130.36
003 Ruang Kaprodi	1	Personal office	31.62	99.73
004 Ruang Staff 1	1	Personal office	32.96	101.89
005 Ruang Staff 2	1	Personal office	15.13	47.33
006 Ruang FPS 1	1	Classroom	50.18	155.07
007 Ruang FPS 2	1	Classroom	23.71	74.54
008 Ruang FPS 3	1	Classroom	26.35	81.94
009 Ruang FPS 4	1	Classroom	23.11	72.29
010 Ruang FPS 5	1	Classroom	31.64	97.76
011 Ruang FPS 6	1	Classroom	37.37	115.67
012 Koridor	1	Circulation and tra...	53.90	170.23
013 Area Tangga	1	Circulation and tra...	26.31	80.95
014 Pantry+Toilet	1	Toilets and sanitar...	17.61	49.86
Total:	**14**		**454.62**	**1411.52**

Figure 4. Gross Floor Area & Volume Source: Simulation with Archicad Software 27, 2025

b. The wall material adjacent to the outer space is red brick masonry with tile finishing on the exterior wall and paint finishing on the interior wall. While the room divider on the inside of the building uses a hollow frame partition with gypsum finishing. With door and window frames using aluminum frames and glass panels. The floor covering material is tile masonry and in several rooms such as the lecturer's room, staff room and lecture room are covered with floor carpet masonry. The ceiling material is gypsum masonry.
c. The building is located between 119°25' East and 5°8' South, with the building orientation facing west.

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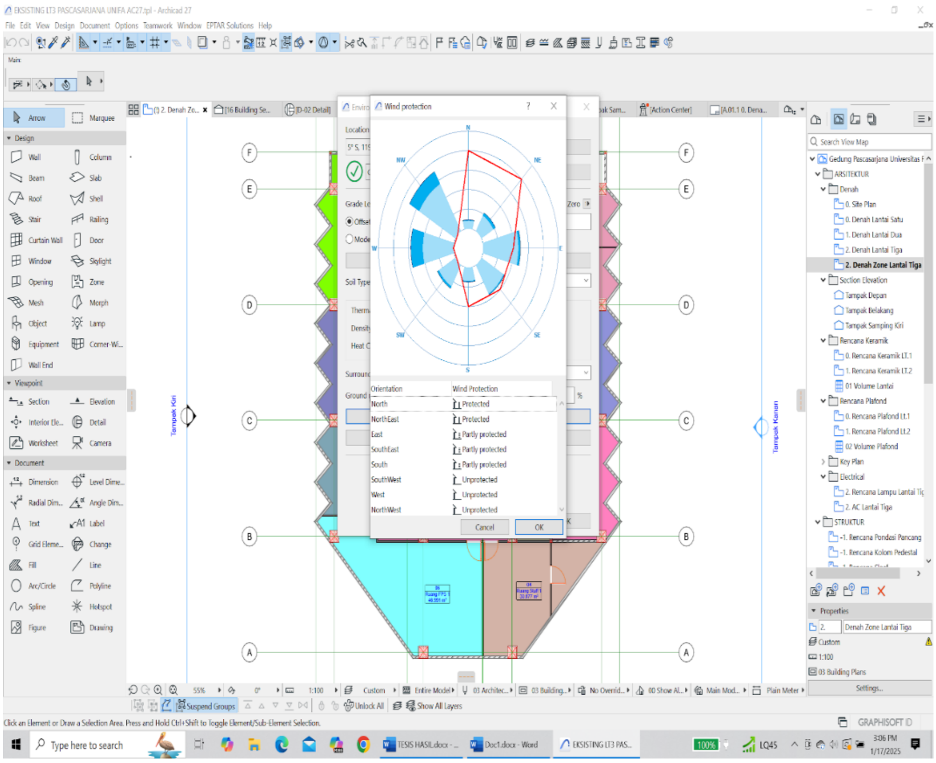

Figure 5. Primary Data on Physical Environmental Aspects in the Design Energy Evaluation Feature. Source: Simulation with Archicad Software 27, 2025

Climate Data and Information

Data is obtained from the nearest weather station, including outside temperature, humidity, wind speed, and solar radiation. This data is usually in EPW (Energy Plus Weather) format for use in the analysis. Data is obtained by downloading from EPW Map. In this study, data was obtained from the Sultan Hasanuddin Airport Makassar weather station.
For climate-related data and information using data available in the application in the form of annual average recording data, namely air temperature of 27.80 ° C; relative humidity 67.50%; solar radiation of 511.00 Wh / m² and wind speed of 5.75m / s.

