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An Efficiency Analysis of Use of Recycled Lights

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Abstract

Light bulb waste is one type of waste that is categorized into B3 waste which can cause environmental pollution, environmental pollution produced by waste and the absence of efficient handling methods is a problem currently faced by the government, especially non-organic waste which includes hazardous waste. and cannot be decomposed. Light bulb waste is included in the inorganic waste category, although the production of light bulb waste is still small, the waste has great potential for environmental pollution, so it is necessary to study environmental conservation efforts from this waste. Another problem is the potential for recycling waste light bulbs which is currently not fully utilized by the government and the public. The Innovation of Emergency Lighting Design based on Environmentally Friendly Technology (TRL) is a study to find out and analyze the results of recycling waste light bulbs into energy-efficient emergency lighting with the concept of Reduce, Reus, and Recycle to produce a product that can be reused. Research with analytical methods is carried out as an approach to the implementation of research. The analysis was carried out to find out the results of the field review data, besides that the analysis was also carried out from the electrical side in the form of measuring the electrical components contained in the light bulb so that it could support the success of the research. The results showed that recycled lighting can be implemented as an alternative lamp that is environmentally friendly.

Keywords
Emergency light; Green technology; Energy Conservation; Recycle

I. Introduction

A number of literatures define waste as all types of solid waste originating from human and animal activities, and are disposed of because they are not useful or are no longer wanted (Tchobanoglous, Theisen & Vigil, 1993). While in PP No. 18/1999 in conjunction with PP No. 85/1999 on the management of hazardous and toxic waste, in general, waste is defined as residual material in an activity and/or production process.

The definition of waste has shifted in recent years because the disposal aspect is not clearly stated, where nowadays there is a tendency not to just throw away garbage, but to recycle as much as possible. This is also stated in Law No. 18 of 2008 concerning Waste Management. Based on Law No. 18 of 2008 it is stated that the definition of waste is the rest of human daily activities and/or natural processes in solid form. In the development of the world of education, especially after the rolling reforms, new phenomena have arisen in educational institutions, which are schools that use the term Integrated Islamic Schools (Titik, 2010: 42). The school is essentially aimed at helping parents teach good habits and add good character, also given education for life in society that is difficult given at home. Thus, education in schools is actually part of education in the family, which is also a continuation of education in the family (Daulay in Ayuningsih, W. et al. 2020).

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The increase in population and the rate of economic growth and development in an area in addition to having a positive impact also has a negative impact. Indonesia, which is a large population, faces many problems related to environmental sanitation, especially the problem of waste management. Based on the MDGs (Millineum Development Goals) target, the solid waste service level is targeted to reach 80%. Based on data from the Department of Hygiene and Parks in Medan City in 2017, the composition of the waste in the Waterfall TPA consists of 71.5% organic; Paper 2%; plastic 10.1%; wood 2%; fabric 2.5% rubber 2.5%; metal 0.6%; glass 0.8%; 1 % chunks; pampers / sanitary napkins 3, 1 % and others 3,8 %. Based on this condition, if waste management efforts are not carried out properly, the level of service based on the national target will be difficult to achieve.

The operational conditions of the TPA, which are mostly carried out by open dumping, are generally due to limited human and financial resources. Law No. 18 of 2008 mandates that starting in 2013 open dumping is no longer allowed. For this reason, the planning process plays an important role in the implementation of solid waste management. Involvement in waste management is not only by stakeholders but includes the community in the decision-making process. For this reason, it is necessary to identify waste, both generated (by weight or volume) and its composition

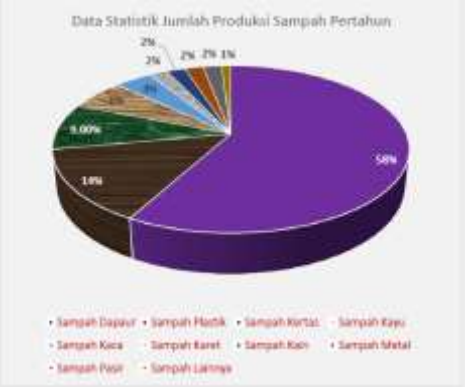

Figure 1. *Identify waste, both generated (by weight or volume)*

It is known that waste that is not handled properly can disturb the aesthetics of the environment, cause odors, and lead to the development of diseases. Environmental disturbances by waste can arise from the source of the waste, where the waste producer does not handle it properly. This can happen to waste producers who don't want to provide trash cans in their homes and prefer to throw the trash into drains or burn them so that they pollute the surrounding environment. Trash cans provided in households and commercial locations such as markets are not covered so this causes garbage to be scattered and becomes a breeding ground for flies and creates odors. In addition, the general pattern of waste handling is still not as required, so pollution problems arise.

