Matrix: Jurnal Manajemen Teknologi dan Informatika
Volume 14 Issue 2 Year 2024 Pages 98-106
DOI: http://dx.doi.org/10.31940/matrix.v14i2.98-106
URL: http://ojs2.pnb.ac.id/index.php/matrix

Internet of Things (IoT) design based on smart farming with solar panels in an agriculture laboratory

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Abstract: The implementation of smart farming still uses AC electricity resources which is estimated to be less effective in its implementation due to wasted electricity costs. As well as the lack of a crop monitoring system by farmers, crop yields are not optimal. This research aims to produce a smart farming system that is used for hydroponic plants to monitor plant conditions periodically and the automatic watering process and nutrient measurements are more efficient, online to the network with the IoT concept, and saves energy by utilizing solar panels. This research is quantitative research with experimental methods. The stages in this system include flowcharts and block diagrams to make it easier to read the workflow that will be created and tested. The results of this research are that the monitoring system with the Blynk Smartphone application turns on if the pH sensor gets a result of 7.2 causing it to open and the pH solution drops in the solenoid which will make nutrients flow into the water container. The solenoid will experience a closed condition because the sensor gets results in the range of 6.2 to 7.2 in pH units. The water level gets an average height of 18.5 to 19.5 cm with the sensor, nutrients are filled into the water container when the solenoid is triggered and turns off when it gets to the maximum value limit. Solar panels as an energy source for detecting acid bases in pH units and hydroponic nutrients are proven to be able to operate all devices within 24 hours during the period of growth.

Keywords: Internet of Things (IoT), Monitoring, Smart Farming

History Article: Submitted 27 May 2024 | Revised 03 June 2024 | Accepted 30 July 2024

How to Cite: M. D. Nugraha, K. A. Mahabojana, G. A. S. Pratama, “Internet of Things (IoT) design based on smart farming with solar panels in an agriculture laboratory,” *Matrix: Jurnal Manajemen Teknologi dan Informatika*, vol. 14, no. 2, pp. 98-106. http://dx.doi.org/10.31940/matrix.v14i2. 98-106.

Introduction

Use of alternative energy in Indonesia for clean energy efforts, a country rich in natural resources but facing significant environmental challenges. By prioritizing the development and deployment of renewable energy technologies, clean energy for the future of life can be applied in Indonesia apart from reducing dependence on fossil fuels, preserving energy resources, and trying to reduce the global climate. The world of agriculture is becoming more advanced day by day with advances in digital technology in monitoring [1]. Apart from that, a hydroponic system requires a fairly large source of electrical energy because the pump is turned on continuously for 24 hours [2], because the pump will continue to run for hydroponic nutritional needs in the water container provided because it can be said to be a waste of energy and electricity costs [3].

Hydroponic plants require more care than plants grown using conventional methods [4]. Therefore, plants grown using this method require good control in terms of nutrition, water quality, light intensity, and air temperature to obtain quality results.

Based on the problem of difficulties in controlling and wasting electricity costs, an idea emerged, how to monitor and make the process of watering and measuring nutrients in hydroponic plants automatic and efficient, integrated with the notion of the Internet of Things (IoT) and conserving energy through the use of solar power (Solar Energy). Previous researchers have recorded it.

The design of the application that has been developed is covered in this earlier study. It can display temperature, pH, and nutritional sensor measurements, set ideal values for these parameters, and show graphs of temperature sensor readings. The application runs smoothly via application of the SIPEDRO 1.0 in Android [5].

This previous study discusses about the design of Smart Urban Farming Hydroponics can provide nutrition, decrease, and increase PH, and monitor the condition of nutrient containers, pH up and pH down containers and reservoirs so that we can know the available capacity [6].

This previous study discusses about design of green power that is sustainable is critical to the survival of humankind. The integration of Internet of Things (IoT) applications with solar panel applications is presented in this publication. The ability to communicate in real time between farmers and plants is the true benefit of the Internet of Things [7]. For best management, the smart electric pump can also be managed by a WiFi-based controller [8].

