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Analysis Of The Performance Of Solar Power Plants (Plts) On The Electrical Energy Needs Of Mosques

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ABSTRAK

The need for electrical energy continues to increase, including in public facilities such as mosques. Solar energy is an environmentally friendly and sustainable solution because it is a source of renewable energy. This study aims to analyze the feasibility of implementing a rooftop Solar Power Plant (PLTS) system at Al-Hakim Mosque, Mabar Hilir Village, which has high sunlight intensity and minimal vegetation obstructions. The methods used include direct observation and interviews. The data collected included location identification, energy needs, and calculations of the solar power system. The results show that the mosque requires a daily power of 7,860 Wh, which can be met with 16 100 Wp solar panels and 9 12V 100Ah $LiFePO_4$ batteries. The research concluded that the location of the Al-Hakim Mosque is suitable for the implementation of the solar power system, while supporting the renewable energy transition and government policies towards energy sustainability in Indonesia

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1. INTRODUCTION

Indonesia is a country that is crossed by the equator, so it gets high intensity of sunlight throughout the year[1]. This condition makes Indonesia very potential in the use of solar energy as one of the renewable energy sources. The potential of solar radiation in Indonesia reaches around 4 kWh/m²/day [2]. which can be used for the generation of electrical energy using solar panel technology. On the other hand, the availability of electricity in Indonesia is still uneven. Indonesia's electrification ratio has only reached 71.2%, lagging behind neighboring countries such as Singapore (100%) and Malaysia (85%). This means that there are still around 28.8% of Indonesians who have not had access to electricity [3]. This condition encourages the need for the use of alternative energy that can reach areas that have not been electrified [4].

Solar Power Plants (PLTS) are one of the efficient and environmentally friendly solutions. Solar power plants do not produce greenhouse gas emissions, thus helping to maintain air quality and reduce negative impacts on human health[5]. Solar PV technology is very suitable for application in remote areas or locations that are difficult to reach by conventional power grids. Based on the operating system, solar power plants are divided into three types: On-Grid, Off-Grid, and Hybrid [6]. In this study, the system used is an Off-Grid type solar power plant, which is an independent system that is not connected to the public electricity grid, so that it can utilize solar energy to the maximum and save costs in the long term.[7].

The Al-Hakim Mosque located in Mabar Hilir Village is a strategic location for the implementation of the solar PV system [8]. Geographically, this mosque gets optimal exposure to sunlight without being obstructed by the surrounding buildings or trees [9]. However, until now there has been no quantitative study that discusses the performance of the solar PV system on the electrical energy needs of the Al-Hakim Mosque. Therefore, this study was conducted to analyze the feasibility and performance of the Off-Grid type solar power system in meeting the daily electrical energy needs of the mosque [10]. Teknologi Pembangkit Listrik Tenaga

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Surya (PLTS), khususnya sistem panel surya tipe Off-Grid, memiliki kemampuan untuk bekerja secara mandiri dalam memenuhi kebutuhan energi listrik tanpa bergantung pada jaringan listrik utama. Sistem ini mengharuskan penggunaan baterai berkapasitas besar untuk menyimpan energi listrik yang dihasilkan, sehingga tetap dapat digunakan saat malam hari atau cuaca mendung [11]. Off-Grid solar power plants are ideal for use in locations that have limited access to conventional electricity, including public facilities such as mosques and surrounding settlements [12]. The Al-Hakim Mosque, as a center of community activities, has the potential to be the main beneficiary of this system, as well as being able to encourage its application on a household scale in the surrounding environment [13].

However, until now there has been no quantitative analysis of the performance of the solar power system on the electrical energy needs at the Al-Hakim Mosque. Based on these conditions, this study was conducted to analyze the performance and feasibility of the Off-Grid type solar power system in meeting the daily electrical energy needs of the Al-Hakim Mosque.

2. METHOD

In this study, using a quantitative method, data collection was taken directly from the al-hakim mosque which coincided with Jl. Rahayu Timur Mabar Hilir, Medan Deli District, and was obtained based on the results of observations, measurements and references made.

