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Modelling of Solar Power Generation Systems as a Source of Agricultural Irrigation Pumps

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Abstract: New and renewable energy (EBT) is a green energy generator because its supply is abundant and will not run out all the time. Renewable energy is clean energy and does not produce pollution because it is not from fossil fuels such as natural gas, and it will not damage the environment on earth. One of the green energy generators is the Solar Power Plant (PLTS), one of the green energies developed by the Indonesian government to replace energy derived from fossil fuels. The government has set a National Energy Policy, targeting the contribution of NRE to the national energy mix by 2025 is 17% (Perpres No. 5/2006), amended by PP No.79/2014, 23% (2025, (31) % (2050) To be able to support this, it is hoped that a study and research will be carried out, "Modeling of solar power generation systems as a source of agricultural irrigation pumps" with research that can obtain results that can be obtained irrigating rice fields in Subak Kanca Tegeh, Selan Bawak Village, Tabanan Regency so that farmers who are having rice fields that cannot drain water can be supplied with water by installing a pump 10 ha from 50 ha, the existing water has not been able to reach this far with a higher topography, it is necessary to plan how much power is needed so that the water pump can obtain enough energy to the pump can work normally.

Keywords: Agriculture; Generation system; Green energy; New renewable; Solar power

Introduction

The existing management system in Bali is the Subak system, where Subak is an organization owned by the farming community in Bali which is specifically regulated for traditional irrigation systems for rice fields. Members of Subak or Kramasubak are the farmers who own rice fields and get a share of water in their fields (Mohsin & Abdulbaqi, 2018). Subak water needs ranging from tilling the soil, growing nurseries, and flowering period require an average of 1.5 liters of water/second ha. So, it is to be able to produce optimal results water is needed that flows continuously. Subak Kance Tegeh is a Subak whose topography is above approximately 3 meters, so that water cannot be flowed from the existing irrigation system except in rainwater. To be able to drain water, a water pump is needed that can increase water (Ding et al., 2019; Gupta, 2019; Pomianowski et al., 2020) to the Kace Tegeh place with a solar power plant in Indonesia as know by PLTS.

Indonesia is an agricultural country where most of the population still relies on agriculture (Amelia et al., 2021; Berg et al., 2020; Mariyono, 2019; Rozaki, 2020) as well as the island of Bali, and the population still relies on agriculture, besides tourism. Karen agriculture is inherited from generation to generation. The existing agriculture is still traditional. The management system in Bali is the Subak system, where Subak is an organization belonging to the farming community in Bali which is specifically regulated regarding the traditional irrigation system for rice fields. Subak members, commonly called kramasubak are farmers who own rice fields and get a share of water in their fields, where each Subak is chaired by someone named "Pekaseh." Subak water needs ranging from tilling the soil, growing nurseries, and flowering period require an average of 1.5 liters of water/second ha. So, it is to be able to produce optimal results requires water flow continuously. The Kance Tegeh subak is a subak whose topography is more than 3 meters high, where 10 ha of

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rice fields have not been able to get water flow, so it cannot be drained from the existing irrigation system, except in the presence of rainwater. To be able to drain water, a water pump is needed (Carroll et al., 2020; Golmohamadi & Asadi, 2020; Morabito & Hendrick, 2019) that can add water to the Kace Tegeh place with a solar power plant (PLTS) source. Solar power plants are a source of energy that comes from clean sunlight and will not run out all the time (Bondarenko et al., 2019; Rezk et al., 2020; Sarkar et al., 2021; Vandana et al., 2022)

On-grid solar power generation system.

On-grid solar panel system or PLTS Grid-Tie System is a system that works directly on solar panels. This technological system does not use batteries, and the electricity generated is used for various purposes. The electricity produced is AC so that this on-grid solar panel can be applied together with the PLN network. If there is an excess of power, the electric power will be sold to PLN if, at night, the power used comes from PLN. This on-grid system of solar power plants is suitable for application in the field by utilizing the roof as a space to absorb solar energy. This system, if installed with PLN, will reduce electricity costs (Wiranata & Ardana, 2020).

