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ABSTRACT

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SOLAR PV MODEL FOR ECO-GARDEN AND HYDROPONIC DAILY WATERING SYSTEMS

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Abstract

Supplying water for eco-garden and hydroponic system using solar photovoltaic system is one of the best way to provide the need of water requirements for daily watering. This paper presents a method that can be used for sizing and modeling Solar PV system for eco-garden and hydroponic system. The model described how to predict the capability of the pump to pumping water, predict the flow rate per hour to meet the daily needed. It used ac centrifugal pump, dc pump, a voltage inverter, and battery storage. The experimental result also provided to calculate the accuracy of the model.

Keywords: *Solar PV system, Eco-garden, Hydroponic system, Pumping water*

1. Introduction

Indonesia is the country that has a lot of potential renewable energy. One of the most potential renewable energy in Indonesia is solar energy because Indonesia passes through equator line. Ministry of energy and mineral of Indonesia in 2015 reported that Indonesia has 112 GW potential of solar energy. [RUKN ESDM 2014]

Photovoltaic (PV) is the device that can convert solar radiation into electricity using photovoltaic effect. Solar photovoltaic systems can provide electricity to supply electrification and water pumping systems. Water pumping is a crucial need in several regions in Indonesia. Hundreds of PV systems have been installed for irrigation, livestock, and domestic need, it's proofed that PV system can provide an economical and reliable method how to meet the demand of hydraulic requirements.

In this paper, we will design Solar PV water pumping system to supply water for

eco-garden and hydroponic system in SD IT Al-Uswah Surabaya, Indonesia. In this case water waste from wudhu can be reused for watering eco-garden and hydroponic system using renewable energy from Solar PV System.

2. Literature Review

Photovoltaic pumping system used for the water reservoir in Algeria village irrigation service areas has been designed by Nabila, Louai, Fouad Khaldi, and Mounir Aksas [1]. The design of the system was made to replace conventional diesel generation technology that has been used. It provides modeling, simulation, and optimization of pump system based solar generation.

The size of pump system based solar generation have been determined by Acakpovi, Amevi, Fifatin F. Xavier, and Robert Awuah- Baffour [2] through analytical method. That method gives us a reference in applying this system.

The theoretical calculation and experimenting pump system based solar generation has been done by Hamrouni,

Nejib, Moncef Jraidi, and Adnène Chérif [3]. The result from it can help us defining system specification that will apply.

Photovoltaic pumping system used in supplying water for drink, clean water, and micro irrigation on destitute socialism in Nepal, has been applied by McLaughlin, Fintan, Aidan Duffy, and Michael Conlon [4]. The paper becomes our reference calculating technical and dynamic of economic considering local characteristic environment, physic, and social economy on each area

Caracas, João Victor M., Luis Felipe M. Teixeira, G. D. C. Farias, and L. A. D. S. Ribeiro [5] has implemented high-efficiency converter and low cost on pump system solar-based generation. To determine optimal specification on applying installation pump system, we used it as the reference.

3. Research Methods

3.1. Water Pump Sizing

The first step designing of solar powered water pump system is determining the size of water tank required for the operation. The amount of water to be pumped is 5100 Liters or equal to 5.1 m³.

Considering the height of water canal between the water tank and water utilization, the height is 15 meters, the size of the water pump can be obtained. The water pump size is 300 Watt.

3.2. PV Array Sizing

PV Array sizing depends on the total system load, which means the determination of total wattage of the water pump. Considering the efficiency inverter 90%, the operating factor 0.75, and mismatch factor 0.85. [1]

$$PV \text{ Array size} = \frac{300}{0.9 \times 0.75 \times 0.85} = 522,876 \text{ Watt}$$

Six 100 WP, 24 V solar panels need to be used for this application. Table 1 shows data given by the manufacturer for 100

WP, 24V Photovoltaic panel. The rated peak power (100 WP) is available only at STC such as cell temperature at 25°C and insolation of 1000 W/m².

Table1. Parameters of the 100Wp PV module.

Specification	Value
Manufacturer	CALTECH
Solar Module Type	SP-100-P36
Output Max Power (Pmax)	100 ±5% W
Current at Pmax (Imp)	5.69 A
Voltage at Pmax (Vmp)	17.6 V
Short-Circuit Current (Isc)	6.09 A
Open-Circuit Voltage (Voc)	22.6 V
Temperature Range	-45°C +80°C

3.3. Pumping System

Electrical power is generated by six parallel photovoltaic modules. Parallel modules generate total current bigger, at the same voltage level than series modules. The output power of photovoltaic modules controlled by solar charge controller, before stored into the battery. Solar charge controller stabilizes the output voltage of PV module. The inverter converts the output power of battery from DC current become AC current, then energize the water pump. The water pump is utilized to irrigate the hydroponic farm on the rooftop of a building.

