Design and installation of a solar water pumping system in Bunaken Island of Indonesia

by Meita Rumbayan 3

Submission date: 20-Jun-2023 06:20AM (UTC+0700)
Submission ID: 2119321016
File name: 060009_1_5.0118276-1.pdf (948.65K)
Word count: 2057
Character count: 11114

RESEARCH ARTICLE | APRIL 26 2023

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AIP Conference Proceedings 2694, 060009 (2023)
https://doi.org/10.1063/5.0118276

Design and Installation of a Solar Water Pumping System in Bunaken Island of Indonesia

Meita Rumbayan[a)], Dringhuzen Mamahit, Feisy Kambey, Benny Maluegha, Glanny Mangindaan, and Helky Jody

Faculty of Engineering, Sam Ratulangi University, Manado, Indonesia

[a)] Corresponding author: meitarumbayan@unsrat.ac.id

Abstract. The purpose of this study is to design and install a solar water pumping system in Bunaken Island of Indonesia. This activity becomes an implementation of solar energy utilization for empowering island communities that face limitation of energy electricity. Bunaken Island is chosen as the site of implementation due to the need of electricity demand to support public facility in a church that located in this small and beautiful island. The method for this study is a research and development through case study in the site by designing and constructing. The result indicates that the utilization of solar energy to power a solar water pumping done well and can be a showcase of case study about utilization of solar energy to empower island communities. In the future, some further studies about solar pump system application need to be explored and scale up more in term of technical and economic consideration.

INTRODUCTION

Indonesia as an archipelago country has five big islands and many small islands surrounding the mainland. Bunaken is one of the small islands located in the North part of Sulawesi Island that faces limited access to electricity from the grid. On other hand, Bunaken Island lies in a tropical country blessed with abundant solar energy potential. As the famous spot of tourist destination, Bunaken Island needs to be supported with self-sufficient power electricity.

The author has previously reported studies about renewable energy utilization in small and remote islands located in North Sulawesi alongside the current ongoing projects [1], [2], [3]. This island has attracted to be a target island to develop the scale-up of implementation for solar energy utilization. A model of a solar home system that is powered by solar photovoltaic to become self-sufficient has been developed [4], [5]. Several systems of solar PV for lighting and charging purposes have been analyzed and installed in Bunaken island. This study presents the configuration and installation of a solar water pumping system, which is constructed in Bunaken island.

Bunaken Island is one of the small islands located about one hour from Manado city by boat. The position of Bunaken Island among the small islands in the North Sulawesi is displayed in Fig. 1.

The 2nd International Conference on Natural Sciences, Mathematics, Applications, Research, and Technology (ICON-SMART 2021)
AIP Conf. Proc. 2694, 060009-1–060009-6; https://doi.org/10.1063/5.0118276
Published by AIP Publishing. 978-0-7354-4461-4/$30.00

FIGURE 1. The site location in Bunaken Island

Through survey and site visit to the island, it is found that the electricity from the diesel power plant cannot supply 24 hours continue for the island's demand. On the other hand, the water need for island communities needs daily without interruption. The solar water pump system can solve the problem of the unavailability of electricity for the demand. Thus, the research activities and community development team will design, construct, and install solar water pumps to supply electricity and water for island communities. This study can be a best practice for solar energy utilization to solve the problem for the small and remote islands, especially in Bunaken island. This installation of solar water pumping system will be the first implementation in Bunaken island's communities.

Photovoltaics Pump System uses the power produced by the PV module to power a pumping system for various water pumping utilization, including domestic water supply and irrigation for rural or isolated areas [6], [7]. Based on a review, solar photovoltaics pump systems have several issues that need to be mitigated—which relate to the procedure in configuration, modeling, control strategy, data availability, and the conditions of the sites [8].

Solar water pumps have plenty of advantages compared to traditional systems. For instance, diesel or propane engines tend to use expensive fuels that pollute the air in remote areas. Solar systems are less harmful to the environment, low-maintenance, and the use of fuels is not required. Therefore, solar water pump is suitable for providing water requirements in remote locations that face limited access to electricity from the grid.

This article will be structured in sections. In Section 2, the method used for the implementation of the appropriate technology based on the solar water pump is described. The proposed design and the installation of a solar pump for the case study of Bunaken Island are presented in Section 3. The conclusion and recommendation for future work are given in Section 4.