An interconnected PLTS system (On-Grid) or a Grid-Connected PV System is a power generation system that utilizes solar radiation to generate electricity. As the name implies, this system will utilize the PLN network by optimizing solar energy through solar modules or photovoltaic modules that generate as much electricity as possible. This system is also considered environmentally friendly and emission-free. The interconnected PLTS system is also a green energy solution for the community, both offices, and housing, which aims to reduce electricity bills from PLN and can provide added value for its owners (Balaji et al., 2021; Islam et al., 2019; Stoyanov et al., 2019).

Power generation system off the grid (hybrid)

The application of the PLTS hybrid system or working principle can run with the PLN electricity system and is regulated in the Minister of Energy and Mineral Resources Regulation of New, Renewable Energy, and Energy Conservation (EBTKE). In this system (Durai et al., 2018; Ebrahimy et al., 2018; Fairley, 2021; Waleed et al., 2019), the PLN electricity network acts as a distributor or liaison for electric current originating from solar panels that are fed to the load. That way, during the day, the use of electricity can utilize electrical energy from sunlight, and at night, because there is no sunlight, so there is no electricity production from solar panels, so you can still use electricity from PLN (Ebrahimy et al., 2018; Javaid & Islam, 2020; Sen & Singh, 2021).

Method

Figures and Tables

The materials used in this research are PLTS off grid specifications as follows:

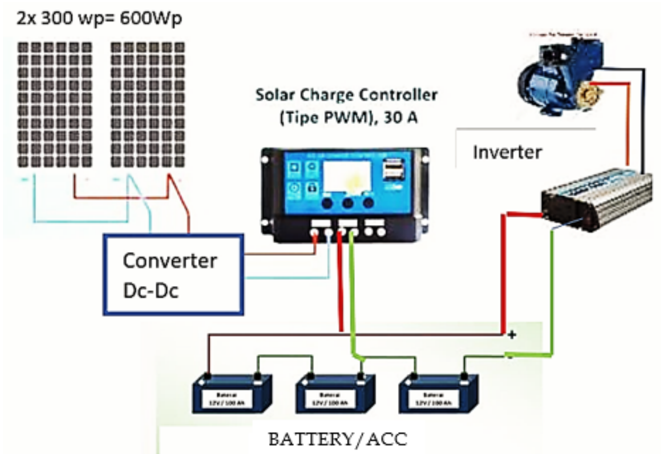

Figure 1. Irrigation pump system with PLTS OFF grid

Specification: Solar Panel 300x 2 = 600 WP, Dc-dc up/down Converter 10A 12volt DC 30 A, SCC 40A/12/24volt., Inverter 300 watt /12volt, Battery 100 x 3 AH VRLA, pump 400watt, Inverter 3000 watt.

The working diagram on Figure 1: The control will convert the sunlight falling on the solar panel into voltage and current; Energy from the solar panel is channeled to the dc-dc converter. The resulting voltage converter will be stabilized with a more optimal buck/boost dc-dc converter to produce a stable voltage output. The solar charger controller receives the current flow; and inside the Solar Charger Controller (SCC), the current flow will be adjusted according to the program using the voltage, current, and load. The battery charger can be programmed so that it lasts longer.

Result and Discussion

Result

Voltage measurement of no-load solar power plants. Measurements are made on the output of the solar panel and the voltage that has flowed to the dc-dc converter. This is done to see how effectively it can stabilize the voltage. Produced by solar panels.

From figure 2 characteristics, the voltage generated by the solar power plant is from 15 volts dc to 18 volts dc, as well as the current that flows from 11 amperes to 13.6 amperes and the amount of power that the solar power meter ranges from 985 to 1100, from the existing data it shows between voltage, current and power generated by PLTS in operation where the light is bright so that PLTS can work optimally.