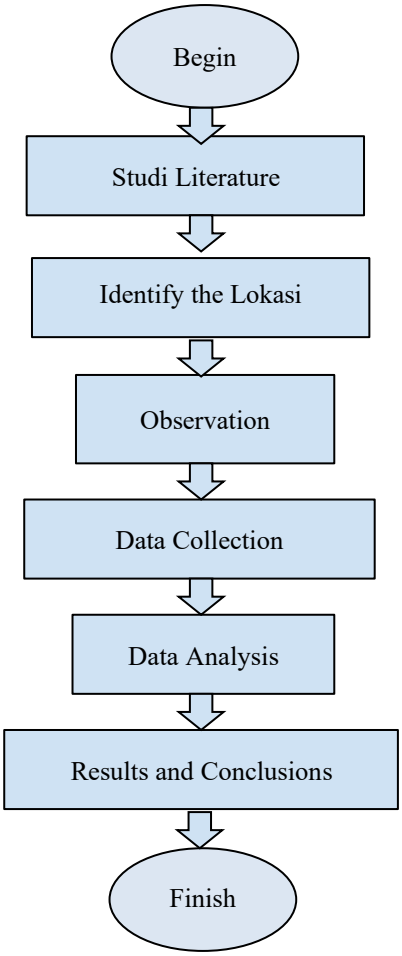

Figure 1 Reasearch Flow Chart

The method used in this study is arranged based on systematic stages as shown in the flowchart. The research began with the literature study stage, which is collecting references from various sources such as journals, books, and technical documents related to the Solar Power Plant (PLTS) system, especially the Off-Grid type, as well as studies related to the need for electrical energy in worship facilities such as mosques. The next stage is location identification, which is carried out to determine the location of the research, namely the Al-Hakim Mosque in Mabar Hilir Village. This location was chosen because it has high sunlight potential and geographical conditions that favor the installation of solar panels[14]. After the location is determined, direct

observation is carried out in the field to find out the actual conditions such as the direction of sunlight, the area available for panel installation, and physical obstacles around the location. Then data collection was carried out which included technical data on the daily electrical energy needs of the mosque, data on the intensity of solar radiation at the location, and the specifications of the planned solar PV system components, such as solar panels, batteries, and inverters.

The data that has been collected then enters the data analysis stage, namely the calculation of the power needed by the mosque and the simulation of the capacity of the solar power system that can meet these needs. The analysis was carried out to determine the number of panels, battery capacity, and system efficiency [7]. The final stage is the preparation of results and conclusions, where the results of calculation and analysis are presented in the form of a report. The conclusion contains the feasibility of implementing Off-Grid type solar power plants in the Al-Hakim Mosque as well as the necessary technical recommendations.

3. RESULTS AND DISCUSSION

The results of the solar power plant design on the roof of the Al-Hakim Mosque in Medan Deli village are as follows:

3.1. Identify Research Locations

The research location of the Al-Hakim Mosque in Medan Deli Village has Latitude (3.661118) and Longitude (98.689874) shown in the satellite layer of the following image:

Figure 2 Research Location

3.2. Problem Identification

Solar panel technology can be used as a source of Solar Power Plants, This is useful as an efficiency in using an energy, namely electrical energy, with this technology Al-Hakim Mosque can cut the budget obtained monthly or per year where the budget can be allocated to other things such as building maintenance or available facilities[8].

This technology can also be an innovation for the Al-Hakim Mosque in the maintenance or development of energy growth, with this Al-Hakim Mosque does not need to worry about the swelling of electrical energy costs if there is an increase in the cost of electricity or the use of electricity when there is an activity held in a week.