4. Analysis & Results

During the simulations, the models were tested with changing speed that change with illumination. The simulation was prepared considering the characteristics of the Solar Panel, installed on the roof of the SDIT Al-Uswah, and using the characteristic of the pump unit in the Garden as shown in Figure 1. The inverter is controlled by DVC technique. We choose for a nominal frequency of 50 Hz and The models of maximum power point tracker electric are closed-loop constant V/Hz control. Simulation results by without load and with considering one induction motor (Pump) are presented by several cases.

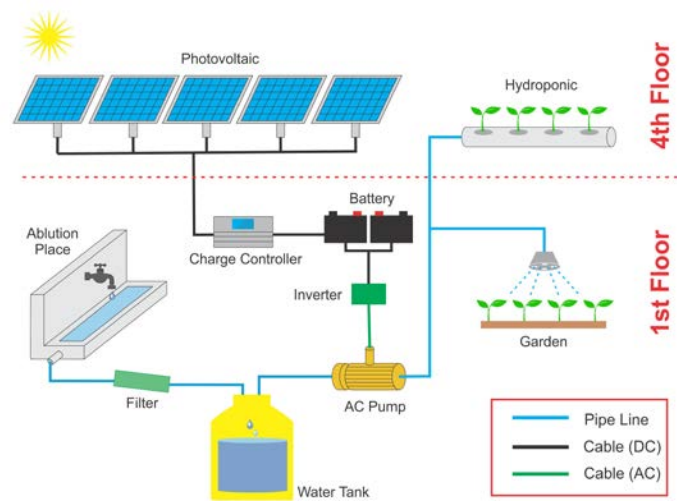


Figure 1 . Solar PV System Model for Eco-Garden and Hydroponic Systems

Case -1: Without Load

In this simulation, we do not install load in this panel, only solar panel, MPPT and battery in Table 2 can be seen how maximum current and voltage in one day, then can know about current charging solar panel to battery.

Table 2. System Simulation Without Load

Time	Output Solar PV (V)	Output Solar PV (Amp)	Input Battery (V)	Input Battery (V)
08:00	20.9	14.03	13,58	14.03
09:00	20.9	17.50	13,58	17.50
10:00	20.9	20.12	13,58	20
11:00	20.9	20.15	13,58	20
12:00	20.9	19.05	13,58	19.05
13:00	20.9	16.69	13,58	16.69
14:00	20.9	13.12	13,58	13.12
15:00	20.9	9.90	13,58	9.90
16:00	20.9	6.10	13,58	6.10
17:00	20.9	5.80	13,58	5.8
18:00	20.9	0.50	13,58	0.5

After that, to validation this circuit, it's safe and can use to turn on pumping this research use emergency test and measuring how many current and voltage in this system. Table 3 explain about measuring how much current and voltage in DC power and AC power. DC power is the Solar panel

to Battery and the next to inverter than AC power is the inverter to induction motor (pump) and in this simulated system is not connected to load. Solar PV modelling is installed as shown in Figure 2.

Table 3. Result Experiment of System

Case (sec)	Solar Panel Output (Amp)	Battery input (Amp)	Battery output (Amp)
1	19.5	15.5	2
2	19.5	15.5	2
3	19.5	15.5	2
4	19.5	15.5	2
5	19.5	15.5	2

In Table 4 can see about how configuration about the emergency in this system.

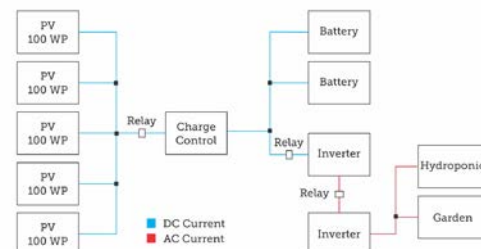


Figure 2. Solar PV Modelling

Table 4. Configuration of Emergency System

Case 1	S1	S2	Lamp	Emergency
Batery	On	Off	Orange	Off

Pukul	Input Inverter (V)	Input Inverter (Amp)	Input Pump (Amp)	Pump (V)
08.00 – 09.00	12	21.72	1.25	220
15.00 – 16.00	12	24.43	1.4	220
Charging				
Load Running	On	On	Green	Off
System Off	On	On	Red	On
System Off	Off	Off	Red	Off/On

Switch one is connected Solar Panel to Battery then Switch two is connected the battery to inverter and inverter to load than the last Emergency can be used Switch Off all the system .

Case-2: Considering single induction motor (Pump) Consider that only one IM is connected to the SOLAR PANEL system

In this simulation we connected the load for the hydroponic daily watering system, the result of this simulation can be seen in this Figure 3.