METHODS

The implementation of solar water pump system technology in island communities of Bunaken provides measurable outcomes that affects the application of appropriate technology to the community and improves the welfare and convenience of the community in church as described in Fig. 2. The installation and implementation of solar water pump technology in the church community in Bunaken Island have been done in several stages as shown in the figure.

Firstly, the approach methods consist of the survey, interview, and field visit. The aforementioned approach, combined with site observation and data collection, will be used to formulate the requirements: the water resource

availability, the distance of the location, the solar panel location, the water pump location, the length of cables requirement, the capacity of water storage, the piping system as well as the type of the pump.

Secondly, the approach method of this stage is conducting a focused group discussion that involves the implementation teams and partners. In such a manner, they could find solutions that could help the community using an electrical energy supply. For instance, the people in that area need water storage for washing hands to support COVID-19 prevention.

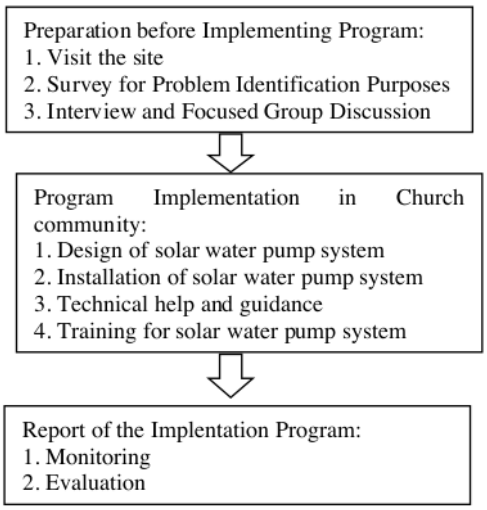

FIGURE 2. The implementation method of the solar water pump system as the appropriate technology

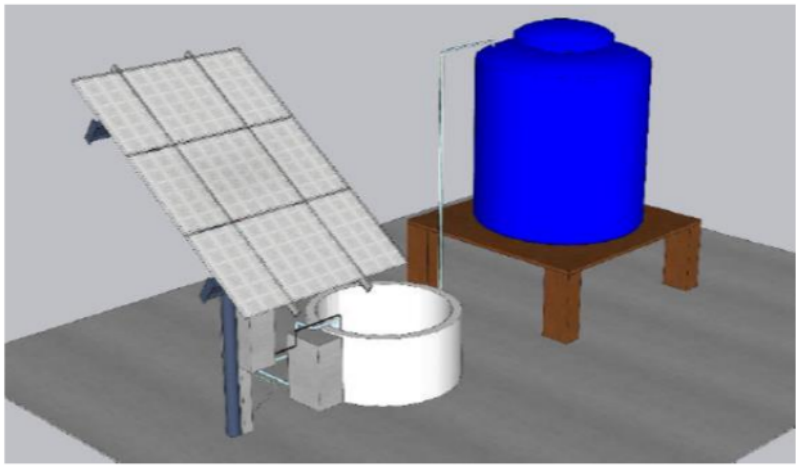

FIGURE 3. Design of solar water pump system

Thirdly, implementing an appropriate technology such as the solar water system will be the next approach to solve the community's problem. In addition, there would be mentoring, technical guidance, and counseling to help grow the skills and to expand the knowledge that the community has, especially in regards to technology solutions.

Moreover, the results from observation and interviews indicated that this community has an issue that needs to be mitigated, which is the limited electricity access supply from the grid. Thus, introducing appropriate technology such as a solar water pump system as a solution.

RESULTS AND DISCUSSION

The proposed model of the PV-based water pump for supplying water for handwashing is depicted in Fig. 3. In addition, the diagram schematic of the solar water pump system design is presented in Fig. 4. The actual installation of the solar water pump system in the site of Bunaken Island is shown in Fig. 5.