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3.3. Data Collection

Al-Hakim Mosque has several facilities that use electrical energy, electrical energy in Al-Hakim Mosque still uses electrical energy through PLN as the main source of electrical energy[15]. Observation of energy consumption data research at Al-Hakim Mosque was carried out by direct interviews with the management of the Mosque. Al-Hakim Mosque has the following facilities:

Table 1 AL-Hakim Mosque Equipment Data

Equipment	Sum	Daya(w)	Usage(h)	Total Power Consumption (Wh/kWh)
Lamp	15	18	8	2.160
AC (1 pk)	4	800	1	3.200
Sound System	1	500	2	1.000
Water Pump	1	400	2	800
Fan	5	70	2	700
Sum				7.860 wh/7.86 kWh

From the data above, it shows that the power of a facility or equipment in the Al-Hakim Mosque. The total daily power load at Al-Hakim Mosque is at 7,860 wh / 7.86 kWh.

Number of batteries used:

Jumlah baterai yang digunakan:

$$Number\ of\ batteries\ = \frac{Watt\ Hours\ \ (wh)}{Battery\ Power} \quad (1)$$

$$Number\ of\ batteries\ = \frac{Watt\ Hours\ \ (wh)}{V\ battery\ x\ Ah\ battery} \quad (2)$$

$$Number\ of\ batteries\ = \frac{7.860\ wh}{12V\ x\ 100Ah} = \frac{7.860\ wh}{1200\ Wh} = \ 6{,}55$$

So the batteries used are 7 (this calculation does not take into account tolerances, power losses and safety factors).

$$Number\ of\ panels\ = \frac{Watt\ Hours\ \ (wh)}{Wp\ panels\ x\ Hours\ sun} \quad (3)$$

$$Number\ of\ panels = \frac{Watt\ Hours\ (wh)}{100\ Wp\ x\ 5h} = \frac{7.860\ Wh}{500h} = 15.79$$

From the following results obtained at the number 15.79, it is rounded to 16 where from the calculation the panels needed are 16 panels with 100 Wp.

To take into account the loss on battery power to load, if the load used on the Mosque is AC. Then input the efficiency factor of the Inverter.

Table 3. Description of the inverter used

Type Inverter	Efficiency (%)	Informationi
PSW	95	Pure Sein Wake Inverter berkisar 90%-95%

Table 2 shows that the PSW inverter has an efficiency of 90%-95%, this battery will lose 10% to 5% of the power, to avoid this, the power consumption must be increased according to the inverter to be used.

The use of the PSW Inverter will add

5% = 7.860+(7.860 x 5%) = 7.860 + 393 = 8.253

$$Number\ of\ Battery\ = \frac{Daya\ Jam\ (wh)}{Daya\ Baterai} \quad (4)$$

$$Number\ of\ Battery\ = \frac{Watt\ Hours\ (wh)}{V\ Battery\ x\ Ah\ Battery} \quad (5)$$

$$Number\ of\ Battery = \frac{8.253\ wh}{12V\ x\ 100Ah} = \frac{8.253\ wh}{1200\ Wh} = 6{,}87$$

The calculation shows that the battery needed is 6.87 with a capacity of 100 Ah 12V, the battery used is a Lifepo4 battery. Lifepo4 batteries can be used at discharge up to 100% of their capacity (only 80% recommended).

Number of Battery = 6,87/80% = 8,5 = 9
Then the batteries needed amount to 9 batteries.
Power requirement = 7,860 Wh
5% energy conversion (PSW inverter) = 8,253 Wh

$$Number\ of\ Battery\ = \frac{8.253\ wh}{12V\ x\ 100Ah} = \frac{8.253\ wh}{1200\ Wh} = 6{,}87\ Ah$$

If using a Lifepo4 battery:
Number of batteries = 6.87Ah/80% = 8.5 = 9 (based on Lifepo4 discharge reference)

3.4. Data Analysis

The data above explains that the use of photovoltaic power plants with electrical voltage on the principle of the photovoltaic effect has a relationship or contact between two electrodes that are connected to a solid or liquid system when obtaining light energy. Solar cells are often also called photovoltaic (PV). The electric current arises due to the received photon energy that successfully frees the electrons in the N-type and P-type semiconductor connections to flow. From this data, it shows that the Al-Hakim Mosque has a consumption power of 7,860 Wh. Therefore, to accommodate the consumption power, 16 solar panels are needed with a capacity of 100 Wp and require a battery of 9 LifePO4 (lithium iron phosphate) batteries. The solar panels used have an advantage of being compact in size, which is easy to install in various locations, both on the roof of the mosque and other open areas, and the cost is relatively low and solar panels have flexibility. Not only solar panels, the selection of LifePO4 type batteries also has advantages in terms of durability, safety, performance at high temperatures, fast charging, and no less important environmentally friendly batteries when compared to lead-based batteries.