Figure 2. *Waste data generated, the percentage of waste can be grouped into the composition as shown in the following diagram:*

The various types of waste and the amount of waste produced by the community can be seen in table 1.

Table 1. Statistical Data on the Amount of Waste Production

Garbage Type	Total Million Tons/Year	Percentage (%)
Kitchen Trash	22.4	58%
Plastic waste	5.4	14%
Paper Trash	3.6	9%
Wood Trash	2.3	6%
Glass Trash	1.4	4%
Rubber/Leather Garbage	0.7	2%
Cloth Garbage	0.7	2%
Metal Trash	0.7	2%
Sand Garbage	0.7	2%
Other Trash	0.5	1%
Total	38.5	100%

Referring to the research conducted by Anisah S. and Darma A, the data shows that the types of Light Emitting Diode (LED) lamps are still categorized as energy-saving and environmentally friendly lighting products. So that this type of LED lamp is very appropriate to be used as lighting [2].

Based on this background, it is deemed necessary to conduct a study to study and produce an energy-efficient lighting product based on green technology and environmentally friendly, to produce a green technology-based emergency lighting product design as alternative energy and solution to the electrical energy deficit. from PLN and aims to reduce waste products to reduce environmental pollution.

Light bulb waste is an indicator of the cause of pollution and environmental damage, environmental pollution produced by light bulb waste and the absence of an efficient handling method is a problem currently faced by the government, especially non-organic waste which includes hazardous and non-biodegradable waste. Light bulb waste is included in the inorganic/B3 waste category, although the production of light bulb waste is

still small, the waste has great potential for environmental pollution, so it is necessary to study environmental conservation efforts from this waste.

Looking at the other side of the problem, the potential for recycling waste light bulbs is currently not being fully utilized by the government and the public. Innovation in the Design of Environmentally Friendly Technology-based Emergency Lighting Lights (TRL) is an effort that aims to recycle waste light bulbs into energy-efficient emergency lighting with the concept of Reduce, Reuse, and Recycle to produce a product that can be reused to replace existing lighting. manufactured by the manufacturer. These efforts are carried out through research conducted with the method of design and analysis, carried out as an approach in the implementation of research. The design is done by making a lamp assembly that is recycled with waste raw materials from lighting lamps, and electricity contained in the light bulb so that it can support the success of the research. The design method is carried out to recycle damaged light bulbs with the concept of Environmentally Friendly Technology (TRL), namely reduce, reuse, and recycle to produce recycled emergency lighting products that can be reused. environmentally friendly emergency lights that can be utilized.

Figure 3. *Waste Lighting Lamp*

II. Review of Literature

2.1 Recycling Technology

Garbage or also commonly known as waste that has a negative impact on the environment has become a big concern both nationally and internationally as seen on youtube with the URL https://youtu.be/wxMK48UAVAY [3]. Meanwhile, nationally in Indonesia, the legal basis for waste management has been regulated and contained in the Law of the Republic of Indonesia Number 18 of 2008 concerning Waste Management [1]. Government Regulation No. 81 of 2012 concerning the management of household waste and similar household waste [4]. Regulation of the Minister of Environment of the Republic of Indonesia Number 13 of 2012 concerning Guidelines for the Implementation of Reduce, and Reuse and Recycle through waste banks. Policies regarding energy efficiency are also regulated in the Law of the Republic of Indonesia Number 30 of 2007 concerning Energy [5].

Referring to the research that has been carried out by Ika Wahyuning, lighting bulbs can be categorized in the type of K3 waste, namely the type of waste that is dangerous and difficult to decompose in the wild [6]. Based on the characteristics of Environmentally Friendly Technology (TRL) it can be categorized:

a. This includes all transition technologies that will become environmentally sound

technologies.

b. All life cycle flows of material, energy and water in production and consumption systems.
c. Covering the entire spectrum from the basic technology of production and consumption systems to the whole integrated technology where environmental technology is a production and consumption technology for itself.
d. Including closed system technology where the target is zero waste and significant reduction in the use of resources as well as environmental technologies that produce few emissions, consider technology development in ecological and social contexts.