Another discusses about design of Solar power can be an excellent solution for generating electricity as a replacement for electricity from PLN in hydroponic plants to guarantee optimal power output, the Internet of Things' application in PV system monitoring must be closely watched. For remote hydroponic monitoring, plants can be monitored on an Android smartphone with the help of the BLYNK application.

Compared to the earlier research, the authors created a monitoring system, a prototype will be created with a Solar Panel as a source and supply electrical power for the IoT system as a sensor to control PH and hydroponic plant nutrition digitally which can be accessed online with a smartphone.

Methodology

The research methodology includes a review of the literature, a framework for research (a flow chart layout), wiring schematics, designing software, hardware and software development, and the conception and build of an Internet of Things (IoT)-based smart farming system for monitoring with solar energy power. The study was conducted in the Agriculture Laboratory of Universitas Warmadewa, one of the private universities located in Bali.

Framework for Research

To assist in organizing and concentrating our research efforts, the research framework describes what is important and offers research questions and objectives. It will be used to put the decisions made throughout the research into practice. Usually, the researcher utilizes it as a guide to help them stay more focused on the parameters of their research process [9]. Figure 1 illustrates how the research was performed.

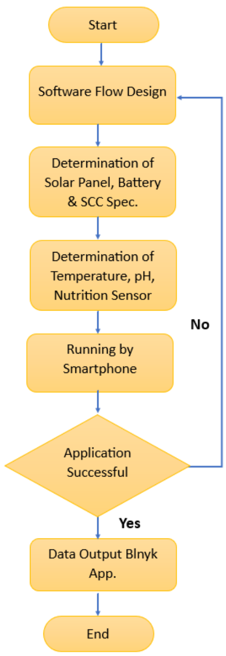

Figure 1. Flowchart Smart Farming System

A literature study was carried out first regarding the concept of Deep Flow Technique (DFT) hydroponic planting until problems were found with the conventional DFT system. Then the design for pump cycle automation, monitoring of temperature and humidity conditions, and the nutritional conditions of the hydroponic system were formulated. After that, the hardware that has the potential to be used as a microcontroller and sensor is determined to fulfill the design objectives as well as design a prototype of the planting media and place all system components. Followed by designing the software flow and calculating the power required by the system. This calculation aims to determine the capacity and specifications of the solar panels, batteries, and SCC that will be used. When appropriate, a report is prepared in the form of a system design blueprint

The Figure 1, it can be explained that the nutrient delivery automation system in the cycle time of a DC water pump is the basis of DFT hydroponics operation. So, the system makes pumps not have to be on continuously while still maintaining water flow requirements (2L/min). The environmental condition monitoring system for planting media and nutrients works based on the reading values of the sensors used, namely the DHT11 temperature and humidity sensor, Ph sensor, nutrient sensor, and water level sensor, water level sensor, nutrition sensor, Ph sensor, and humidity and temperature sensor DHT11. When the sensor reading value is at the abnormal threshold according to plant standards, a buzzer will trigger as a notification to the user. Apart from that, renewable energy sources are also designed through the use of solar panels, batteries, and SCC. Because this energy source produces DC power, all components also use DC current, including the water pump [10]. Apart from that, the data processed by the NodeMCU ESP8266 will be stored in the Blynk Cloud and then displayed via the SmartPhone [11].

Hardware Design

Figure 2 shows the microcontroller with type ESP8266 as a control center for sensors and other components, as well as connecting IoT via its WIFI feature. This controller is used because it has a powerful Analog pin feature and built-in WIFI which allows connection to the internet and IoT server [12]

