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Planning and Development of Solar Cells for Illumination of Dragon Fruit and Fish Pools at the Farming Group of Kampung Daun, Baumata-Kupang

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Abstract— *This paper aims to plan and utilize renewable energy sources or solar cell energy for lighting systems in fish ponds and dragon fruit gardens. The activity occurred at the Kampung Daun farmer group in Baumata Village, Kupang Regency, East Nusa Tenggara. The method used is to design and install a Solar Power Plant (SPP) according to the needs of the planned load. There are 4 LED lamps with 9W power and one 100Wp solar cell panel installed. This SPP design specifically serves fish ponds. Based on the assumption of a 12-hour irradiation time, the required battery capacity is 65 Ah/12 Volts with 50% Dead of Discharge (DoD). However, considering saving energy reserves, the battery is installed 165Ah. In addition, considering the efficiency based on the 90% output power requirement, a 500Watt inverter is used. The function of the inverter is to convert DC voltage to AC. Meanwhile, 30W lamps are used for dragon fruit orchards equipped with small solar panels. These solar cell lights are installed scattered in the dragon garden area as many as ten pieces.*

Keywords— *Renewable, Battery, Solar energy*.

I. Introduction

Baumata Village, Taebenu District, Kupang Regency, East Nusa Tenggara (NTT) has an Ecotourism plantation area of 212 hectares, known as the "Kampung Daun Farmer Group." On this plantation, there are several types of horticultural cultivation, such as bananas, papayas, dragon fruit, and several other vegetables. The location of this plantation has the potential for waterways that are quite heavy and flow around the land all day (never dry), both day and night. Therefore, the Kampung Daun farmer group has empowered the potential of water by building a pond for catfish, goldfish, gourami, and tilapia fish. The management of this fish pond empowers as many as 12 workers with incomes ranging between 2–6 million. In this plantation, three fish ponds have been builtwith each size (13mx12mx2m) and one water reservoir (12mx6mx2m), which are all built on the ground (not an excavated pond).

Based on information from the head of the Kampung Daun farmer group, the average production per harvest for the three ponds was 27,000 individuals. The next plan will be to increase to 100,000 head. At each harvest, the average income is around 20-30 million (depending on the price of fish). Generally, catfish prices are Rp35,000/kg, tilapia Rp30,000/kg, and goldfish Rp40,000/kg. The problem when cultivating fish is the decline in pond water quality due to pollution from feces and leftover feed, both liquid and solid. These wastes come from fish manure and leftover feed that is not consumed. This polluted waste can affect the water quality of fish farming habitats. Polluted water can cause a lack of oxygen, poisoning, and the emergence of various diseases in fish; it affects fish's growth and mortality rate. That needs to be anticipated and managed because it can affect catfish yields [1], [2].

A way to overcome this condition, each fish pond to be equipped with one water pump with a capacity of 400W/220Volt. Its function is to purify water by flowing water through filters and water bubbles to help provide oxygenfor fish. These pumps certainly add to the operational costs of managing ponds using electricity from the State Electricity Company or PLN. Therefore, adding a pump that increases the burden of PLN's electrical power is necessary, while currently, the installed power at the plantation area is only 1300VA. As a result, it will increase the cost of electricity payments, where the electricity cost/month currently ranges from Rp1,000,000 to Rp1,500,000.

A new method fishery researchers have carried out is managing pond water waste through phytoremediation. This method uses aquatic plants which are often considered weeds but are known to have phytoremediation abilities, namely,water hyacinth (*Eichornia crassipes*), water spinach *(Ipomea aquatic)*, and water hyacinth (*Pistia stratiotes*). According to [3], the three aquatic plants can maintain pond water quality and increase fish survival. Then, Hernayati [4] revealed that apu-apu could be used asfertilizer at a dose of 0.25 mg/l for good water flea population growth. Water fleas (*Daphnia sp*) are one natural food that is very important for fish feed [5]. However, these water fleasare rarely found, if not cultivated, especially in freshwater.This condition causes water fleas to be limited and need to be cultivated. Therefore, managing it in fresh waters requires biological and ecological aspects of water fleas. In addition, the main thing is to provide photosynthesis at night so that the development of apu apu plant cultivation is faster by providing electric energy lighting at night.

On the other hand, one of the superior productions of the Kampung Daun farmer group is dragon fruit, usually sold for

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Rp35,000-Rp40,000/kg. According to [6], light intensity and duration of irradiation on dragon fruit play an important role in fruit production. Dragon fruit plants are long-day plants (plants that require long exposure to sunlight), meaning that for these plants to produce, more than 12 hours of irradiation is required [7]. Cultivating dragon fruit plants for leaf villages only relies on sunlight during the day. Have not used the help of LED lighting at night.

