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Solar Electricity Generating Technology as a Power Supply Automatication of Deep Well Water Pumps in Gunungkidul, Indonesia

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ABSTRACT

Water is a vital human need that must be met for human survival and carrying out daily activities. However, the condition of natural resources in each region is different, not all regions have sufficient water availability. One of them is in Serut, Gunungkidul which is an area with hilly geography. During the dry season, clean water sources in Serut District become scarce and very limited. Therefore, the Serut District Government cooperates with the Community Self-Help Group (KKM Tirta Abadi Jaya) to drill deep wells to distribute water to residents. However, along the way, the operational costs are very large, especially for water pump electric pulses. In addition, the geographical condition of Serut which is hilly and has many trees causes frequent power outages, especially in extreme weather. This affects the resistance of the water pump because it is often on and off. The power outage can also stop the distribution of water to residents. This community service provides a solution to these problems, namely the installation of solar electricity generation. With this solar electricity generation, it can reduce the operational costs of electric pulses. In addition, using solar electricity generation can increase the durability of the tool because there is no on-off. Residents also still have their water needs met even though there is a power outage because the electricity needs for water pumps are supplied from solar electricity generation.

INTRODUCTION

Human survival is highly dependent on the availability of clean water. Water is a vital human need. Unfortunately, not all areas have the availability of clean water. One of them is in the Serut Village, Gedangsari District, Gunungkidul Regency, Yogyakarta. The Serut Village area is a rural area with hilly geography. Demographically, despite the hilly areas, the population in Serut Village is quite large, which is more than 5000 people. Serut has seven hamlets, each of which is separated by a hill. In the dry season, the availability of clean water becomes scarce and very limited. Residents scattered in the hills will go down to look for water at several springs in Serut at a considerable distance. Due to the limited water supply, the residents initiated the formation of the Community Self-Sufficiency Group (KKM Tirta Abadi Jaya) for water management in Serut Village. KKM Tirta Abadi Jaya manages water by finding springs and then drilling wells. The source of water from drilled wells is lifted using a water pump and channeled to a reservoir at the top of the hill and then distributed to residents based on the principle of gravity.

The presence of clean water in Serut has a major impact on the development of the social and economic life of the community. However, there are crucial obstacles in water management, namely operational costs and maintenance costs for water pump machines. The problem boils down to the high cost and unstable electric power of the water pump. The hilly topography of the area causes frequent power outages, especially when it rains and winds. So that when there is a power outage, the pump cannot run and cannot fulfill the community's water needs. In addition, the on-off condition of the electric power causes the pump resistance to weaken and even several times there is damage to several components of the water pump. From an economic point of view, a water pump that has to be running for 24 hours causes very high electricity costs.

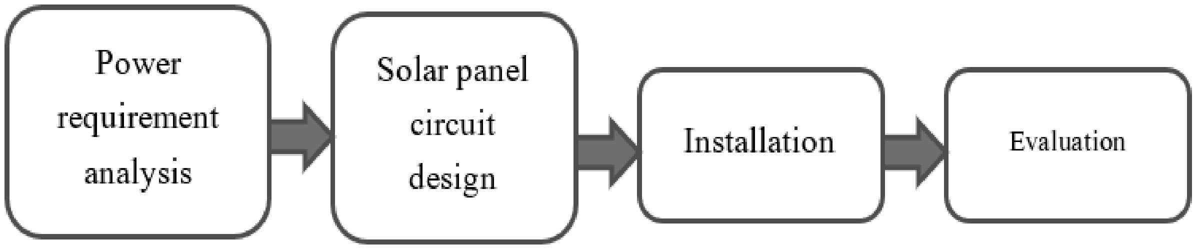
One of the renewable energies to meet electricity needs is the presence of solar electricity generating technology (Chel & Kaushik, 2018; Edward et al., 2019). In this community service, installing solar electricity generating technology as a power supply for the well water pump. Solar electricity generating technology can reduce operational costs, especially the cost of electricity pulses and pump resistance because on and off often do not occur. Solar electricity generating technology is not a new technology in the research and academic world, but solar electricity generating technology is still a luxury technology for rural communities. Solar electricity generating technology is one of the renewable energies that is being developed in the world as alternative energy to replace fossil-based energy (Chel & Kaushik, 2018; Egli et al., 2018).

