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Energy Audit and Assessment of Energy Saving Opportunities Using Analytical Hierarchy Process in Public Health Center Buildings in Jakarta to Optimize Energy Efficiency

[1]Ratih Monika, [2]Iwa Garniwa
[1,2]*Departement of Electrical Engineering, Faculty of Engineering*
[1,2]*University of Indonesia*
Depok, Indonesia
Email : [1]ratihmonui@gmail.com, [2]iwa@eng.ui.ac.id

Abstract*- The Government of Indonesia has issued a regulation through Government Regulation No. 33 of 2023, mandating central and regional governments to implement energy conversion efforts. Conducting energy audits in public health center buildings in DKI Jakarta has become an essential step toward realizing concrete energy conservation actions. This study was conducted at the XYZ District Public Health Center with the objectives of assessing energy consumption patterns, identifying potential energy-saving opportunities, and determining the prioritized recommendations to optimize energy efficiency. The audit findings indicate that the building still holds an energy-saving potential of 54.66%, with an estimated annual saving of 146,204.95 kWh or approximately IDR 139,625,731. If energy-saving strategies are applied on a broader scale, Jakarta's potential energy savings could reach 0.43%, or about 6,433,017.8 kWh/year, equivalent to IDR 1,030,598,693/year. At the national level, potential energy savings could reach 19.5%, amounting to 1,030,598,692.55 kWh/year or IDR 984,221,777,819/year. To assist public health center management in determining the prioritization of energy-saving opportunities, this study employed the Analytical Hierarchy Process (AHP) method using 4 criteria and 8 alternatives based on the energy audit recommendations. Expert assessments involving representatives from the health center, government, and practitioners determined that the priority order for the criteria level: ease of implementation, implementation cost, impact on service, and energy-saving potential. Meanwhile, the prioritized alternatives level: AC temperature setting, socket management, reduction in AC infiltration load, lighting operation management, AC operation management, AC maintenance, application of motion sensor technology, and replacement of energy efficient air conditioning technology.*
Keywords: *Energy Audit, Analytical Hierarchy Process, AHP, Energy-Saving Opportunities*

I. INTRODUCTION.

The government issued a regulation that the central government and local governments make efforts to implement energy conversion [1]. Energy conservation is a systematic, planned, and integrated effort to conserve domestic energy resources and improve the efficiency of their utilization [1][2]. In addition, the central government and local governments are obligated to implement energy conversion through energy management in energy utilization activities. The energy management is intended through the appointment of an energy manager, the preparation of an energy efficiency program, the implementation of regular energy audits, and the implementation of recommendations on the results of energy audits [2].

One of the users of electrical energy is the building sector. According to the survey results, the largest energy usage in the building sector is electricity with the highest usage in air conditioning [3]. The public health center building is one of the government-owned buildings where electricity plays a crucial role in supporting public health services. Therefore, energy audits in public health center buildings are deemed necessary to be carried out, especially within the DKI Jakarta government as a real effort and step in energy conservation in order to carry out energy savings and energy efficiency optimally. This is also an implementation of the governor's regulation where the target of saving electricity usage by 20% (twenty percent) is calculated by comparing the average electricity usage of 6 (six) months before the enactment of this governor's regulation and/or electricity usage reaches the minimum efficient criteria [4][5]. As for what is meant by energy audit is the process of evaluating energy utilization and identifying energy saving opportunities and recommendations for improving efficiency in energy users and energy source users in the context of energy conservation [1].

This study was conducted at the XYZ District Public Health Center building to determine the portrait of energy usage and identify energy saving opportunities through an energy audit and determine the priority of energy saving opportunities based on recommendations from the results of the energy audit to optimize energy efficiency using the Analytical Hierarchy Process (AHP) method. Analytic Hierarchy Process (AHP) is a basic approach to decision making [6]. AHP is carried out to make it easier for management to implement energy saving measures or efforts to optimize energy efficiency which has an impact on reducing overall energy costs in the public health center building.

II. RESEARCH METHODS

The method used in this study consists of an energy audit and Analytical Hierarchy Process (AHP).

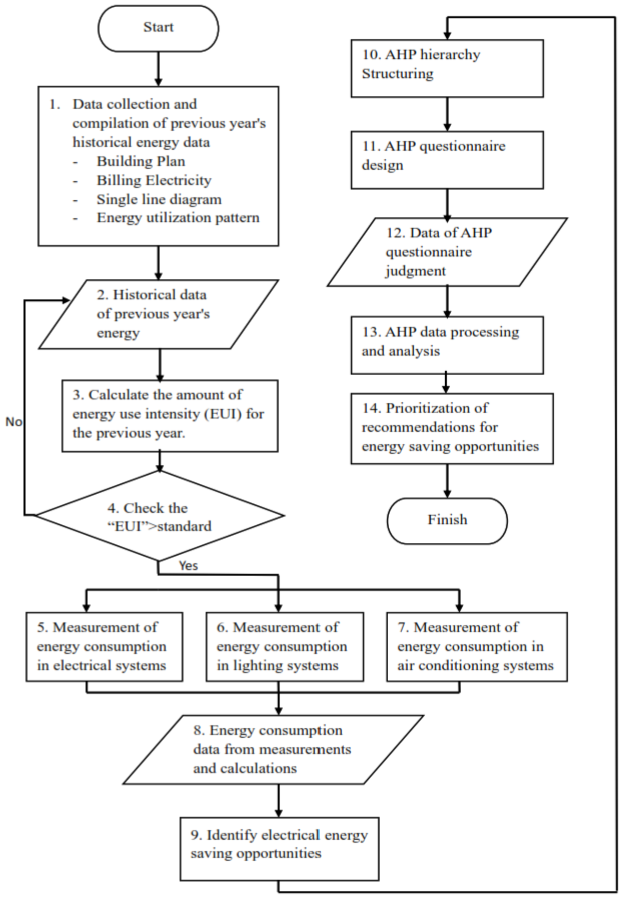

Figure 1. Research Flow Chart

The explanation of the flowchart is as follows:

