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1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012057 IOP Publishing doi:10.1088/1755-1315/1097/1/012057 1 The Implementation of the Internet of Things (IoT) on an Automatic Plant Watering and Fertilizing System Based on Solar Electricity Hendra1, Trinovita Z. J., M.

Riza Nurtam, Indra Laksmana, Jamaluddin, Amrizal, Perdana Putera, Nurazizi, Ihsani Amaliah Putri, Soecipto Politeknik Pertanian Negeri Payakumbuh, 50 Kota, Indonesia *hendra.bgd@gmail.com Abstract. This research aimed to design a plant fertilizing and watering system that can be controlled and observed through a smartphone and use the solar electric energy source. The results of this study can ease the work of farmers in terms of energy and cost because they allow the fertilizing and watering processes to run automatically.

The system is assembled using the following components: 100WP solar module, 30A solar charge controller, deep-cycle battery, Arduino Uno, ESP8266WiFi, DHT11 sensor, soil moisture sensor, and 12V DC electric solenoid valve. This system works in the following way: if the soil moisture sensor reads that the soil is dry and if the air temperature sensor reads that the air is cool, then the microcontroller will order electric faucets to drain water containing fertilizer to the ground until the soil becomes wet.

This system is supported by connection to the Internet so it can be controlled and observed from an Android-based smartphone. The calculation conducted in an economic analysis of the system yielded cost principal of Rp47.6/l and BEP for production of 11,389 l/year. K eywo rd s : Internet of Things, fertilizing and watering, solar electricity 1.

Introduction The frequently used plant watering and fertilizing method is the traditional one. This watering method involves human labor, in whic h he/she waters plants from water containers while walking around a piece of land where the plants are planted every morning and evening. Usually, fertilizer is applied to the soil around the plants using human labor too.

This method of watering and fertilizing is low in water and fertilizer use efficiency because it is not in accordance with the needs of the plants. It is also inefficient in terms of labor because the amount of labor needed to water and fertilize a vast area of land will also be big. The IoT (Internet of Things) is a concept that aims to expand the benefits of being continuously connected to the Internet.

Its applications include data sharing, remote control, and sensor reception on objects, such as foodstuffs, electronics, collectibles, any piece of equipment, and, being no exception, living things, all being connected to local and global networks through embedded sensors and always active. This research utilizes the IoT technology to control plant fertilizing and watering through an application on a smartphone [1][2][3].

The application of the IoT by researchers has been widespread [4][5][6][7]. There is a need to fulfill the electrical energy demand in agricultural land and remote areas unreachable by the PLN (State Electricity Company) network. To meet this demand alternative sources of electrical energy will be required.

One suitable, most efficient power generation mode is one that is 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012057 IOP Publishing doi:10.1088/1755-1315/1097/1/012057 2 solar-based. This is supported by the geographical location of Indonesia along the equator [4], which allows the conversion of solar energy into electrical energy because the sun shines throughout the year. A solar panel is a device that can convert solar energy into electrical energy.

Solar panels have been widely used as an energy source for public street lighting. This tool can also be used as an energy source for other devices that require an independent energy source. In this study, solar panels as the main source of electrical energy are used [8][9].

Considering the description above, the author designs an automatic plant fertilizing and watering system using solar electricity power by incorporati ng the IoT technology. This system is expected to allow for automatic plant fertilizing and watering through a smartphone application so as to help ease the work of farmers in plant cultivation.

Solar panels are used to convert solar energy into electricity and store it in a battery, sparing the need to incur monthly electricity costs and allowing to work unaffected by power outages [10]. This system comes with a soil moisture sensor and an air temperature sensor so that it is optimal and more efficient at water use because when and how long to do the watering according to the plant needs is known. 2. Methodology This program begins with the identification of the problems faced by farmers.

In this step, the existing watering and fertilizing methods are observed for weaknesses and strengths. After the weaknesses are identified, then a design is made and refined according to the idea. The next step is making a prototype circuit drawing, followed by the prototype making according to the drawing.

After the prototype is completed, function testing is carried out. This test is conducted to find out whether each component has functioned as intended. If the prototype does not work as intended, modifications are made until all components function properly. After the prototype is declared feasible from the function test, it then goes through a performance test to determine its performance capability.

