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THE EFFICIENCY OF SOLAR POWER GENERATION SYSTEM APPLICATION ON AGRICULTURAL AUTOMATIC DRIP IRRIGATION IN INDONESIA

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ABSTRACT

Irrigation is one of the important components of farming producers in cultivation. Lack of irrigation water causes crop failure risk, while excess water also causes agricultural crop failure. It is necessary to regulate irrigation water to achieve technical and economic farming efficiency. This study aims to determine the efficiency of solar power generation in agricultural automatic drip irrigation. This study uses experimental research with the design of materials and research tools. Efficiency estimation uses a simple ratio by looking at the cost components of each treatment so that the value that appears becomes the final efficiency value. This study showed that automatic drip irrigation for solar power generation was more economically efficient than ordinary electricity. The use of automatic drip irrigation can save costs of IDR4,346,200. In addition, unlimited renewable energy support is a major advantage besides being environmentally friendly and an agricultural climate change adaptation strategy. The system's performance on the automatic pump is running well, as seen from P1, P2, P3, P4, and P5; the pump turns on at a percentage of water ranging from 10-90% and turns off after reaching 100% water or water-saturated soil conditions. The main obstacle faced during the research was the climate problem because this research model used the solar system. This means that as long as sunlight shows its existence, the energy obtained is also perfect, but vice versa. In addition, it is still difficult for traditional farmers to carry out the operational control system, so further research is needed.

Keywords: agriculture; drip irrigation; efficiency

INTRODUCTION

An increase in population can lead to a rise in energy consumption (Sirait et al., 2015) even though an increase has yet to match this increase in energy demand in the application of new renewable energy to anticipate the energy shortage ratio (Widodo, 2012). Indonesia has a lot of renewable energy potential that is clean and environmentally friendly, but its resources need to be appropriately utilized (Pramudiyanto & Suedy, 2020). One of them is the sun. Sunlight produces alternative energy using photovoltaics (Myori et al., 2019). Solar power station applications are developing both on-grid and off-grid (Hasanah et al., 2019).

Irrigation is an activity of supplying and regulating water to fulfil agricultural interests by utilizing water that comes from surface water and groundwater (Gustya Putra & Saptomo, 2022; Salman et al., 2016). An irrigation crisis is impossible even though technical irrigation is available (Tarigan, 2016). The problem is that the water supply chain for the needs of farming producers is limited due to climate (Priyanto et al., 2021). As a result, efficiency in the allocation of water outflow is required (Miran et al., 2022). The assumption is that production outcomes can be improved by supplying water for farming activities. (Felania, 2017).

The drip irrigation system is one sort of irrigation efficiency; therefore, it gives water with a slight discharge and is easy to do. According to Yanto et al., (2014) That overcoming the restrictions of water drip irrigation systems is the best option for boosting water use efficiency (Dursun & Ozden, 2012). The drip irrigation system works in tandem, focusing on the root area, So the required water discharge is minimal. If the stations' roots have enough water, the irrigation system can temporarily stop (Kumar et al., 2017; Venkumar et al., 2019). In addition, the ratio of the cost of using a drip irrigation system may be lower than the manual system (Deveci et al., 2015).

Technological developments make it easier for farmers to access markets. Micro control technology can aid the output through drip irrigation instructions by applying electronic data input (Jiang et al., 2014). The Internet of Think is used (IoT) for microcontroller technology to function. It is possible to convert the internet-based drip irrigation system into automatic drip irrigation. This indicates that drip irrigation is modern technical irrigation that can assist crop irrigation, which many farmers still need to undertake. Since that extreme weather cannot be forecast, plant water discharge reserves cannot be predicted in advance. Using solar electricity systems in drip irrigation allows agricultural producers to have a sustainable irrigation option (Yang et al., 2023).

