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ANALYSIS OF SAVING ELECTRICAL LOAD COSTS WITH A HYBRID SOURCE OF PLN-PLTS 500 WP

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ABSTRACT
Short-term and long-term energy needs and consumption in the provision and use of sustainable energy nationally, require strategic directions and steps to achieve. The strategic directions and steps are contained in the National Energy Policy (KEN) which has been stipulated in PP. 79 of 2014 concerning KEN. KEN is an implementation of the mandate of Law no. 30 of 2007 concerning Energy. Apart from being used as primary energy for power generation, NRE is also being developed as energy that is used directly by the user sector. At this time the type of EBT that is most widely used by users is PLTS, in addition to its simple construction and heat sources can be obtained anywhere, this is also the government's recommendation to achieve the PLTS development target. In fact, until now, consumers are still very less willing to use PLTS in meeting their electrical energy needs, this is due to several problems, including the high cost of PLTS construction, besides that the material costs are also relatively expensive. In this study, an overview of the calculation of how much cost can be saved or saved if the energy source used is a Hybrid between PLN and PLTS 500 Wp which is used alternately in supplying the electrical load of a simple house. with specifications of 2 solar panels of 250 wp each, 2 batteries of 100 Ah each, 130 solar panel control and 1300 watt inverter. The cost of electricity charges paid monthly before using PLTS Roof ranges from 300 to 400 thousand rupiah, After using PLTS Roof, the monthly electricity costs are 200 to 300 thousand rupiah, the average monthly savings is 100 thousand rupiah, if you take into account the investment costs will return in 1 year, the average material life of PLTS is around 20 years. The cost savings in electricity costs are around Rp. 22.800.000,- in 20 years. Economically, this value is still very small, but it has succeeded in saving electricity costs per month, and increasing the use of Renewable Energy
Keywords : *PLTS, Cost Saving, Hybrid PLN-PLTS*

1. Introduction

In the National Energy Policy (KEN), one of the national energy management targets is to achieve a national energy mix consisting of four primary energy types, namely Oil, Natural Gas, Coal, and New and Renewable Energy (EBT), with the target of achieving each – each of these primary energies in 2025(Hidayat et al., 2022; Simanjuntak et al., 2022; Santosa et al., 2021), namely:

a. the role of New Energy and Renewable Energy is at least 23%,
b. the role of petroleum is less than 25%,
c. the role of coal is at least 30%, and
d. the role of natural gas is at least 22%

Fossil energy, which has been the main focus in energy consumption, has resulted in the depletion of non-renewable natural resources and the increasing impact of environmental damage. This has prompted various calls to reduce and limit the use of fossil energy and replace it with renewable New Energy (EBT). Utilization of EBT or known as clean energy has become a joint action program from various countries in the world, including Indonesia(Anggraini & Indah, 2021; Maghfuri et al., 2021).

The importance and target of energy supply and utilization is to realize energy independence and national energy security to support national development. Therefore, the supply and utilization of energy relies on four aspects, namely affordability, accessibility, availability and acceptability. These aspects are influenced by various strategic environments, both internal and external, including developments in energy supply and demand, investment in supporting

infrastructure development and the impact of policies and regulations from related sectors and across sectors(Chofreh et al., 2021).

Indonesia, which has quite large potential for NRE, but not all of this potential can be utilized to support national development. Until now, energy users are still not interested in utilizing this potential, one of the things that becomes an obstacle is the thought of the large investment costs for the development of EBT. Based on the above, as an academic, the researcher is moved to provide insight into the calculation of the costs needed for the construction of an EBT with Solar Energy and how much cost will be saved (saved) by utilizing the solar potential. For this reason, the researchers made an analysis of the conditions of the use of electric loads using a hybrid electricity source of PLN and PLTS(Al Hafiz et al., 2022; Suriana & Sugarayasa, 2022; Effendy et al., 2021).