1. Data collection and compilation of previous year's historical energy data
   At this stage, the previous year's historical energy data was collected in the form of:
   a. Building Plan
   b. Billing Electricity
   c. Single Line Diagram
   d. Energy Utilization Pattern
2. Historical data of previous year's energy consumption
   At this stage, historical data on energy consumption for the previous year is obtained from the results of processing the data that has been collected.
3. Calculating the amount of Energy Use Intensity (EUI) of the previous year
   At this stage, the EUI value for the building being audited is calculated.
4. Check EUI > Standard
   At this stage, it is checked whether the calculated building Energy Use Intensity (EUI) value is greater than the referenced standard. If No, then it will return to stage No. 2, if Yes then the research continues to the next stage.
5. Measurement of energy consumption in Electrical Systems
   At this stage, direct measurements are taken to determine the voltage, current, and power profiles as well as the load profile and energy profile. Quality/profile measurements to determine voltage and current imbalances, harmonics, and power factor. The tool used is the PQA meter.
6. Measurement of energy consumption in Lighting Systems
   Measurement of lighting system conditions to determine the parameters of the lighting system, namely the lighting level. At this stage, data collection is carried out on the number of lamps, types of lamps. Measurement of length, width of room, and calculation of area, total power for lighting density value. The tool used to measure the lighting level with lux meter.
7. Measurement of System energy consumption Air Conditioning
   At this stage, the number of AC units, the power used, the operating pattern of AC use, temperature measurement with a thermometer, and air humidity with a humidity meter were recorded.
8. Energy consumption data from measurements and calculations
   At this stage, energy consumption data is obtained from the measurement and calculation results.
9. Identify electrical energy saving opportunities
   At this stage, opportunities for saving electrical energy are identified by comparing measurement results with standards and analyzing electrical energy consumption that does not comply with standards. Then look at the possibility of improving the performance and efficiency of the use of electrical energy and calculate the potential for energy savings. projecting the potential for energy savings in Jakarta and nationally.
10. AHP Hierarchy Structuring
    At this stage, the AHP hierarchy is compiled by preparing objectives, criteria, and alternatives.
11. AHP questionnaire design
    At this stage, the AHP questionnaire is prepared for the comparison of criteria and alternatives which will be filled in by experts.
12. Data of AHP questionnaire judgement
    At this stage, the questionnaire assessment is collected after the experts fill out the questionnaire.
13. AHP data processing and analysis
    After obtaining the results of the questionnaire, the data is processed and analyzed in accordance with the calculations in AHP.

14. Prioritization of recommendations for energy saving opportunities
    At this stage, the priority order of recommendations for energy saving opportunities will be given based on the results of the AHP analysis.

2.1 Building Profile

This study was conducted at the XYZ District Public Health Center Building in North Jakarta. This building consists of 5 floors and there is a rooftop. The area of the 5 floors, which is 2,021.25m^{2}with an air-conditioned building floor area of around 1,325.25m^{2}and those without air conditioning 696 m^2.

2.1.1 Electrical Energy Sources

The source of electrical energy used by the XYZ District Public Health Center Building comes from two sources, the main electricity supply from PLN LS2 electricity group with a connected power of 197 KVA and a backup supply from a generator with a capacity of 150 KVA. In addition, the XYZ District Public Health Center has a rooftop solar power plant with a capacity of 30 kWp.

2.2 Historical Electric Energy Consumption Data

Based on Figures 2 and Figures 3, the electrical energy consumption of the XYZ district public health center in 2022 and 2023 is depicted in the following graph:

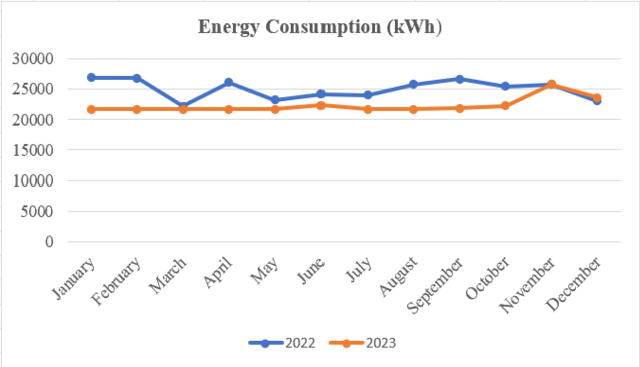

Figure 2: Energy consumption in 2022-2023

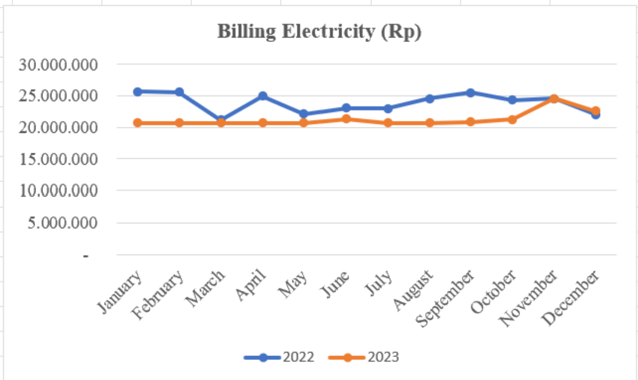

Figure 3. Energy Cost for 2022-2023

2.3 Energy Audit

Types of energy audits consist of walk-through audits, preliminary audits, and detailed audits. A detailed energy audit needs to be carried out if the brief energy audit / preliminary energy audit recommends that further research be carried out on the entire building or on special / specific objects that are considered to have large energy saving potential and offer an attractive level of feasibility. Generally, EUI values greater than the specified benchmark or target values are the reason for recommending detailed energy audit activities [7].

In this study, a detailed audit was carried out in July 2024. Measurements were made on electrical systems, lighting, air conditioning, and other equipment. Before filed measurements, historical data collection and calculations of Energy Use Intensity (EUI) were performed. Energy Use Intensity (EUI) is defined as the ratio between energy consumption and the unit area of the building in a certain period [7]. The main indicator of energy savings in a building generally uses Energy Use Intensity [8]. The EUI calculation formula is as it.

$$EUI = \frac{Total\ Energy\ Consumption\ (kWh)}{Building\ Area\ (m^2)} \quad \dots (1)$$

The calculated EUI value is the EUI of the XYZ District Public Health Center in 2022 and 2023. The EUI standard used as a reference for the annual EUI value as follows [3]:

Table 1. EUI Standard Values according to Technology Assessment and Application Agency and Ministry of Energy and Mineral Resources

Building Type	EUI Standard (kWh/m2/year)
Office Building	180,95
Hotel	208,15
Hospital	180,81
Shopping Center	286,54

In addition to annual EUI, monthly EUI is also calculated with the following reference values [4]:

Table 2. IKE Standard Values of Buildings without Air Conditioning according to Governor's Regulation of Jakarta No.156 Year 2012

Criteria	Energy Intensity (kWh/m2/month)
Highly Efficient	Smaller than 8.5
Efficient	8.5 to less than 14
Moderately Efficient	14 to less than 18.5
Wasteful	Greater than 18.5

After the energy audit, energy saving opportunities were identified from field conditions and literature. Then projected for the potential energy savings of DKI Jakarta and Indonesia.