This research implements the results of laboratory-scale research to a field scale, namely to solve electrical energy problems in the community. the purpose of this activity is to present renewable energy technology that has been integrated with a monitoring system so that people who are still unfamiliar with technology can operate and maintain the technology.

METHODS

The materials and equipment used in this service include 250Wp solar panels, 3000-5000 watt off-grid inverters, 200AH 12V VRLA batteries, solar panel frames, poles, and other supporting components. The solar electricity generating technology installation process is carried out in several stages as shown in Figure 1.

Figure 1. Stages in Solar Electricity Generating Technology Installation



The analysis of power requirements is carried out as a basis for designing the required series of panels so that they can meet the electrical needs of the water pump. The next stage, namely the design of a solar panel circuit, this stage is also important for the efficiency of the materials used with real needs in the field (Bhatt & Verma, 2014; Hidayah et al., 2019; K & Dewantara, 2020). If the analysis and design of the circuit have been determined, then the solar panel installation is carried out. The evaluation is carried out for two weeks to determine the stability of the solar electricity generating technology output power in that month. While the methods of implementing community service carried out include:

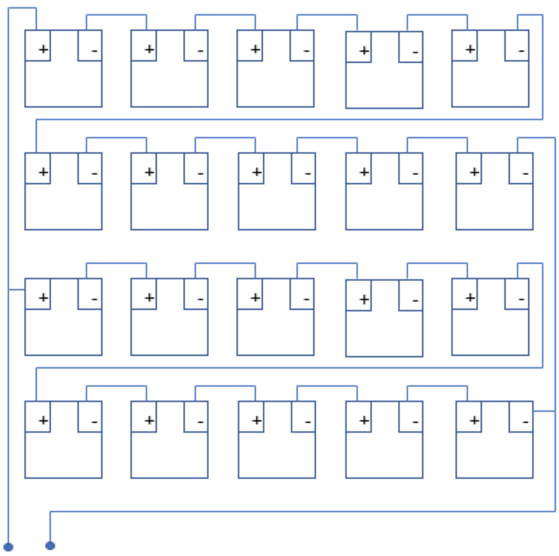
1. Field orientation and partnership
   Field orientation is carried out by discussing with target partners to explore the problems faced by partners. In addition, to determine the downstreaming of the service activities to be carried out.
2. Governance Strengthening
   This governance strengthening is carried out to improve the quality of human resources who manage water and who will be responsible for solar electricity generating technology so that the solar electricity generating technology that has been installed is maintained.
3. Outreach Program
   This program was carried out with the target of the Serut Village community, to introduce solar electricity generating technology into the village area.
4. Solar electricity generating technology installation
   Solar electricity generating technology installation is carried out together with partners and residents.

5. Training
   This training targets representative from several partners in Serut Village, who are trained for PV mini-grid installation and maintenance. The methods used in this training include providing material and also direct practice to the solar panel house.

RESULTS AND DISCUSSION

The water source used by the community in Serut Village is a deep well water point with a depth of 100 m. To lift water at that depth, a water pump was used which was previously connected to the electricity grid. To replace the grid electricity with solar cell technology, it is necessary to analyze the power requirement data first. Solar electricity generating technology installation begins with an analysis of power requirements. In this power requirement, it is known that the depth of the well is 100 m and the water pump is at a depth of 40 m. The pump used has a power of 3 HP. The water pump requires 2700 watts of power but will be developed for lighting around the panel house with a need of about 1200 watts(Khan & Yesmin, 2019; Ramzy E. Katan et al., 1996). From this analysis, it is installed with 5000 wp power. The panels used are 20 panels with a true power of 250 wp each. The installed panel design is shown in Figure 2.