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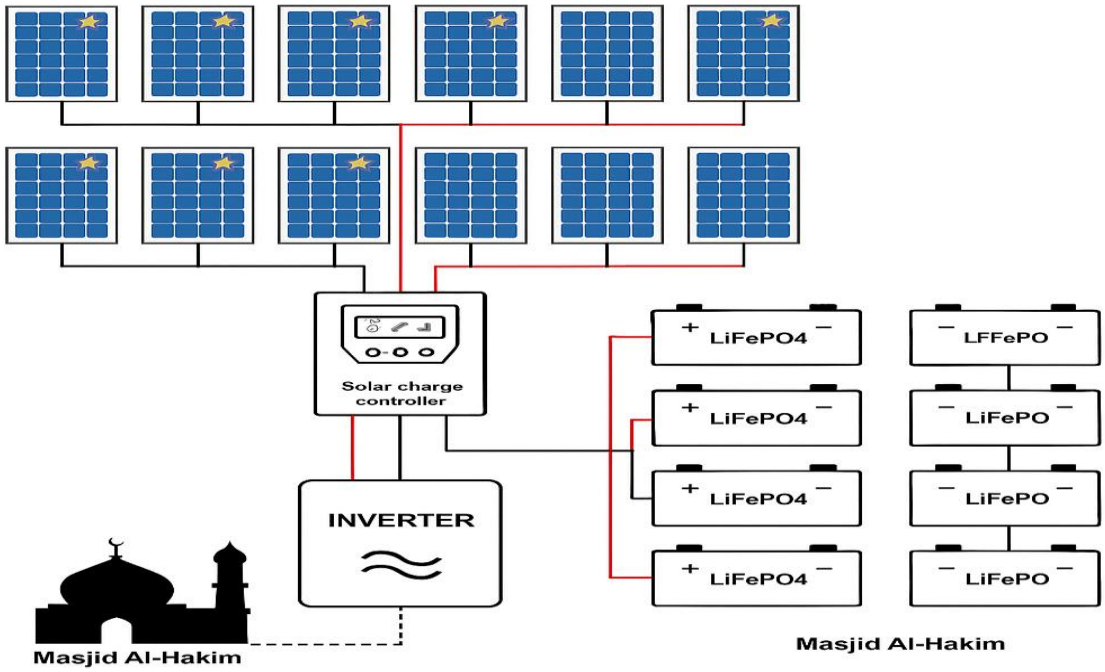

Figure 3 Wiring Diagram

4. CONCLUSION

Based on the results of the analysis of the performance of the Solar Power Plant (PLTS) system on the electrical energy needs of the Al-Hakim Mosque, it is known that this mosque has a daily energy consumption of 7,860 Wh. To meet these needs, 16 solar panels with a capacity of 100 Wp and 9 LiFePO4 batteries with a capacity of 12V 100Ah are needed.

This configuration provides a fairly high system efficiency, with the system able to supply energy stably according to the daily load of the mosque, as well as minimize dependence on conventional electricity supply. This efficiency is supported by the use of LiFePO4 batteries which have advantages in cycle endurance, charging efficiency, and safety.

In terms of economic and operational benefits, the implementation of this solar power system can significantly reduce monthly electricity bills in the long term, as well as provide sustainable energy independence. In addition, the system has low maintenance costs and a long service life.

Overall, the implementation of solar power plants in the Al-Hakim Mosque is feasible and can be applied in other mosques or on a household scale, especially in buildings that have medium energy needs and have direct access to sunlight. This also supports the government's program in the transition to green and sustainable energy in Indonesia.

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