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Mini Solar Power Resources for IoT System in the Vannamei Shrimp Pond Model

Damar Widjaja[1*], Yohanes Priyanto Seli Laka[1]

[1]*Faculty of Science and Technology, Sanata Dharma Universit, Campus III Paingan Maguwoharjo Depok Sleman DIY, 55282, Indonesia*
[*]*Corresponding Author: damar@usd.ac.id*

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Abstract

Shrimp pond water quality is one of the challenging issues for shrimp farmer to keep or even increase their production level to meet the domestic and export needs. Many researches have been done to help shrimp farmer to manage water quality using Internet of Things (IoT) technologies. In order to make all the devices in the IoT system work properly, it needs an adequate power supply. Mini solar power plant installation is an alternative way to give shrimp farmers an electricity power access when their area has no electricity power network. In this study, we propose the use of mini solar power plants to supply the power to IoT devices in shrimp pond model. There are two main sub-system in this model, i.e. power supply sub-system and IoT based monitoring and controlling sub-system. Power supply sub-system consists of solar panel, solar cell controller, battery, INA219 sensor, and LM2596 step down IC. IoT sub-system perform monitoring and controlling on two shrimp pond models with Arduino Mega microcontroller works as the main processor. The mini solar power system works well as it was designed. Mini solar power plant capable of charging the 12V 40Ah battery in 5 hours. In order to make the IoT system works, it only needs 75,6 Wh from 480Wh battery capacity.

Keywords: Electricity, Solar Cell, Shrimp Pond, IoT.

1 Introduction

Shrimp is one of the export commodities in fisheries sub sector in Indonesia that has high economic value [1]. Indonesia exports many types of shrimps, including vannamei shrimp and tiger prawns. Vannamei shrimp contribute 36% of fisheries export commodities [2]. Several main export destination countries for Indonesian vannamei shrimp are Malaysia, United States, Great Britain, Japan, and China [3].

Shrimp farmer in Indonesia need to keep or even increase their production level to meet the domestic and export needs. Water is a natural resource that is very important for the survival of shrimp, so that they can live healthily and grow optimally. Shrimp pond water quality is one of the challenging issues for shrimp farmer as well as water quality management. There are several parameters used in water quality management, such as temperature, salinity, dissolved oxygen, pH, and alkalinity [4].

Many studies have been developed to help shrimp farmer to manage water quality using Internet of Things (IoT) technologies. Some of them try to control and monitor turbidity and ammonia [4], salinity level [5,6], pH level and water temperature [6,7], build an aeration monitor and a highly precise moving feeder [8], control water quality using fuzzy logic [9], and implement smart feeding system [4,6,10].

In order to make all the devices and IoT system work properly, it needs an adequate power supply. It has no problem in providing electricity to power up any kind of system in urban area or even sub urban area that has farming culture society. These types of areas have good access of electricity covered by electricity company. However, some of shrimp ponds in Yogyakarta province, Indonesia, especially in coast area in Kulon Progo City has no access to electricity power. This area needs an alternative energy that can be provided independently by the community, such as mini solar power plant.

Some studies related to solar power plant to provide electricity for shrimp pond have been done recently. Nizar Amir et al. studied the energy consumption of paddle wheel aeration and air blower as a circular technology for shrimp pond [11]. The result of this study is that the configuration of a solar photovoltaic meet the needs of electrical power for circular technology in shrimp pond. This configuration also reduces emissions of carbon dioxide, sulfur dioxide and nitrogen oxide per year.

Another study related to solar energy consumption for shrimp pond paddle wheel has been conducted by Aljurfri et al. [12]. The result of this study is that the power system using solar panel capable to support paddle wheel operation for 35 minutes. Idris and Thaha have designed solar power plant as an aerator driver in shrimp pond in Pinrang city [13]. The design uses Matlab to calculate the amount of electrical load, battery capacity requirement, number of solar modules, and inverter capacity.

Moreover, solar radiation and air temperature in the pond area has been measured.

The aforementioned studies above focus on providing electrical power for wheel paddle or aerator driver in shrimp pond. In this study, we propose the use of mini solar power plants to power IoT devices in shrimp pond model. This IoT monitoring system will provide data related to water quality of shrimp pond, such as temperature, pH level, dissolve oxygen, salinity, and control automatic feeder sub-system. This study aims to provide efficient power supply for simple IoT based monitoring and controlling system and evaluate the adequacy of the electricity power provided by mini solar power plant in shrimp pond model.