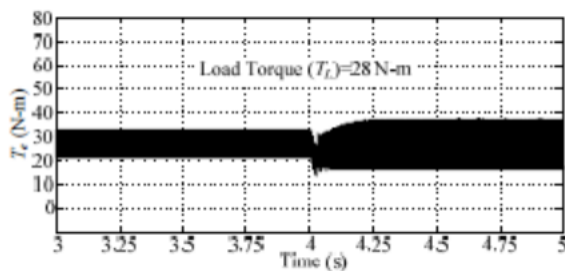


Figure 3. Response of Torque generated by the motor

The speed of the motor is dependent on the availability of Solar Panel power. At any case, the controller of IM maintains energy management between load and source. This system can show the response

of speed of IM when reduced the irradiance from 200 WP at $t = 4$ sec. However, the load torque remains same and the response of torque generated by the motor is shown in Figure 4. However, if solar power is very low that indicates reference speed of IM is below the base speed (ω_b) then the motor cannot pump the water.

Form this research for hydroponic watering system based on Solar Panel system. The simulation results demonstrate that the performance of the controllers is satisfactory under steady state as well as dynamic conditions.

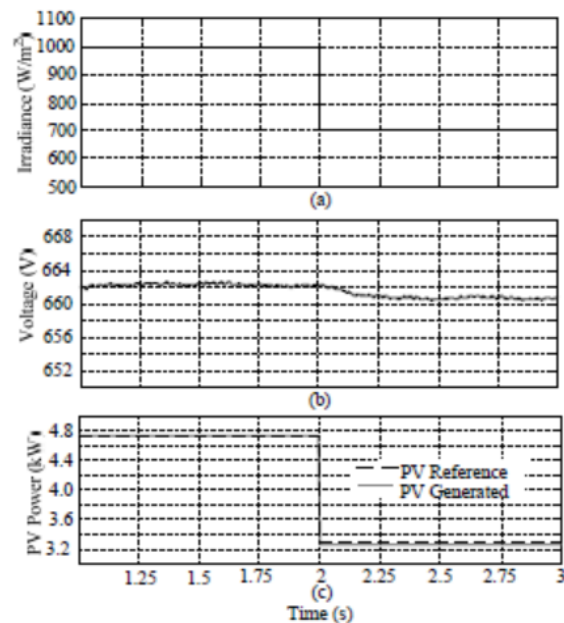


Figure 4. (a) Solar irradiance; (b): V_{mpp} or V^*_{dc} ; (c): SOLAR PANEL Power

5. Discussion & Conclusion

Solar PV System is installed in parallel mode as to adjust the voltage of the inverter, 12volt and maximize charging

current. At 10.00 am until 11.00 am, the charging current is maximal, 20.12 – 20.15 ampere. When the pump water is connected to the solar panel system, the inverter absorbing power about 260.64 – 293.16 watt. The pump water is operated as much as twice a day, at 08.00 am until 09.00 am and 03.00 pm until 04.00 pm. As photovoltaic still, work to charge the battery power at that time.

In order to maintain the quality of work and continuity of using Solar-Water Pump, is necessary to periodic inspection and maintenance as well as their evaluation after installing that Solar-Water Pump.

6. Acknowledgment

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References

- [1] Nabila, L., Khaldi, F. and Aksas, M., 2014, March. The design of photovoltaic pumping system using water tank storage for a remote area in Algeria. In Renewable Energy Congress (IREC), 2014 5th International (pp. 1-5). IEEE.
- [2] Acakpovi, A., Xavier, F.F., and Awuah-Baffour, R., 2012, October. The analytical method of sizing photovoltaic water pumping system. In 2012 IEEE 4th International Conference on Adaptive Science & Technology (ICAST) (pp. 65-69). IEEE.
- [3] Hamrouni, N., Jraidi, M. and Chérif, A., 2009. Theoretical and experimental analysis of the behavior of a photovoltaic pumping system. Solar energy, 83(8), pp.1335-1344.
- [4] McLoughlin, F., Duffy, A. and Conlon, M., 2013, September. Solar photovoltaic water pumping for Multiple Use Systems (MUS) in Nepal. In Power Engineering Conference (UPEC), 2013 48th International Universities' (pp. 1-6). IEEE.
- [5] Caracas, Victor, J., Teixeira, L. F. M., Farias, G. D. C. and Ribeiro, L. A. D. S., 2012. Implementation of a high efficiency and low-cost converter for a photovoltaic water pumping system. In Applied Power Electronics Conference and Exposition (APEC), 2012 Twenty-Seventh Annual IEEE (pp. 2080-2086). IEEE.
- [6] Kavitha, B., Karthikeyan, S. and Iswarya, B., 2014. The design of solar PV water pumping system using BLDC drives using the sensorless method. The International Journal Of Engineering And Science (IJES) Volume, 3, pp.41-46.