Meanwhile, according to [8], dragon fruit plants that initially could only bear fruit in one season can be engineered to bear fruit throughout the year with the innovation of irradiating lights at night. The treatment of white LED light has a significant effect on flower buds, but not as much as the effect of yellow LED lights [6]. When applied to partners, of course, it also increases the cost of the electrical load, which impacts increasing power and electricity payments.

Furthermore, Kupang Regency is an area with high potential for solar energy because it has a longer dry season than the rainy season, with nine months of the dry season and three months of the rainy season. The Ministry of Energy and Mineral Resources (MEMR) revealed that the theoretical potential of solar energy in NTT Province reaches 66 GW [9]. Low rainfall shows the potential for solar energy is quite high, especially in September 271,830, which is a large enoughsource of electrical energy using solar cell/solar paneltechnology [10]. With this potential, it is possible to utilize the potential of solar energy to overcome the problems faced by the Kampung Daun farmer group. For example, it utilizes solar cell panels for photosynthetic lighting at night. Therefore, the problems of farmer groups regarding the availability of electrical energy can be overcome by building SPP in the plantation area. Solar energy utilization can be maximized by adjusting the slope of the solar panels to obtain optimal and efficient electrical energy [11]. Using this solar cell light panel can solve the problem of using light at night for dragon fruit plants without adding electrical power. Currently, many solar lamp technologies range from 10W- 200W, which are energy efficient and can replaceconventional lamps [12].

II. MATERIALS AND METHODS

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A. *Methods*

This paper uses experimental methods through planning, installing solar cell lights, and installing an SPPaccording to the load required at gardens and fish ponds. The first step begins with an analysis of the panel requirements according to the required load on the fish pond. Especially for the needs of dragon fruit garden lights are not included because they use separate/tertiary solar cell lights already equipped with small solar panels. The second step is to analyze the potential of solar energy available at the site using secondary data. In this case, solar intensity data is required and is obtained from NASA data available in Restscreen software.

Furthermore, an analysis of battery and inverter requirements is carried out. Then, do the installation of solar cell panels and the installation of lights and control panels of the Solar Charge Controller (SCC). Finally, the SPP test and analysis were carried out with the lamp load for 12 hours.

B. *Research Site*

Figure 1 shows the coordinates of the location of the Kampung Daun Farmer Group. This location is located at latitude -10011'47.35" S – Longitude 123041'14.92" E.

Fig. 1. Location of Kampung Daun garden

III. RESULTS AND DISCUSSION

A. *Analysis of Solar Energy Potential*

Based on data from https://id.weatherspark.com/, summer lasts 1.9 months, from September 23 to November 19, with the highest average daily temperature above 32°C. The hottest month of the year in Kupang Regency in November. The lowest average temperature is 32°C, and the highest is 25°C.

TABLE 1. Solar Temperature Data in Baumata Village

No	Month	Average Temperature (ºc)
1	January	30
2	February	29
3	March	30
4	April	32
5	May	31
6	June	30
7	July	30
8	August	31
9	September	32
10	October	32
11	November	32
12	December	30

TABLE 2. Horizontal Daily Radiation Data in Baumata Village

No	Month	Horizontal Daily RadiationData ($kWh/m^2/d$)
1	January	5.87
2	February	5.73
3	March	6.25
4	April	6.35
5	May	5.93
6	June	5.52
7	July	5.76
8	August	6.53
9	September	7.21
10	October	7.54
11	November	7.25
12	December	6.41

Winter lasts 2.5 months, from December 30 to March 14, with average daily highs below 30°C. The coldest month in Kupang Regency is July, with an average low of 23°C and a high of 30°C. Table 1 shows solar temperature data for 12 months, while Table 2 shows horizontal daily radian data in Baumata Village.