Data and information on usage profile and room specifications

In accordance with the function or use of the dominant room on the third floor is for lecture activities with an average of 7 hours of operation from 09.00 - 16.00, a temperature range of 20.5 ° C - 27.1 ° C and additional power for lighting of 3 watts / m². For staff and lecturer rooms with an average of 9 hours of operation, namely from 08.00 - 17.00, a temperature range of 20.5 ° C - 27.1 ° C and lighting of 0.5 watts / m². The following is a screenshot of the data and information on the space usage profile used in this energy evaluation simulation:

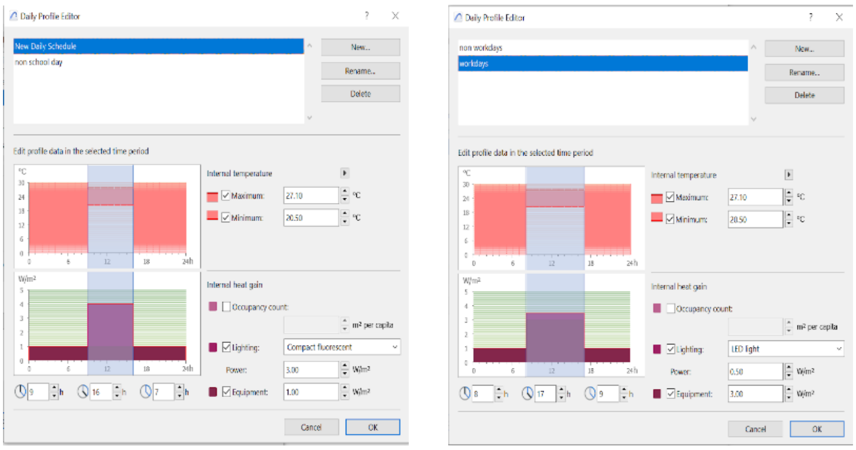

Figure 6. Primary Operation Profile Data on the Design Energy Evaluation Feature Source: Simulation with Archicad Software 27, 2025

Energy source data and costs

For the source of electrical energy used for the artificial air conditioning (AC) system, it comes from PLN electricity. The price of electrical energy is based on the basic electricity tariff price for the segment > 5500 VA of Rp. 1,699.53 / KWh.

Insulation Material to Achieve Thermal Comfort Levels

Thermal comfort parameters according to SNI03-6572-2001
The Indonesian National Standard (SNI) 03-6572-2001 regulates the thermal comfort parameters that must be met in building design. Here are the details of these parameters:
Thermal Comfort Parameters According to SNI, Effective Temperature (TE)

a. Comfortable Cool: 20.5 °C – 22.8 °C
b. Optimal Comfort: 22.8 °C – 25.8 °C
c. Comfortable Warm: 25.8 °C – 27.1 °C

Insulation Walls

To obtain the expected level of thermal comfort in the Fajar University Postgraduate Building, this study was carried out by adding insulation walls to the exterior of the building and to the interior walls that directly border the outside space. Thermal comfort analysis with insulation walls is a process to evaluate how the use of insulation materials on walls can affect thermal conditions inside a building. The use of proper insulation walls can significantly improve thermal comfort inside a building by maintaining temperature and humidity at comfortable levels. This analysis is important for designing buildings that are not only energy efficient but also provide comfort for their occupants.

Aluminum Composite Panel (ACP)

Insulated walls with Alucopan, which is a type of Aluminum Composite Panel (ACP), offer various advantages in building construction. Insulated walls with Alucopan refer to the use of sandwich panels consisting of two layers of aluminum (Alu) on the outside and an insulating core, usually made of materials such as polyurethane or polystyrene.

Advantages of Alucopan as an insulated wall

a. Lightweight Construction: Alucopan is lightweight, making it easy to install and reducing the structural load on the building.

b. Thermal Insulation: The core made of insulating material provides good thermal capabilities. This material has good insulating capabilities, helping to keep the indoor temperature stable.

