System design of smart solar photovoltaic water pump in Indonesia

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Abstract. Indonesia has a vast agricultural land. However, during the dry season, agricultural land does not get enough water. The problem can be solved by using the abundant amount of solar light during the dry season. It is Smart Solar Photovoltaic Water Pump (SSPWP). This research is system design of SSPWP. It consists of Photovoltaic panel, solar charger control, accumulator, inverter, water pump, mobile phone, and alarm. The working principle of the system is a solar cell in Photovoltaic panel exposes solar light then it produces direct current electricity. It is supplied to the water pump to irrigate farm. This system is connected to a mobile phone so that farmer can control irrigation for their farm automatically. System design consists Electric water Pump 220 Volt AC 200 Watt, with four Photos voltaic panels 12 – 36 Volt 180-Watt Peak Maximum power 720 Watt, and 72 Ampere Hour Battery.

1. Introduction
Indonesia is a country that has a tropical climate. So there are two seasons in Indonesia that is the dry and rainy season. It can support agriculture. Until now, Indonesia still has a large agricultural land. On the other hand, there are problems that must be addressed especially during the dry season. Farmers generally use diesel pump for irrigation. Some of the problems that occur when farmers use diesel pump. There are an operating cost of diesel pump is expensive, wasted energy and long for waiting time, impractical tools, unfriendly to the environment.

The problem can be solved by using the abundant amount of solar light during the dry season. It is a solar water pump. Some research about it is done. In India, a solar-powered water pumping system is made up of two basic components. These are Photovoltaic panels and pumps. The principle is the energy from the sun is converted into the electrical energy in the form of DC voltage which fed to the battery and inverter at the same time. Battery store this energy and inverter convert this DC voltage into AC voltage, which is input to the AC pump. The inverter is required between the Photovoltaic panel and the motor. It has a function to convert from the direct current generated by the solar panel to the alternate current required by the electric pump motor [1]. Solar Photovoltaic pumping offers a way out to the farmers of Bangladesh from the energy crisis. The research demonstrates that solar Photovoltaic technology can be integrated into irrigation systems. The research deals with the design, technical and economic analysis of a low cost 1 HP (746 W) small size DC Photovoltaic water pumping system for irrigation. A buck converter is designed and constructed to improve the performance of the DC pump. All components of the system are procured locally except the solar panels [2]. As a region located in the equator line, Indonesia has a huge amount of renewable energy potential, especially solar energy and wind energy. Unfortunately, there are just 1.96MW wind farm
and 19.2 solar farms installed, although wind energy has potential up to 970MW and solar energy have 4,80kWh/m²/day [3]. It is mean still many renewable resources that can be maximized to explore.

Based on some researches that had explained, repairing a solar water pump is needed. It to reduce fuel consumption cost and safe. Because of the purpose, this research will compare solar water pump using photovoltaic and smart system using SMS gateway. This research is Smart Solar Photovoltaic Water Pump (SSPWP). SSPWP is recommended to apply not only because of renewable energy but also smart. Smart, it means help owner to protect SSPWP anywhere and anytime.

Photovoltaic (PV) system has taken massively attention as the most prospective renewable energy resources. The research and development of this technology have been increased significantly in these decades [4]. A Photovoltaic module (PV) is equipment utilized renewable energy, it is solar radiation. It can be changed become electric energy directly [5]. A system is easy to implement and environment-friendly solution for irrigation. This system demonstrates the feasibility and application of using solar PV to produce energy for pump water for irrigation. It calls the Solar powered smart irrigation system [6] and autonomous solar-powered irrigation system [7]. DC converter selection such as buck, boost or buck-boost depends on the selection of Maximum Power Point (MPP) from solar photovoltaic and type of battery [8]. SMS Gateway can be defined as a system or mechanism that facilitates SMS transition by transforming the messages from several types of communication media to mobile network traffic, in vice versa, allowing, receiving or transmitting the SMS messages with or without the use of mobile phone [9].

2. Methods
The working principle of the system is a solar cell in PV panel exposes solar light then it produces direct current electricity. It is supplied to the water pump to irrigate farm. This system is connected to a mobile phone so that farmer can control irrigation for their farm automatically. The control system can use to protect SSPWP from robbing. The information will transfer from the control system to the alarm and mobile phone. The alarm will turn on and mobile phone receives short message system to SSPWP owner or farmer. The SSPWP system is shown in Figure 1.

![Figure 1. Smart Solar Photovoltaic Water Pump (SSPWP) System.](image)

The SSPWP system consists of PV module, solar charge control, accumulator, inverter, controller communication device, water pump, SMS gateway, and alarm. The system consists of two devices, a main device and slave device. It showed in Figure 2.

Water pump specifications are AC 220 V produce power 200 Watt supplied by PV module that produces voltage DC 12 until 36 Volt with 1 until 8 Ampere with total power supply 720 Watt peak. The voltage produced from four PV module will be converted using an inverter in order to DC voltage become AC voltage according to voltage need by a water pump.
The power supply of the PV module is determined by the time duration of the pump using. The pump power supply will be supported by a battery to supply power backup when sunlight is not maximum. Based on a calculation of load then this system using batteries with 72AH.

The SSPWP is completed by a controller to shut down the pump if the wireless sensor at slave indicates that water level or ground condition according to desired. The controller also has a function to turn on an alarm and send short message service (SMS) to a farmer if a pump is stolen.

Slave consist of PV module, battery, humidity sensor, and level sensor. Sensors send data information to solar pump to turn off a pump if the condition has desired.

3. Results and Discussion
Solar radiation is measured by pyranometer. Figure 3 shows solar radiation for each hour angle on 2017. The measurement is done in Surabaya, East Java, Indonesia (coordinate 7°18’44.7804” S and 112°42’53.5716” E [10]) Based on Figure 3 Indonesia has potential solar radiation for a year. From January until December on 2017, solar radiation has a value between 200 W/m² until 1400 W/m². The highest solar radiation happens when hour angle is zero for each month, it means when measurement at 12:00.
Figure 3. Solar radiation in a year

Figure 4 shows the voltage, ampere, and power produced by a PV module for each solar radiation. Figure 4 is results for one PV module. The measurement use voltage meter and amperemeter. Based on figure 4, power produced by PV module depend on solar radiation. The high solar radiation will produce high voltage, ampere and also power.

The SSPWP has many advantages which are summarized. Low operating cost, it because SSPWP does not need fuel such as oil for a diesel engine. The SSPWP is friendly equipment because this system does not produce air pollution in the environment. It is different from a diesel engine that produces Carbon Monoxide. The SSPWP is safe. It is because SSPWP completed with alarm if something happens.

4. Conclusion

There are many conclusions can describe from this research. There are Smart Solar Photovoltaic Water Pump is a solution for irrigation using renewable energy. Smart Solar Photovoltaic Water Pump is a combination of two devices, master and slave. Master is the main controller to turn on and turn off...
the water pump. Slave has a function to send a signal at master about a ground condition. The high solar radiation will produce high voltage, ampere and also power. The advantages of Smart Solar Photovoltaic Water Pump are low operating cost, friendly and safe.

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