The Concept and Design of Solar Powered Sprinkler System Based on IOT Monitoring

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ABSTRACT

South Sumatra has an abundant solar energy source waiting to be optimally optimized. This potential is promising in all the economic sectors, such as agriculture. Solar energy application is one of digital farming implementation for agriculture and is expected to ease the farmers' workload. This paper presents the concept and design of a solar-powered sprinkler system based on IoT Monitoring. The effectiveness of the proposed method is proven by an experimental testbed of a solar-powered automatic watering system applied in a plantation. The watering system is activated based on soil moisture and is powered by solar energy. The experimental results show that the Concept and Design of Solar Powered Sprinkler System Based on IOT Monitoring are applicable for any plantation that requires regular watering.

Keywords: *Automatic sprinkler, digital farming, solar energy, soil moisture sensor*.

1. INTRODUCTION

South Sumatra, in particular, and Indonesia in general, have an unlimited amount of solar power. This renewable energy source, if used properly, can serve as a replacement for fossil energy, which is becoming scarce [1]-[17]. This new energy source is abundant and much more environmentally friendly in reducing CO2 emission [3]-[5].

The use of solar power is also consistent with the government's policy of increasing the use of renewable energy as a substitute for conventional energy (Government Regulation No 79/2014). However, the implementation of solar power has been limited to state-owned enterprises or other large-scale institutions [6]-[8]. It is still very limited in terms of the population environment. Solar farm installation for housing is limited or only at the research stage [9]-[12]. This condition is extremely unfortunate given the potential of solar energy [14]-[17].

Solar panel applications in everyday life can begin with the smallest and most basic of items, such as a solar-powered automatic solar sprinkler [18]-[22]. This sprinkler is suitable for use in residential areas and plantations. Automatic sprinklers will be extremely beneficial in plantations, reducing farmers' work in watering plants. Watering can be done regularly and in a timely manner, allowing it to be applied to plants that require consistent watering, such as tomatoes and Japanese mustard spinach. Irregular tomato and Japanese mustard spinach watering can result in various issues, including healthy tomatoes but split open before they are fully ripe. This problem occurs due to fluctuations in the amount of water received. When watering is irregular and excessive, the pulp inside the tomato retains moisture and swells faster; hence, the tomato skin can stretch. As a result, the tomato's skin splits and cracks. Water the tomato plant regularly to keep it from cracking.o

The application of an automatic watering system can be more effective by adding online monitoring or IoT monitoring. This application enables the user or farmer to monitor their farm online and in real-time. The implementation of electronics technology in the plantation is called digital farming. The installation of automatic solar sprinklers on plantations is ideal because solar power eliminates the need for farmers to rely on supplies from government utilities and, as a result, makes them more efficient.

This paper discusses the concept and design of a solar-powered automatic sprinkler system applied in plantations with online and real-time monitoring using

IoT monitoring. The effectiveness of the proposed method is proven by the experimental testbed applied in a plantation.

2. METHOD

This paper shows the concept and design of a solar-powered automatic sprinkler system with IoT monitoring expected to be applied in plantations and reduce farmer workload in farming maintenance. The proposed system design is shown in Figure 1. The electronics design of the proposed method includes moisture sensors that give input to Arduino to activate the pump. The LCD display shows the condition of water moisture.