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This contributes to thermal comfort for occupants and reduces energy costs for heating or cooling.

c. Weather and Corrosion Resistance: Two layers of aluminum on the outside provide structural strength, weather and corrosion resistance. Alucopan is designed to withstand various weather conditions, including rain, heat and humidity. This makes it a good choice for exterior applications.
d. Aesthetics: With a variety of colors and finishes, Alucopan can enhance the aesthetic appearance of a building. This material is often used on modern building facades to provide a clean and professional look.
e. Easy to Clean: Alucopan's smooth surface makes it easy to clean and maintain, maintaining a new appearance for a long time.
f. Quick Installation: These panels are often easier to install than other traditional construction methods because they are lightweight and consist of prefabricated elements.

High Density Polyurethane

High Density Polyurethane Insulation Wall is an insulation system that uses high-density polyurethane foam to improve the thermal and acoustic efficiency of buildings. Insulation walls with High Density Polyurethane (HDPU) core materials are an excellent choice in modern construction, especially for applications that require high thermal and acoustic insulation. HDPU is a synthetic foam material made from the reaction between polyol and isocyanate, resulting in a closed-cell structure. This material has a higher density compared to ordinary polyurethane, thus providing better durability and stability.

Characteristics of High-Density Polyurethane:

a. High Density: High density polyurethane foam generally has a density between 38 kg/m³ to 80 kg/m³. This provides better structural strength and superior insulating ability compared to lower density foams.
b. Thermal Insulation: HDPU has an excellent R-value (heat resistance value), making it one of the most efficient thermal insulation materials. It helps reduce energy costs by maintaining the interior temperature of the building. c) Water and Moisture Resistance: Polyurethane foam, especially the closed cell type, has the ability to resist water and moisture, making it a good choice for applications in areas that are prone to leaks or moisture.
c. Long-lasting: High-density polyurethane is not easily damaged by moisture or pest attacks, so it has a long life and requires minimal maintenance.

Glass Wool Partition Walls

Insulated partition walls using glass wool are one of the popular options in modern construction, especially for increasing energy efficiency and sound control. However, like all materials, the use of glass wool also has environmental impacts that need to be considered.

Here are some points about Glass Wool partition insulation walls:

a. Thermal and Acoustic Insulation: Glass wool is very efficient in insulating heat and sound, helping to maintain comfortable temperatures inside the room and reducing noise between rooms.
b. Lightweight and Easy to Install: This material is lightweight, making it easy to install without burdening the building structure.
c. Fire Resistance: Glass wool is fire resistant because it is made from glass fibers, making it a safe choice for building applications.
d. Environmentally Friendly (Relatively): Some manufacturers make glass wool from recycled materials, such as glass waste, which can reduce the environmental impact compared to new materials.

Evaluation Results

HVAC Design Data

Table 1. HVAC Design Data Evaluation Results

	Existing	ACP	HDPU	Glass Wool

Average minimum temperature	24,2 °C	23,9 °C	24,0 °C	23,7 °C
Average maximum temperature	33,9 °C	34,2 °C	33,5 °C	34,1 °C
Average annual temperature	29,0 °C	29,1 °C	28,8 °C	28,9 °C