Some related studies were conducted in drip irrigation systems. The first studies from Sapsal et al., (2018) Research the application of drip irrigation with a control system in chilli cultivation. The second research from Sanjaya et al., (2019) conducted and designed an agricultural irrigation system with a solar power generator. While the design of an automatic drip irrigation system based on changes in soil moisture content using the Arduino Uno microcontroller was conducted by (Franata et al., 2014)—Arduino microcontroller application in a drip irrigation system for mustard greens (Salman et al., 2016). I applied an automatic drip irrigation system utilizing solar power (Dursun & Ozden, 2012; Venkumar et al., 2019). A solar-powered automated drip irrigation system (SPADIS) uses wireless sensor network technology (Kumar et al., 2017). Utilization of solar power applications in irrigation systems (Kanna et al., 2020).

Research on automatic drip irrigation using solar energy has been carried out based on related studies. In comparison, research on the efficiency of applying solar power generation systems in mechanical drip irrigation systems has yet to be widely carried out. Thus, it is necessary to study the estimation efficiency of solar power generation systems in automated drip irrigation systems so those farm producers can technically and economically adopt mechanical drip irrigation systems. This study aims to estimate the efficiency of applying a solar power generation system in an agricultural automated drip irrigation system.

MATERIALS AND METHODS

Automatic drip irrigation is a micro control device that uses photovoltaic technology to improve watering efficiency. This study's primary method is experimental to develop an autonomous drip irrigation system powered by solar energy and PLN electricity. Photovoltaic, batteries, inverters, cables, PWM, Arduino Uno microcontrollers, jumpers, LCDs, relays, sensors, cables, plugs, USB cables, adapters, laptops, and stationery were utilized in the research. **Solar Power Station design**

The schematic of a solar power station's circuit can be seen in Figure 1. The figure shows a solar power station's input and output components.

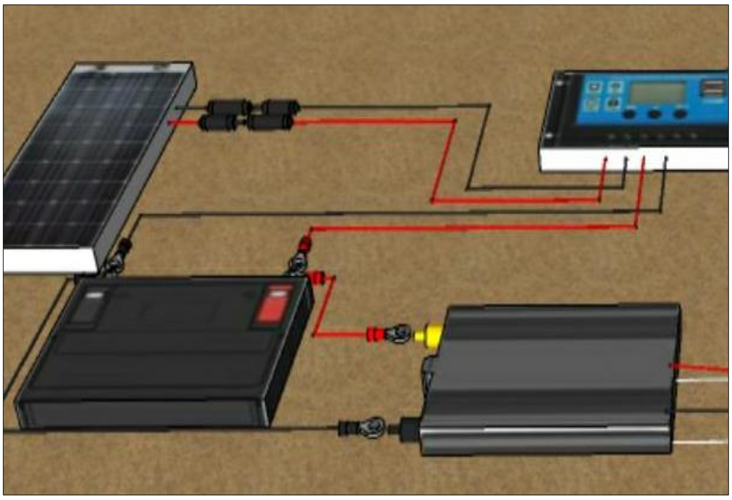

Figure 1. PLTS design

Control System Circuit Design

Figure 2 shows the range of automatic drip irrigation control systems created for this investigation. Figure 2 illustrates the Arduino port's connections to the input-output system components for the control system.

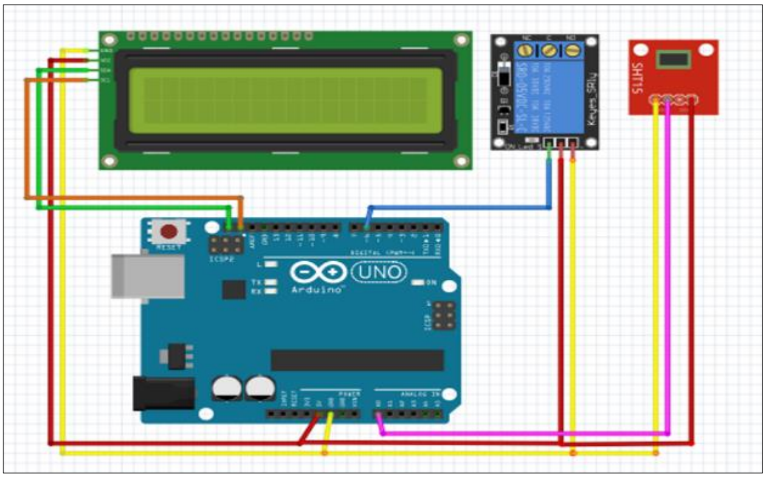

Figure 2. Schematic of the control system

The control system's input-output component connects with the Arduino Uno system, creating the following automatic drip irrigation control system.

