ANALYSIS OF LOSSES IN THE ELECTRICAL INSTALLATION NETWORK OF THE INTEGRATED LABORATORY BUILDING OF AHMAD DAHLAN UNIVERSITY CASE STUDY OF THE FIFTH FLOOR

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ABSTRACT

Electrical installation systems are configurations specifically designed to deliver electrical energy within a building to provide the necessary supply for electronic equipment. The importance of efficient and stable power distribution is paramount. Possible losses in the electrical installation network can not to be ignored, so understanding the factors that cause these losses is a key in evaluating the effective of the system in the building. Analyzing power losses, commonly called PLosses, is an urgent step to identify and understand the electrical energy losses of buildings. Ahmad Dahlan University receives electricity from PLN with a capacity of 1385 KVA distributed to all four campus buildings. The research was conducted on the electrical installation network in the integrated laboratory building, especially on the fifth floor, focusing on the power distribution system at the load point. Excess power in electrical installations can generate excess heat in the conductor potential to degrade efficiency, suboptimal performance, and increase the risk of fire and equipment damage. This research aims to identify the causes of these losses and determine the power losses (PLosses) in order to improve network efficiency and reliability. In this context, an interface for an electrical installation usage database using an open-source method that allows users to enter and view data in real time was used to create the database. Losses were analyzed on the electrical installation network by calculating PLosses on power distribution, both on the main line and in each room, both on the main line and in each room. Using 4mm NYM copper cable conductor for the main line and 2mm NYA cable for each room shows different resistance values for each conductor. The results showed that the average loss on the main line reached 434.28 W per hour, while the line in each room also experienced an average loss of 106.94 W per hour. Consequently, Ahmad Dahlan University has to pay for the electrical installation losses of the fifth-floor integrated laboratory building to PLN every month.

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1. INTRODUCTION

As time develops so that the increasing need for electricity to meet the needs of teaching & practicum, the electrical installation of the building has increased both in quality and quantity. The quality of the building's electrical installation is not proportional to the quantity of the building's load points, as a result it affects the loss of electricity usage. Losses in the electrical installation network can affect the feasibility and service life of the electrical installation. The integrated laboratory building at Ahmad Dahlan University plays an important role as a center for research & experimentation activities in the fields of science & technology.

The availability of reliable, efficient & safe electrical infrastructure is a major prerequisite in ensuring the smooth & safety of academic, research & scientific development activities in this building. However, with the growth of technology & the increasing need for electricity, the electrical installation network in this laboratory building is at risk of loss due to interference or failure which can negatively affect the smooth running of activities in it.

The importance of reliable & safe electrical infrastructure in laboratory buildings is a crucial aspect in ensuring the smooth running of academic activities, research & scientific development at Ahmad Dahlan University. Integrated laboratory buildings that are the center of research & experimental activities at these 2 universities must be ensured to have an electrical installation network that works optimally to avoid losses due to electrical power disruptions. Most buildings use complex installation networks, building needs become a reference for determining electricity needs, distance & type of cable also determine the level of efficiency of electrical installations. The building's electrical installation network requires analysis to determine losses, analysis of electricity usage losses can determine the feasibility of using electricity in buildings.

The electrical installation network in Indonesia refers to the General Electricity Installation Regulations (PUIL) & Indonesian National Standards (SNI), not prioritizing the aesthetic beauty of the building. Electrical installations must refer to the applicable rules & regulations in accordance with PUIL 2011. The building requires considerable electrical energy, therefore the distribution of electrical energy must be taken into account so that electrical energy can be fulfilled properly & in accordance with applicable regulations. The building electrical installation network has its own complexity because it involves various kinds of equipment & laboratory equipment with various electrical power. Potential losses caused by disruption or failure of the electrical network can be very detrimental, both in terms of time, finance, and safety.

Improving the quality of electric power distribution is one of the important elements in an effort to increase effectiveness and meet the needs of electrical energy efficiently. Planning is something that is needed to ensure a sustainable or maintained electrical energy. Things that need to be considered in maintaining the sustainability of electrical energy distribution to buildings by considering the value of frequency, current & voltage stability so that energy distribution can take place optimally.

