Analysis of Electrical Energy the Effect of Using a Smartphone-Based Water Pump Control System Controller (Case Study of Yulihamri's Rent at Merak Sakti Road)

Antonius Rajagukguk [1], Iman Sahrobi Tambunan [2], Anhar [3], Alfian Ma'arif [4]
[1,2,3] Universitas Riau Kampus Bina Widya Jl. HR Soebrantas KM 12.5 Pekanbaru, 28293, Indonesia
[4] Universitas Ahmad Dahlan, Yogyakarta, Indonesia

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ABSTRACT

The development of science and technology will increasingly have an impact on human life, especially electronic devices at home. In-home reservoirs, commonly, the owner of the water pump cannot detect the level of the water reservoir in his house due to no automation in the water pump. This study seeks to design a device that can control one water pump for filling three reservoirs, where the reservoir filling path will be regulated by a solenoid valve. It also aims to increase the efficiency of electrical energy in the water pump and be monitored by homeowners. The research was conducted at Yulihamri's rented house on Merak Sakti Road. In testing the measurement of electrical energy without using a control, the results obtained in the first reservoir of 1253.99 Wh, 2072.83 Wh, and 2136.27 Wh in the first, second, and third reservoirs, respectively. Meanwhile, in testing the measurement of electrical energy using the control system, the results obtained on all reservoirs in sequence are 1234.70 Wh, 1754.52 Wh, and 1644.12 Wh. The electric energy efficiency of the water pump after using the control system enhance by 15%. The contribution of this research is to reduce the use of excessive electrical energy due to the filling of water that exceeds the storage capacity so as to make it inefficient for the use of electrical energy as well as the water released. The research also limits the use of electrical energy at the end of the month, which makes this system more efficient compared to other systems.

Corresponding Author:

Iman Sahrobi Tambunan, Universitas Riau, Pekanbaru, Riau 28293, Indonesia
Email: iman.sahrobi1304@student.unri.ac.id

1. INTRODUCTION

Microcontrollers and microcomputers since the early 1970s have grown rapidly since the beginning of today [1]. The evolution of the microcontroller has attracted considerable interest from researchers in the field of automation applications due to its performance and effectiveness [2]. For example, electronics and any equipment [3].

A smart home is an application of the Internet of things (IoT) that allows residents to conveniently monitor, control, and monitor their home activities from any location [4]. Analyzing and evaluating data to predict environmental actions and conditions, as well as optimizing automation, are other advantages of using machine learning algorithms in smart home automation [5].

Several studies related to this, among others, in the agricultural sector [6][7], Smart home [8][9], and smart fish farms [10]. Nowadays, many different technologies are often combined into one complete system to improve efficiency, effectiveness, production speed improvement, and profit leading to industrial evolution and realization of Industry 4.0 [11].

In recent years, the new energy industry has developed very rapidly. It is an important part of new energies, such as vehicle cooling systems and electronic water pumps, which often have a large impact on the performance of the entire vehicle [12]. According to the International Energy Agency statistics on energy balance, energy consumption in the tertiary sector (residential, commercial, and public services) accounts for more than 59% of total energy consumption in the world [13].

In the last 5 years, it is estimated that half of the world's population will live in areas experiencing water stress [14]. A consistent and universally accepted measure of water demand makes it difficult to clearly characterize the scale of the problem [15]. The life Cycle Cost (LCC) of a water pump system includes the cost of the motor pump, maintenance costs, and costs incurred for energy spent on water pump maintenance. More than 82% of pumping LCC is due to the energy used to pump the water [16].

Water pumps are a vital method of supplying water from some resources, the gravity system of which cannot be sufficient due to the influence of topography and side level [17]. Water pumping is the process of providing kinetic and potential energy to water to distribute from one place to another [18]. Water is the most important natural resource in human life [19]. In everyday life, water is also the main element for domestic or commercial purposes [20]. Water will be very beneficial for the life of the earth proportionally [21]. The field of water insecurity research, which is fairly new, is advancing various emerging methods for assessing and calculating human water requirements [22]. Priority for water needs includes industry, domestic, and public services and the need for water used to replace leaks [23].

Optimization of the water supply system can not only save a lot of energy but also allow the water distribution system to be in a reasonable operating state, that is, to make energy distribution more reasonable. The water crisis is one of the biggest problems in the whole world, and water crisis is reaching a very worrying level day by day [24]. The purpose of the distribution system is to make water accessible to every home, industrial plant, and public place [25].