Table1. Connectivity port input-output system Arduino

Input/Output Series	Port System Arduino Uno
Input series	
Sensors	
Pin GND	Port Power GND
Pin VCC	Port Power 5V
Pin AOut	Port Analog A0
Output	
LCD	
Pin GND	Port Power GND
Pin VCC	Port Power 5V
Pin SDA	Port SDA
Pin SCL	Port SCL
Relay	
Pin GND	Port Power GND
Pin IN1	Port
Pin VCC	Port Power 5V

Solar Power Station-based Automatic Drip Irrigation Design.

An assembly flow chart for PLTS-based automatic drip irrigation uses a 30-watt water pump, a water tank, and a power source. The emitter distributes water to flow through the lateral pipe to the ground, and the central and lateral lines are additional supporting elements that act as a driving force. The BCU controller is a power storage controller, the inverter converts DC to AC, and the solar panel is a solar energy collector.

All device components such as photovoltaics, batteries, inverters, cables, PWM, Arduino Uno microcontrollers, jumpers, LCDs, relays, sensors, cables, plugs, USB cables, adapters, laptops are connected according to the input-output function (figure 4). The final step of designing the autonomous drip irrigation system is setting up the programming language. The relay turns the pump on and off in response to an Arduino command based on readings from the soil moisture sensor. This is based on readings from the soil moisture sensor, and the LCD may display sensor reading values as part of the control system's ability to operate in line with the operator's directions.

