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Operation Scheme and Maintenance of Parabolic Solar Desalination with PV Pump System for Isolated Island

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Abstract*: Water is very important for all living things. Without adequate and sustainable water, the life we know today will not be on the face of the earth. Not only needed for basic needs of life, but water is also needed to produce various products with modern technology. The issue of clean water is not only limited in number but also in uneven distribution. This makes not all regions have access to the same clean water, especially the outer island island in Indonesia. One of the islands that has a problem with clean water is the island of Marore and Kawalasu, North Sulawesi. The island which is located on the border between Indonesia and the Philippines has always had difficulties with clean water every dry season because there is no clean water source to get clean water residents are forced to buy from docked ships. In this paper is proposed an Eco Water Treatment by using Parabolic Solar Concentrator and Photovoltaic Pump. This method consists of two main parts, namely PV Sea Water Pump and Solar PV-Distillator so that it can be used to meet the needs of residents in Marore and Kawalasu islands.

***Index Terms*: Desalination, Parabolic Solar Concentrator, PV Pump, Isolated Island.**

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I. INTRODUCTION

Water is very important for all living things. Without adequate and sustainable water, the life we know today will not be on the face of the earth. Not only needed for basic needs of life, but water is also needed to produce various products with modern technology. Along with population growth, demand for water will also increase. [McKinney, 1963]. But in fact the whole water in the whole world is only about 1% which can be used for daily consumption needs [UN, 1997]. The issue of clean water is not only limited in number but also in uneven distribution. Lack of clean water problem also occurs in Indonesia [7]. As the largest archipelagic country in the world with a total area of 5,193,252 km2, Island in Indonesia has different geographical conditions [8]. This makes not all regions have access to the same clean water, especially Indonesia's rural island. One of the islands that has a problem with clean water is the island of Marore and Kawalasu, North Sulawesi. The island which is located on the border between Indonesia and the Philippines has always had difficulties with clean water every dry season because there is no clean water source to get clean water residents are forced to buy from docked ships. Actually there are springs which unfortunately are contaminated with seawater so they cannot be used directly for daily consumption [9]. In fact, these springs can be utilized through desalination processes [10]. Desalination is a process that takes away mineral components from saline water. More generally, desalination refers to the removal of salts and minerals from a target substance [11]. In this paper, the working operation of the desalination system with solar consentrator technology and the PV pump for seawater processing is discussed, so that it can be used to meet the needs of residents in Marore and Kawalasu islands

II. LITERATURE REVIEW

On this paper, stand-alone PV system will be used as a power source for the solar distillation system which determine the scheduling of the hydroponic pump. Stand-alone PV system consist of solar cell, controller, and inverter that separate from infinity grid [10]. This system frequently used for remote areas which can barely be reached by grid and has been implemented by Fara, L. and Craciunescu,

D. at remote mountain areas in Romania [11]. There are several things to be considered before PV system can be used. The first one is to determine the size of the PV panel. The method we used to calculate the sizing of the PV panel was based on Jadin (2015) [12]. The power output and scheduling of the PV system created by Chen (2014) aims to regulate the loading and charging of the energy storage used in the PV [13]. The distillation system itself use the principle of solar concentrator that directing sunlight to the side of boiler tank. The boilertank will be filled by water in certain of time interval [14]. The hydroponic drip technique used as a way to economize water. With addition of automation system based on Umamaheswari (2016) for the pump activation schedule, the whole system will conserve quite amount of water and electricity [15].

III. RESEARCH METHOD

There are many references in literature focused on photovoltaic pump [12] and the using of parabolic solar concentrator [13] for isolated island. It is related to the water problem condition in the island of Marore and Kawalasu. In general, this system consists of following main components: photovoltaic, desalinator, and concentrator. Photovoltaic is the device that can convert solar radiation into electricity using photovoltaic effect, desalinator to remove wasteful material, and concentrator to convert thermal radiation. In designing the system, some things need to be considered such as estimation of water needs for daily needs, estimation of solar potential, and components selection [14]. The following is the specification of tools that needed in this system.