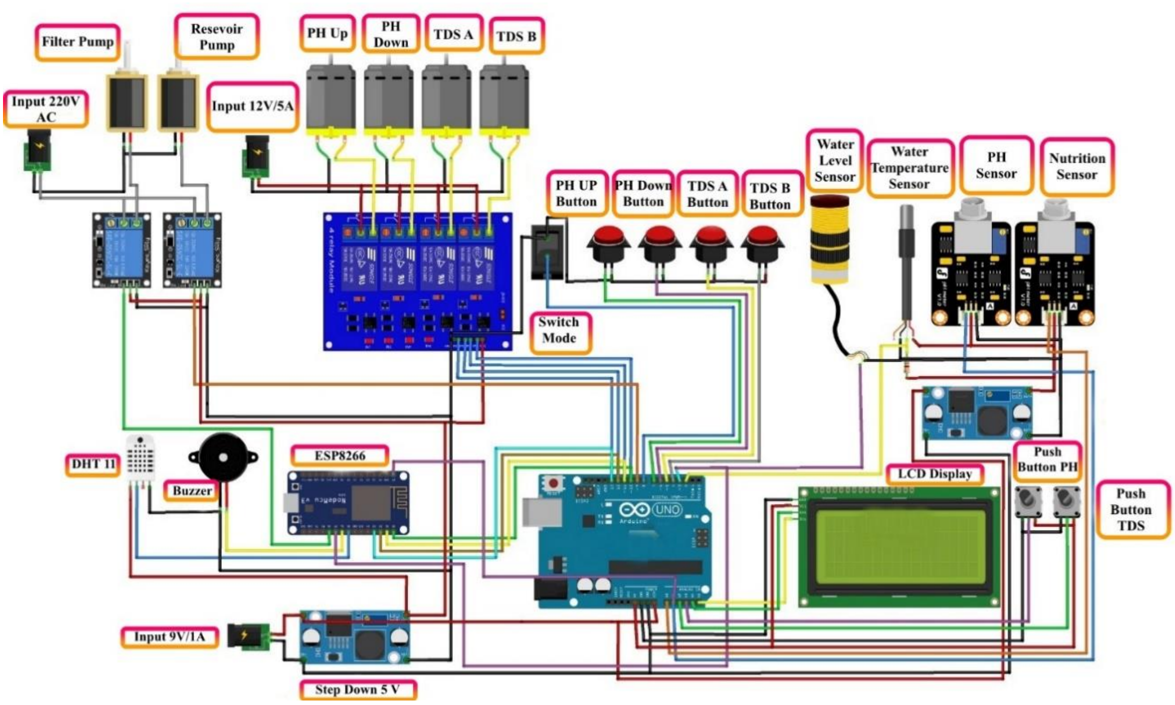

Figure 2. Smart Farming with IoT Wiring Diagram

The monitoring system uses a DHT11 sensor with a digital pin connection, a PH sensor with an analog pin connection, and a nutrition sensor and water level sensor with an analog pin connection, When the sensor reading value is at the abnormal threshold according to plant standards, a buzzer will trigger as a notification to the user [13]. The automation system uses a 5V relay connected to a digital pin which will regulate the 12V electric current from the SCC to the DC pump. It uses a battery of 12 volts with characteristics that will be determined later, a solar charge controller, with connecting solar panel elements to provide power [14]. Because the microcontroller and other components require a 5V voltage supply, a voltage-reducing component such as a step-down is used. To be able to connect to the IoT server, the ESP8266 is first connected to a WIFI connection from a router that has internet access. So, ESP can communicate with Blynk's IoT server. With Blynk, it is possible to monitor sensor conditions, input cycle pump threshold parameters, and input threshold alarm sensor measurements via the available Blynk mobile application.

Software Design

The Arduino default software is used to execute the coding procedure. The Arduino IDE (Integrated Development Environment) is the common name for this program. The process of writing a source program, building it, uploading the output, and then running it on the serial interface are the first steps in using an IDE for microcontrollers [15].