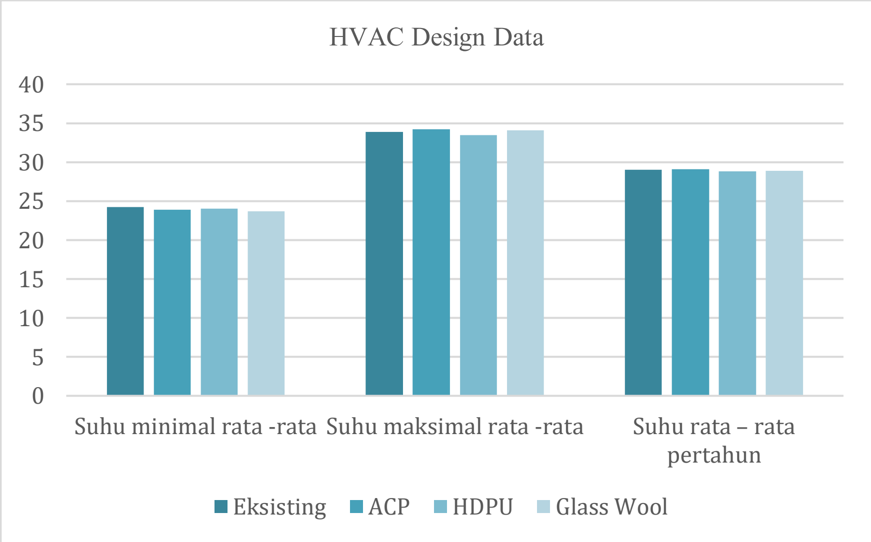

Figure 7. HVAC Design Data Evaluation Results

Overall, the average temperature in the Postgraduate Building of Fajar University does not meet the thermal comfort parameter standards according [26], so it is still necessary to use an artificial air conditioning system, namely by using an Air Conditioner.

Energy Consumption by Target

Table 2. Results of Energy Consumption Evaluation by Target

	Cooling		**Lighting & Appliances**		**Total**	
	Cost (Rp.)	**CO_2 Emission (kg/a)**	**Cost (Rp.)**	**CO_2 Emission (kg/a)**	**Cost (Rp.)**	**CO_2 Emission (kg/a)**
Eksisting	4.051.985	514	8.653.752	1099	**12.705.737**	**1.614**
PVC	4.060.560	516	6.641.088	844	**10.701.648**	**1.360**
HDPU	3.971.716	504	6.641.367	844	**10.613.083**	**1.348**
Glass Wool	3.847.007	488	6.594.223	838	**10.441.231**	**1.327**

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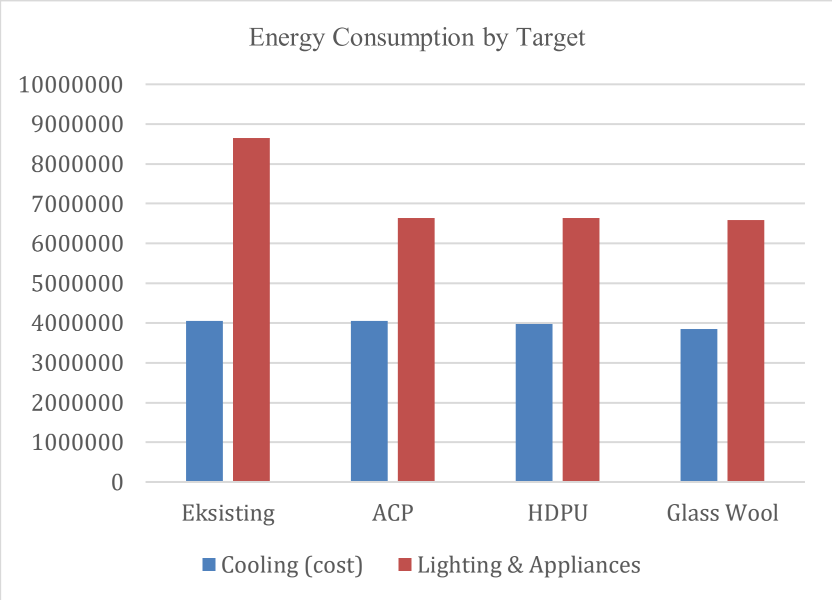

Figure 8. Results of Energy Consumption Evaluation by Target (Cost)