Table 1. Solar panel voltage measurement and converter dc-dc output dan power of solar cell

Hour	V_{out} PV (V)	Current (A)	Solar Power Meter
10:00	16.5	13	985
10:10	16.5	13	985
10:20	16.5	13	986
10:30	17	11	1000
10:40	17	11	1000
10:50	17	11	1000
11:00	17	11	1000
11:10	17.5	13.5	1050
11:20	17.5	13.5	1050
11:30	17.5	13.5	1050
11:40	17.5	13.5	1050
11:50	18	14	1100
12:00	18	14	1100

Table 2. Solar panel voltage measurement and converter dc-dc and water charger / minute

Hour	Vout PV (volt)	Water Debit/liter
10:00	16.5	75
10:10	16.5	76
10:20	16.5	88
10:30	17	89
10:40	17	89
10:50	17	89
11:00	17	89
11:10	17.5	91
11:20	17.5	91
11:30	17.5	91
11:40	17.5	91
11:40	18	92
11:50	18	92
12:00	18	80
Average of debit water		87.36

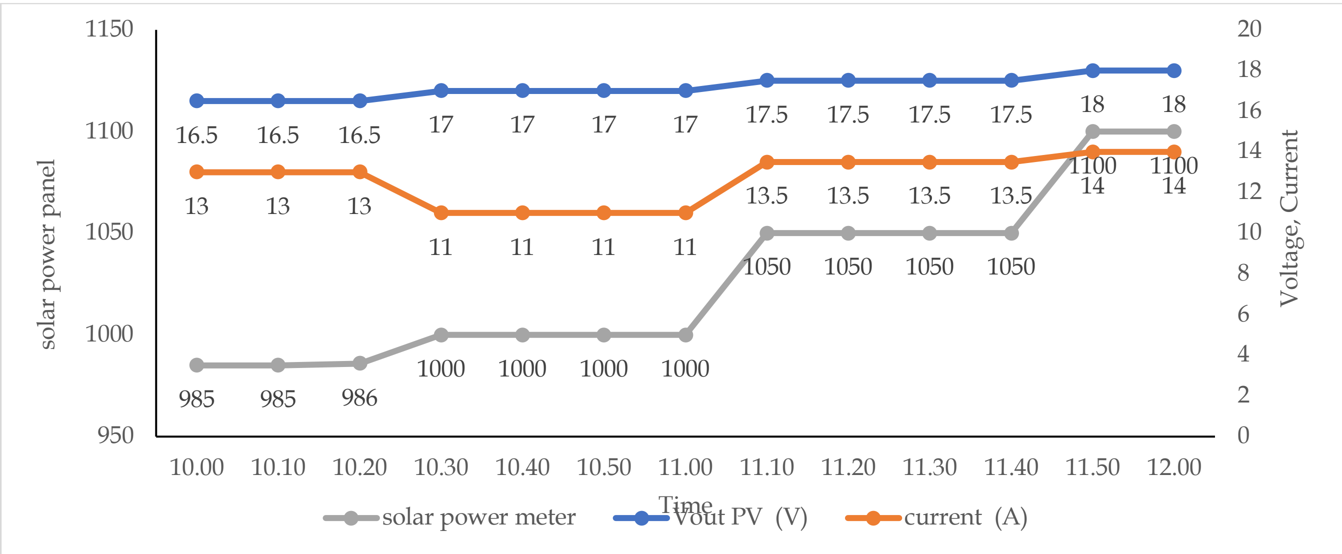

Figure 2. Characteristics of the voltage/current/ solar power function of time

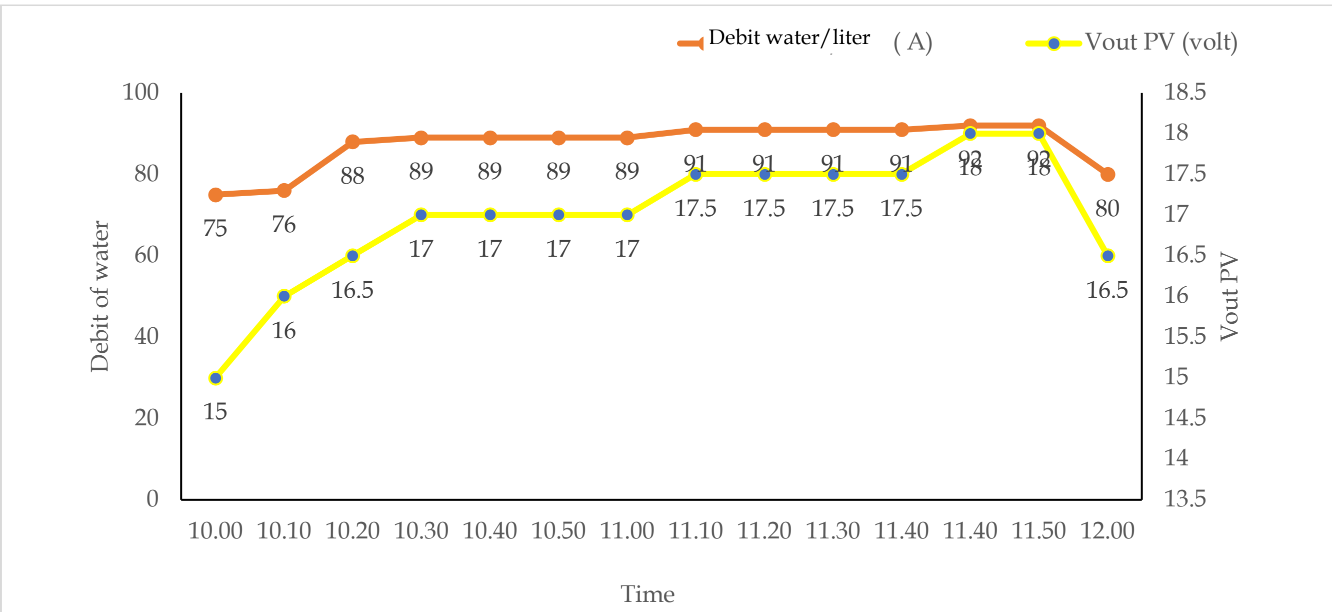

Figure 3. Characteristics of voltage, water discharge function of time

From the characteristics of figure 3, the voltage generated by PLTS ranges from 15 volts dc to 18 volts. Moreover, the amount of water flow (water discharge) the amount of water discharge that the pump can generate ranges from 75 liters/minute to 1.25 liters/second to 92 liters/minute, or equals 1.53 liters/second. Because the pump can operate for 2 hours where the average flow produced is 87 liters/minute or equal to 1.45/second, the water produced for 2 hours is 1.45 liters/second x 3600 x2 = 10,440 liters/ for two hours.

From figure 4 characteristics, the voltage generated by the solar power plant is from 9 volts dc to 17.5 volts dc, as well as the current that flows from 11 amperes to 13.5 amperes and the amount of power the solar power meter ranges from 850 to 1010, from the existing data it shows between voltage, current and power generated by PLTS in operation where the light is bright so that PLTS can work optimally.

From figure 5 characteristics, the amount of current flowing from 10 amperes to 13.5 amperes, and the amount of water that flows for two hours is 70 liters/minute or 1.16 liters second to 95 liters/minute or 1,583 liters/second. To be able to optimize the water discharge, the voltage and current generated by the Solar Power Plant must be maximized. The average water discharge flowing in the irrigation in the second stage is: 1.39 liters/second x 3,600 x 2 = 10,062 liters/for two hours. From 13.00 to 15.00.

Based on the data obtained from the table 2 and table 4, the flow of water flowing for 4 hours of pump operation under normal conditions is 11,280 + 10,062 = 21,342 liters/second for 4 hours.