With the increasing growth of regional energy consumption in order to encourage economic growth and development in the regions as part of the economy and national development, the directions, objectives and targets for the management and supply of energy in the regions still refer to reducing the use of fossil energy and replacing it with New and Renewable Energy (EBT)(Khamid, 2022; Kusumandari et al., 2021). To provide knowledge and eliminate the assumption that NRE is expensive, a study was made on the use of electricity loads and their cost savings by utilizing Solar Energy as a complementary energy source or backup from fossil energy sources (PLN), so that electricity users are encouraged to utilize the potential of Solar Energy to achieve their goals. The government's target in the National Energy Mix is 23% in 2025 and 31% in 2050 the use and utilization of EBT(Raharjo et al., 2022).

Energy Mix Targets in several ASEAN countries can be seen in the following table(Overland et al., 2021; Phoumin et al., 2021):

Table 1 - Energy Mix Targets in several ASEAN Countries

COUNTRY	ENERGY MIX TARGET	POLICY DOCUMENT
Brunei Darussalam	By 2035 it will reach 10% ET (954,000 MWh) of the total installed generation	Energy White Paper (2014)
Cambodia	There are no ET specific targets, except for hydropower. By 2020 it will reach 2,241 MW of large hydropower (80% of total installed capacity)	Power Development Plan 2008-21 (2007)
Indonesia	By 2025: 23% ET of the total primary energy supply, or 92.2 MTOE from electricity of 69.2 MTOE (45.2 GW) and non-electricity of 23 MTOE Petroleum < 25% Coal at least 30% Natural gas at least 22% In 2050: 31% ET of total primary energy supply Petroleum < 20% Coal at least 25% Natural gas at least 24%	PP No. 79 of 2014 concerning KEN (2014)
Laos	By 2025: 30% ET (1,479 KTOE) of total final energy consumption (excluding major hydropower)	Renewable Energy Development Strategy Policy (2016)
Malaysia	By 2020: 7.8% ET (2,080 MW) of total installed capacity, consisting of: 38% biomass, 24% mini-hydro, 17% solid waste, 12% biogas, 9% solar PV (excluding large hydropower with capacity > 30 MW) in 2025: 20% ET of the total national power generation mix	National Renewable Energy Policy and Action Plan (2011) and 11th Malaysia Plan 2016-2020 (2015)
Myanmar	In 2030-2031: 38% hydropower (8,896 MW), 20% natural gas (4,758 MW), 33% coal (7,940 MW), 9% ET (2,000 MW)	National Energy Policy (2014)
Philippines	In 2015: 277 MW additional capacity from biomass;	National Renewable Energy Program (2012)

	By 2022: 2,345 MW of additional capacity from wind power; By 2023: 5,398 MW of additional hydropower; By 2025: an additional 75 MW of marine energy; By 2030: 15.3 GW ET of installed capacity, an additional 284 MW from solar PV and an additional 1,495 MW from geothermal.	
Singapore	In 2018: 10,140 tonnes/day from Waste to Energy power plants; By 2020: 350 MWp of solar power; By 2030: 8% ET of peak electricity demand	Singapore Sustainable Blueprint (2009)
Thailand	By 2036: 30% ET in final energy consumption, in the form of: electricity (20.11% in generation or 19,684 MW), heat (36.67% in heat production, or 25,088 KTOE), biofuels (25.04% in the transportation sector , or 8,712 KTOE)	Alternative Energy Development Plan (2015)

2. Literature Review

a. Definition of Energy

Energy is the ability to do work or work. In everyday life, energy is usually called energy. Energy can be obtained from energy sources that exist around human life. Based on the source of energy can be classified into:

1) Conventional Energy (Fossil Energy)

Conventional Energy or Non-Renewable Energy is an energy source that cannot be renewed/requires a relatively long time to be regenerated, for example: oil, coal, natural gas, and others. Petroleum is a pile of fossils that have been buried millions of years ago, and through natural processes produce petroleum so its availability is limited(Zhukovskiy et al., 2021).