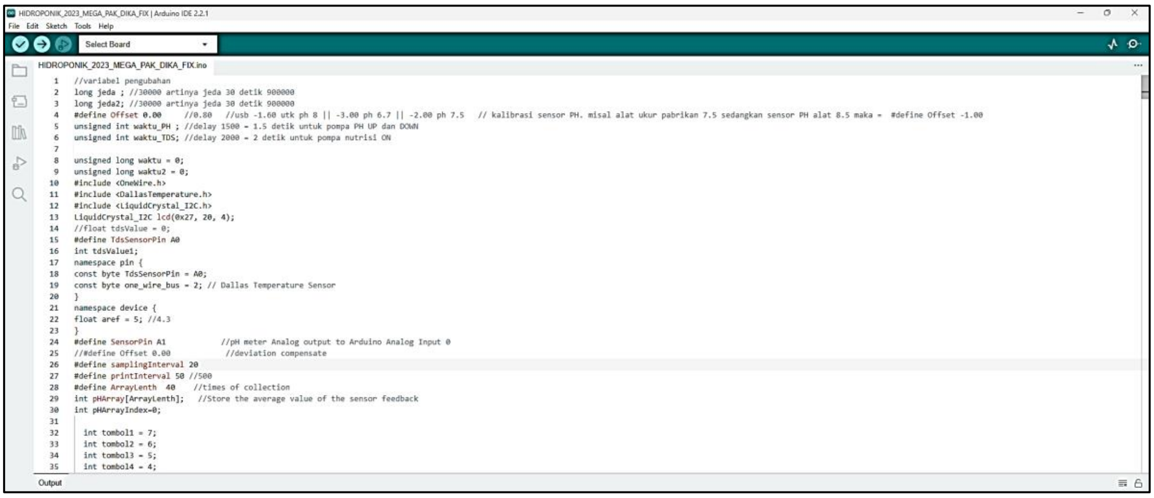

Figure 3. Programming NodeMCU ESP 8266 in the Arduino IDE Application

The system for monitoring is developed in the Arduino application, as seen in Figure 3 above. Typically, this monitoring program includes initializing, naming, choosing data formats, and providing logic to DC pumps and sensors. The pH, water level, temperature, and nutrition sensors are used, and a DC pump is used for distribution. Through the analog pins, the sensors are included in the Arduino programming [16].

When connecting the analog pins, DC pumps are incorporated into the Arduino program. The data from the sensor is connected to the DC pump through this pin. The rationale for the distribution of bases, acids, and nutrients that are in conventional program listings is supplied based on data from the connected sensors. With an Android smartphone, the Blynk app can be used to access the monitoring system [17].

Result And Discussion

Hardware Build Result

Figure 4, that when turned on the ESP will Connect the WIFI and Blynk server until it is successfully connected. Then continue with initializing the pins used by sensors, LCD, and buzzer. Then the loop function (void loop), ESP will receive temperature, humidity, PH, and PPM sensor data input from the sensor.

Figure 4. Hardware Monitoring of Smart Farming-based IoT

The threshold input (normal measurement range) for conditioning sensor values from the server Blynk. The threshold results are used as a reference in the branching program for switching on the buzzer as an alarm [18]. Followed by sending sensor data to the Blynk server and displaying it on the LCD. A delay of 1 second is given before the looping again program.

Pump cycle regulation automation system based on the time threshold specified by the user on the Blynk server. For example, the pump will turn on for 20 seconds and turn off for 180 seconds. So, after turning on the relay, the ESP will loop with a delay of 20 seconds after turn on the relay. During the loop, the ESP can be inserted into a condition-monitoring program sensor