2.4 Analytical Hierarchy Process (AHP)

The AHP method is used in this study to process data and analyze data from energy audits to determine the priority of energy saving opportunities that have been recommended to optimize energy efficiency at the XYZ District Public Health Center. The AHP steps taken in this research are:

1. Determine the goal to be achieved
   The objective of this research is to prioritize energy saving opportunities.
2. Determine the criteria that affect the goal
   The criteria are derived from the literature approach and the results of the energy audit analysis.
3. Determine the alternatives to be used
   Alternatives obtained from the results of the energy audit analysis in the form of energy saving opportunities
4. Develop a hierarchical structure consisting of objectives, criteria, and alternatives.
5. Develop a pairwise comparison questionnaire for each element in each level of the hierarchy.
   Questionnaire validation was conducted by experts.
6. Conduct a pairwise comparison judgement on each element in each level of the hierarchy. The assessment refers to the comparison scale according to the following table [6]:

Table 3. AHP Fundamental Scale for Pairwise Comparisons

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective
3	Moderate Importance	Experience and judgment sightly favor one activity over another
5	Stronge Importance	Experience and judgment strongly favor one activity over another
7	Very Strong or Demonstrated Importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme Importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6,8	Center value between 2 adjacent considerations	Can be used to express intermediate values intenses
Reverse/reciprocal	If element i has one of the above nonzero numbers assigned to it when compared with element j, then j has the reciprocal value when compared with it	

This assessment is carried out by filling out a paired comparison questionnaire by experts who have knowledge related to energy audits and energy saving goals, have supervisory authority or duties so that they can make decisions or provide responses that affect policy, strategic and technical, and have relevant experience or background. The expert respondents consisted of respondents from the public health center, the government, and practitioners.

7. Create a pairwise comparison matrix for each element at each level of the hierarchy.
8. After all pairwise comparison data is obtained, priorities are sought and consistency is tested. This consistency test is carried out by calculating the consistency ratio (CR) value where if $CR \leq 0.1$ then an assessment is considered consistent. To calculate the CR value using Experchoice software.
9. Prioritize the results of data processing so as to obtain the priority of energy saving opportunities.

III. RESULT AND ANALYSIS

3.1 Energy Use Intensity of XYZ Public District Health Center

Energy use intensity is one aspect in portraying the energy use of a building. Electricity Energy Use Intensity (EUI) is a term used to fulfill the amount of energy use in a system (building) [9]. EUI of a building can be assessed based on monthly or annual period energy use. The EUI value of the XYZ District Public Health Center for the monthly period from January-December in 2023 is moderately efficient. While the annual IKE is as follows:

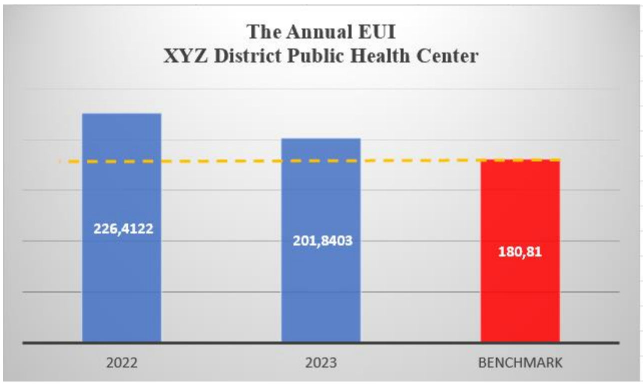

Figure 4. Energy Use Intensity Diagram of Annual Period of XYZ District Public Health Center

From Figure 4, it can be seen that the annual EUI value is still above the benchmark. This indicates that there are still opportunities for energy savings in the XYZ District Public Health Center Building.

3.2 Electrical System Analysis

The energy audit of the electrical system has the aim of knowing the quality of electricity in the XYZ District Public Health Center Building, including profiles of voltage, current, power factor, load, energy, and harmonics. Measurements were installing a Power Quality Analyzer (PQA) on the main panel for 5 days, from July 4-8, 2024.

3.2.1 Voltage and Current Profile

The voltage and current profiles are measured to see the imbalance of voltage and current in each phase. The graph of the measurement results on the main panel can be seen in Figure 5.

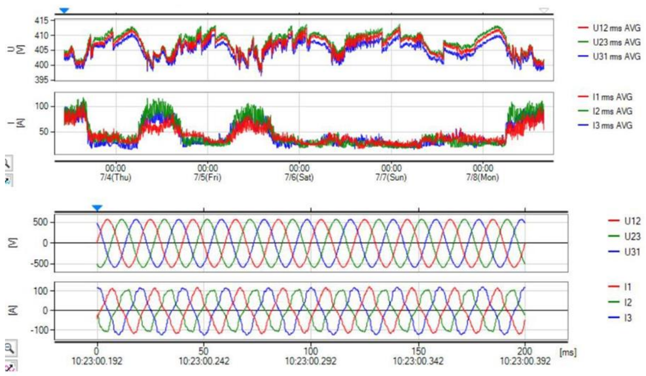

Figure 5. Graph of Voltage Current in the Main Panel of the XYZ District Public Health Center

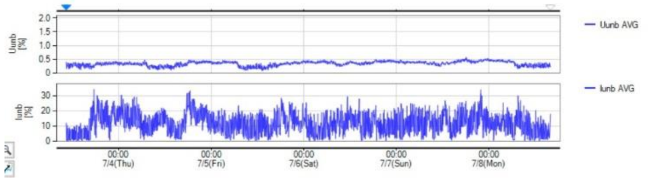

Figure 6. Imbalance Chart in the Main Panel of the XYZ District Public Health Center

In Figure 5 and Figure 6, it can be seen that the voltage and current in the main panel of the XYZ District Public Health Center are unbalanced. Based on measurements, the voltage imbalance in the main panel is 0.45% and the current imbalance is 21.94%. The voltage and current imbalance in the main panel is still below the standard IEEE 1159-2009 where the maximum voltage imbalance is 2%, while the maximum current imbalance is 30% [10]. This current imbalance is a result of unbalanced loading on each phase.

3.2.2 Load and Energy Profile

Load profiling to determine the total load usage in the building as well as the peak load, trending load usage during the day and night. The graph of load profile at the main panel is shown in Figure 7.