Fig 1. Coal Mine

2) Renewable Energy

Renewable Energy is an energy source that can be renewed/regenerated in a relatively short period of time, for example: water, wind, sunlight and others(Arévalo et al., 2021).

Fig 2. Renewable Energy Sources

Renewable energy utilizes environmentally friendly energy sources that do not pollute the environment and do not contribute to climate change and global warming. This is because the energy obtained comes from sustainable natural processes.

In relation to development activities, energy is an important aspect and a fixed variable that must exist in general categories of development, such as the social, technological, political, economic and environmental sectors.

b. Solar Power Plant (PLTS)

Fig 3. Solar Power Plant (PLTS)

PLTS is one type of power plant that utilizes New Renewable Energy with its energy source being sunlight and converting solar energy into electrical energy. Solar energy is a very potential renewable energy alternative, because the number of energy sources is unlimited and available in almost all parts of the world. Indonesia is a country located on the equator, so it is a country that receives a lot of sunlight(Affiandi & Setiawan, 2022).

The PLTS systems commonly used are:

1. On-Grid system, the system includes solar modules/panels, inverters, import export kWh meters, PLN connections, and electrical load connections. Parallel with PLN
2. Off-Grid System, the system includes solar modules, batteries, inverters, solar panel control, electrical connections and loads. Batteries to ensure the continuity of electrical energy.
3. Hybrid system, the system includes solar modules, inverters, hybrid control, generators, electrical connections and loads. Parallel with generator, battery to maintain stability.

c. PLTS Working Principle

When the sun shines on the surface of a semiconductor device commonly called a solar cell or solar panel, the photoemission process (photoelectric effect) occurs inside the solar cell, and solar energy is directly converted into electrical energy. Sunlight that hits the semi-conductor (photovoltaic) medium, causes electrons in the medium to be released from their bonds and flow / move, resulting in reverse current activity. This transfer is known as photovoltaic.

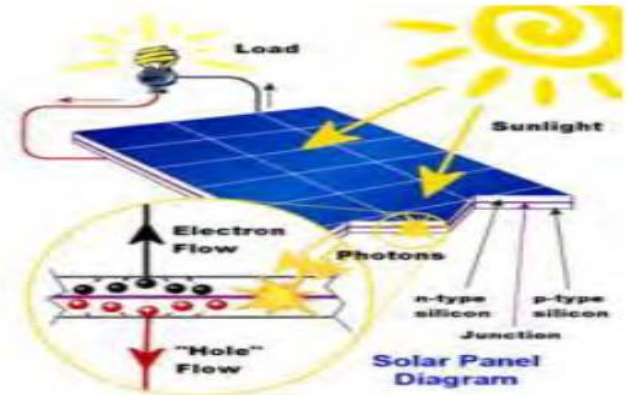

Fig 4. The Process of Converting Light Energy to Electrical Energy

All photovoltaic cells have at least 2 layers of semiconductors, one for a positive charge and one for a negative charge. When a photovoltaic cell is exposed to sunlight, the electron charge will flow to a high potential charge. The connection between the two layers causes electricity to flow, generating DC current. The stronger the light received, the stronger the electric current obtained(Liu et al., 2021).

Currently, solar power has been widely used and applied to electronic devices. As is the case with calculators, street lighting, traffic lights, and others on a small scale. Photovoltaic is also used to provide electricity in very remote areas and lack of electricity grids. Not only used in remote areas, but PLTS is also an alternative to meet the electricity needs in homes, even in government agencies as well as factories and high-rise buildings.

d. Calculations in PLTS

The calculations commonly used in determining component requirements in PLTS include:

1) Determining the Total Load Current in Ampere-Hours (Ah)

Ah is the product of amperes and hours, which is a unit for the size of the battery and shows the battery's ability to provide current and for how long. The load current can be determined using the formula below:

Itot DC load = x hours of daily use $\frac{P}{Vop}$

Itot AC load = x hours of use per day)/0.8 $\left(\frac{P}{Vop}\right.$

Load itot = DC load itot + AC load itot

Where:

Itot DC load = Total current flowing in DC load

Itot AC load = Total current flowing in AC load

P = Total power used

Vop = Photovoltaic operating voltage

Itot load = Total current load in units Ah…… (1)

2) Determine Total Power Requirement

The total power is obtained by calculating the entire load that will be supplied by the PLTS per unit of time multiplied by the length of time used mathematically can be written:

Ptot = Watt/hour x hour……. (2)

3) Total Solar Cell Needs

The need for solar cells (solar panels) can be determined by dividing the total power requirement per day by the time the battery capacity can be formulated as follows:

Number of solar cells = ……. (3) $\frac{\textbf{Total Power per day}}{\textbf{Battery working time}}$

4) Number of Battery Requirements

The number of batteries needed depends on the size of the selected battery, that is, by dividing the amount of power required per day by the power in the battery, it is mathematically written:

$$\text{Number of batteries} = \ldots\ldots\ldots (4) \frac{\text{Total power/day}}{\text{power on battery}}$$

3. Research Methods

The research approach is to observe and pay attention to the performance of PLTS Roof installed on a type 45 residential house, with an installed load of 1300 VA. Environmentally friendly electrical energy sourced from sunlight has a specification of 500 Wp. Then take data from the location where the PLTS Roof is installed, then analyze the load used and the length of time it operates, then perform calculations and analyzes related to the electricity bill that will be paid.

a. Research Location and Time

This research was conducted in the time span between December 2021 to August 2022 with the following locations/places:

1. Electrical Engineering Laboratory, Universitas Pembangunan Panca Budi Jalan Gatot Subroto km 4.5 Medan.
2. Luxor Housing, Jalan Karya Wisata Ujung, Delitua Village, Namorambe District, Deli Serdang Regency.

b. Variable Operational Parameter

The parameters observed in this study are:

1. The amount of electricity used
2. Rooftop PLTS operating hours
3. How much you have to pay for the electricity bill every month

c. Population And Sample

This study did not use a population and sample, because the research data used were not derived from questionnaires, interviews or observations, but from experiments and measurements carried out.

d. Data collection technique

The data revealed in the research can be divided into three types, namely: facts, opinions and abilities. This study aims to see the fact that the use of EBT can reduce the cost of electricity bills and the ability of PLTS Roof to supply household electricity loads, to obtain facts and measure capabilities is through tests or experiments, thus in this study data collection techniques were obtained by observing and carry out experiments or measurements so that conclusions are obtained.

e. Data analysis method

The method used in data analysis is the method of Quantitative Research Analysis, where the data obtained are based on measurements and experiments carried out, and aims to develop mathematical models related to natural phenomena.

To facilitate the course of the research, the following procedures or work stages are carried out:

1) Preparation phase
   In the preparation stage, the research team made preparations in the form of theoretical studies related to the research carried out, discussions, sharing knowledge and searching for literature were activities at this stage.
2) Implementation Stage
   The implementation of the research began by testing the use of a hybrid PLN-PLTS at a house load of 1300 VA, then taking data from the tests carried out and calculating the used electricity load and the electrical load needed in a type-45 house, and analyzing the data obtained. and

calculate it according to the tariff to be paid, and discuss it in drawing conclusions.

3) Reporting Stage
At this stage the researcher and the team make a report on the results of the research conducted to the LPPS, by making a written result report according to applicable standards, then attending a seminar to disseminate the research results, and writing it in a National Journal as a scientific publication. Furthermore, developing research results into teaching materials, in the form of textbooks, and implementing the research in a community service in villages or to communities in need.