Table 1. Specification tools in this system

Photovoltaic	(8x100WP) 12 V
Charge Controller	12 V / 30 A
Battery	(4x100 AH) 12 V
Inverter	I/O 12 V/220 V
Seawater Pump	750 Watt
Boiler	50 lt

The working scheme of this system started with the energy converted by photovoltaic and will be stored in a battery with the input control from charge controller. The battery is equipped with voltage sensor to determine the time to supply voltage. If the percentage of voltage is drop under 20%, then battery will stop supply. And if the percentage above 95%, it will start supply again. Then followed by an inverter DC-AC to the seawater pump 750 Watt. It will pump the water from the sea to the boiler that located above the parabolic solar concentrator coated with chrome. The boiler is installed on the focal point of the solar concentrator. Inside the boiler, there is water level sensor. If level of the water below the minimum limit, the pump will work. And if the level of the water meets the height limit, it will stop working. The process continued with the creation of desalination component consisting of a heater tank, hose pipe and condenser tank (for the cooling process). After all of the components are finished, it is coupled into single entity directly in the field.

Figure 1. Design to be implemented

The electric components of photovoltaic, parabolic solar desalination and concentrator process has been tested in open area of Electrical Engineering Department of ITS. To check the content of water desalination process, it will be tested again in Enviromental Engineering Laboratory of ITS. The test results will be evaluated and analysed again to improve the performance of equipment. After the research has done, the last phase is making conclusion about this process. Figure 2 shown boiler with the size of 50 ltr and solar concentrator with the diameter of 90 cm. The tools were build in Power System Simulation Laboratory, Electrical Engineering Department of ITS, and took a week of work.

Figure 2. Tools of boiler and solar concentrator

IV. RESULT AND ANALYSIS

A. PV System Results

Power that produced by solar panel are measured . The solar panel system consists of 5 pieces of 200 WP PV, DVC controlled inverter, charge controller, closed loop MPPT, and battery. Full working PV from 6:00 a.m. to 19:00 p.m. / Day. With the number of pump needs of 746 WATT and the pump works 6 times a day for 30 minutes, the need for 2300 Watts / Day. Then it can be concluded, that the results of the PV system will be able to meet the overall system requirements.

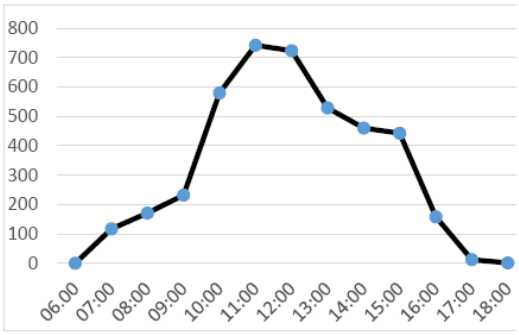

Figure 3. PV System Result

B. Operation Schemes

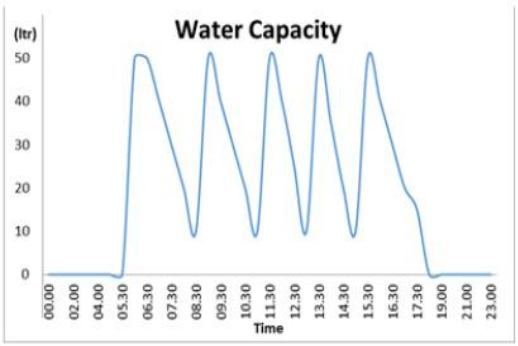

Figure 4. Water Capacity Graph

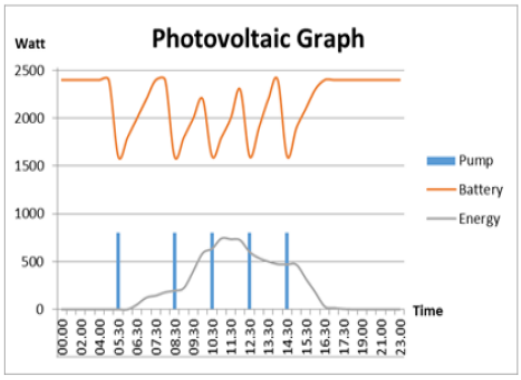

Figure 5. Photovoltaic Graph

The pump will work based on the water height in the boiler. It will pump when the water level sensor sense the water quantity is below the limit and the pump will stop working when the water meets the height limit. In Figure 5, the water height is measured based on the duration of the light that penetrates through the water. From the graph, the seawater pump will pump whenever the water capacity is 10 ltr or lower and it starts pumping from 5:30 until 14:30. The pump requires 800 Watt to pump the sea water and fill the water tanks. The pumping progress takes one hour to operate. It uses the energy from the battery that recharges from 5:30 until 16:30.