2. METHODS

2.1. Energy

Energy is a concept that is closely related to transformations, processes, or changes that occur in a system. This concept is often related to force displacement or temperature change, so it can be measured in joules, where one joule is equivalent to one meter of force displacement. Similarly, energy is related to specific heat, which is the amount of energy required to increase the temperature by one degree in a mass of material. In a practical context, energy is often associated with aspects such as fuel or electrical energy consumption, the ability to perform various types of work, including those of heat, light, mechanics, chemistry & electromagnetics.

Energy, in concept, is a subject matter that is closely related to various physical processes & changes in everyday life. Its association with force displacement or temperature change enables measurement & further understanding of the energy phenomenon. The unit of joule becomes an important parameter to measure the extent to which energy can be transformed or transferred in a system. Likewise, the concept of specific heat shows that energy has a role in influencing the temperature of a material, which is then related to various physical & chemical processes.

2.2 Electrical Energy

Electrical energy plays a central role as a basic necessity in our lives. Without it, human activities are difficult to run properly & efficiently. However, it should be noted that excessive consumption of electrical energy can bring significant negative impacts. Therefore, it is important to utilize electrical energy efficiently to avoid wastage & negative impacts on the environment.

In an effort to maintain the efficient use of electrical energy, an electrical energy audit is conducted on buildings. The energy audit process consists of several important stages. The first stage involves collecting data related to the use of electrical energy in the building. The next step is to take direct measurements to get more accurate information on how much electrical energy is being used. Furthermore, the third stage involves the calculation of the intensity of electrical energy demand (IKE), which provides a comprehensive picture of the extent of energy use efficiency in the building. By conducting an electrical energy audit, it is expected that potential energy savings can be identified & steps taken to improve the efficiency of electrical energy use in the building.

2.3 Energy Conservation

In the context of its implementation, the efficiency & effectiveness of energy use are top of mind. Energy conservation refers not only to the preservation of resources, but also to efforts to use energy in a more efficient & effective manner. Efficiency is defined as a general effort to achieve equivalent or better results using lesser amounts of energy. Hence, energy conservation not only covers the aspect of resource preservation, but also emphasizes the importance of quality & efficiency improvement in energy utilization.

Building types have different levels of standards, so that the standard values that have been set can effectively reduce the waste of electrical energy beyond the standard limits described in SNI 6197: 2011. Thus, understanding & implementing standardized values in lighting systems is key in reducing inefficient electrical energy consumption. By detailing the intensity of energy consumption in units of kWh/m2 /year, energy efficiency evaluation can be done in more detail, enabling the identification & implementation of specific corrective actions in an effort to reduce environmental impact & energy wastage.

2.4 Electrical Power

Electrical power reflects the capacity to conduct energy in a circuit. This concept highlights the ability of a system to transfer & conduct electrical energy through a designed path. Electrical power not only refers to the amount of energy, but is also an important measure in evaluating the performance of an electronic system or device.

In the context of electricity, power reflects the level of available & potential energy that a circuit can deliver. Therefore, the concept of electrical power is a key element in the design & evaluation of the effectiveness of various electronic devices, from household appliances to large power systems. An in-depth understanding of electrical power enables the development of more efficient technologies & the improvement of overall electrical system performance.

Electrical voltage tolerance limits:

Tolerance limit -10% (minimum limit) **2. 1**

Tolerance limit +5% (maximum limit) **2. 2**

2.5 Electrical Installation

Electrical installation is the electrical system in a building or area. Electrical installation includes the placement of cables, electrical devices, fixtures & protection systems needed to connect electrical power sources with electrical equipment & lighting. The main purpose of an electrical installation is to provide a safe, reliable & efficient electricity supply to various parts of a building, including residential homes, commercial buildings, factories, or public areas.