2.2 Legal Basis of Waste Management

The legal basis for discussing waste management is as follows:

a. Law of the Republic of Indonesia Number 18 of 2008 concerning Waste Management.
b. Law of the Republic of Indonesia Number 30 of 2007 concerning Energy.
c. Government Regulation No. 81 of 2012 concerning the management of household waste and similar household waste.
d. Regulation of the Minister of Environment of the Republic of Indonesia Number 13 of 2012 concerning Guidelines for the Implementation of Reduce, and Reuse and Recycle through Waste Banks.
e. Regulation of the Minister of Environment of the Republic of Indonesia Number 7 of 2011 Number 1 of 2013 concerning Guidelines for the Implementation of the Adipura Program.

Energy policy according to lawno. 30 of 2007 concerning energy, the national energy policy is an energy management policy based on the principles of justice, sustainability, and environmental insight in order to create independence and national energy security. Renewable energy sources are sources of energy produced from sustainable energy resources if managed properly, including geothermal, wind, bioenergy, sunlight, water flows and falls, as well as movements and differences in sea layer temperature. Energy policy according to law no. 30 of 2007 on energy

The National Energy Policy consists of:

a. Key policies include:
   - Availability of energy for national needs;
   - Energy development priorities;
   - Utilization of national energy resources; National energy reserves.
b. Supporting policies include:
   - Energy conservation and diversification;
   - Environment and safety;
   - Energy prices, subsidies and incentives;
   - Infrastructure, community access and energy industry;
   - Energy research and development; and
   - Institutional and funding.

2.3 Electrical Energy

The energy of an object is a measure of the object's ability to do work. The unit of energy is the joule. Electrical energy is the final energy needed for electrical equipment to drive motors, lighting, heating, cooling or to move mechanical equipment back to produce other forms of energy. The unit of power = joules/second is often referred to as watts. Energy units can also be expressed in watts, namely watt-hours or Wh

$$1 \text{ Wh} = 1 \text{ J/sx } 3600 \text{ s} = 3600 \text{ J}$$

$$1 \text{ KWh} = 1000 \text{ Wh} = 3600 \text{ kJ}$$

Light is a source of lightwhen we are active. The higher the required focus of an activity, the brighter the light we need. Vice versa, the lower the focus of an activity, the dimmer the light we need. Currently, there is no sensor technology that can work to feel the high-low activity of one / several people in a room. The lamp itself, was produced with the concept of one light power. Not dynamic to be able to produce several levels of bright light. With the condition of the lights that are already like that, we really can't change it. However, we can change / adjust the lighting technique in a room to make efficient use of power by using several lights in it. To find out or identify where and how much energy is used in the lighting system (various types of lighting), it is necessary to observe and or directly measure the various types of lighting. The use of different types of lighting will also produce different amounts of power, load characteristics are needed so that the power system and the effects of loading can be analyzed properly, this analysis is included in determining the initial conditions that will be projected in planning so that the use of loads can be more effective.

a. Electrical power

Every load must have power, this power is generated by the load when connected to the supply, as well as the lights. The lamp can produce light because it consumes a certain amount of power according to the standards of each lamp manufacturer. This power is usually listed on each product, but this power can also be obtained by direct measurement of each lamp

b. Electrical Load

Broadly speaking, the load can be classified into household expenses, commercial expenses, and industrial expenses. Load characteristics arise due to the use of electric power whose magnitude changes over time. The amount of the load every certain time interval varies according to what is needed by electricity consumption or consumers, regarding the selling price of electricity provided by PLN, electricity tariffs for household customers are divided into three, R1, R2 and R3. In electricity costs there are 2 types of costs, namely load and usage costs. The load charge is the fee that must be paid per month for each 1000 VA (1kVA) connection. Meanwhile, the usage fee is the cost for every 1kWh of electricity used. Specifically for the R1 group, the term block consists of blocks I-III. The goal is to save electricity consumption. Load characteristics are needed so that the power system and the thermos effect of loading can be analyzed properly. This analysis is included in determining the initial conditions that will be projected in the next planning so that the load characteristics can be used effectively. Broadly speaking, the load can be classified as follows:

- Households: The values of these household load factors are: The demand factor is 70-100%. Diversity factor 1.2-1.3 and load 10-15% .
- Commercial: Generally 90-100% demand factor. The diversity factor is 1.1-1.2 and the load factor is 25-30%.
- Industry: For large-scale industry the demand factor is 70-80% and the load factor is 60-65%.

c. Lighting

Lighting lamps have different characters, taking into account the power required and the level of lighting produced, (Sukisno, Wardani 2011), in general lamps can be classified into three types, namely:

- **Incandescence;**
  Light is produced by a tungsten filament (melting point >2200°C) which glows due to heat. The efficacy of this lamp is low, only 8-10% of energy is converted into light. The rest is wasted as heat. In general the lamp.

Figure 4. *Incandescent Lamp*

Incandescent lamps have a yellowish light that creates a warm, romantic, and intimate atmosphere. Large wattage incandescent bulbs are more efficient than low wattage bulbs. For example, a 100 W (120 V) lamp produces 1750 lumens, while two 50 W (120 V) lamps will only produce 1280 lumens. Incandescent lamps have various types, including clear bulbs, argenta lamps, superlux lamps, opaque bulbs, candle-shaped bulbs, luster lamps, and halogen lamps.

- **Fluorescence lamp**
  These lamps are usually referred to as fluorescent lamps. However, in the industrial world, these lamps are known as TL lamps. Now there are the latest types of fluorescent lamps, some lamp manufacturers refer to these lamps as SL and PL lamps. The light of ordinary fluorescent lamps is white, while SL and PL lamps besides white also have yellow and bluish-white types. Advantages of using fluorescence lamps: Efficacy (lumen per watt) is high. Durable (long life), up to 20,000 hours (assuming 3 hours of ignition per service). The more often turned on and off, the shorter life. The elongated shape of the lamp illuminates a wider area with diffused light. For lighting that does not require shadows, fluorescent lamps are better than incandescent lamps.

Figure 5. *TL lamp*

- **LED light**
  LED lights are made of semiconductor materials that will only allow electric current to flow in one direction and not the other way around. LED chips generally have a relatively low breakdown voltage. The characteristics of LED chips in general are the same as those of diodes, which only require a certain voltage to operate. However, if too large a voltage is applied, the LED will be damaged even though the applied voltage is a forward voltage. The objectives of this study are: To know the character produced by

the LEDs made. To know the effect of using LEDs on indoor lighting. Comparing the performance of LED lamps and incandescent, TL, and LHE (Energy Saving Lamps) lamps by observing the power value (P) and light intensity (Lux) produced.

Figure 6. *LED Lights*

The light in an LED is electromagnetic energy emitted in the visible part of the spectrum. Visible light is the result of a combination of different wavelengths of visible energy, the eye reacts to see at wavelengths of electromagnetic energy in the region between ultraviolet and infrared radiation. Light is formed from the movement of electrons in an atom. Where in an atom, electrons move in an orbit around an atomic nucleus. Electrons in different orbits have different amounts of energy. An electron that moves from an orbit with a higher energy level to an orbit with a lower energy level needs to release its energy. The energy released is in the form of photons that produce light. The greater the energy released, the greater the energy contained in the photon. How do we know a product has good quality. Of course, from the results of the tests it does. The same is true for LEDs. Before being marketed, LED lights go through a testing stage, to ensure their quality. This testing stage is called the binning process. In LEDs, there are four things that must be proven through the binning process, namely color consistency, color rendering, lifespan (lifetime), and efficacy (amount of light per power) expressed in lumens per watt (LPW). The function of binning is to ensure that each LED produced meets these standards. The same is true for LEDs. Before being marketed, LED lights go through a testing stage, to ensure their quality. This testing stage is called the binning process. In LEDs, there are four things that must be proven through the binning process, namely color consistency, color rendering, lifespan (lifetime), and efficacy (amount of light per power) expressed in lumens per watt (LPW). The function of binning is to ensure that each LED produced meets these standards. The same is true for LEDs. Before being marketed, LED lights go through a testing stage, to ensure their quality. This testing stage is called the binning process. In LEDs, there are four things that must be proven through the binning process, namely color consistency, color rendering, lifespan (lifetime), and efficacy (amount of light per power) expressed in lumens per watt (LPW). The function of binning is to ensure that each LED produced meets these standards. and efficacy (amount of light per power) expressed in lumens per watt (LPW). The function of binning is to ensure that each LED produced meets these standards. and efficacy (amount of light per power) expressed in lumens per watt (LPW). The function of binning is to ensure that each LED produced meets these standards.