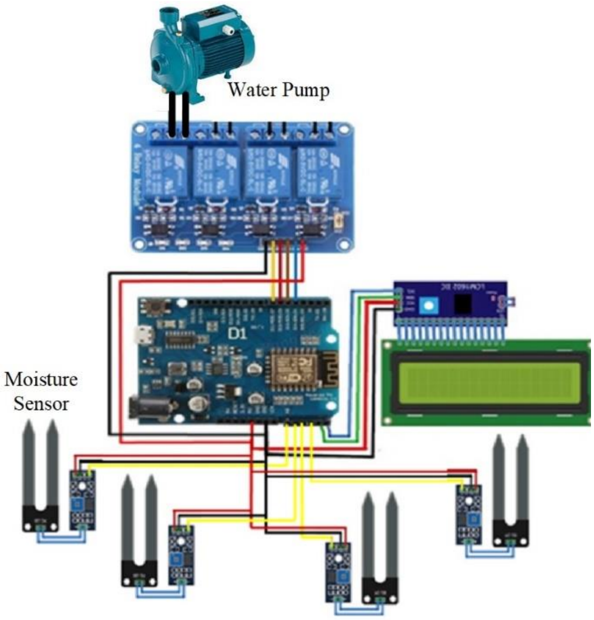

Figure 1 Electronics design of the solar-powered automatic sprinkler system

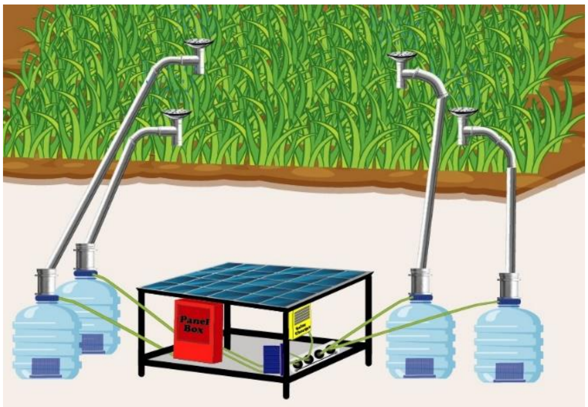

Figure 2 The mechanical design of the proposed system.

The complete design solar power automatic sprinkler system is shown in Figure 2. The prototype in this study is shown to use water tanks to accommodate a particular area. This system is also applicable for a system using direct water sources such as well or river, if applicable nearby.

3. RESULT AND DISCUSSION

The proposed method was implemented on a plantation as the automatic sprinkler for Japanese mustard spinach. This implementation is possible for any plant that needs regular watering. The experimental testbed considered in this study is shown in Figure 3 where the water sources are simulated using 4 gallons pumped by 4 water pumps. Figure 1 only shows 1 water pump since the number of water pumps can be easily added to the system.

Figure 3 Testbed of the solar powered automatic sprinkler system

The effectiveness of the proposed methods is proven by setting the system to automatically water Japanese mustard spinach plantations by considering the soil moisture. Table 1 shows the data inputs from 4 soil moisture sensors (S1 to S4) to activate 4 pumps (P1 to P1). The soil moisture sensor is connected to Wifi Module Wemos D1 ESP8266 that shows ADC numbers from 0-4095. This range from 0 to 4095 indicates soil humidity. 0-2500 the soil considered humid, 2500-3000 means the ground is in good condition, not too dry and not too moist. 3000-4095, the soil is dry.

Table 1 Soil moisture sensor data (S1-S4) in activating pumps (P1-P4)

Time	S1	P1	S2	P2	S3	P3	S4	P4
09:00 AM	1271	Off	1247	Off	1263	Off	1307	Off
10:00 AM	1787	Off	1804	Off	1777	Off	1793	Off
11:00 AM	2650	Off	2745	Off	2689	Off	2772	Off
12:00 PM	3426	ON	3490	ON	3573	ON	3533	ON

Table 1 shows the soil condition from 09:00 – 12:00 AM. At 09:00 AM, the soil moisture sensors sense that the soil humidity is moist/humid, indicated by the S1 to S4 reading (1271 - 1307); hence, the pumps (P1-P4) are off. From 10:00 to 11:00, the soil moisture sensors send data that the soil is in good condition, not too dry, and not too humid; hence, the pumps are off. At 12:00 PM, the soil moisture sensors indicate that the soil is dry, and Arduino, as the system controller, actives all pumps.

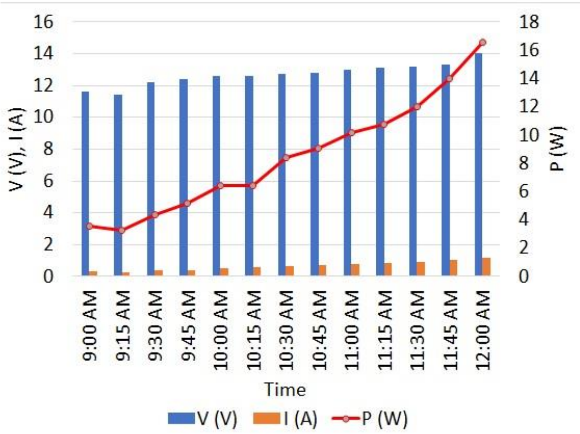

Figure 4 Voltage, current, and power produced by solar panel.

The voltage, current, and power produced by the solar panel are shown in Figure 4. The experiment was conducted from 09:00 AM; however, the produced voltage is still below 12V. The solar panel's produced energy is stored in the storage system to ensure the sprinkler system works in any weather condition.