Safety & reliability are top priorities in any electrical installation process. This emphasizes the importance of careful planning & accurate implementation in accordance with applicable safety standards & ordinances. Thus, a proper electrical installation not only provides the required electrical power source, but also provides adequate protection against risks & potential hazards associated with the use of electricity.

2.6 Electrical Power Distribution

Electrical Power Distribution The process of electrical power distribution is crucial in an electrical infrastructure that allows for efficient & reliable access to energy sources. Distribution substations, which act as a link between the main energy source & consumers, have a strategic role in reducing the voltage of electricity from the transmission level to a voltage that is more suitable for use by end users. Through primary distribution cables, electrical energy is routed to distribution transformers that are usually located close to the consumer area. The transformer serves to adjust the voltage to suit the needs of households, industries & commercials.

Efficient & integrated distribution systems enable a stable & reliable flow of electricity to end users. Secondary distribution cables give household & commercial consumers direct access to the electricity supply required for various daily needs. In addition, consumers who have larger power demands, such as large industries, are generally directly connected to primary distribution substations or primary distribution cables. Thus, the electrical power distribution system plays a key role in ensuring the availability of reliable & safe electricity to the society at large.

2.7 Power Loss

Power loss refers to the loss of power that occurs when electricity is transmitted through a conductor due to resistance in the conductor material. This phenomenon causes some of the delivered power to be lost in the form of heat or useless energy. This aspect becomes very important in any electrical distribution system because the quality of power received by the user depends on the amount of voltage drop at the receiving point, especially close to the consumer's location. The length of the conductor or cable & its resistance will affect the level of power losses experienced along the distribution line. These power losses, in turn, can impact the efficiency of electrical power delivery, especially at the receiving endpoint or load.

Attention to power losses is important in maintaining the efficiency & reliability of an electrical distribution system. Excessive power losses can result in energy wastage & increase system operating costs. In addition, significant power losses can cause a reduction in the quality of power received by consumers, and can even disrupt the operation of equipment that is sensitive to fluctuations. As a result of the load imbalance between each phase on the secondary side of the transformer (phase R, phase S, phase T) a current flows in the neutral of the transformer. The current flowing in the neutral conductor of this transformer causes losses. Power losses are calculated using the following formula:

$$\mathbf{PLosses = I2\ .R} \qquad \mathbf{2.\ 3}$$

where:
I = Current
R = Conductor type resistance

2.8 Conductor

Conductors are in the form of metals or non-metals, which have the ability to conduct electric current from one point to another. This conductor can be in the form of a cable or conductor wire. A cable is a type of conductor that is coated with an insulating layer & the entire core is protected with a protective sheath. Conductors in electrical systems play an important role in carrying electric current from one place to another. There are different types of conductors used depending on the specific needs & applications.

1. Insulated conductor - can be an insulated wire or cable, the limitation of an insulated wire is a single conductor assembly, either fiber or solid insulated (NYA, NYAF).
2. Non-insulated conductor - is a conductor that is not coated by an insulator, an example of a non-insulated conductor BC (Bare Conductor). Types of isoalsi used in electrical conductors include insulation from PVC (Poly Vinyl Chlorid).

Wires are a common choice because they come with an insulating layer that helps protect against potential electrical interference or leakage. In contrast, uninsulated conducting wire is often used in certain areas or situations that require flexibility or special configurations. Understanding the difference between cables & conducting wires helps in designing & selecting components that suit the needs of the electrical system. Calculate conductor resistance with the following formula:
Mencari nilai R dengan rumus:

$$\frac{\text{Wire Length (M) x Wire Type Resistance }(\Omega)}{\text{Cross-Sectional Area}} \qquad \mathbf{2.\ 4}$$

2. 9 Flowchart of Data Collection

Data collection on the electrical installation network of the electrical installation network on the fifth floor of the UAD integrated laboratory is carried out as shown in the flow chart, figure 1.

The data collection process was carried out through direct observation in the fifth floor integrated laboratory at UAD campus four. This observation involved reviewing the building and space, as well as measuring the length, width & height of the room to determine the dimensions of the installation network used. Next, spatial mapping was done using Microsoft Visio software based on the data collected. This step provided an overview of the laboratory space.