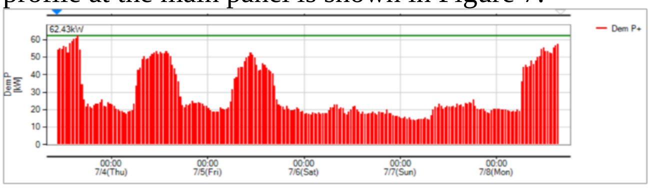

Figure 7. Load Profile Chart of XYZ District Public Health Center

The graph above shows that the load profile on weekdays is the highest load of 62.43kW. As for the holiday (Saturday-Sunday), the highest load is 25.89 kW and the lowest is 13.83 kW.

In addition to load profiling, energy profiling to see patterns of electrical energy usage that vary over time or fluctuate within a certain period. The measurement starts from Wednesday to Monday. The daily energy profile of the XYZ District Public Health Center Building can be seen in Figure 8 below:

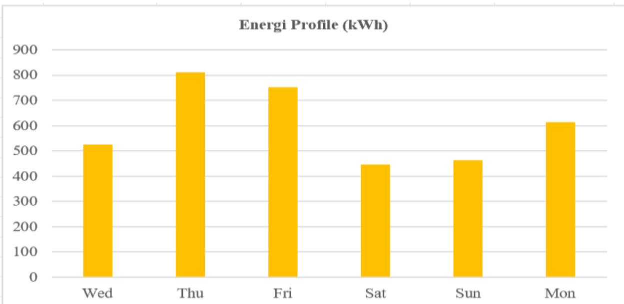

Figure 8: Energy Consumption Profile Graph

The diagram above shows the daily energy profile for 6 days on weekdays on average in the main panel of 675.81 kWh, while on holidays (Saturday-Sunday) the average is 454.39 kWh.

3.2.3 Power Factor

Power factor is one of the efficiency parameters of electrical energy utilization. Power factor is the ratio between active power (W) and apparent power (VA). A high-power factor (close to 1) indicates efficient power usage which means that the power provided by PLN is maximally used to do work by customers and there is no power loss. Meanwhile, a low power factor indicates a waste of energy or a lot of wasted energy. The power factor value of the XYZ District Public Health Center building based on the measurement results in the main panel is shown in Figure 9.

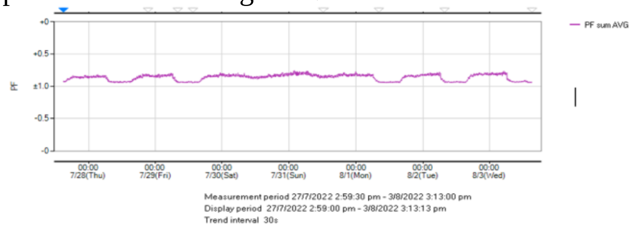

Figure 9. Power Factor Graph

In the graph above, the power factor is still in the range above 0.85 with a maximum of +0.9397. This shows that the power delivered by PLN (kVA) will be converted optimally in the form of Watts.

3.2.3 Voltage and Current Harmonics

Harmonics are one of the power quality problems in power systems. Harmonics are waves with frequencies that are multiples of the fundamental frequency. Harmonics can occur in the XYZ District Public Health Center Building due to the use of non-linear loads, such as electronic equipment which are computers, TVs, printers, UPS, etc. In Figure 10, it can be seen that the waveforms of the voltage and current are not pure sinusoidal but have ripples. This indicates that harmonics occur in the system. Harmonic measurements are carried out on the main panel with measurement parameters in the form of Total Harmonic Distortion (THD) values of voltage and current. Data from the measurement results are as follows:

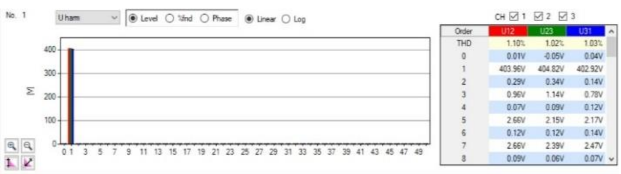

Figure 10. Voltage THD in the Main Panel

In Figure 10, it can be seen that the value of the voltage THD of the XYZ District Health Center Building is around 1%, still below the standard for voltage THD according to IEEE 519-2022 maximum of 5% and the maximum standard for Total Demand Distortion (TDD) of current is 20% [11]. However, the measured data is not TDD but current THD. The measured current THD is about 16%, still below the standard if using 20%. The measurement data is shown in Figure 11.

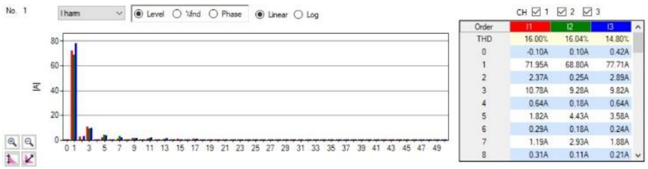

Figure 11. Current THD in the Main Panel

3.3 Lighting System Analysis

The Lighting System at the XYZ District Public Health Center Building uses natural and artificial lighting. Artificial lighting in the form of lamps using LED lamp types according to table 4.

Table 4. Types of Lights at the XYZ District Public Health Center

Lamp Type	Number of Lights	Power (Watt)	Total Power (Watt)
LED TL	164	16	2624
LED Bulb	41	19	779
	64	10	640

Lighting operations are carried out according to the work activities in each room. However, there are some rooms that have lights on even when there is no activity and there are lights that are on even when there is natural lighting.

The energy audit of the lighting system was carried out by measuring the illuminance with a luxmeter at several points in several rooms on each floor from the 1st floor to the 5th floor. The standard used for the lighting level is the Minister of Health Regulation [12], while the lamp power density uses SNI [13]. The results of some of the lighting level measurements are in Table 5 and some of the results of the lighting density measurements are in Table 6.

Table 5. Measurement Results of Lighting Level (lux) of XYZ District Health Center

No	Room Name	Measurement (Lux)	Benchmark MoH 2/2023	Description
1	Daily Medication Storage	311,9	minimum 200	Meets Standard
2	R. Pharmacy	300,3	Minimum 200	Meets Standard
3	R. Waiting Room 1st Floor & Hallway	258,6	minimum 100	Meets Standard
4	R. ER	302,5	minimum 100	Meets Standard
5	Registration Lobby	257,1	minimum 100	Meets Standard
6	R. Postpartum Care	465	300-500	Meets Standard
7	R. Midwife	264,4	minimum 100	Meets Standard
8	UKP Management	365,3	minimum 100	Meets Standard
9	Laboratory	282	75-100	Meets Standard
10	R. Head of Health Center	373	minimum 100	Meets Standard

Table 6. Lamp Power Density Measurement Results

No	Room Name	Density (Watt/m^2)	SNI 6197: 2020	Description
1	Daily Medication Storage	3,56	17,76	Meets Standard
2	R. Pharmacy	3,17	17,76	Meets Standard
3	R. Waiting Room 1st Floor & Hallway	2,33	7,64	Meets Standard
4	R. ER	4,92	7,64	Meets Standard
5	Registration Lobby	2,53	7,64	Meets Standard
6	R. Postpartum Care	3,56	7,32	Meets Standard
7	R. Midwife	5,63	7,64	Meets Standard
8	UKP Management	3,17	7,64	Meets Standard
9	Laboratory	3,28	12,16	Meets Standard
10	R. Head of Health Center	2,38	7,64	Meets Standard

Based on the data from the measurement results, it can be seen that the lighting level and lamp power density in the measured rooms all still meet the standards.