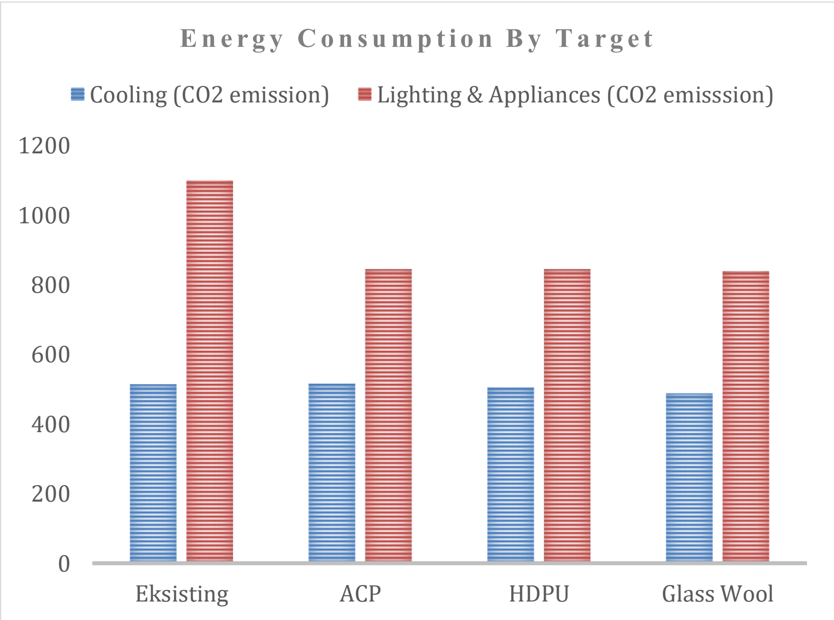

Figure 9. Results of Energy consumption by target (CO_2 Emission) evaluation

From the data above, it can be concluded that the lowest level of energy consumption by target in one year is the installation of gypsum partitions with the addition of Glass Woll insulation material. Able to reduce costs by Rp. 2,264,506.00, namely from Rp. 12,705,737.00 to Rp. 10,441,231.00 and reduce carbon emissions by 287 kg/a, namely from 1,614 kg/a to 1,327 kg/a.

Energy Consumption by Sources

Table 3. Results of Energy Consumption Evaluation by Sources

	Electricity		**Difference with existing**	
	Cost (Rp.)	CO_2 Emission (kg/a)	Cost (Rp.)	CO_2 Emission (kg/a)

Existing	12.705.737	1.614		
PVC	10.701.648	1.360	2.004.089	254
HDPU	10.613.083	1.348	2.092.654	266
Glass Wool	10.441.231	1.327	2.264.506	287

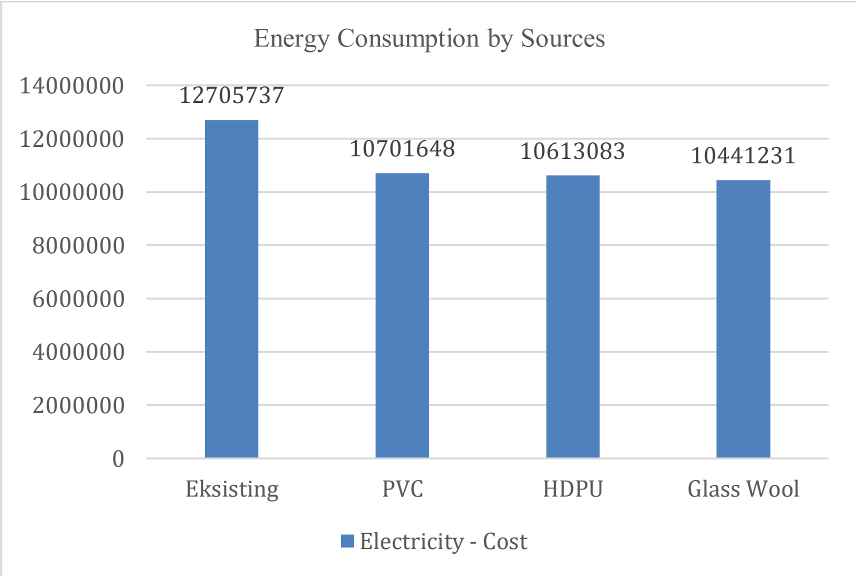

Figure 10. Results of Energy Consumption Evaluation by Sources (Cost)