2 Material and Methods

Model system for this study is depicted in Fig. 1. There are two main sub-system in this model, i.e. power supply sub-system and IoT based monitoring and controlling sub-system. Power supply sub-system consists of solar panel, solar cell controller, battery, INA219 sensor, and LM2596 step down IC. IoT sub-system perform monitoring and controlling on two shrimp pond models with Arduino Mega microcontroller works as the main processor. All the monitoring and controlling data from Arduino Mega then are transmitted to Blynk IoT Platform via ESP32 microcontroller as a transmitting device.

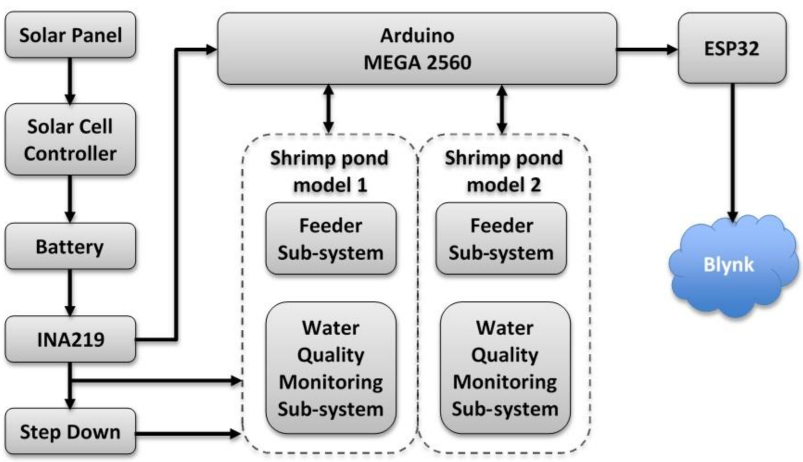

Figure 1. Model system.

Solar Cell Controller (SCC) regulates the voltage and current flowing from solar panels to a battery. The INA219 sensor measure both voltage and current on the whole system. A step-down device, LM 2596, functions as a step-down (buck) switching regulator, which converts a higher voltage (12V) to a lower voltage (5V). The IoT system needs those two voltage levels.

Two shrimp pond models use two aquariums with dimension of 30 cm weight x 35 cm height x 60 cm long. There are some water quality related sensors installed in each aquarium; DS18B20 water temperature sensor, SKU SEN 0237 dissolve oxygen sensor, SEN0161 pH sensor, and TDS salinity sensor. Outside the aquarium, there are some actuators to maintain water quality, pellets feeder control, and local display (OLED) to monitor water condition on site. Shrimp pond model is shown in Fig. 2.

There are many DC Motors work on each aquarium. Those are used for aerators, water cooler and heater pump to normalize water temperature, acid and alkaline liquid pump to neutralize water pH condition, salty and bland water pump to neutralize salinity condition. Servo motor is used for controlling the moving part of pellets feeder,