The next step is to conduct a comprehensive data capture to involve current, frequency & voltage in the installation network. During data capture, the accuracy & precision of the data is the main focus to ensure that the captured data reflects the actual activity within the laboratory.

Data processing is used as a reference for whether the electrical installation network is good or not, carried out as an analysis of electrical installation network losses. Understand energy consumption patterns and losses. Data collected from data processing of electrical installation networks can determine electrical energy users and system efficiency.

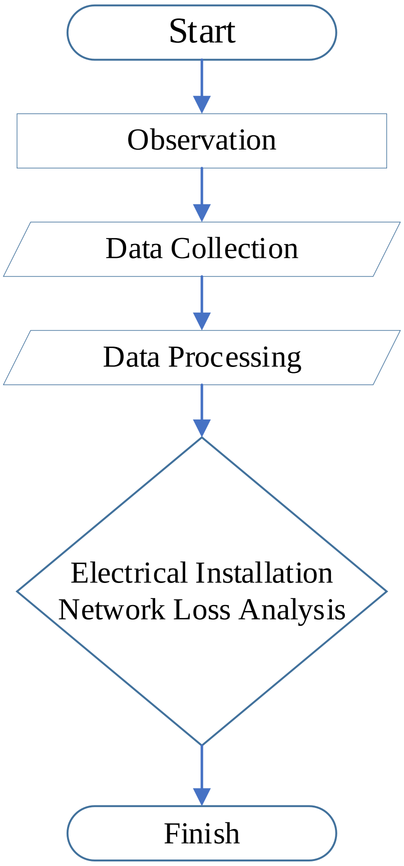

Figure 1. Flowchart of Data Collection

3. RESULT AND DISCUSSION

3.1 Lighting System

Lighting system of the integrated laboratory building of campus 4 UAD on the fifth floor has various types of lamps, such as LED Downlight, LED Beam TKO, LED TKI Mirror Louvre, LED Bulb Downlight & LED Wastafle Lamp. The use of lights in the lighting system in the integrated laboratory building on the fifth floor of Campus 4 UAD, Table 1.

Table 1. Data on Number of Lamps

Place	Type of Lamp					
	Downlight LED	TKO Balok LED	TKI Mirror Louvre LED	Downlight Bulb LED	Lamp LED Wastafle	Total
Lantai 5	97	5	142	41	8	293

Lights used in the integrated laboratory building campus 4 UAD, LED Downlights amounted to 97 power each lamp 20 watts, LED Beam TKO amounted to 5 power each lamp 16 watts, TKI Mirror Louvre LED amounted to 142, each lamp 16 watts, LED Bulb Downlights amounted to 41 power each lamp 7 watts & for LED Wastafle Lights amounted to 8 power each lamp 16 watts, Table 2.

Table 2. Lighting Load Data

Lamp Types	Total Lamp	Lamp Load (W)	Total Load (W)
Downlight LED	97	20	1.940
TKO Balok LED	5	5	25
TKI Mirror Louvre LED	142	16	2.272
Downlight Bulb LED	41	7	287
Lampu LED Wastafle	8	16	128
Total Lamp Load (W)		**4.652**	

It can be seen that the total load of the lighting system in the integrated laboratory building campus 4 UAD fifth floor amounts to 4,652 Watts, the lighting users of each room are different based on the needs & functions of the room.

3.2 Electric Current

Electric current refers to the continuous & sustained flow of electrons in a conductor, triggered by differences in the number of electrons at various locations. This process occurs when there is a difference in the number of electrons in a medium, which encourages the flow of electrons towards areas with a lower number of electrons, creating electricity in the conductor.

Flow continuously until the power source is cut off, data collection is carried out at 07.00 - 17.00 WIB, the results of data collection of amperage per phase in the integrated laboratory building campus 4 UAD, Table 3.