To overcome this challenge, we propose to control the reservoir [26]. If optimal pump operation is used in all water supply systems, up to billions of kWh of electric power will be saved annually, which brings huge economic benefits [27]. On a global scale, population and economic growth lead to increased demand for energy. At the same time, climate change and population growth are depressing freshwater resources [28].
In addition, energy intensity is now likely to decrease markedly as a result of more efficient use of energy-especially in developed industrialized countries [29]. If storing water in a reservoir, it must be monitored continuously to start and stop the water pump [30].

According to application requirements, the control system design requirements include: (1) Optimizing water supply methods and control strategies, (2) improving the human-machine interface, which can detect and display water temperature and water level in real time and accurately, (3) realize intelligent control and working state detection, show the running state of field equipment, (4) apply industrial network and monitoring host computer to adapt the development trend of solar water heating engineering projects [31].

Research conducted by Suppachai Howimanporn and colleagues is the design of a scheduled PID controller based on swarm optimization for monitoring water levels [32]. This research is the development of a Smart Water Level Control System [WLCS] based on IoT and Cellular by Siddartha Shankar [33]. The following research discusses the steam generator control system as the most difficult control system in nuclear power plants [34]. This study discusses the monitoring and collection of household water supplies by Tanvir Rahman [35].

This research helps to turn off and start the water pump motor based on the water level in the overhead reservoir, but this work is only useful when one relies on underground water to fill the overhead reservoir [36]. This study aims to design a water-filling control system in the reservoir using the Microcontroller Node MCU ESP 32 as a control and an ultrasonic sensor as a water level detector [37]. The results of this study can overcome water wastage effectively by monitoring the water level in the reservoir and asking the user to control the engine water on and off automatically [38]. This research is useful to save the most valuable human time as the water pump switching happens automatically, and they can utilize the time they spend to monitor the city water effectively [39].

In connection with this, this study was conducted to analyze the electrical power of a water pump control system and determine the path of the reservoir or tank to be filled via Smartphone so that users know more about the condition of the water level in each reservoir so as to save time and power consumption. Thus, in this study, we will analyze the use of electrical energy in a Smartphone-based water pump control system on rent. The difference between this study compared to the existing research is that this research limits the use of electricity at the end of each month so that electricity consumption can be monitored regularly.

The contribution of this research is to reduce the use of excessive electrical energy due to the filling of water that exceeds the storage capacity so as to make it inefficient for the use of electrical energy and also the water released. This research also limits the use of electrical energy at the end of the month, which makes this system more efficient compared to other systems.

2. METHOD

A. Needs analysis (requirement definition)

Monitoring of Level Control uses the Node MCU ESP 32 microcontroller as the main processor, as a processing water level measurement and to be displayed on the LCD, ultrasonic sensor as ultrasonic as a water level detector [40]. In making the program using Arduino IDE software that uses the C programming language.

B. System design (system and software design)

After the existing system is analyzed and in accordance with research needs, a logical design is made using flow charts as a tool to build the system. The system requirements needed to build this Water [41]. In this stage, the researcher describes the design of the system to be built in accordance with the data analysis carried out in the previous stage. In modeling the system, researchers use procedural concepts.

In system design, the software is needed. The design of this software is loaded on a flowchart. The flowchart is used in building an algorithm program which will later be applied to the system. The flowchart can be seen in Fig. 1.