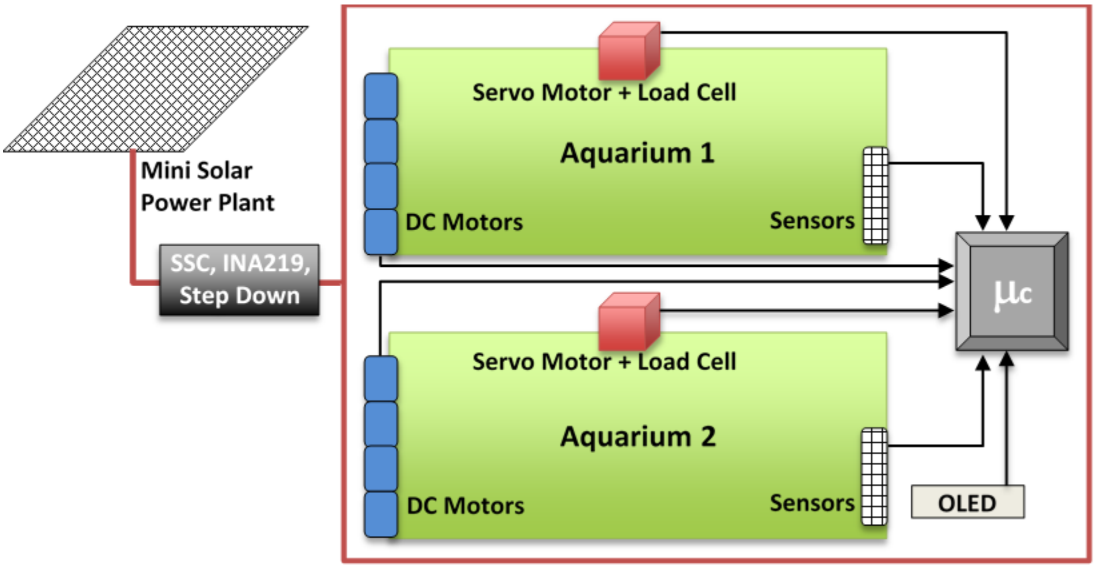

Figure 2. Aquariums and hardware configuration.

to open and close pellets feeder outlet. Load cell is used for measuring pellets weight inside the feeder container.

The power consumption specification of each component and total consumption needed based on the component specification is depicted in Table 1. The specification of each component refers to data specification sheet in [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], and [26]. It can be seen in Table 1 that total power consumption that is needed for all active components is 63, 418 W. This total power consumption does not take into account power losses along cables (wiring between components) and other transmission media.

Table 1. Power consumption specification of each component.

No	Device	Power (W)	Number of Device	Total Power (W)
1	Arduino Mega	13,56	3	40,68
2	ESP 32	2,844	3	8,532
3	Sensor INA219	0,005	3	0,015
4	Sensor DS18B20	0,0055	2	0,011
5	Sensor SEN0237	0,1	2	0,2
6	Sensor SEN0161	1	2	2
7	Sensor TDS	0,03	2	0,06
8	Display OLED	0,06	2	0,12
9	Relay	0,15	8	1,2
10	Pompa DC	1,65	4	6,6
11	RTC DS3231	2,5E-06	1	2,5E-06
12	HX711 Load Cell	0,2	2	0,4
13	Motor servo MG996R	1,8	2	3,6
		Grand Total		**63,418**

3 Results and Discussions

The first test has been carried out to find out how much voltage, current, and power the solar panel produces as a source of electricity. The power from solar panel then transferred to battery 12V 40 Ah for charging mechanism. Voltage, current, and power were measured during 5 hours of battery charging. The result of these measurement is shown in Figs. 3-5.

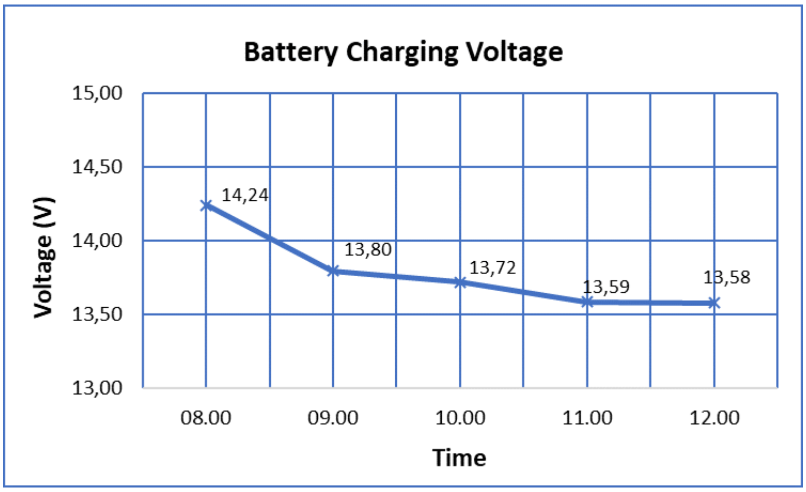

Figure 3. Battery charging voltage in 5 hours.

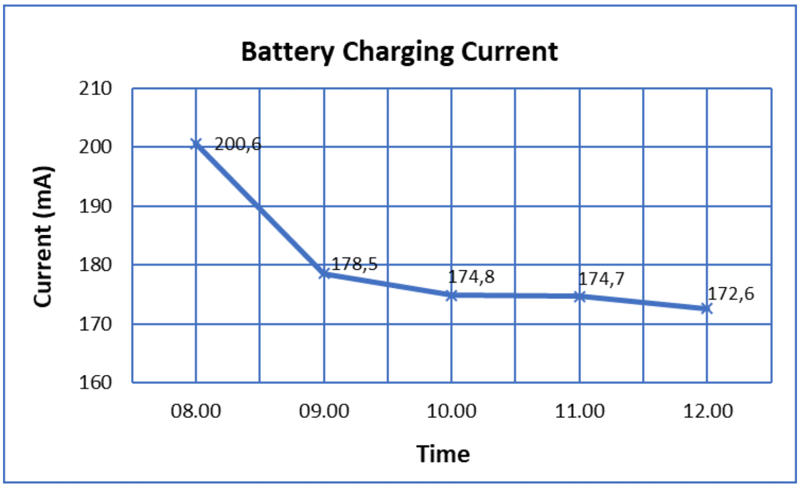

Figure 4. Battery charging current in 5 hours.