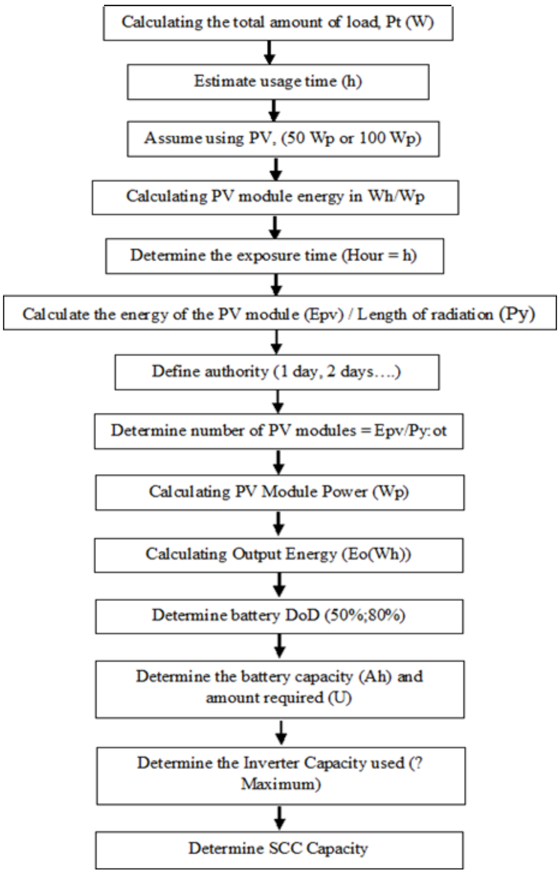

Fig. 2. Solar cell planning stages

B. Planning of Solar Panels and Their Equipment

The lighting system in the fish pond is planned to install four light points for each corner of the pond with a power of 9W LED lights for each. Several steps to determine the capacity of solar cell panels and battery capacity are as Figure 2.

Based on the plan, the type of lamp used is 4 LED lamps with 9W power equal to 36W. Then, with an estimated 12 hours of lamp usage, the energy consumption is 36Watt x 12 hours = 432 E(Wh). For example, it is assumed to use a solar cell panel with a capacity of 100 Wp, the amount of panel energy required is Epv = 432/100 = 4.32 Wh. Furthermore, assuming 5 hours of irradiation with one day of authority, the number of panels needed is J=4.32Wh/5 hours = 0.86 pieces, or the same as the 86.0 PPV module power (0.86x100 Wp). With a 86 PPV module power, only one panel with a capacity of 100W is needed.

The next step is determining the battery capacity based on the planned load capacity supplied (432 E(Wh). One criterion that needs to be considered for the battery to last longer is the Dept of Discharge (DoD), which is the amount of energy the battery uses. The battery DoD shows the percentage of the battery discharged relative to the overall battery capacity [13]. For example, if we have a battery that holds 100 watt-hours (Wh) of electricity and plans to release 80 Wh, your DoD will be around 80%. It means energy use should not exceed 80% of its nominal capacity.

On the other hand, when the battery is supplied with a larger charging current, the resulting terminal voltage value at the State of Charge (SoC) value will be even greater. Thus, when the battery supplies a higher discharge current, the nominal voltage value of the battery gets smaller at the same SoC value. SoC is a value representing the battery capacity used by the system. Figure 3 shows an illustration of the percentage comparison of the DoD and SoC conditions of the battery.

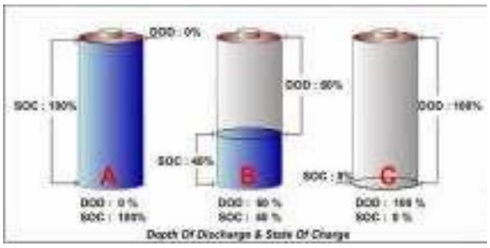

Fig. 3. Illustration of the comparison of the percentage of SoC and DoD conditions from batteries

TABLE 3. PV mini-grid component specifications

Vol	P(w)	Pt(w)	t(h)	E(Wh)	50wP	Py	Epv/Py	Ot	PPv	JPV	Eo	DoD	Battery		Inverter
					Epv (Wh/Wp)	Jam	W	day	Wp	Unit	Wh	%	Ah	V	W
4	9	36	12	432	4.32	5	0.86	1	43.2	0.86	432	50	72	12	500

Information:

- Vol = Volume (Number of lamps) - P(w) = Lamp Power (Watts)
- Pt(w) = Total Load Power (Watt) - t(h) = Time (in hours)
- E(Wh) = Energy (in Watt-hours) - Epv = Solar panel energy, (Wh/Wp)
- Py = Sun irradiance (in hours) - Ot = Authority day
- PPV = Solar cell power

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Fig. 4. Solar cell panel

C. *Planning of Solar Panels and Their Equipment*

Figure 4 shows a solar cell panel with the following panel data:

- Rated Max. Power, P_{max} = 100Wp
- Open voltage circuits, V_{oc} = 22,1 Volt
- Rated Voltage, V_{p-p} = 18,3 Volt
- Short Circuit Current, I_{sc} = 6,0 Ampere
- Rated Current, I_{p-p} = 5,49 Ampere

Generally, two battery DoD options are used to plan battery capacity, namely 50% and 80%. If the battery is discharged at only 50% of its capacity, it will last longer than 80%. However, this condition will make the system moreexpensive because it requires a larger battery capacity to accommodate the same needs. In this study, the DoD of the battery used was 50%. Therefore, the battery capacity is 72 Ah (432 Eh/50% x 12 Volt = 72 Ah), and the 100Ah battery capacity available in the market is selected. The overall specifications of the component requirements in the SPP planning can be seen in Table 3. Then a 500W inverter with 90% efficiency for the AC energy source is used.