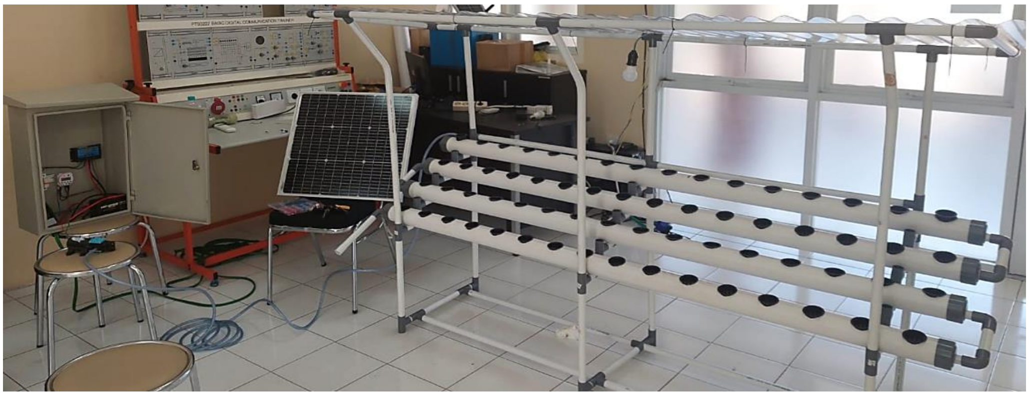

Figure 5. Hardware Solar Panel of Smart Farming

Figure 5 shows the framework of the DFT hydroponic system planting media which is arranged in layers and resembles a half-triangle shape [19]. So, it is possible to plant at a slope. The framework is designed using 1.5-inch pipes with a size of 1 meter each. The frame has a maximum height of 150 cm. So, the pump specifications with a maximum height of 2m assuming 32 Liter/minute (L/min) of flow rate, can theoretically meet the flow requirements exceeding the standard requirement of 2 L/min for PVC pipes. By using PVC pipe material, it is hoped that it will have a long service life. Considering the sturdy nature of PVC and cannot rust. In assembling it requires around 4 pieces of 2,5-inch pipe with a length of 2 meters. Then proceed with the placement of 4 pipes measuring 2.5 inches with a length of 2m which have been given 20 planting holes in each pipe. So that the overall system has 80 planting holes. The pipes are installed in stages by maintaining the appropriate water level in the pipes. DFT hydroponic system with a discharge of 2 liters/minute. Figure 5, the installation of solar panel on the system, Solar Charge Controller, Voltmeter, ACCU and DC delay timer installed in the IP66 Outdoor Type panel box IoT monitoring consists of a microcontroller, LCD, buzzer, and relay. There is also a nutrient water reservoir at the bottom which contains a DC water pump, TDS sensor, and Ph sensor.

Discussions

Figure 6, Analysis of pH and water level sensor monitoring tests using the Blynk application by smartphone. The purpose of the test is to find out how long the monitoring system needs to respond when the sensor picks up a value for a parameter that is different from what is expected. Testing pH parameter control is used by conditioning the value of pH to acidic conditions, namely less than 6, and alkaline conditions, namely more than 7.

Figure 6. Hardware Solar Panel of Smart Farming

The pH measurement data can be seen in Figure 7. In this graph, information can be obtained that from 06:00 AM to 06.00 AM the next morning for 24 hours, the pH value remains within the range of values needed by hydroponic plants. At 1:00 PM the pH value exceeds 7, As a result, after 15 minutes, the pH down liquid flows to the nutrition container when a solenoid valve for pH down instantly opens.

Namely from 1.15 PM onwards, the pH returns to the range of values required by hydroponic plants. The highest pH value is 7.21 at 1:00 PM, this proves that during the day the plant absorbs oxygen to the roots which causes the pH condition to change towards alkaline (basic) and the lowest pH is 6.20 at 11:00 PM. because at that time the plants do not get enough sunlight, so the plants only carry out the process of respiration (breathing) and the pH changes to an acidic level.