3.4 Air Conditioning System Analysis

XYZ District Public Health Center uses 2 (two) types of Air Conditioner / AC with the composition in Table 7.

Table 7. AC type of XYZ District Public Health Center

No.	Type	Number of Units	Power
1	Split AC	20	PK
2	Split AC	32	2 PK
3	AC Cassete	2	5 PK

The air conditioning system audit was carried out by measuring the temperature and humidity in each room on the 1st floor to the 5th floor. The standard used is the Minister of Health Regulation [12]. The temperature measurement results of several rooms are shown in table 8 and humidity is shown in Table 9.

Table 8. Temperature Measurement Results of XYZ District Public Health Center

No	Room Name	Temperature (°C)		
		Actual	MoH 2/ 2023	Description
1	R. Waiting Lt. 1	26	20-28	Standard
2	R. ER	26.7	20-24	Above standard
3	Registration Lobby	26.2	20-28	Standard
4	R. Post-hospitalization Labor	24.2	22-23	Above standard
5	R. Midwife	25.5	20-28	Standard
6	Laboratory	24.3	20-22	Standard
7	R. Vaccines	26	20-22	Above Standard
8	R. Head of Health Center	24.9	20-28	Standard
9	The Hall	25.3	20-28	Standard
10	Ladies' Restroom	26.3	20-28	Standard

Table 9. Humidity Measurement Results of XYZ District Public Health Center

No	Room Name	RH (%)		
		Actual	Permenkes 2/ 2023	Ket
1	R. Waiting Lt. 1	58.5	40-60	Standard
2	R. ER	58.8	40-60	Standard
3	Registration	55.9	40-60	Standard
4	R. Post-	52.3	40-60	Standard
5	R. Midwife	50	40-60	Standard
6	Laboratory	49.7	40-60	Standard
7	R. Vaccines	48.2	40-60	Standard
8	R. Head of Health Center	48	40-60	Standard
9	The Hall	53.2	40-60	Standard
10	Ladies' Restroom	55.2	40-60	Standard

Based on the measurement data, it can be seen that the temperature of some of the rooms measured has met the standard and some are still above the standard, while the humidity of all rooms measured has met the standard.

3.5 Identify Energy Saving Opportunities

Identifying and recommending energy saving opportunities is the purpose of conducting an energy audit. The results of this energy audit will be considered by management to implement recommendations for energy saving opportunities. Based on the results of the energy audit at the XYZ District Public Health Center Building, energy saving opportunities can be identified as in table 10.

Table 10. Potential and Opportunities for Energy Savings in the XYZ District Public Health Center Building

No.	Implementation of Energy Saving Opportunities	Energy Saving Potential (kWh/year)	Potential Cost Savings (Rp/year)	Percentage Energy Saving Opportunity (%)
1	Socket Management	13.374,44	12.772.590	5
2	Lighting Operation Management (SOP)	1.902,68	1.817.059	0,71
3	Application of Motion Sensor Switch Technology in Toilet Lights	1.040	993.200	0,39
4	AC Operation Management (SOP)	27.183	25.959.765	10,16
5	AC Temperature Setting	8.024,66	7.663.554	3
6	Reduction in AC Infiltration Load	30.079	28.725.541	11,24
7	AC Maintenance	19.339,17	18.468.911	7,23
8	Replacement of Energy Efficient Air Conditioning Technology	45.261,90	43.225.111	16,92
Total		**146.204,95**	**139.625.731**	**54,66**

Table 10 shows that the potential energy savings at the XYZ District Public Health Center Building is 146,204.95kWh/year or Rp 139,625,731. When compared to the energy consumption in 2023, the energy saving opportunity is 54.66%.

3.6 Projected Energy Savings Opportunities for Jakarta and Indonesia

Based on data [14], the health centers in Jakarta consist of 2 types, namely District Public Health Centers and Urban Village Public Health Centers. Jakarta has 44 district public health centers and 339 urban village public health centers. As based on [15] there are 10.212 public health centers in Indonesia, while according to [16] the number of districts in Indonesia in 2025 is 7.281 districts.

The Minister of Health Regulation states that a public health center should be established at least in every district [17]. If we assume that each district has at least 1 public health center type and the Papua region and surrounding provinces have the same number of public health center type, there are 7049 district public health center in Indonesia.

If it is assumed that district public health centers in Jakarta and public health centers in each district in Indonesia have the same energy consumption patterns as the XYZ District Public Health Center and based on data from PLN 2023 [17] that the energy sold per customer group for government office building customers in Jakarta is 1.482,22 GWh and in Indonesia is 5.285.12 GWh, the energy saving opportunities can be seen in Table 11 below:

Table 11. Projected Energy Savings Opportunities

Region	Jakarta	Indonesia
Potential Energy Savings (kWh/year)	6.433.017,8	1.030.598.692,55
Potential Cost Savings (Rp/year)	1.030.598.693	984.221.777.819
Energy sold to Government Office Building customers (GWh)	1.482,22	5.285,12
Energy Saving Opportunities	0,43%	19,5%

Table 11 shows that by implementing energy saving efforts in district public health centers, the opportunity for energy savings in Jakarta is 0.43%, and in Indonesia it is 19.5%.

3.7 Analytical Hierarchy Process (AHP) Result Analysis

After analyzing the results of the energy audit and obtaining energy saving opportunities in the XYZ District Public Health Center Building, an AHP hierarchical structure can be prepared which consists of three levels, they are goal level, criteria level, and alternative level. The Hierarchical Structure in this study is depicted in figure 12.