Solar cell panels are installed near the garden house building to get enough sunlight in the garden area, according to the assumption of a minimum of 5 hours a day. That is considered because the area is not protected from the shadows of the trees around the park. In principle, when solar panels receive energy from sunlight and convert it into electrical energy, the energy is transferred to a battery which functions to store energy. The energy flowing from the input is the process of charging the battery. Then after the energy from the PV array is stored in the battery, the load receives energy fromthe battery to operate. In the battery, the process is called the battery discharge process (discharging). Figure 5 shows the installation of solar cell panels using iron pipes.

After that, the next step is to install the SCC control panel, inverter, and battery, as shown in Figure 6. Then the installation of electrical cables and lights is carried out fromthe center of the SPP with a pool at a distance of 30-40m (Figure 7). Meanwhile, the installation of solar cell lights inthe dragon fruit garden area can be seen in Figure 8.

Fig. 5. Installation of solar cell panels

Fig. 6. Installation of SCC Control, Inverter, and Battery

Fig. 7. Installation of cables and lights in the fish pond area

(a) (b)

Fig. 8. Installation of solar cell lights in the Dragon Fruit Garden area: (a) Cell Solar Lamp; (b) Installation of lights

D. *Testing*

Testing of the lighting system is carried out after all SPP devices have been installed. Of course, observations are made of the level of flux or irradiation, the voltage, and the currentlyused. In general, the irradiation level of LED lamps with a capacity of 9 Watts (equivalent to 36 Watts of ordinary lamps)is quite bright and provides illumination around the fish pond. In addition, current and voltage measurements are carried out to determine the current and voltage capacities used by the installed load. Measurements are made every hour to determine the voltage drop on the SCC display. Figure 9(a) shows a view of lighting in a dragon fruit garden, while Figure 9(b) shows a view of lighting a fish pond at night.

a. b.

Fig. 9. Illuminating tests: (a) Dragon fruit photosynthesis; (b) Grass photosynthesis

IV. Discussion

After finishing all the SPP installations, an irradiation trial was carried out at night. In the initial state, the SCC display data shows 13 Volts. That means that the battery is fullyenergized. Then, all 4 LED lights with 9W power are turnedon at night. Observations were made every hour starting at 6.00 PM with a position of 13V. After loading for 1 hour (at 7.00 PM), it can be seen in the display that the voltage dropsto 12.8 Volts, and at 20.00 PM, it becomes 12.6 Volts. Itmeans that if there is a voltage drop of 0.2 Volts every hour multiplied by the operating time for 12 hours, then the position of the battery before charging in the morning becomes 10.6 Volts. That indicates that the DoD position of the battery is at the 81% level.

Based on the test results, it can be seen that the DoD of the battery exceeds the threshold between 50-80% (critical condition). Therefore, to anticipate the continuity of the fish pond lighting system so that it can be served without blackouts throughout the night and the battery will last longer, another 65 Ah battery is added in parallel so that the installed battery capacity becomes 165 Ah. In paper [14], [15] explained that when the battery is supplied with a larger charging current, the resulting terminal voltage value at the SOC value is greater. Conversely, when the battery supplies a higher discharge current, the nominal voltage value of the battery gets smaller at the same SOC value.

Therefore, in installing a PV mini-grid, DoD and SoC analysis need to be carried out to determine the continuity of battery use to become durable. The SoC value is a value that interprets the available or usable capacity of the battery. On the other hand, DoD is the value of used capacity, and generally, SOC and DOD are expressed in percent [16]. As illustrated in Figure 3, if the battery is fully charged, the SOC of the battery is 100%, and the DOD is 0%. The SoC value shows the state of the battery charge that can be used the next day, while the DoD value shows the battery discharge carried out during that day. Thus, the removable capacity of an operating battery is the capacity that is released when it is completely discharged. The SoC is the percentage of discharge capacity relative to a given battery energy capacity based on the manufacturer's design.

V. Conclusions

In planning the SPP, a 100Wh solar cell panel and a 65Ah battery with 50% DoD were used. The load used is four lamps with a total power of 36W. However, in its application with light irradiation at night for 12 hours, the DoD activity of the battery reaches 81%. Therefore, to keep the battery life longer and longer, the battery capacity has increased to 165Ah.

VI. Recommendations

Pay attention to the charging obtained from SPP to ensure the battery charging process has full energy (minimum 5 hours of charging). That is due to fluctuating solar radiation, especially when the rainy season has arrived.

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