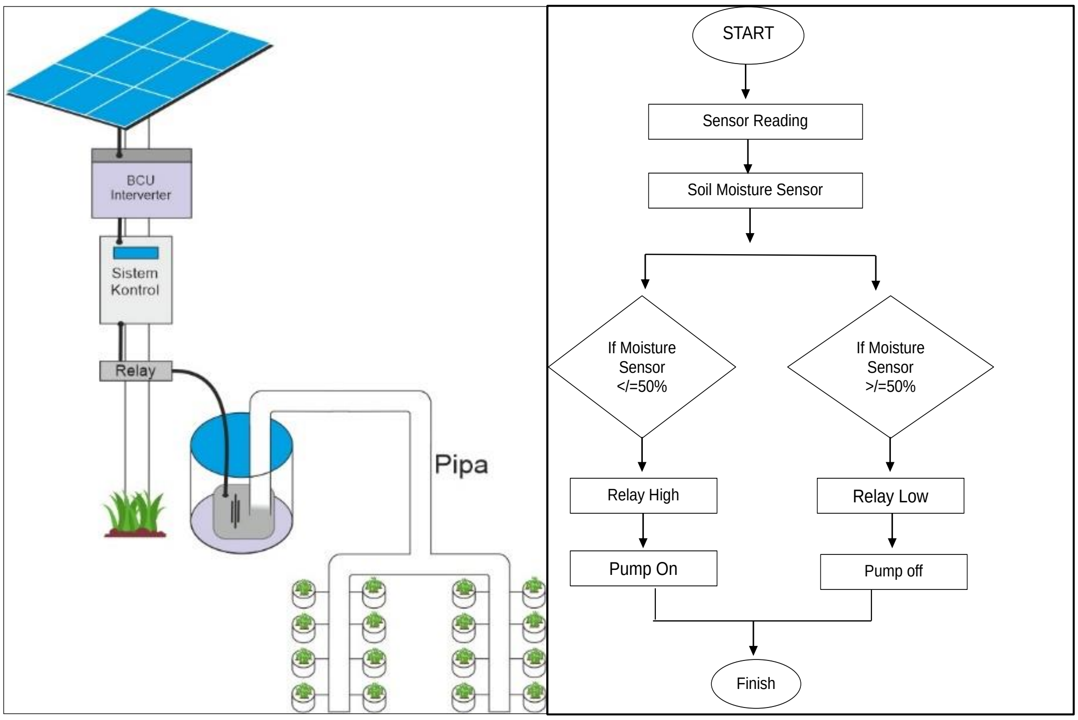

Figure 3. Schematic and flowchart of an automatic drip irrigation system

RESULTS AND DISCUSSION

Solar Power Station

Solar power Stations and solar cell photovoltaic (PV) systems are frequently used in the procedure of using solar energy to generate electricity. The solar cell is the main component produced entirely from the sun's electrical power. Electricity generated by photovoltaic energy can be used for various tasks that only need a little electricity. The following autonomous drip irrigation scheme is based on a solar power station.

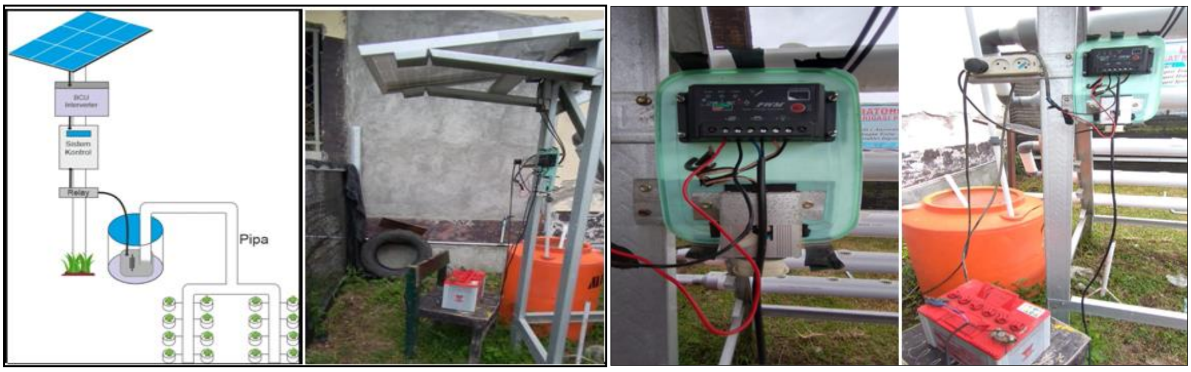

Figure 4. Solar power station component installation circuit

Before carrying out electrical installations, both on and off-grid, solar panels must be tested for performance to determine their suitability. The table below contains 50 WP solar panel performance test measurements.

Table 3 shows the results of an experimental evaluation of solar panel performance based on the intensity of sunlight on the solar panel's surface instead of the consequent value of the solar panel's voltage and current. The greater the power of sunshine, the bigger the voltage created (Galih Mardika & Kartadie, 2019). The temperature of the solar panel influences the amount of energy generated. According to Iqtimal & Devi (2018), the size of the solar panel temperature substantially affects power gain. Furthermore, the employment of reflectors to obtain sunlight is more efficient, while the temperature produced by solar panels rises (Suwarti et al., 2019).

Table 3. Solar power performance test measurement table

Time	Light intensity		DC			Temperature (c)	
	Lux	W/M2	Volt	Ampere	Power	Temperature Pv	Temperature Ling
9:00	88000	695.20	19.4	2.54	49.27	33.9	34.4
10:00	104000	821.60	18.4	2.68	49.31	35.5	37.5
11:00	120600	952.74	17.4	3.32	57.76	36.8	41.4
12:00	126200	996.98	17.1	3.36	57.45	37.7	40.3
13:00	123200	973.28	18.0	3.38	60.84	37.1	40.2
14:00	111900	884.01	16.6	2.83	46.97	36.8	36.1
15:00	111400	880.06	15.4	2.61	40.19	36.0	34.4

Renewable Energy Cost Efficiency with PLN Electricity Payment Tariffs

In an autonomous drip irrigation system, the cost of the propulsion source is highly significant. The pricey core structure of PLTS builders is to blame for the high expenses sacrificed. This runs counter to how quickly agricultural technology is adopted. Although technically feasible and supported by farmers, the cost must still be within reach (Rahmiyati, 2016). Following is a breakdown of the costs associated with automatic drip irrigation by time frame.