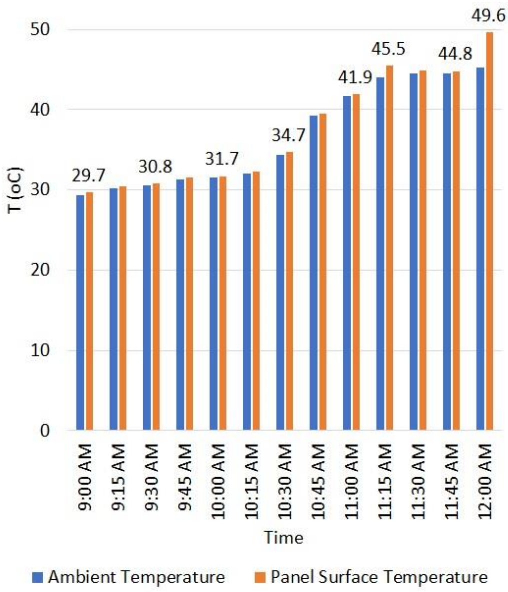

Figure 5 Ambient temperature and panel's surface temperature during the experiment

Figure 5 shows the ambient temperature and solar panel's surface temperature. The temperature was below 50ºC; this temperature is sufficient for solar energy implementation and will not cause an overheated to the solar cell.

Figure 6 IoT Monitoring on moisture sensors

Figure 6 shows the IoT monitoring of moisture sensors. This monitoring is beneficial for the farmer in monitoring the solar-powered automatic sprinkler system.

The experimental data shows that solar energy is possible for automatic sprinkler systems, which is one of the digital farming applications and, in the long run, will be beneficial for the farmers.

4. CONCLUSION

Digital farming application is expected to reduce farmer workload. One of the examples of this technology application is the solar-powered automatic sprinkler system. The automatic sprinkler can help the farmer timely regular watering the plantation, and solar energy can help reduce the electricity cost and is also applicable to villages located in remote areas. The automatic sprinkler system is possible by considering the input from moisture sensors which are monitored online by IoT monitoring. The experimental result shows that the proposed method is effective in realizing the solar-powered automatic sprinkler system.

AUTHORS' CONTRIBUTIONS

T. Dewi designed, directed the project, and wrote the paper. Rusdianasari and Ahmad Taqwa were responsible for data analysis and article writing, and Teddy Wijaya was responsible for designing the mechanical system and data collections.

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REFERENCES

[1] A. T. Wardhana, A. Taqwa, and T. Dewi, "Design of Mini Horizontal Wind Turbine for Low Wind Speed Area," in Proceeding of 2nd Forum in Research, Science, and Technology 30-31 October 2018, Palembang, Indonesia, Journal of Physics: Conference Series, Vol. 1167, 2019.

[2] R. B. Yuliandi, T. Dewi, and Rusdianasari, "Comparison of Blade Dimension Design of a Vertical Wind Turbine Applied in Low Wind Speed," in Proceeding of The 1st Sriwijaya International Conference on Environmental Issues 2018 (1st SRICOENV 2018), E3S Web of Conferences EDP Sciences, Vol. 68, 2018.

[3] T. Dewi, P. Risma, Y. Oktarina, M. T. Roseno, H. M. Yudha, A. S. Handayani, and Y. Wijanarko, "A Survey on Solar Cell; The Role of Solar Cell in Robotics and Robotic Application in Solar Cell industry," in Proceeding of Forum in Research, Science, and Technology (FIRST), 2016.

[4] M. H. Yudha, T. Dewi, P. Risma, and Y. Oktarina, "Life Cycle Analysis for the Feasibility of Photovoltaic System Application in Indonesia," in Proceeding International Conference on Science, Infrastructure Technology and Regional Development (ICoSITeR) 2017 "Energy Security for Enhancing National Competitiveness" 25-26 August 2017, South Lampung, Indonesia, IOP Conference Series: Earth and Environmental Science, Vol. 124, 012005, 2017.

[5] T. Dewi, P. Risma, and Y. Oktarina, "A Review of Factors Affecting the Efficiency and Output of a PV system Applied in Tropical Climate," presented at 2018 International Conference on Science, Infrastructure Technology and Regional Development, the IOP Conference Series: Earth and Environmental Science, Vol. 258, p. 012039, 2018.

[6] A. Edward, T. Dewi, and Rusdianasari, "The effectiveness of Solar Tracker Use on Solar Panels to The Output of The Generated Electricity Power," presented in 6th International Conference on Sustainable Agriculture, Food and Energy 18-21 October 2018, Manila, The Philippines, IOP Conference Series: Earth and Environmental Science, Vol. 347, No. 1, p. 012130, 2019.

[7] B. R. D. M. Hamdi, T. Dewi, and Rusdianasari, "Performance Comparison of 3 Kwp Solar Panels Between Fixed and Sun Tracking in Palembang-Indonesia," presented in 6th International Conference on Sustainable Agriculture, Food and Energy 18-21 October 2018, Manila, The Philippines, IOP Conference Series: Earth and Environmental Science, Vol. 347, No. 1, p. 012131, 2019.