C. Desalination System Performence

In Destilation system performence, 4 identic parabolic concentrators and 1 boiler are used. Parabolic concentrator is used to focusing the thermal radiation on the point, then the thermal boils the sea water and begin the desalination process. The system shown as figure below

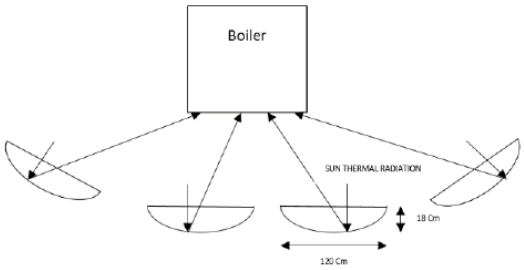

Figure 6. Desalination System

To calculate the System performence several equations are used. First, calculate the area of solar concentrator that conducted by heat radiation. By the calculation the 1,55 $m2$ total area of parabolic concentartor is obtained. Then, calculate the power transfer from parabolic concentrator to boiler. The material reflectiviy and copper conductivity is also calculated, and from the calculation the result is each parabolic concetrator can transfer 1196,44 W to the boiler during ideal condition and based on measurement, each paraboic concentartor can increase the boiler temperature up to 300℃.With the boiler specification heat needed is 15,141Kj. Based on the experiment, Sea water boils in 24 minutes and 32 second.

D. Desalination Results

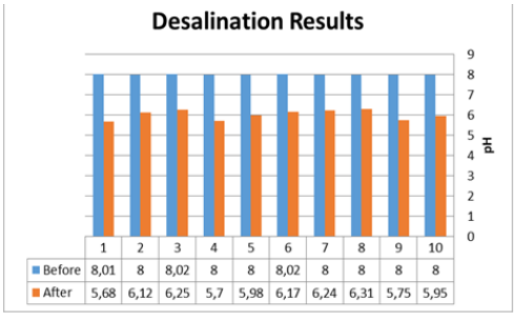

Figure 7. Desalination Result of pH

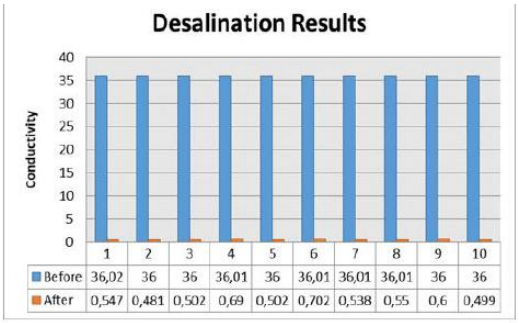

Figure 8. Desalination Result of Conductivity

Based on the data of pH measurements of seawater before desalination, the average value was 8,005, while the average pH after the desalination is 6,015. From these data, it can be concluded that there is a decrease pH level which proves that the salinity of the water has decreased. Electrical Conductivity testing is aimed to determine the salinity of the water. If the conductivity is small, then the salinity will decrease (Davis and Weist, 1996).

From the experiment, the average salinity level before desalination was 36,006 S/m, while the average salinity level after the desalination is 441,9 S/m. Based on Figure 8, after the desalination processes have been done, it can be concluded that the pH of the water decrease by 25% and the conductivity also decrease by 81.46%.