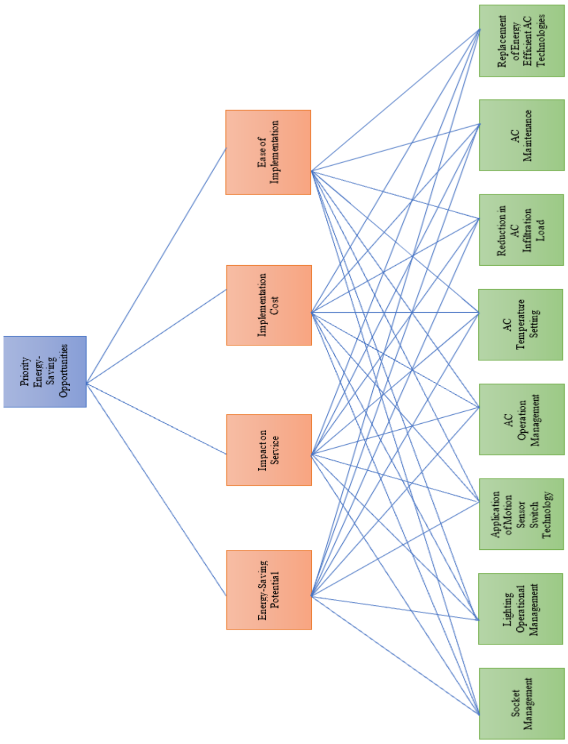

Figure 12. Hierarchical structure of Analytical Hierarchy Process (AHP)

The explanation of the hierarchy in Figure 12 is as follows:

a. Goal level is the main goal or target in this study where the goal is to get priorities for energy saving opportunities at the XYZ District Public Health Center so that the optimization of energy efficiency can be fulfilled.
b. Criteria level is what influences and determines the priority selection of energy saving opportunities where the criteria level consists of several elements:

Table 12. Criteria of Energy Saving Opportunities

No	Criteria	Description
1	Energy Saving Potential	How large is the potential reduction in energy consumption resulting from the implementation of the solution
2	Impact on Services	How much influence does the solution have on service effectiveness
3	Implementation Cost	What is the estimated cost required to implement energy saving solutions
4	Ease of Implementation	Level of technical or non-technical ease of applying energy saving solutions

c. Alternative level is the last level of the hierarchy which is composed of various alternative steps that can be taken to save energy. The alternative level of the hierarchy consists of several elements:

Table 13. Alternative of Energy Saving Opportunities

No	Alternative	Description
1	Socket Management	Unplug appliances connected to the socket when not in use or turn off electrical appliances connected to the socket.
2	Lighting Operation Management	Create a Standard Operating Procedure (SOP) for turning on and off lights and regulate the operating hours of lights
3	Application of Motion Sensor Switch Technology	Using a motion sensor switch on the toilet light so that it can detect movement in the room and automatically turn on/off the lights.
4	AC Operations Management	Establish a Standard Operating Procedure (SOP) for air conditioning on and off and regulate air conditioner operating hours.
5	AC Temperature Setting	Set the temperature of the air conditioning to maintain the comfort standard limit
6	Reduction in AC Infiltration Load	Reducing outside air from entering the air-conditioned room, such as closing doors and window vents
7	Air conditioning maintenance	Perform regular maintenance, such as cleaning the AC filter
8	Replacement of Energy Efficient Air Conditioner Technology	Replacing standard air conditioners with VRV/VRF inverter air conditioning technology

3.7.1 Pairwise Comparison Assessment

After compiling the AHP hierarchy and making a questionnaire that has been validated by experts, an assessment is carried out by 3 expert respondents, from the public health center, the government, and the practitioner. This expert assessment uses a questionnaire.

The following are the calculation steps using the AHP method as an example is respondent 1. Table 14 is a pairwise comparison matrix for the criteria level of respondent 1.

Table 14. Pairwise Comparison Matrix of Criteria Levels Respondent 1

Criteria	Energy Saving Potential	Impact on Services	Implementation Cost	Ease of Implementation
Energy Saving Potential	1	1/3	1/3	1/5
Impact on Services	3	1	1/3	1/3
Implementation Cost	3	3	1	1/3
Ease of Implementation	5	3	3	1

The step taken after making the pairwise comparison matrix is to weight the criteria in table 15.

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Tabel 15. Weighting of Criteria Levels Respondent 1

Criteria	Energy Saving Potential	Impact on Services	Implementation Cost	Ease of Implementation
Energy Saving Potential	1,00	0,33	0,33	0,20
Impact on Services	3,00	1,00	0,33	0,33
Implementation Cost	3,00	3,00	1,00	0,33
Ease of Implementation	5,00	3,00	3,00	1,00
Energy Saving Potential	**12,00**	**7,33**	**4,67**	**1,87**

Next, normalization is done by dividing the value of each element by the sum of each column as in Table 16.

Table 16. Normalization of Criteria Levels for Respondent 1

Criteria	Energy Saving Potential	Impact on Services	Implementation Cost	Ease of Implementation
Energy Saving Potential	0,08	0,05	0,07	0,11
Impact on Services	0,25	0,14	0,07	0,18
Implementation Cost	0,25	0,41	0,21	0,18
Ease of Implementation	0,42	0,41	0,64	0,54
Total	**0,08**	**0,05**	**0,07**	**0,11**

After normalization, the next step is to calculate the consistency ratio. As for the steps, namely determining the eigen vector first by averaging each row in the normalization results table. The results can be seen in Table 17.

Table 17. Eigen Vector of Criteria Levels for Respondent 1

Criteria	Eigen Vector
Energy Saving Potential	0,08
Impact on Services	0,16
Implementation Cost	0,26
Ease of Implementation	0,50

If the eigen vector already exists, the Weight Sum Vector (WSV) calculation is carried out by multiplying the weight of the criteria with the eigen vector. The calculation results are as follows:

$$\begin{bmatrix} 1,00 & 0,33 & 0,33 & 0,20 \\ 3,00 & 1,00 & 0,33 & 0,33 \\ 3,00 & 3,00 & 1,00 & 0,33 \\ 5,00 & 3,00 & 3,00 & 1,00 \end{bmatrix} x \begin{bmatrix} 0,08 \\ 0,16 \\ 0,26 \\ 0,50 \end{bmatrix} = \begin{bmatrix} 0,32 \\ 0,64 \\ 1,14 \\ 2,15 \end{bmatrix}$$

The next step is to calculate by dividing the WSV result with the eigen vector, then the following results are obtained:

$$\begin{bmatrix} 0,32 \\ 0,64 \\ 1,14 \\ 2,15 \end{bmatrix} / \begin{bmatrix} 0,08 \\ 0,16 \\ 0,26 \\ 0,50 \end{bmatrix} = \begin{bmatrix} 4.14 \\ 4,05 \\ 4,33 \\ 4,29 \end{bmatrix}$$

The results of the above calculations are averaged to get the largest eigenvalue (λmax) then get λmax = 4.201. The next step calculates the Consistency Index (CI) value as follows:

$$CI = \frac{\lambda max - n}{n-1} \; ... (2)$$

$$CI = \frac{4{,}201 - 4}{4 - 1}$$

$$CI = 0{,}067$$

Thus, the Consistency Ratio (CR) value in Criteria Levels for Respondent 1 can be calculated with the RI value for n = 4 is 0.89. The following is the calculation:

$$CR = \frac{CI}{RI} \; .... (3)$$

$$CR = \frac{0{,}067}{0{,}89} = 0{,}07$$

From the calculation results, the consistency value is obtained below 10% so that the assessment of respondent 1 is declared consistent and can be used as an analysis in the AHP method.