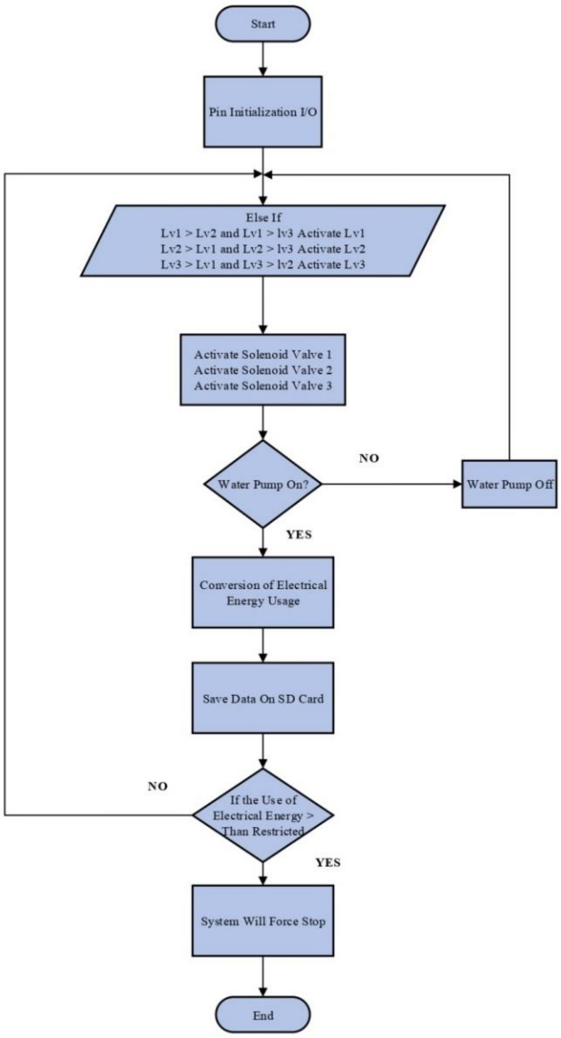

Fig. 1. Flowchart Water Pump Control System

Based on the flowchart in Fig. 1, it can be explained as follow. The first process is to initialize the pin Node MCU ESP32 as I/O. The ESP32 MCU input node used is a digital input. This input is used to read the water level from the ultrasonic sensor. The ultrasonic sensor will measure the level of the water level whose reservoir needs water the most. The solenoid valve will open according to the input received from the ESP32

MCU node based on the readings from the ultrasonic sensor, and the pump will start. When the water pump is running, the system will calculate the use of electrical energy with data obtained from the voltage and current sensors. If the use of electrical energy exceeds the usage limit, the system will automatically shut down forcibly until there is a response from the user.

C. Encoding (implementation)

The program design in the previous stage is translated into the form of codes using a programming language. In this system, the programming language used is C++.

D. Testing (system testing)

The process of system testing is to prove the system is running as expected. At the testing stage, the comparison method is used to find differences between the system before and after.

2.1. Block Diagram

The design of this water pump control system controller has several parts. Starting from measuring the water level, adjusting the solenoid valve that must work, and storing data. The block diagram can be seen in Fig. 2.

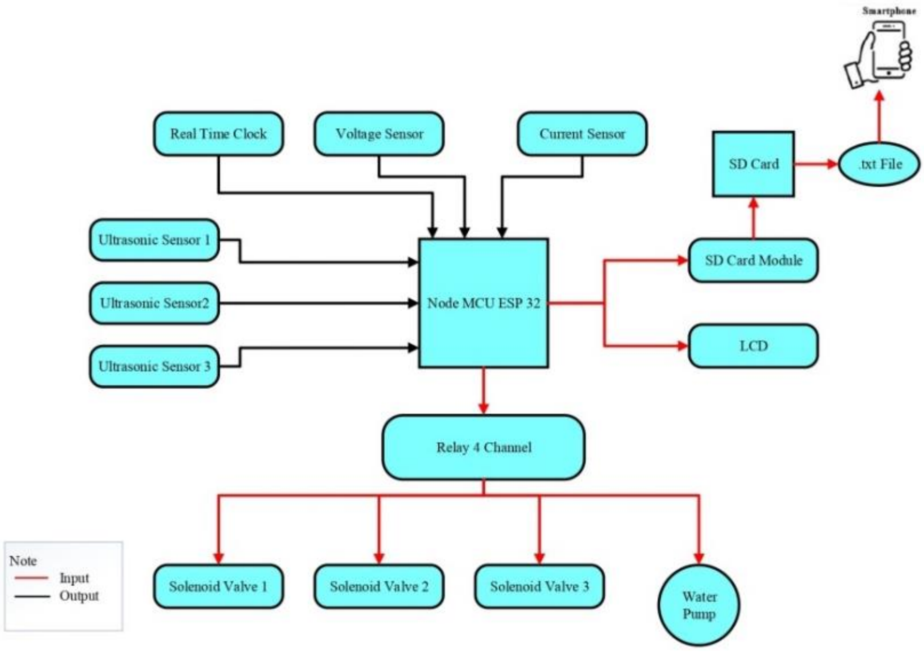

Fig. 2. Block Diagram Water Pump Control System

The design of this water pump control system controller (Fig. 2) uses the ESP32 MCU Node as the control. Where when the ultrasonic sensor measures the water level, the ultrasonic sensor will send output to the controller so that it can be processed based on the condition of the ultrasonic sensor. The programmed ESP32 MCU node will instruct the Solenoid Valve to open according to the output of the ultrasonic sensor earlier. So that when the Solenoid Valve is open, the water pump will also turn on.