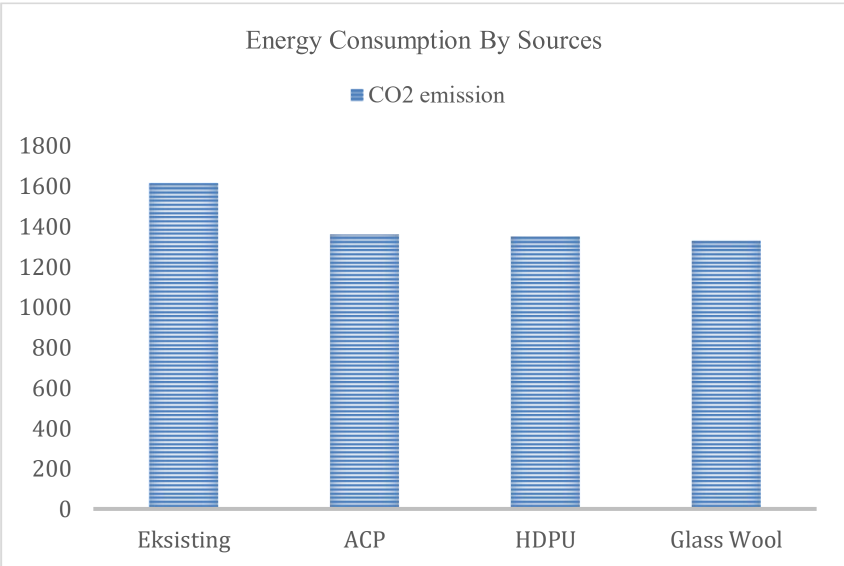

Figure 11. Results of Energy Consumption by Sources (CO2 Emission) Evaluation

From the data above, it can be seen that the lowest level of energy consumption by sources in one year is the installation of gypsum partitions with the addition of Glass Woll insulation material. Able to reduce costs by Rp. 2,264,506.00, namely from Rp. 12,705,737.00 to Rp. 10,441,231.00 and reduce carbon emissions by 287 kg/a, namely from 1,614 kg/a to 1,327 kg/a.

CONCLUSION

From the results of the re-modeling of the third floor of the Fajar University Postgraduate Building which was studied using BIM Archicad 27 software and energy evaluation simulation using the

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integrated Energy Evaluation Simulation feature, several things can be concluded, namely: 1) The existing condition of the average temperature in the Fajar University Postgraduate Building does not meet the thermal comfort parameter standards according to SNI 03-6572-2001. Based on the results of the Energy Performance Evaluation analysis using the Design Energy Evaluation feature in the Archicad 27 software, Existing data shows that during the 2024 period the average minimum indoor temperature is 24.2 ° C and the average maximum temperature is 33.9 ° C, 2) According to SNI 03-6572-2001 the thermal comfort parameters of air temperature are cool and comfortable: 20.5 ° C–22.8 ° C, optimal comfort: 22.8 ° C–25.8 ° C and warm and comfortable: 25.8 ° C – 27.1 ° C, 3) The average temperature after installing insulation material both on the outside and inside of the building based on simulations using BIM Archicad 27 has also not been able to meet the thermal comfort parameters according to SNI 03-6572-2001 so that the use of an artificial air conditioning system is still needed, namely by using an Air Conditioner, 4) based on the HVAC Design Data parameters with using the Design Energy Evaluation feature in Archicad 27 software, the simulation results show that by installing High Density Polyurethane (HDPU) wall panels on all parts of the building's exterior walls, it can reduce the average temperature from 29.0 ° C to 28.8 ° C, 5) based on the Energy Consumption by Target and Energy Consumption by Sources parameters using the Design Energy Evaluation feature in Archicad 27 software, the simulation results show that installing gypsum partitions with the addition of Glass Wool insulation material can reduce costs by Rp. 2,264,506.00, from Rp. 12,705,737.00 to Rp. 10,441,231.00 and reduce carbon emissions by 287 kg/a, from 1,614 kg/a to 1,327 kg/a.

RECOMMENDATIONS

Based on the analysis of the Energy Performance Evaluation simulation results using Building Information Modeling (BIM) with Archicad 27 software, the simulation results show that the most effective according to the HVAC Design Data parameters to achieve thermal comfort levels on the Third Floor of the Fajar University Postgraduate Building is to install High Density Polyurethane (HDPU) wall panels on all parts of the exterior walls. The average minimum temperature during 2024 with the installation of HDPU wall panels on the exterior of the building is able to reduce the average temperature from 29.0°C to 28.8°C. The simulation results show that the most effective according to the Energy Consumption by Target and Energy Consumption by Sources parameters to achieve the level of thermal comfort on the Third Floor of the Fajar University Postgraduate Building is to install gypsum partitions with the addition of Glass Wool insulation material. Able to reduce costs by Rp. 2,264,506.00, namely from Rp. 12,705,737.00 to Rp. 10,441,231.00 and reduce carbon emissions by 287 kg/a, namely from 1,614 kg/a to 1,327 kg/a. After analyzing the simulation results above, the author concludes that the installation of gypsum partitions with the addition of Glass Wool insulation material is more recommended because in terms of energy consumption and carbon emissions it is lower than other alternatives.

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