Table 3. Solar panel voltage measurement and converter dc-dc output, Idc and solar power meter.

Hour	Vout PV (Volt)	Idc PV (A)	solar power meter divided 100
13:00	17.5	12	1010
13:10	17.5	12	1000
13:20	17.9	12	1008
13:30	17.9	12	1008
13:40	17.9	12	1008
13:50	17.5	11.5	1000
14:00	17	11	900
14:10	17	11	900
14:20	16	11	900
14:30	12	12	900
14:40	9	11.5	800
14:50	9	11.5	800
15:00	10	12	850

To be able to meet the water needs of Subak Kance Tegeh with an area of 10 ha, it is necessary to have the following water discharge: The daily water requirement for a land area of 10 ha can be calculated as follows: Average water requirement liter/second.ha ×Area land = 1.5 liters/second/ha = 1.5 liters/second = 1.5×3,600/hour/ha = 5,400 liters/hour/ha.

From the results of the above calculation, the amount of water discharge that can be used to drain water from the installed pump is as follows:

The amount of water discharge required for a land area of 10 ha. The flow of water = 5,400 liters x hours of flow x land area = 5,400 x 4 (hours) x 10 (land area) = 216,000 liters. With the installation of a pump, the water discharge can be generated by = 216,000 – (10,440+ 10,064) x 10 ha = 216,000 -205,040 = 10,960 liters.

From the calculation results, with the data obtained, the installation of pumps for irrigation in Subak Kance Tegeh still lacks water discharge of 10,960 liters.