Table 3. Current Data Collection (Phase to Neutral) 5th Floor

	Current (A)			
HOURS	**R**	**S**	**T**	**N**
07.00	9,95	5,91	5,06	6,34
08.00	24,71	19,82	19	9,20
09.00	30,10	26,11	23,28	10,35
10.00	31,27	27,65	29,57	11,48
11.00	32,71	29	29,14	12,19
12.00	26,77	27,14	24,15	9,78
13.00	32,48	30	28,44	8,60
14.00	29,48	28,28	29,44	10,07
15.00	22,3286	17,42	15,57	8,36
16.00	17,914	15,14	12,63	6,78
17.00	15,05	10,45	8,91	7,60

Data collection of the current of the Integrated Laboratory Building Campus 4 Floor 5 UAD at 07:00-17:00 WIB at the outgoing transformer. The value of electric current can change due to the use of electronic equipment during peak hours, the use of electronic equipment in the UAD integrated laboratory building on the fifth floor is reduced, so the current value will decrease. The current value decreases if the electronic equipment has been turned off properly. The greater the number of active loads, the electric current flowing in the system will increase, while the less load installed, the current will decrease. The data collection process is carried out in the time span from 07:00 to 17:00 WIB, which provides information on the values of the R, S, T & N parameters in the system, figure 2.

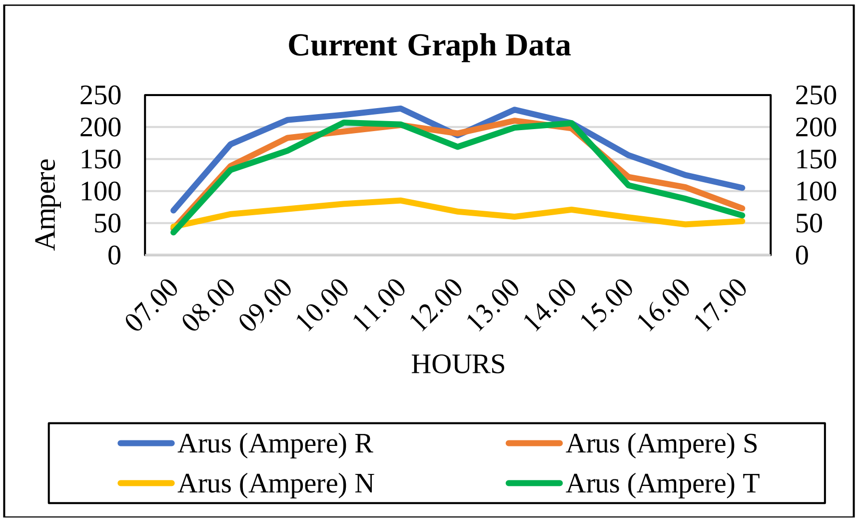

Figure 2. Current Graph

Electric current load increases during peak hours using electronic equipment, then at 12:00 before break time starts to experience a decrease due to the use of electronic equipment. Then at 13:00 it starts to increase due to the use of electronic equipment starting to be used after the break. At 15:00 the load decreased due to the use of electronic equipment decreasing. After 15:00 the current fluctuation is not too significant because the UAD campus 4 laboratory building has little electrical equipment activity, then it starts to turn off & stabilize.

Current value of the fifth floor there is a difference in value between phases R, S, T & N. The value of phases R, S, T, N, for the ideal RSTN phase the value is not too high a difference (flat), thus indicating a current distribution error in the RSTN value, causing energy consumption in the Integrated Laboratory Building 5th Floor Campus 4 UAD is very wasteful. In the maximum current value of phase N, the value is 12.19286. Ideally the value of phase N is close to 0 for ground, indicating that there is a leak in the grounding system in the laboratory building, resulting in very wasteful energy consumption.

3.3 Electrical Voltage

Voltage increases as the electric current load decreases during peak hours of electronic equipment use & will decrease when the electric current load of electronic equipment use increases, voltage measurements were taken from 07.00 to 17.00 WIB, Table 4.