Table 4. The cost of electricity per period uses the PLN electricity source

PLN Electric Current								
Pump use time (hour/ day)	Automatic drip irrigation component			Price of electricity per kWh (IDR)	Payment			
	Pump (KWh)	Relay (KWh)	Micro controller (KWh)		Price of electricity per day (IDR)	Price of electricity per month (IDR)	Price of electricity per year (IDR)	Price of electricity per 5 years (IDR)
1	0.03	2.5	0.01	1.352	3.434	103.020	1.236.240	6.181.200

Table 4 shows the efficiency of using solar power stations with an automatic drip irrigation system. If the price of electricity per KWh is IDR1,352 (considered constant) costs incurred in the 5th year, amounting to IDR6,181,200. This can be compared with the cost of installing solar power, which reaches IDR 1,835,000 (Table 5). The profit margin of using solar power is IDR 4,346,200. This cost ratio shows that solar power generation is lower than the regular irrigation use of the state electricity company (PLN). The advantages of this application are supported by environmentally friendly renewable energy technology. Nasution et al., (2022)state that the useful life of an automatic solar drip irrigation system reaches an economic age of 25-30 years.

Meanwhile, in this study, the estimated year of use is five years; considering the useful life of the solar power station, it needs periodic maintenance and repairs to minimize damage. According to Iman & Pambayun, (2018), automatic drip irrigation solar systems can reduce climate change and contribute to modern energy management. In addition, solar power stations are environmentally friendly, with unlimited energy sources and minimal costs (Anisatu, 2021; Hidayat et al., 2021).

Table 5. The total cost of installation Solar Power Plant (PLTS)

No	Component	Capacity	Account	Price
1	Solar panels	50 WP	1 pcs	450.000
2	Battery	12V/65 Ah	1 pcs	1.050.000
3	Inverters	300 Watt	1 pcs	150.000
4	PWM	30 Watt	1 pcs	85.000
5	Battery cable	4 mm	2 meters	80.000
6	Crouch	3 holes	1 pcs	20.000
		Total		1.835.000

Sensor's Calibration

The soil moisture sensor is an electronic component sensitive to changes in soil moisture content. Changes in soil water content that the sensor reads cause the automation system to run on the pump. Calibration aims to determine the accuracy of sensor use. Calibration is done by comparing the mass of water given the sensor readings. The greater the addition of the amount of water, the higher the soil water content, while the percentage value of moisture increases. In line with Galih

Mardika & Kartadie, (2019), adding water to the soil causes soil moisture to continue increasing, followed by simultaneous sensors.

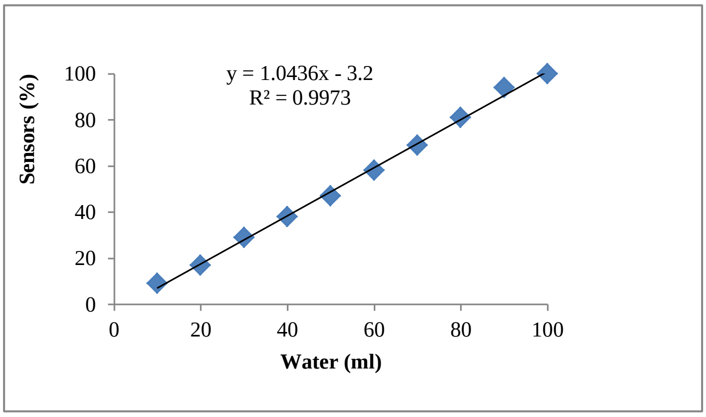

Figure 5. Sensors calibration

The ratio of soil moisture sensor readings to water addition is shown in Figure 5. If the percentage of soil moisture in the sensor rises, the soil moisture sensor is accurate. This indicates that as soil moisture increases, sensor readings do as well. R2 = 0.997 correlation coefficient for the linear equation y=1.043x-3.2. As a result of being so near to 1, this equation demonstrates exceptional tool accuracy (Hasanah et al., 2019).