3.8 Analysis of Analytical Hierarchy Process (AHP) Results for the Three Expert Respondents

The analysis was carried out to determine the priority order of energy saving opportunities at the Public Health Center Building in Jakarta by processing data from three expert respondents consisting of the public health center, the government, and the practitioner. The analysis uses ExpertChoice to facilitate data processing. Based on the results of data processing, the three expert respondents are as follows:

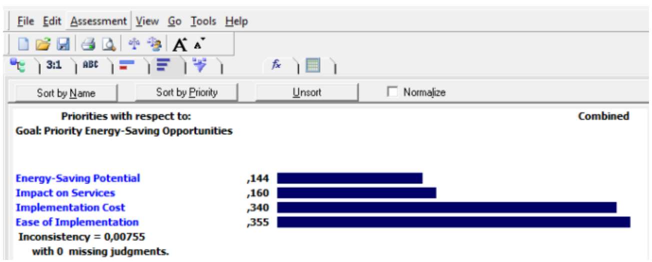

Figure 13. Combined Criteria Rank Prioritization Results of Expert Respondents

In Figure 13, it can be seen that the combined consistency value of expert respondents for the criteria level is 0,00755 or 0,0755% where the consistency value is below 10% indicating that the data processing results of this combined consistency are consistent. The order of priority at the criteria level for the priority goal of energy saving opportunities is ease of implementation (0,355), implementation cost (0,340), impact on services (0,160), and potential energy savings (0,144). In addition to the criteria, the following are the results of data processing with Expertchoice for alternative levels which can be seen in Figure 14, Figure 15, Figure 16 and Figure 17

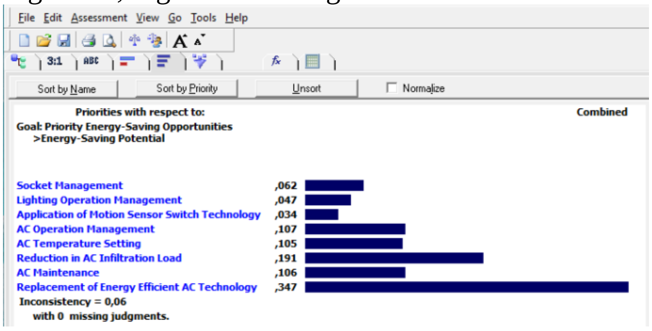

Figure 14. Results of Prioritization of Alternative Levels Against Criteria for Potential Energy Savings for Combined Expert Respondents

In Figure 14, it can be seen that the combined consistency value of expert respondents for the level of alternatives to the criteria for potential energy savings is 0,06 or 6% where the consistency value is below 10% indicating that the results of data processing from this combined consistency are consistent. The order of priority at the alternative level to the criteria for potential energy savings is the replacement of energy-efficient AC technology (0,347), reduction in the AC infiltration load (0,191), AC operation management (0,107), AC maintenance (0,106), AC temperature setting (0,105), socket management (0,062), lighting operation management (0,047), and application of motion sensor switch technology (0,034).

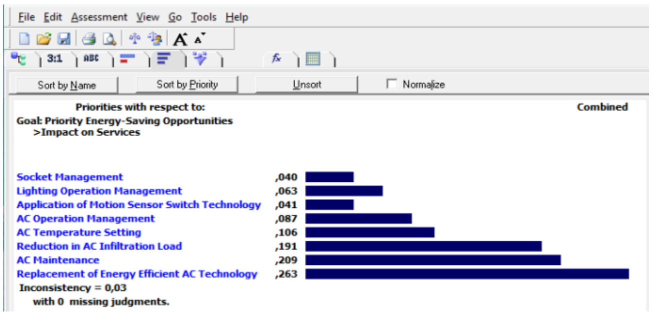

Figure 15. Results of Prioritization of Alternative Levels Against Criteria for Impact on Services for Combined Expert Respondents

In Figure 15, it can be seen that the combined consistency value of expert respondents for alternative levels of impact criteria on services is 0,03 or 3% where the consistency value is below 10% indicating that the results of data processing from this combined consistency are consistent. The order of priority at the alternative level to the criteria for impact on services is the replacement of energy-efficient AC technology (0,263), AC maintenance (0,209), reduction in AC infiltration load (0,191), AC temperature setting (0,106), AC operation management (0,087), lighting operation management (0,063), application of motion sensor switch technology (0,041), and socket management (0.040).

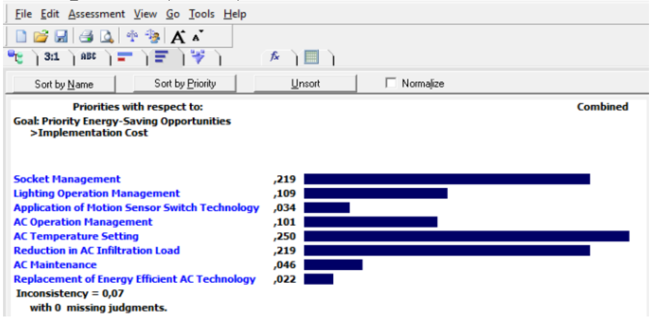

Figure 16. Results of Prioritization of Alternative Levels Against Criteria Implementation Cost for Combined Expert Respondents

In Figure 16, it can be seen that the combined consistency value of expert respondents for the level of alternatives to the implementation cost criteria is 0,07 or 7% where the consistency value is below 10% indicating that the data processing results of this combined consistency are consistent. The order of priority at the alternative level to the implementation cost criteria is the AC temperature setting (0,250), socket management (0,219), reduction in AC infiltration load (0,219), lighting operation management (0,109), AC operation management (0,101), AC maintenance (0,046), application of motion sensor switch technology (0,034), and replacement of energy-efficient AC technology (0,022).