Table 4. Voltage Usage Data

Hours	Voltage (Volt)		
	R	S	T
07.00	395,75	396,14	394,51
08.00	394,73	393,31	392,7
09.00	392,03	392,32	389,71
10.00	391,19	391,82	388,86
11.00	396,13	397,82	394,58
12.00	394,4	395,86	392,19
13.00	390,4	391,86	389,91
14.00	398,5	399,87	395,18
15.00	399,4	398,78	399,19
16.00	401,6	401,27	399,39
17.00	403,7	404,76	401,39

Voltage data of the integrated laboratory building on the 5th floor of Campus 4 UAD at 07:00-17:00 WIB at the outgoing transformer. The value of R, S, T. The voltage value changes due to the use of electronic equipment during peak hours, the users of electronic equipment decrease, so the voltage value decreases, Figure 3.

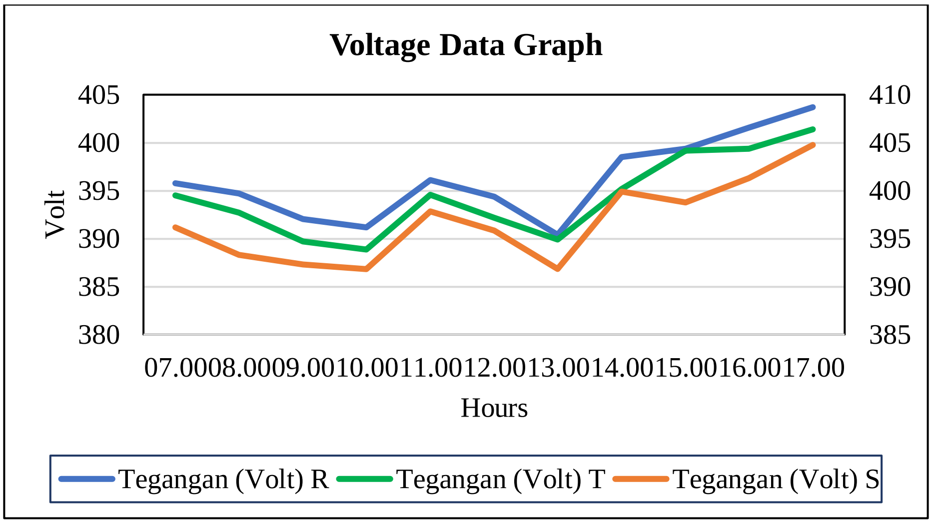

Figure 3. Voltage Graph

The voltage at 7:00 a.m. decreased as the use of electronic equipment increased. At 12:00 the voltage increases as the use of electronic equipment decreases before the break time. Then at 13:00 the voltage increases as the use of electronic equipment increases after the break time. At 15:00 the voltage slowly increased because the use of electronic equipment decreased before the completion of activities in the laboratory.

Measurement of voltage fluctuations 390.40 volts - 404.76 Volts. assuming that each floor has the same load per floor. The electrical voltage tolerance limit is based on the Minister of Energy and Mineral Resources Regulation, the minimum limit is 198 V and the maximum limit is 231 V.

Through the calculation of voltage tolerance, it can be concluded that the voltage fluctuations that occur in the integrated laboratory building are still within the tolerance limits set by PUIL 2011. The minimum limit & maximum limit of voltage fluctuations still meet the regulated tolerance standards, indicating that the voltage system in the building operates in accordance with applicable regulations.

3.4 Electrical Frequency

Frequency plays an important role as an evaluation parameter to assess the reliability & quality of electrical installation networks. Basically, frequency measures the number of alternating current cycles that occur in one second. This parameter gives a direct idea of the degree of consistency of electricity flow in the network, which is a key determinant of the operational efficiency & quality of an electrical installation. Table 5.

Table 5. Frequency Data Collection

Hours	Frequency (Hertz)
07:00	50,1
08:00	49,96
09:00	50,1
10:00	49,99
11:00	49,99
12:00	49,99
13:00	49,96
14:00	49,98
15:00	50,05
16:00	49,96
17:00	50,02

Frequency data collection of Integrated Laboratory Building 5th Floor Campus 4 UAD at 07:00-17:00 WIB at the outgoing transformer. Frequency is the number of alternating current (AC) cycles per second. Frequency is directly proportional to electric current, frequency data, Figure 4.