Figure 2. Panel design from the analysis of electrical power requirements



To meet these power requirements, a panel circuit is designed with a combination of series and parallel circuits (Edward et al., 2019; Khan & Yesmin, 2019). In Figure 2 it can be seen that in the 20 panels used, 10 panels are arranged in series so that they consist of 2 series circuits, then the 2 circuits are arranged in parallel. The mathematical power calculation can be seen in Table 1. Where *I* is the electric current, *V* is the voltage and *P* is the electric power.

Table 1. Calculation of solar electricity generating technology

No	Type of electric circuit	Power
1	Series circuit 1	$I_{seri1} = I$ $V_{seri1} = 10V$ $P_{seri1} = Ix10V$
2	Series circuit 2	$I_{seri2} = I$ $V_{seri2} = 10V$ $P_{seri2} = I\ x10V$
3	Parallel circuit	$I_{total} = 2I$ $V_{tot} = 10V$ $P_{tot} = 2I\ x10V$ $= 20\ I\ x\ V$ $= 20\ x\ 250$ wp **= 5000 wp**

The frame of the solar panel is made of a fixed frame, so in addition to the analysis of power requirements, an analysis of the slope of the frame of the panel is also carried out to get maximum solar radiation. Serut itself is at latitude 7^o, with the maximum temperature of solar radiation in Serut is 39^oC (Charles et al., 1981; Sharma et al., 2016). In determining the slope of the solar panel frame, a simple formulation is used based on the latitude of the Serut District, namely (latitude x 0.9) – 23.5^o(Han & Chang, 2014; Najib et al., 2020). From this formulation, it is found that the slope of the panel frame is at a slope of about 16^o. Based on the results of the power analysis and also the analysis of the slope of the panel frame, the solar panels are installed. The solar electricity generating technology installed is shown in Figure 3.

Figure 3. Solar panel installation using 20 panels

The next stage in the solar electricity generating technology installation is the electrical installation. In this installation, the water pump used is an AC water pump so an inverter is needed to convert DC current and voltage into AC current and voltage (El-Tayyan, 2011; Hinga et al., 1994; Obukhov et al., 2016). The inverter used in this installation is shown in Figure 4.

Figure 4. Solar electricity generating Inverter

This inverter has a capacity of 3000 to 5000 wp. The mode used in this inverter is the SBU mode, namely the electrical power used first is the electrical power generated from the solar electricity generating technology, if the solar electricity generating technology's electrical power is insufficient, then grid electricity is used from the State Electricity Company (PLN).

The installed solar electricity generating technology becomes a source of electrical energy for the water pump so that operational costs are minimized, so this has an impact on the profit of water managers. To find out, monitoring of the PLN meter account is carried out every month to find out how many kWh of PLN electricity is used after solar electricity generating technology installation. The monitoring results are shown in Table 5.1 as follows.

Table 5.1 Results of monitoring PLN electricity meter accounts

Date/month/years	Electricity Meter Account Data (kWh)
August 19, 2021	187,41
August 30, 2021	186,39
September 2, 2021	186,39
September 12, 2021	186,39
October 3, 2021	176,81

The final stage in this installation is evaluation. The indicator used in this evaluation is an evaluation of a technical study by looking at the operation of the water pump and the PLN meter account. Before the solar electricity generating technology installation is carried out, the cost for electricity pulses is IDR 650,000,-/month, if you calculate the electricity pulses paid after the solar electricity generating technology installation (since it is effectively operating from 19 August to 3 October 2021) = 187.41 -176.81 = 10, 6 kWh, if the basic tariff used is IDR 1,112, then 10.6 x 1,112 = IDR 11,787. This fee is the cost for more than two months. So that the presence of this solar electricity generating technology does have an economic impact, namely increasing partner profits.

CONCLUSION

The solar electricity generating technology installed in this community service activity has been operating well. In the analysis of power requirements, the solar electricity generating technology design was obtained with a power capacity of 5000 wp so 20 panels of 250 wp were used. While in the analysis of the slope of the panel frame around 16o. Increased profit in water management after solar electricity generating technology installation above 600,000 rupiahs. So it can be concluded that the presence of solar electricity generating technology in Serut Village can improve the welfare of the community.

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