Programming Languages

The components of the water pump control system receive input directives from the programming language. This implies that accurate input is required to produce output following orders (Hasanah et al., 2019). The Arduino 1.8.5 application and USB A-B drivers must be installed on programming language distributors' systems before computer programming languages can be used with Arduino. The drip irrigation system's microcontroller receives input commands executed using the Arduino 1.8.5 software. The relay's functioning mechanism as an automatic switch for the irrigation water pump is shown in Figure 6. If soil moisture exceeds 50 %, the relay will turn on, and the pump will start automatically. Otherwise, if the soil moisture equals or exceeds 100 percent, the relay is off (Low), and the pump will automatically turn off.

```
if(kelembabantanah <= 50){
  digitalWrite(relay,HIGH);
}
else if(kelembabantanah >= 100){
digitalWrite(relay,LOW);
```

Figure 6. Programming languages of relay

```
lcd.clear();
lcd.setCursor(0,0);
lcd.print("kelembaban:");
lcd.setCursor(11,0);
lcd.print(kelembabantanah);
lcd.print("%");
lcd.setCursor(0,1);
lcd.print("pompa:");
```

Figure 7. Programming languages of LCD

The output command codes for the LCD, including those for soil moisture and pump status, are shown in Figure 7. Both LCD.setCursor(0, 0) and LCD.print ("moisture"). This indicates that the soil moisture reading sensor is displayed on LCD line 0 column 0 (humidity). SetCursor (11, 1) and LCD.print(turn servo) display that row 0 column 11 represents the range of soil moisture from 0% to 100%. With the command code LCD.setCursor(5, 1); and LCD, the state of the pump is printed on line 1, column 0 using LCD.setCursor. Print ("drj"). The outcome of a trial using a solar power plant and an autonomous drip irrigation system is as follows.

Table 2 demonstrates how the water pump control system and the amount of additional water flowing through the pump in the plant's root zone are affected. According to soil moisture sensor P1, the pump state is (on) and (off) at a water percentage of 100%, or the soil is saturated with water. The pump activates in the subsequent trials P2, P3, P4, and P5, where the water percentage ranges from 10 to 90%, and it shuts off when the water content reaches 100%, or the soil is saturated with water.

This result is in line with the findings of Solihin and Dedi Triyanto, (2021); the response time for Pump A is obtained with a duration of 6 seconds and an off time of 2 seconds, while the on-time of Pump B is obtained with a long time of 8 seconds and an off time of 4 seconds.

Table 6. Automatic pump test results

Treatment	Percentage of Water Addition (%)									
	10	20	30	40	50	60	70	80	90	100
P1	√	√	√	√	√	√	√	√	√	×
P2	√	√	√	√	√	√	√	√	√	×
P3	√	√	√	√	√	√	√	√	√	×
P4	√	√	√	√	√	√	√	√	√	×
P5	√	√	√	√	√	√	√	√	√	×

Description: √ (On) and × (Off)

CONCLUSIONS

In terms of irrigation, automatic drip irrigation is an excellent agricultural product. This style allows for easy irrigation based on the needs of the water discharge supply of grown plants. Automated drip irrigation powered by solar panels is more cost-effective than conventional energy. The usage of automatic drip irrigation can save IDR4,346,200 in expenditures. This result is the margin ratio of the cost of installing solar power to PLN's electricity for a 5-year forecast period. Within 5 years, the cost of using PLN electricity is IDR6,181,200, while solar power is only IDR1,835,000. This means that economically the solar power system is more profitable. Furthermore, besides being environmentally benign and an agricultural climate change adaptation plan, infinitely renewable energy assistance is a significant benefit. The system's performance on the automatic pump is good, as shown in P1, P2, P3, P4, and P5. The pump goes on at a percentage of water ranging from 10-90% and switches off when it reaches 100% water or water-saturated soil conditions. This solar power installation can run well if there is full support from the sun because solar panels fuel the utilization of natural heat. Besides that, this technology needs further development with direct treatment designs in the field to obtain the latest results.

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