[8] I. N. Zhafarina, T. Dewi, and Rusdianasari, "Analysis of Maximum Power Reduction Efficiency of Photovoltaic System at PT. Pertamina (Persero) RU III Plaju," VOLT: Jurnal Ilmiah Pendidikan Teknik Elektro, Vol. 3, No. 1, pp. 19-25, 2018.

[9] I. Arissetyadhi, T. Dewi, and RD. Kusumanto, "Experimental Study on The Effect of Arches Setting on Semi-Flexible Monocrystalline Solar Panels," Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control KINETIK, Vol. 5, No. 2, 2020.

[10] H. A. Harahap, T. Dewi, and Rusdianasari, "Automatic Cooling System for Efficiency and Output Enhancement of a PV System Application in Palembang, Indonesia," presented in 2nd Forum in Research, Science, and Technology, Journal of Physics: Conf. Vol. 1167, p. 012027, 2018.

[11] H. Budiman, A. Taqwa, RD Kusumanto, and T. Dewi, "Synchronization and Application of IoT for on Grid Hybrid PV-Wind System," in Proceeding of 2018 International Conference on Applied Science and Technology (iCAST) IEEE, pp. 617-621, 2018.

[12] T. Dewi, P. Risma, Y. Oktarina, A. Taqwa, Rusdiansari, and H. Renaldi, "Experimental Analysis on Solar Powered Mobile Robot as the Prototype for Environmentally Friendly Automated Transportation," presented in International Conference on Applied Science and Technology (iCAST on Engineering Science) Bali, Indonesia, of Physics: Conference Series, Vol. 1450.

[13] Sarwono, T. Dewi, and RD Kusumanto, "Geographical Location Effects on PV Panel

Output - Comparison Between Highland and Lowland Installation in South Sumatra, Indonesia," Technology Reports of Kansai University, Vol. 63, No. 02, pp. 7229-7243, 2021. ISSN: 04532198.

[14] K. Junaedi, T. Dewi, and M. S. Yusi, "The Potential Overview of PV System Installation at the Quarry Open Pit Mine PT. Bukit Asam, Tbk Tanjung Enim," Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control, Vol. 6, No. 1, pp. 41-50, 2021. https://doi.org/10.22219/kinetik.v6i1.1148.

[15] A. Sasmanto, T. Dewi, and Rusdianasari, “Eligibility Study on Floating Solar Panel Installation over Brackish Water in Sungsang, South Sumatra,” EMITTER International Journal of Engineering Technology, Vol. 8, No. 1, 2020.

[16] B. Junianto, T. Dewi, and C. R. Sitompul, “Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra,” presented in 3nd Forum in Research, Science, and Technology Palembang, Indonesia, Journal of Physics: Conf. Series 2020.

[17] F. Setiawan, T. Dewi, and S. Yusi, “Sea Salt Deposition Effect on Output and Efficiency Losses of the Photovoltaic System; a case study in Palembang, Indonesia,” presented in 2nd Forum in Research, Science, and Technology, Journal of Physics: Conf. Vol. 1167, p. 012027, 2018.

[18] T. Imjai, K. Thinsurat, P. Ditthakit, W. Wipulanusat, M. Setkit, and R. Garcia, “Performance Study of an Integrated Solar Water Supply System for Isolated Agricultural Areas in Thailand: A Case-Study of the Royal Initiative Project,” Water, Vol. 12, p. 2438, 2020. doi:10.3390/w12092438.

[19] V. S. Korpale, D. H. Kokate, and S. P. Deshmukh, “Performance Assessment of Solar Agricultural Water Pumping System,” Energy Procedia, Vol. 90, pp. 518-524, 2016. https://doi.org/10.1016/j.egypro.2016.11.219.

[20] M. Elrefai, R. A. Hamdy, A. ElZawawi, and M. S. Hamad, “Design and Performance Evaluation of a Solar Water Pumping System: a Case Study,” 2016 Eighteenth International Middle East Power Systems Conference (MEPCON), Cairo, 2016, pp. 914-920, doi: 10.1109/MEPCON.2016.7837005.

[21] A. Ba, A. Aroudam, O. E. Chighali, O. Hamdoun, and M. L. Mohamed, “Performance Optimization of the PV Pumping System,” presented in 11th International Conference Interdisciplinarity in Engineering, INTER-ENG 2017, 5-6 October 2017, Tirgu-Mures, Romania, Procedia Manufacturing, Vol. 22, pp. 788-795, 2018. https://doi.org/10.1016/j.promfg.2018.03.112

[22] P. P. Putra, T. Dewi, Rusdianasari, "MPPT Implementation for Solar-powered Watering System Performance Enhancement," Technology Reports of Kansai University, Vol. 63, No. 01, pp. 6919-6931, 2021. ISSN: 04532198.