III. Result and Discussion

3.1 Lighting Lamp Waste Recycling Process

Light bulb waste is one of the non-organic component wastes and is included in the B3 waste component with glass materials that cannot be decomposed in the wild, so a solution is needed to reduce this waste. One of the waste lighting lamps that can be recycled is the type of LED (light Emitting Diode). In the research conducted focused on recycling types of LED lamps.

This type of LED lamp is an energy-saving lamp with light emitting in the form of electromagnetic energy which can be seen that the basic material of LED is a semiconductor with the characteristic of electric current flowing in one direction and not in the opposite direction. The characteristics of LEDs in general are the same as those of diodes which only require a certain voltage to operate. LED lamps are a type of lamp with low power consumption so that energy use is very efficient. In addition to being efficient and energy efficient, LED lamps also do not contain harmful materials so they are friendly to the environment. The research approach in the independent research program uses observation and design analysis methods that will produce a light bulb waste design concept, followed by design and testing methods for the resulting product. an approach is taken to obtain data on the potential for waste light bulbs to be recycled. The analysis and observation methods are very effective in determining the recycling potential so as to produce a new concept, the results of the analysis will be followed up with the design of recycled emergency lighting products as follows:

a. Bulb Waste Analysis:
   At this stage, a study is conducted on the effects and impacts of light bulb waste on the environment. This stage is also carried out for the collection of waste light bulbs to be selected for recycling. (Environmental Engineering Discipline)
b. Electrical Data Analysis:
   At this stage, an analysis of the electrical components contained in the light bulb is carried out, and the need for electrical components for design. (Electrical engineering discipline) This stage is carried out by testing the resulting product, testing is carried out to ensure that the product is feasible and safe to use, and that the electrical components are in accordance with standards.

Based on the results of studies and calculations carried out on the results of the design of LED lighting waste, it has the potential to be recycled based on reduce, reuse and recycle.

The data collection was carried out in order to obtain information by conducting direct interviews and field observations.

3.2 Procedure

a. Check each component of the lamp with a multimeter.
b. Find the reason why the LED light won't turn on.
c. Discard the LED light casing by rotating it.
d. Prepare a multitester avometer, soldering elements, and tweezers.
e. Test one by one the micro LEDs with the Avometer multitester. If there is a micro LED that does not light up, it means that the micro LED is broken. If one of the micro LEDs breaks, then everything will not work.
f. Mark the micro LED that is not lit.
g. If there is no avometer multitester, look closely at the black scorched spots on the micro LED. If there are black spots, it means the micro LED is broken. Remove the

outer LED component, place the LED component on the solder element, with the marked (or charred) micro LED position directly above it .

h. Remove the broken micro LED using tweezers, after the micro LED is released, unite the positive and negative positions using a soldering iron. This serves as a pathway to turn on another micro LED.
i. Place the outer components back into the lamp body.

Figure 7. *Connect the LED light fitting to the switch, the LED light will turn on again.*