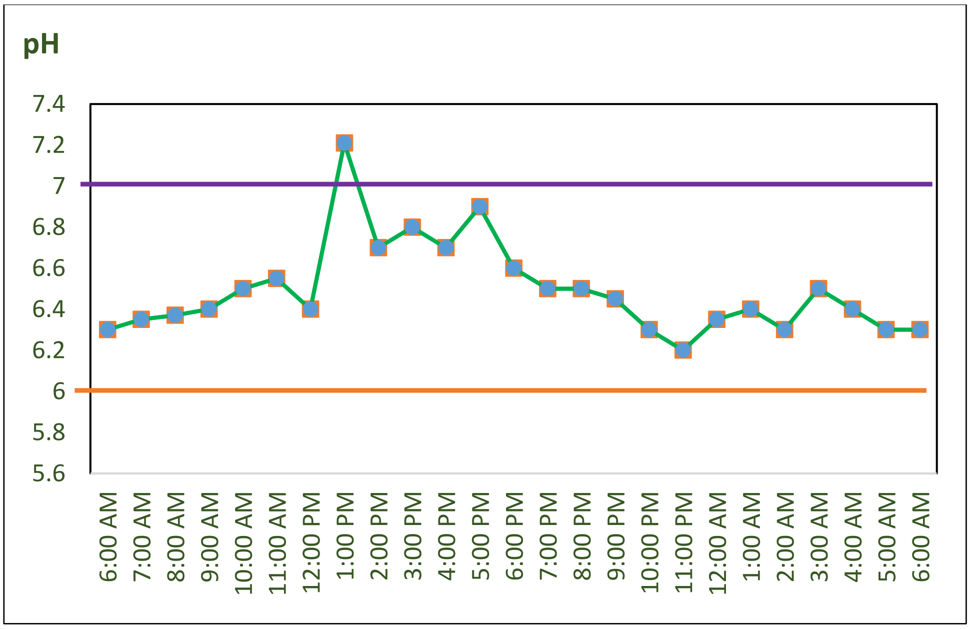

Figure 7. Output pH Measurement

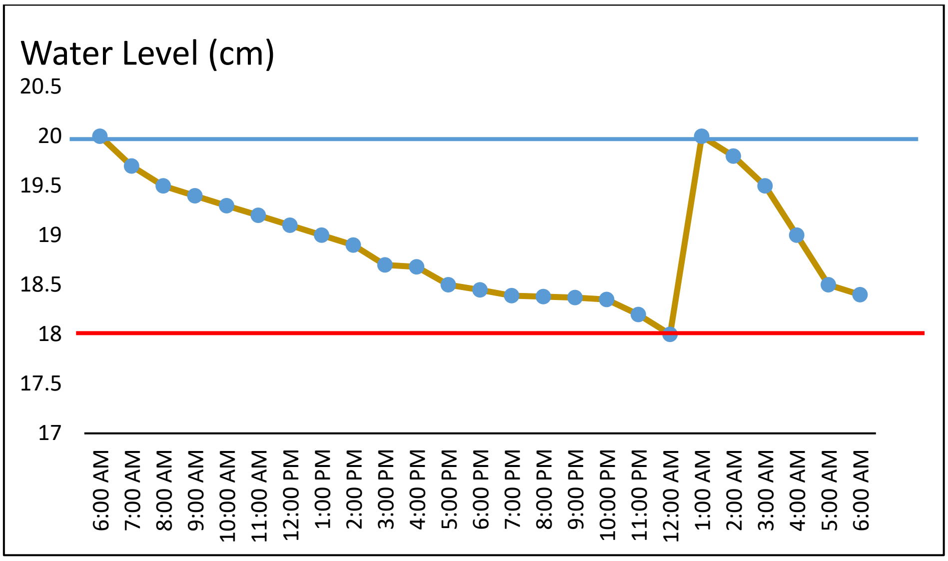

Figure 8. Output Water Level

Figure 8 is monitoring data for nutrient water levels. The graph shows that the water level has decreased. The initial height is 20.0 cm. At noon the water level reaches 18.0 cm, so the solenoid valve automatically opens and flows the nutrient water to the main nutrient tank. After 15 minutes the water level is at a height of 20.0 cm and the solenoid valve closes automatically.

The system for controlling and monitoring pH parameters and water levels for hydroponic plants uses energy sources from solar panels. The loads used in this research are a 60-watt hydroponic pump, 4-watt solenoid valves (32 watts) each, and 0.2-watt Arduino Uno. The total load on the hydroponic system is 92.02 watts. The loads that work continuously are the pump and Arduino Uno. When the sensor identifies a value that is different from the reference value, the solenoid valve needs to be opened. The solar panels used have a maximum power of 50 WP and the maximum power that the solar panels can produce is 250 watts. However, in its application, Figure 9 is the amount of power on the solar watt meter with data collection carried out from 06:00 AM to 16:00 AM with the highest result being 239.3 watts at 01.00 PM, while the amount of power consumed by the load from 06:00 AM to 06.00 AM with the highest result is 127.1 watts, so the highest result of power stored on the battery is 112.2 watts.