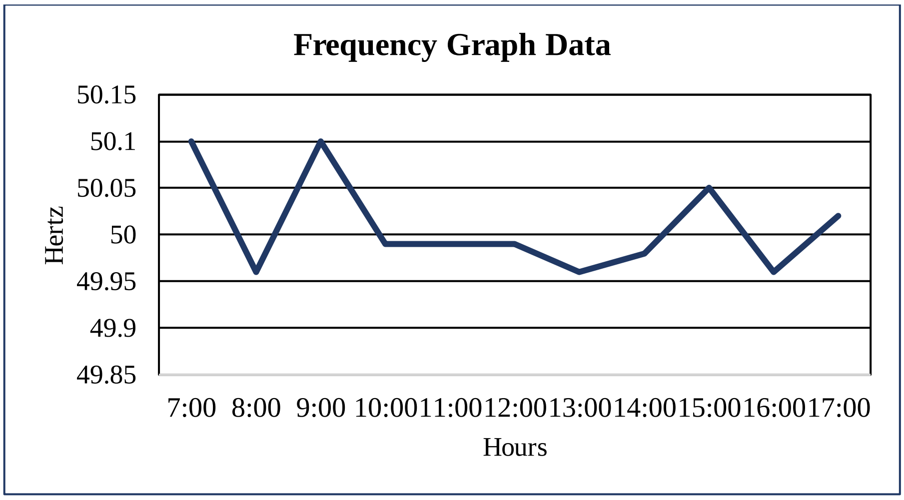

Figure 4. Grafik Frekuensi

Voltage at 08:00 the frequency increases when electronic equipment users increase before activities begin. At 12:00, the frequency increases as electronic equipment usage decreases in the break time. At 13:00, the frequency increased because the electronic equipment users increased after the break time. At 15:00 the frequency slowly decreased due to reduced activity & towards the end of laboratory activities.

Frequency measurements were taken at the integrated laboratory building on the 4th campus floor of UAD, the results of the outgoing transformer frequency averaged 53.56 Hz, assuming that each floor has the same load on each floor. Based on the measurement results, the average voltage frequency is 49.96 Hz - 50.05

Hz. Indonesian frequency standards use 50 Hz, minimum tolerance limit - 0.5 Hz (49.5 Hz) & maximum tolerance limit +1 Hz (51Hz).

Based on the calculation of frequency tolerance, the frequency fluctuations in the fifth floor integrated laboratory building, meet the tolerance set. A good frequency supply will prevent consumer equipment from damage & when there is a situation where the frequency < 50 Hz plus the total amount of energy supply to the system by adding a working generating unit.

3. 5 Calculating the Installation Network PLosses

Calculations of PLosses or power losses in the electrical installation network of the UAD integrated laboratory on the fifth floor is an important part of evaluating performance & energy efficiency. By calculating the power losses, it can be understood how efficient the electrical installation network is & where the main points of losses occur. This analysis provides valuable insights for improvements & increased efficiency in energy use in the laboratory.

Furthermore, power loss analysis also provides a basis for the development of more efficient energy saving strategies. By knowing where energy losses occur & how much they impact, efforts to improve efficiency & reduce wastage can be directed in a more focused & measurable manner. This allows facility managers to take concrete steps that can yield significant results in energy savings & overall operational cost reduction. Calculating the PLosses of 2.5 mm NYA cable room installation network and its resistance value of 25.05 Ω, Table 6.

Table 6. Network Plosses of Each Electrical Installation Room

Hours	I2	R	P_{losses} (I^2.R)
07.00	1974,02	25,05	49,46
08.00	4147,36	25,05	103,93
09.00	5254,8	25,05	131,68
10.00	6462,55	25,05	161,95
11.00	7284,62	25,05	182,55
12.00	4694,99	25,05	117,65
13.00	3630,063	25,05	90,96
14.00	4975,89	25,05	124,69
15.00	3424,59	25,05	85,81
16.00	2258,15	25,05	56,58
17.00	2835,56	25,05	71,05

Calculating the PLosses of the main installation network with 4 mm NYM cable type. Using the formula I2.R & the average value of I, Table 7.