The stages of the research can be seen in the image below:

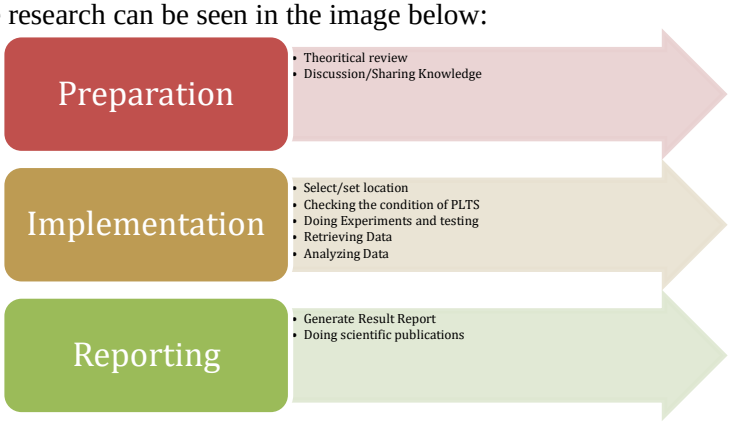

Fig 5. Research Stages

4. Results and Discussions

a. Observation result

From observations and measurements obtained the following data:

1) Load type data and used power
2) Data on the cost of electricity rates every month without using PLTS Roof
3) Data on the cost of electricity rates every month using PLTS Roof

The three data can be seen in the table below:

Table 2 - Types of Loads and Powers

No	Load Type	Quantity	Power (Watt)
1	Lamp	9	134
2	Refrigerator	1	120
3	Dispenser	1	85
4	Magic Com	1	68
5	Fan	1	72
6	Television	1	125
7	Air Conditioner	1	800
		Total Power	1404

From the table above, it can be seen that the load used in a simple house with a total power of 1404 Watt, in this case not all loads are activated simultaneously so that there is no overload in it.

Table 3 - The Cost of Electricity Tariffs Without Using PLTS Roof

No	Month	Electricity Tariff (Rupiah)
1	June 2021	407000
2	July 2021	452000
3	August 2021	376000
4	September 2021	450000
5	October 2021	389000

From this table, the average electricity tariff per month is = $\frac{407000+452000+376000+450000+389000}{5}$ = IDR 414,800,-

Table 4 - Electricity Tariffs for Rooftop PLN-PLTS Hybrid

No	Month	Electricity Rates
1	November 2021	342000
2	December 2021	275000
3	January 2022	212000

4	February 2022	200000
5	March 2022	210000

From this table, the average electricity tariff per month is = $\frac{342000+275000+212000+200000+210000}{5}$ = IDR 247,800,-

b. Analysis and Discussion

From the data obtained, we can see that the use of electricity with pure PLN sources is higher in monthly tariff costs. Savings can be seen in the use of hybrid PLN-PLTS, but the cost of electricity tariffs is not constant every month because the power used is also not constant. The difference in electricity tariff costs can be seen in the following table:

Table 5 - Difference in Electricity Tariff Costs

No	Pure PLN	Hybrid PLN-PLTS	Difference
1	407000	342000	65000
2	452000	275000	177000
3	376000	212000	164000
4	450000	200000	250000
5	389000	210000	179000

From this table, the difference in average electricity rates per month is = $\frac{65000+177000+164000+250000+179000}{5}$ = IDR 167,000,-

So based on the analysis above, it can be seen that the cost savings in electricity tariffs per month can reach one hundred and sixty-seven thousand rupiah. And if it is calculated for 1 year, then 12 x 167000 means that savings can reach 2,004,000 per year. Furthermore, if we calculate for 10 years then: 10 x 2.004,000 = Rp. 20,040,000,-

By looking at the values above, if the installation of a 500 Wp PLTS Roof requires an investment cost of approximately Rp. 15,000,000 with a minimum equipment life of 10 years, then the return on investment is obtained before 10 years of use.

5. Conclusion

Solar or solar power plants are environmentally friendly power plants. Solar power plants require large investment costs and require a long time to pay off investment. Rooftop solar power plants have not been able to become the main energy source because the battery capacity is not sufficient for storing electrical energy. Rooftop solar power plants are able to save about 59.7% of electrical load costs. Weather conditions affect battery charging time. We recommend that the solar panels used are larger, so that the battery charging is faster. The battery used is as much as possible as much as the power is used so that the Rooftop PLTS has better performance.

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