E. Maintenance Model

Maintenance carried out on this system consists of two main parts. The first is regularly cleaning the PV from dust and pollution which can affect the performance of PV. The second is cleaning the boiler and seawater pump from sedimentation of seawater pumped and settling in the pump and boiler. Routine checks for PV is important to prevent damages, such as verify the presence of dusts on the panel, check the existence of hotspots in the inverter and charge controller, check the seals of the lids and any damge cables, and turn off/on the inverter to check if it restart properly.

V. CONCLUSION

This paper provides information about operation scheme of the photovoltaic pump with the combination of parabolic solar concentrator to provide clean water in a coastal area that has water crisis by taking advantages from solar energy and seawater in Indonesia as the largest archipelagic country in the world. This system can produce a power efficiency greater than 80% which means the system is good enough to be applied.based on the capacity the boiler can provide clean water for 50 ltr countinously when solar consentrator could increase boiler temperature up to 300℃

REFERENCES

1. W. Said, H. A. Gaber and A. Mami, "Sizing and Simulation of an Energy Sufficient Stand-alone PV Pumping System," International Conference on Promising Electronic Technologies (ICPET), pp. 8-13, 2017.
2. Acakpovi, Amevi, F. F. Xavier and R. A.-. Baffour, "The analytical method of sizing photovoltaic water pumping system," IEEE 4th International Conference on Adaptive Science & Technology (ICAST), pp. 65-69, 2012.
3. R. Antonello, M. Carraro, A. Costabeber, F. Tinazzi and M. Zigliotto, "Energy-Efficient Autonomous Solar Water-Pumping System for Permanent-Magnet Synchronous Motors," IEEE Transactions on Industrial Electronics, pp. 43-51, 2017.
4. Hutchinson, C. Whitaker, T. Townsend and R. Reid, "Operations and maintenance at PVUSA: utility perspective on the operation of PV systems," Conference Record of the Twenty Third IEEE Photovoltaic Specialists Conference - 1993 (Cat. No.93CH3283-9), pp. 1170-1175, 1993.
5. A. S. Wardhana, H. Suryoatmojo and M. Ashari, "Design of parabolic solar concentrator to improve the optical efficiency for thermal engine generator using dual reflector Gregorian method," International Seminar on Intelligent Technology and Its Applications (ISITIA), pp. 457-464, 2016.
6. A. Jones and R. Campbell, "Sea water desalination: a generalized model for feedwater intakes," Proceedings of OCEANS 2005 MTS/IEEE, vol. 3, pp. 2647-2651, 2005.
7. M. Z. Rakhmat, "Asiasentinel," Asiasentinel, 2 April 2018. [Online].Available: https://www.asiasentinel.com/society/indonesia-growing-water-safety-crisis. [Accessed 26 November 2018].
8. M. N. Mumek, "thedailyroar," The Daily Roar, 8 october 2013. [Online].Available:https://thedailyroar.com/lifestyle/indonesia-the-largest-archipelago-in-the-world/. [Accessed 26 November 2018].
9. V. Suak, "Manado.tribunnews," Tribun Manado, 26 September 2015.[Online].Available:http://manado.tribunnews.com/2015/09/26/warga-pulau-terluar-sulit-dapatkan-air-bersih. [Accessed 27 November 2018].
10. M. Abbas, H. Aburideh, Z. Tigrine, N. K. Merzouk and A. Hamadene, "Thermal Study of a Brackich Water Desalination Process using Solar Energy," International Renewable and Sustainable Energy Conference (IRSEC), vol. III, no. 1, p. 1, 4-7 December 2017.
11. D. M. Company, in The American Heritage Science Dictionary, Dunder Mifflin publisher, 2007, p. 56.
12. V. C. Sontake and V. R. Kalamkar, "Solar photovoltaic water pumping system - A comprehensive review," Renewable and Sustainable Energy Reviews, vol. 59, p. 1038–1067, 2016.
13. A. B. Pouyfaucon and L. García-Rodríguez, "Solar thermal-powered desalination: A viable solution for a potential market," Desalination, vol. 435, pp. 60-69, 2018.
14. L. Nabila, F. Khaldi and M. Aksas, "Design of photo voltaic pumping system using water tank storage for a remote area in Algeria," in 2014 5th International Renewable Energy Congress (IREC), Hammamet, Tunisia, 2014.