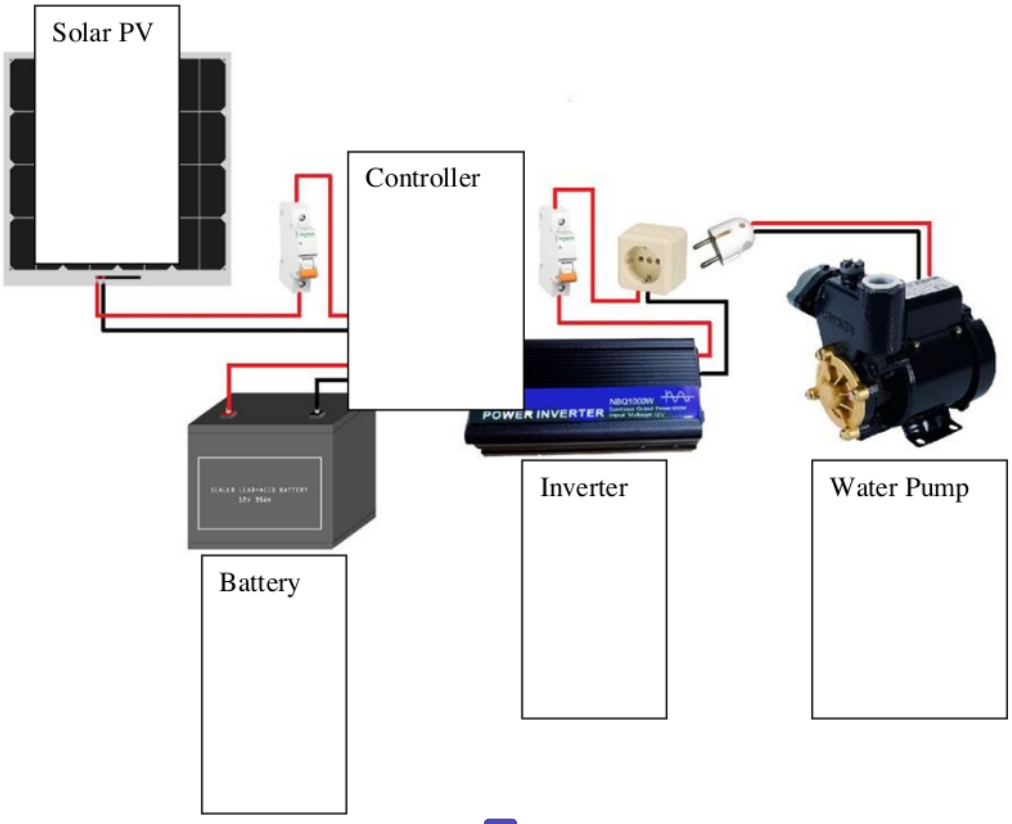

FIGURE 4 . Schematic diagram circuit of solar water pump system

The schematic diagram circuit of solar water pump system consist of solar photovoltaics (PV), Battery, inverter and a water pump. The solar photovoltaics function is to convert sunlight energy to electricity energy. The battery is used as a storage of electrical energy when there are service interruptions or blackouts due to emergency situations. Solar charge controllers regulate the energy flowing from the PV array and transmit it directly to the batteries, which is the most efficient and effective method. An inverter converts the Direct Current (DC) electricity from sources such as batteries to Alternating Current (AC) electricity for supplying power to the water pump.

FIGURE 5. The installation and implementation of solar water pump system in Bunaken island

Implementation of solar home system as a small pilot in a church community for washing hand requirement which is located in Bunaken Island has been done by using a solar panel 100 Wp, 50 Ah of battery, 1000 W of inverter and 10 A of system controller and a water pump. It is observed that in order to fill the 350-liter water tank for washing hand requirement, it takes 30 minutes to operate water pump. The energy used is energy that comes from solar energy stored in the battery and converted to an inverter to supply Alternating Current (AC) water pump type.

Furthermore, technology transfer, technological guidance, and training of solar water pump system maintenance are conducted as additional activities after the actual installation. The activities are shown in Fig. 6.

FIGURE 6. The dissemination of solar water pump system in Bunaken island

Technical aid on how to operate the installed solar pump system at a church has been done by the team, who also designed the system. Monitoring and evaluation of the implementation of the proposed installation of solar water pump in Bunaken Island have been conducted through training.

CONCLUSION

The solar water pump system has been designed and installed as the watering system, which can be used to wash the hand in the church as a public facility. It has been working well and is capable of pumping water up to 5 m head with approximately 10 liter per minutes speed. In a half and one hour operating time, the water tank can be filled with 300 liters of water. It's an applicable and off-the-grid solution for the island communities for solving energy limitations and water requirements. This appropriate technology is proven for the Bunaken Island site and could be an example practice for other islands surrounding in order to solve the problem about water and energy crisis for remote communities. In the future, further studies about solar pump system application need to be explored and scaled up to more in terms of technical and economic considerations.

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