Table 7. Hourly Main Network Plosses

Rooms	**Cable Length**	**I^2**	**R**	**P_{losses} (I^2.R)**
Lab. Otomasi & Instalasi Listrik	52,5	4115,33	104,74	431,07
Lab. Dasar Elektro	22,5	4115,33	44,89	184,74
Lab. Komputer	15	4115,33	29,92	123,16
Lab. Telekomunikasi & Frekuensi Tinggi	30	4115,33	59,85	246,32
Lab. Mikroprosesor	37,5	4115,33	74,82	307,91
TELKOMNIKA	22,5	4115,33	44,89	184,74
RESEARCH GROUP	37,5	4115,33	74,82	307,91
Lab. Teknologi Pendidikan Matematika	45	4115,33	89,78	369,49
Lab. Microteaching FAI	37,5	4115,33	74,82	307,91
Ltps	52,5	4115,33	104,74	431,07
Lab. Pembelajaran Biologi 4	67,5	4115,33	134,67	554,24
Lab. School Physics	67,5	4115,33	134,67	554,24
Lab. Komputasi Pemodelan Matematika	75	4115,33	149,64	615,82
Lab. Pembelajaran Berbasis Lingkungan	82,5	4115,33	164,60	677,40
Lab. Program Studi Matematika	90	4115,33	179,56	738,98
Lab. Komputasi Dasar	97,5	4115,33	194,53	800,57
R. Admin 1	37,5	4115,33	74,82	307,91
R. Admin 2	45	4115,33	89,78	369,49
R. Admin 3	84	4115,33	167,59	689,72

Rooms	Cable Length	I^2	R	P_{losses} (I^2.R)
TOILET 1	30	4115,33	59,85	246,32
TOILET 2	30	4115,33	59,85	246,32
TOILET 3	60	4115,33	119,71	492,65
TOILET 4	97,5	4115,33	194,53	800,57

Total kWh that has been used with a total of 100% PLN distribution electricity is divided into lecture buildings using 40%, laboratory buildings using 35%, medical buildings using 25% & Muhammadiyah museums using 5%, electricity usage during lecture holidays, Table 8.

During the lecture holiday period, there is a decrease in electricity usage due to reduced academic activities and needs. This is due to the decreased use of facilities and activities in the campus environment during this period. every month the value of electricity users varies, due to differences in activities when on campus, electricity usage is divided into 4, namely for the lecture building by 40%, laboratory building 35%, medical building 25% & Muhammadiyah museum by 5%.

Table 8 Electricity Usage During College Holidays

MONTHS	KWH	
	LWBP (OUTSIDE PEAK LOAD TIME)	**WBP (PEAK LOAD TIME)**
Juli 2021	125,184	17,584
Agustus 2021	125,536	17,184
Maret 2022	147,808	17,952
Agustus 2022	126,320	18,192

4. CONCLUSIONS

Based on the research that has been carried out, it can be concluded as follows:

1. The conductor used in the installation of the fifth floor integrated laboratory building, the main installation of NYM 4 mm and NYA 2.5 mm for the installation of each room.
2. Losses on the network of each electrical installation of the fifth floor integrated laboratory building averaged 106.94 W per hour.
3. On the main network of the fifth floor integrated laboratory building there is a loss with an average hourly 434.28 W.

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Penulis 2 Pas Foto (3x4cm)	**Nama Penulis 2 (9 pt)** Penulis 2 menyelesaikan pendidikan sarjana di program studi teknik elektro universitas ahmad dahlan pada tahun 2020. Saat ini penulis 2 adalah dosen tetap di program studi teknik elektro universitas ahmad dahlan. Bidang penelitiannya adalah sistem kendali dan robotika.