If its performance capability is considered unfit, improvements are made to obtain optimal performance. Finally, an economic analysis of the prototype is carried out to determine the fixed costs, variable costs, basic costs, and break even points. The stages of this prototype design are illustrated in the flowchart in Figure 1. Figure 1.

Flowchart Problem identification stage At this stage, identification of problems faced by farmers is carried out using the observation method. The locations of the farmers are reviewed and observed. Observations are also performed on the fertilizing and watering methods employed in plant cultivation. Fertilizing and watering are still done in the traditional way, namely by using human labor.

Fertilizing is done by mixing fertilizer with the soil around the plant, whereas watering is done by watering plants from a water container while walking around the piece of land where the plants grow every morning and evening. Perfecting the idea and design stage In this stage, improvements are made to the idea and design made to overcome the problems faced by farmers.

The idea is to create an automatic fertilizing and watering system that can be observed and 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021)

IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012057 IOP Publishing doi:10.1088/1755-1315/1097/1/012057 3 controlled via a smartphone. This system uses solar power as the main power source to eliminate monthly electricity costs.

A block diagram to illustrate the idea and design can be seen in Figure 2. Figure 2. Block Diagram System and device making stage In this stage, the system and device are crea ted by assembling the required hardware. The main hardware consists of a 100 WP solar panel, a 30A solar charge controller, a deep-cycle battery, Arduino Uno, ESP8266WiFi, a DHT11 sensor, a soil moisture sensor, and a 12V DC electric solenoid valve.

This set of hardware is also supported by addition al components such as solar panel support poles, cables, bolts, boxes, etc. At this stage, software deve lopment is also carried out. The software here is used to enable the sensors to read soil moisture a nd air temperature and to control water faucets using Arduino IDE.

Function test stage At this stage, a function test is carried out on the system that has been created. The function test is carried out in the following way. The output voltag e of the solar panel is measured in the morning, afternoon, and evening. This measurement is carried out to see if the solar panel is working or not.

The output voltage of the controller is also measured to see if the controller is working or not. Readings of soil moisture change data on the soil moisture sensor were then carried out. If from the function test the system and device are declared not feasible, then repairs or modifications will be made to the system and the device partially or entirely until they are declared feasible. Performance test stage At this stage, a performance test is carried out on the system and the device as a whole.

It is carried out by observing and measuring the amount of water released according to the water needs of the plants. Tests are also carried out on the soil moisture sensor and air temperature sensor. Both of these sensors are calibrated using a measuring instrument. If the performance test results declare that the system and device are not feasible, they will be corrected or modified until the performance results declare otherwise.

Analysis stage At this stage, an economic analysis is carried out on all the materials and tools used in this research. It is a tool to determine the fixed costs, variable costs, basic costs, and break even points. 3. Results and Discussion All components are assembled into an integrated circuit.

In the solar power block, the 100 WP solar module component is connected to the 30A solar charge controller, which is connected to a deep-cycle battery. In the microcontroller and sensor block, Arduino Uno is connected to the DHT11 sensor, soil moisture sensor, and 12V DC electric solenoid valve. Pipes and hoses are connected to the 12V electric solenoid valve to drain water.

1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf. Series: Earth and Environmental Science 1097 (2022) 012057 IOP Publishing doi:10.1088/1755-1315/1097/1/012057 4 Figure 3. (a) Plant watering control system circuit; (b) Solar panel circuit This system is equipped with software that func tions to control and ob serve the hardware.

The software runs on smartphones with the Android operating system, enabling the system to be easily used by users. The software display can be seen in Figure 4. Figure 4. Android Application Interface 4. Conclusion The research resulted in a design of a solar electricity-based watering and fertilizing system that can be observed and controlled from a smartphone.

This system consists of integrated components, namely 100 WP solar module, 30A 12V solar charge cont roller, 12V 50Ah VRLA gel battery, Arduino Uno, ESP8266WiFi, DHT11 sensor, YL-69 hygrometer sens or, and 12V DC NC Electric Solenoid Valve. The results of the calculation of the device's economic analysis showed a BEP of 11,389 l/year, meaning that the system does watering and fertilizing as much as 11,389 l/year to achieve a return on investment. (a) (b) 1st Lekantara Annual Conference on Natural Science and Environment (LeNS 2021) IOP Conf.

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