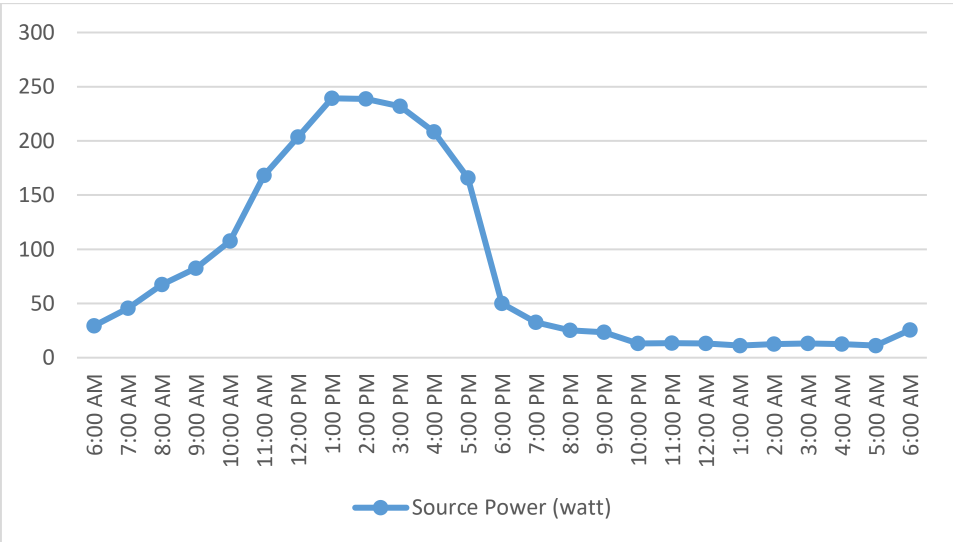

Figure 9. Data Result Produce by Solar Panel (06.00 AM to 06.00 AM Next Day)

Figure 9 shows the energy generated by solar panels between 6:00 AM and 6:00 AM the next day. The data collection that started at that time refers to the solar charger controller, namely after 07:00 PM the solar panel indicator was not readable, because the solar panel did not receive light or it was said that after 07:00 PM it was dark. The graph is fluctuating, meaning that the power produced and consumed goes up and down all the time. Hydroponic in daytime production, Solar panels generate electricity when exposed to sunlight. Typically, the highest production occurs around midday when the sun is at its peak. Hydroponic in nighttime production, Solar panels do not generate electricity at night when there is no sunlight. Production drops to zero during these hours.

Morning (6:00 AM - 12:00 PM), Solar panels start generating electricity after sunrise. Hydroponic loads such as pumps for nutrient circulation and initial lighting may be activated to coincide with increasing solar production. Midday (12:00 PM - 6:00 PM), Solar production peaks. This is an ideal time to power high-energy-consuming devices like grow lights, as solar output is strongest. Evening (6:00 PM - 6:00 AM), Solar production diminishes and eventually stops after sunset. Battery storage, if available, can supply power during this period to maintain essential hydroponic operations like pump circulation and minimal lighting.

Conclusion

When the pH sensor reports a value of 7.2, the valve with a solenoid activates, enabling the pH-down solution to enter the nutritional solution and function as part of the system for monitoring via the Blynk smartphone application. When the sensor reads a pH in the range of 6-7, the valve with a solenoid will close once more. The solenoid valve opens to allow nutrient water to enter the nutrition container when the sensor reports a measurement of 18.5 cm, and it closes again when the sensor reports a value of 20 cm. This is how the water control system operates.

It has been shown that using solar energy systems as a power source to regulate the pH levels and concentration in hydroponic fertilizer solutions can power all equipment during the period of growth.

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