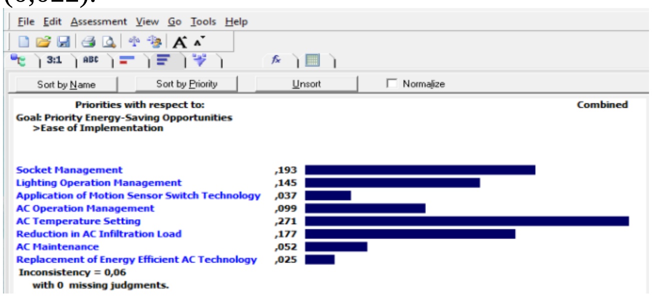

Figure 17. Results of Prioritization of Alternative Levels Against Criteria Ease of Implementation for Combined Expert Respondents

In Figure 17, it can be seen that the combined consistency value of expert respondents for the level of alternatives to the ease of implementation criteria is 0,06 or 6% where the consistency value is below 10% indicating that the results of data processing from this combined consistency are consistent. The order of priority at the alternative level to the ease of implementation criteria is the AC temperature setting (0,271), socket management (0,193), reduction in the AC infiltration load (0,177), lighting operation management (0,145), AC operation management (0,099), AC maintenance (0,052), application of motion sensor switch technology (0.037), replacement of energy-saving AC technology (0,025).

IV. CONCLUTION

The results of the energy audit at the XYZ District Public Health Center building indicate that the building still has energy saving opportunities because the annual and monthly Energy Use Intensity (EUI) values are still above the benchmark limit. Based on electrical system measurements, a voltage imbalance in the main panel of 0.45% and a current imbalance of 21.94% which are still below the maximum limits set by standard of IEEE 1159-2009. The peak load on working days reached 62.43kW, the power factor is above 0,85. The voltage THD was around 1% and the current THD of about 14-16%, still below the maximum standard of IEEE 519-2022. Measurements of the lighting system showed that the illuminance levels in all measured rooms met the standards set by the Indonesian Ministry of Health Regulation No. 2 of 2023, and the lighting power density complied with the Indonesian National Standard SNI 6197:2020. For the air conditioning system, the measured temperatures in several rooms already met the temperature standards of Minister of Health Regulation No.2 Year 2023, however, the humidity levels in all measured rooms were found some rooms are still above the standard, while for humidity all rooms measured have met the standard.

The potential for energy savings at the XYZ District Public Health Center Building is 146,204.95kWh/year or Rp 139,625,731. When compared to energy consumption in 2023, the opportunity for energy savings is 54.66%. By applying the same energy consumption pattern to district public health centers, the opportunity for energy savings in Jakarta can reach 0.43%, which is 6,433,017.8 kWh/year or Rp 1,030,598,693/year at Rp 955/kWh and in Indonesia by 19.5%, which is 1,030,598,692.55kWh/year or Rp 984,221,777,819/year.

Based on data processing using ExpertChoice, with the priority objective of identifying energy-saving opportunities according to the assessments of expert respondents from public health centers, the government, and practitioners, the highest criteria are ease of implementation, and the priority order of alternatives that can be applied to public health center buildings in Jakarta based on the highest criteria are AC temperature settings, socket management, reduction in infiltration load, lighting operation management, AC operation management, AC maintenance, application of sensor technology.

REFERENCES

[1] Government of Indonesia, *Government Regulation No.33* of 2023: *Energy Conservation.* Jakarta, Indonesia: State Secretariat of the Republic of Indonesia, 2023.

[2] Government of Indonesia, *Law No. 30 of 2007: Energy*. Jakarta, Indonesia: State Secretariat of the Republic of Indonesia, 2007.

[3] Center for Energy Conversion Technology B2TKE – BPPT, *Benchmarking Report on Specific Energy Consumption in Commercial Buildings*. Jakarta, Indonesia: Ministry of Energy and Mineral Resources, 2020.

[4] Governor of Jakarta Special Capital Region Province, *Governor Regulation No. 156 of 2012: Energy and Water Saving*. Jakarta, Indonesia: Legal Information Document Network of Jakarta Province, 2012.

[5] Governor of Jakarta Special Capital Region Province, *Governor Instruction No. 127 of 2014: Energy and Water Saving*. Jakarta, Indonesia: Legal Information Document Network of DKI Jakarta Province, 2014.

[6] T. L. Saaty and L. G. Vargas, *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process*, 2nd ed. New York, NY, USA: Springer, 2012.

[7] National Standardization Agency, *SNI 6196:2011 – Energy Audit Procedure for Buildings*. Jakarta, Indonesia: BSN, 2011

[8] Wirawan, N. Hiron, N. Busaeri. "Analysis of Potential Opportunities for Saving Energy Consumption at Brits Hotel Karawang". *Journal of Energy and Electrical Engineering*, vol.02 no.1, 2020, ISSN: 2720-989X, doi: 10.37058/jeee.v2i1.2141.

[9] A.S. Santoso., A. Hermawan, and S. Harianto. "Energy Audit Analysis of Electrical Energy Consumption Intensity of Lighting System and Fish Storage System in Cold Storage". *Journal of Electrical Systems*, vol. 8 no. 3, ISSN 2407-232x, E-ISSN 2407-2338, pp 11-16, Oct. 2021

[10] IEEE Power & Energy Society, *IEEE Standard 1159™: Recommended Practice for Monitoring*

Electric Power Quality. New York, NY, USA: IEEE, 2009.
[11] IEEE Power & Energy Society, *IEEE Standard 519™: Standard for Harmonic Control in Electrical Power Systems*. New York, NY, USA: IEEE, 2022.
[12] Ministry of Health of the Republic of Indonesia, *Regulation No. 2 of 2023: Implementation Regulation of Government Regulation No. 66 of 2014 Concerning Environmental Health*. Jakarta, Indonesia: Ministry of Health, 2023.
[13] National Standardization Agency, *SNI 6197:2020 – Energy Conservation in Lighting Systems*. Jakarta, Indonesia: BSN, 2020.
[14] (2025) Epidemiological Surveillance Section homepage. [Online]. Available: https://surveilans-dinkes.jakarta.go.id/sarsbaru/umum_pkm.php
[15] Ministry of Health of the Republic of Indonesia, *Decision No. HK.01.07/MENKES/1690/2024: Integrated Public Health Data for the First Semester of 2024*. Jakarta, Indonesia: Ministry of Health, 2024.
[16] (2025) The BPS website [Online]. Available: https://www.bps.go.id/
[17] Ministry of Health of the Republic of Indonesia, *Regulation No. 19 of 2024: Implementation of Community Health Centers*. Jakarta, Indonesia: Ministry of Health, 2024.
[18] PT PLN (Persero), *PLN Statistics 2023*. Jakarta, Indonesia: PT PLN (Persero), 2024. ISSN: 0852-8179.