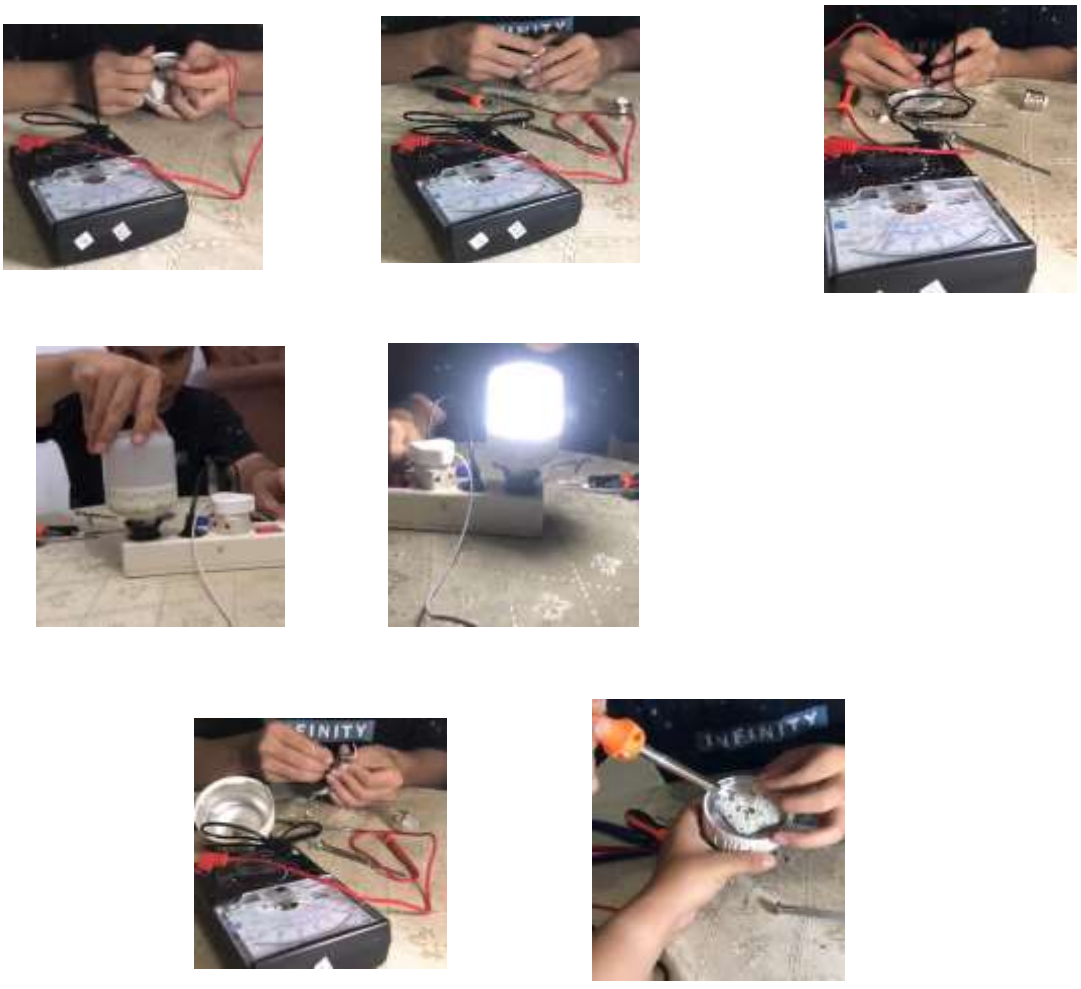

Figure 8. *Recycled Lighting Design Drawing*

3.3 Analysis of Recycled Lighting Lamps

In carrying out the research, the design and testing of several samples of recycled lamps was carried out as shown in the following table

Table 2. *Types and Capacity of LED Lights*

No	Lamp Type	Capacity (in Watts)
1	LED light	9 Watt
2	LED light	12 Watt
3	LED light	14 Watt

Based on the results of calculations and analysis, the results of calculations, Power Calculations, Voltage Calculations, electric current calculations, analysis calculations are carried out with a sample of 10 hours per day to get how much economic value is obtained for 1 month (30 days).

From the data in the table above, we can determine the values of P, V, and I

a. Power Calculation
b. Voltage Calculation
c. Flow Calculation
d. Load Calculation

3.4 Calculation of the electrical load on the use of LED lamps

- On 9 Watt LED lamp

  KWH Electricity consumption = Power of electric appliance x duration of use (in hours)
  KWH lamp usage in a day = 9 Watt x 10 Hours x 30 Days = 2700 WH = 2.7 kWH

  Then the monthly electricity costs for using 9 Watt lamps are:

  Electricity Cost = Usage (kWH) x TDL
  Electricity Cost = 2.7 x 1.034 = Rp. 2,791
  Total Cost = Number of lamps used x Electricity Cost
  Total Cost = 4 x 2,791 = Rp. 11.164

- On 12 Watt LED lamp

  KWH Electricity consumption = Power of electric appliance x duration of use (in hours)
  KWH lamp usage in a day = 12 Watt x 6 Hours x 30 Days = 2160 WH = 2.1 kWH

  Then the monthly electricity costs for the use of 12 Watt lamps are:

Electricity Cost = Usage (kWH) x TDL
Electricity Cost = 2.1 x 1.034 = Rp.2.171
Total Cost = Number of lamps used x Electricity Cost
Total Cost = 6 x 2,171 = Rp. 13.026