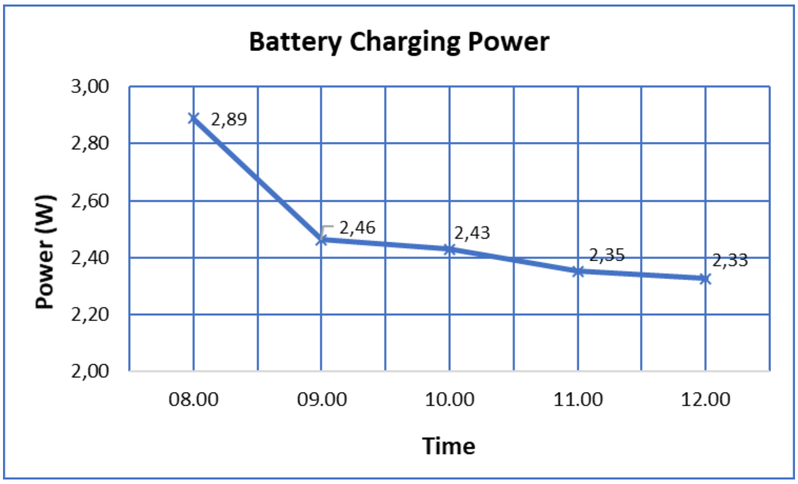

Figure 5. Battery charging power in 5 hours.

This INA219 sensor test was carried out from 08:00 to 12:00 when the sunlight was in the hottest condition. As the battery condition is getting fully charged, the voltage, current, and power transferred also getting lower. The decline in electrical parameters in the first hour is quite steep. However, in the next 4 hours, the decline in electrical parameters became sloping.

Sensor testing (INA 219 testing) to find out the needs of the system was done by dividing the system into 3 sub-systems, so that the system has three INA219 sensor. The first INA219 sensor was used to measure electricity parameters for pellets feeder and pH controlling and monitoring sub-system. The second INA219 sensor was used to measure electricity parameters for dissolved oxygen and temperature controlling and monitoring sub-system. The last INA219 sensor was used to measure electricity parameters for salinity controlling and monitoring sub-system and the need of mini solar power plant itself. Total electricity parameters that were needed for the IoT system is shown in Table 2.

Tabel 2 shows that total power consumption is far below battery capacity. Battery capacity is 480 Wh, while IoT system consumption is only 75,6 Wh. It means that the designed mini solar power plant is more than enough to supply the power needed for the IoT system of the shrimp pond model.

Table 2. Electricity consumption for shrimp pond IoT system

Sub-system	Voltage (V)	Current (Ah)	Power (Wh)
Pellets feeder and water pH	5,7	1,77	10,2
Dissolved oxygen and water temperature	10,6	2,75	29,4
Water salinity and mini solar power plant	12	3	36
Total consumption	12	7,52	75,6

Compared to the total power needed for all components in Table 1, the power consumption that is measured in the system is bigger. If the system can maintain the power consumption in one hour, it can be written that system need 63,418 Wh, that is 12,182 Wh different compared to actual condition. This is due to power loss in wiring and other transmission media that cannot be calculated or predicted accurately.

This study presents the system model performance in laboratory scale. As a model, there are many simplifications in terms of system parameters and size of the pond. This model need to be enhanced with more complex parameters and more extensive pond is it will be applied in the actual shrimp pond. It need to take into account for the long-term system sustainability, the long-term durability of system components, such as the battery and sensors, especially in harsh aquatic environments.

4 Conclusions

The mini solar power system works well as it was designed. Mini solar power plant capable of charging the 12V 40Ah battery in 5 hours. Battery capacity is big enough to supply power to IoT controlling and monitoring system of shrimp pond model. In order to make the IoT system works, it only needs 75,6 Wh from 480Wh battery capacity.

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