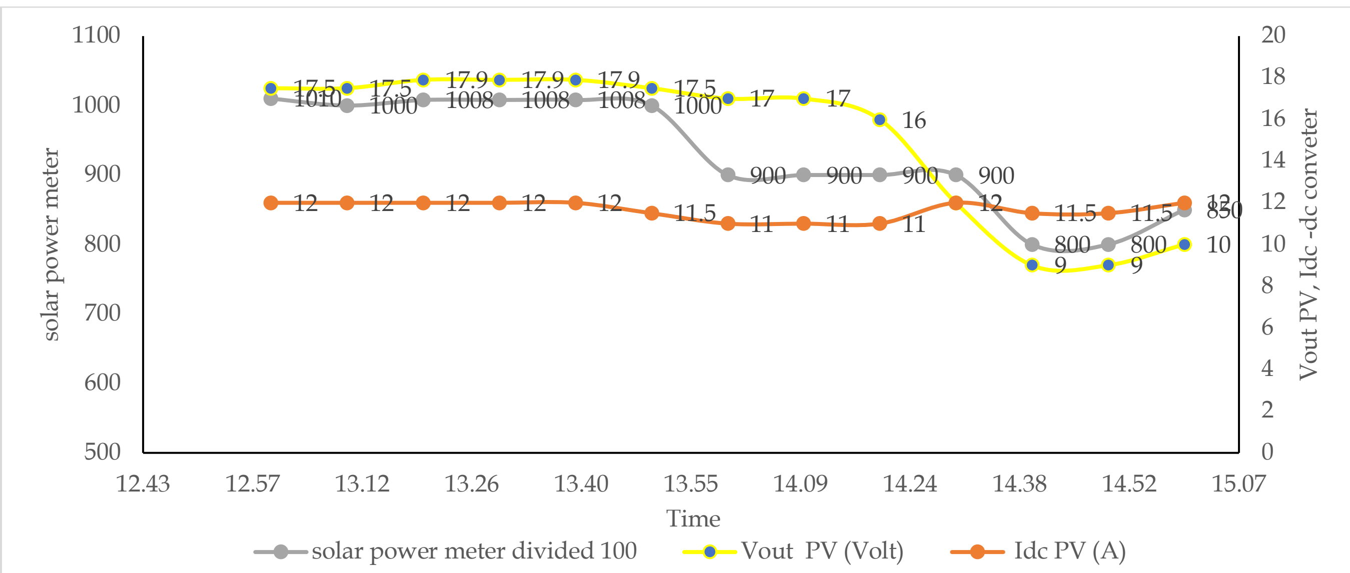

Figure 4. Voltage, current,solar powermetr, function of time

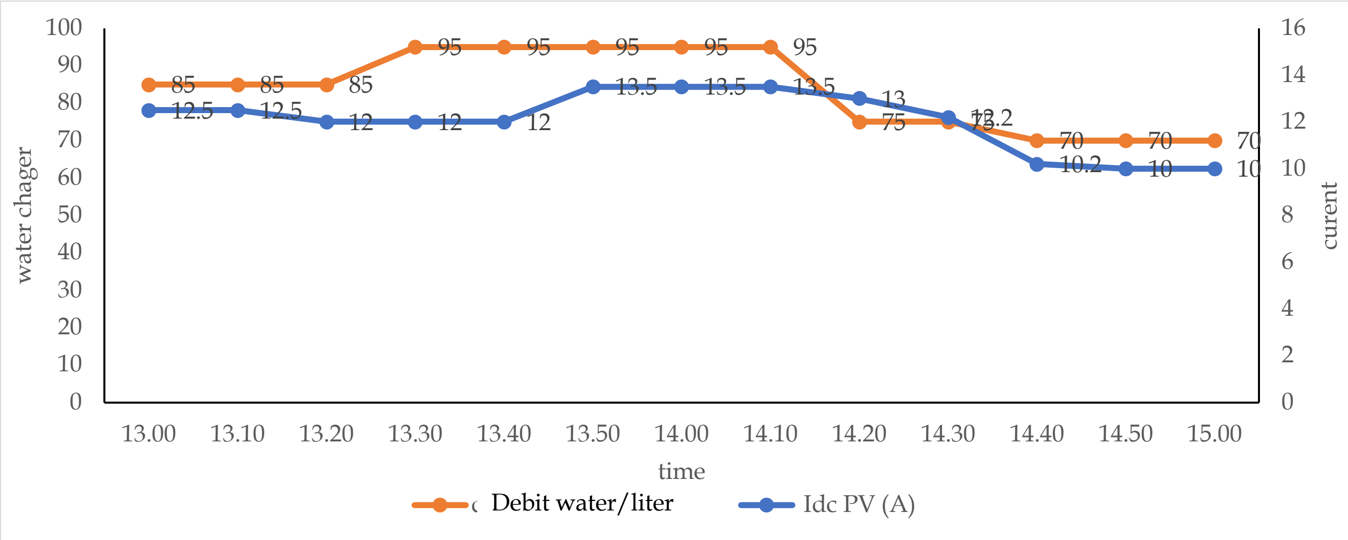

Figure 5. Charateristic, Idc, water charger function time

Table 4. Solar panel voltage measurement and converter dc-dc dan debit water/ minute

Hour	Idc PV (A)	debit water /liter
13:00	12.5	85
13:10	12.5	85
13:20	12	85
13:30	12	95
13:40	12	95
13:50	13.5	95
14:00	13.5	95
14:10	13.5	95
14:20	13	75
14:30	12.2	75
14:40	10.2	70
14:50	10	70
15:00	10	70
Average		83.85

Conclusion

Pump irrigation systems with solar power plants can be carried out as follows pump irrigation pump system with a solar power plant, in Subak Kance Tengah, Selan Bawak Village, the pump can operate normally from 10.00 to 12.00, where the average water discharge is 87.857 liters/minute or equal to 1.4 liters per seconds.The irrigation pump system in the second section of the pump also operates normally from 13.00 to 15.00, where the average water discharge produced is 83,846 liters/minute or 1.39 liters/second. The irrigation pump can only produce 205,040 liters of water, so there is still a shortage of 10,960 liters.

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