- On 14 Watt LED lamp

  KWH Electricity consumption = Power of electric appliance x duration of use (in hours)
  KWH of lamp use in a day = 14 Watts x 6 Hours x 30 Days = 2520 WH = 2.5 kWH

  Then the monthly electricity costs for the use of 14 Watt lamps are:

Electricity Cost = Usage (kWH) x TDL
Electricity Cost = 2.5 x 1.034 = Rp. 2,585
Total Cost = Number of lamps used x Electricity Cost
Total Cost = 3 x 2,585 = Rp. 7,755

The total load of electricity usage on TL lamps in kWH is:

Rp.11,164 + Rp. 13,026 + Rp. 7,755
= Rp. 31,945

Table. 3. Assumed load usage in 1 month on LED lamp

No	Lamp Type	Current Used	Usage Load 1 month
01	9 W LED Lamp (5 pcs)	0.2 A	Rp. 17.373
02	12 W LED lamp (6 pcs)	0.3 A	Rp. 19,848
03	14 W LED lamp (3 pcs)	0.18 A	Rp.13,338
04	**Total number**	**0.68 A**	**Rp. 31,945**

3.5 Field implementation

After analyzing the data, the implementation is carried out directly to the field by replacing the lamps used by partners with energy-saving lamps with LED types, and then comparing the amount of monthly electricity payments using lamps before and after being replaced.

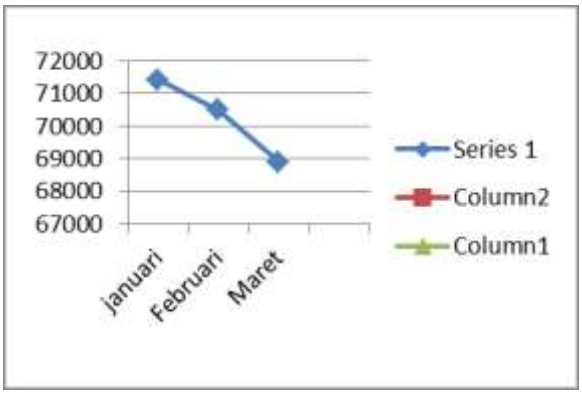

Figure 9. *Graph of Monthly Payment of Electricity Account Before Lamp Replacement*

From Figure 9 above, it can be seen that the payment of electricity loads varies every month, this is due to the use of unstable electrical loads.

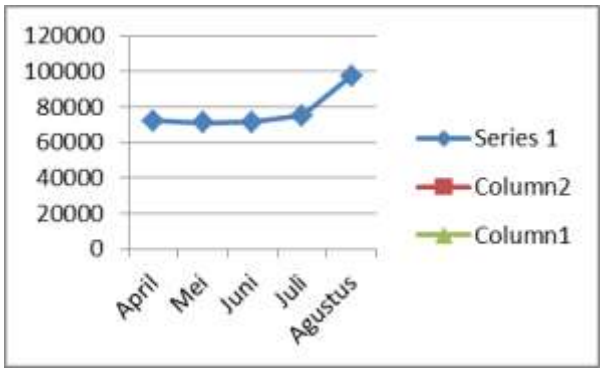

Figure 10. *Graph of Monthly Payment of Electricity Account After Lamp Replacement*

3.6 Calculation of Lumens of Illumination

Based on the results of the analysis and measurement of the lumen value measured using a lux meter on several recycled lighting lamps with different power specifications, namely 9 Watt, 12 Watt, 14 Watt.

Based on the results of the analysis, there are differences in the amount of lumens from the type of lamp produced by the manufacturer and the type of lamp that is recycled, this is due to the brightness and color of the bulb tube which is already opaque, thus affecting the amount of light or lumen emitted by the bulb.

Table 4. Lumen Comparison Table of Manufacturer's Lighting with Recycled Lighting Lamp

No	Lamp Type	Lumens Lamp Manufacturer	Lumens Lamp Manufacturer
1	9 Watt LED Light	450	413
2	12 Watt LED Lamp	800	715
3	14 Watt LED Lamp	1100	1025

IV. Conclusion

From the results of the study, it can be concluded that:

1. The use of LED lighting can increase the savings and efficiency in the use of electrical energy compared to using other conventional lighting lamps.
2. The use of LED lighting can have a positive impact on the environment, this is because LED lighting types can be recycled after use.

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