The ESP32 MCU node is also connected to the Real Time Clock to provide live time information. Other components connected to the ESP32 MCU Node are voltage sensors, current sensors, an SD card module, and an LCD (Liquid Crystal Display). The voltage sensor and current sensor function to measure voltage and current so that later on, the ESP32 MCU Node will calculate the use of electrical energy used while the pump is running. This electrical energy data will be stored on the SD card, which is connected to the SD card module, so that it will be calculated every month.

2.2. Water Pump Control System Controller Design

The design of the water pump control system controller in this study consisted of three ultrasonic sensors, which were used to detect the water level, which would then be processed by the MCU ESP 32 Node. The design of the water pump control system controller designed through the Fritzing application can be seen in Fig. 3.

As shown in Fig. 3, there are four connecting colors in the image. The first is the black connector, which means the connecting circuit is connected to the negative power supply. The second is the red connector, which is connected to the positive power supply. The third is the blue connector which means the circuit is a circuit that becomes the control system in the above circuit. And fourth is the yellow connector, which indicates that the link is a part controlled by the system.

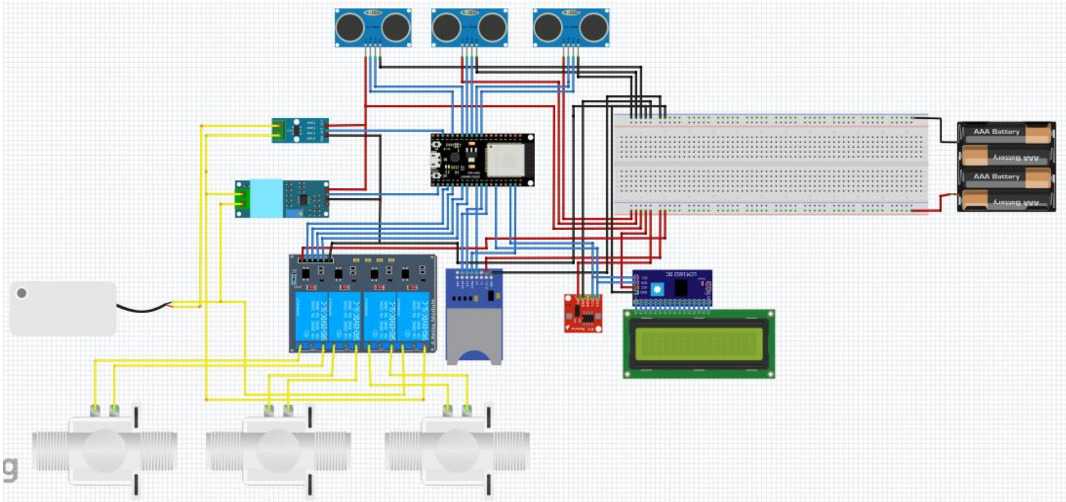

Fig. 3. Water Pump Control System Controller Design

3. RESULTS AND DISCUSSION

The design of the research tool consists of ultrasonic sensors, RTC, SD Card Module, Relay 4 Channel, current sensors, and also voltage sensors. The results of the measurement of electrical energy were obtained from the results of data collection in the field, which was carried out for 30 days on the lease of Yulihamri Jalan Merak Sakti by measuring energy use before and after the use of the control system. The results of the design of the water pump control system controller can be seen in the picture below.

3.1. Electrical Energy Measurement Results Without Using a Control System

3.1.1. Day One to Day Ten

The results of measuring electrical energy without using a control on the first day to the tenth day can be seen in Table 1.

Table 1. Usage Amount Day One to Day Ten

Day	Pump 1	Pump 2	Pump 3
	Usage Amount (Wh)		
Wednesday, 1/9/2021	40.43	51.99	74.59
Thursday, 2/9/2021	29.18	84.07	70.53
Friday, 3/9/2021	40.68	68.18	77.64
Saturday, 4/9/2021	51.96	72.69	66.52
Sunday, 5/9/2021	28.75	81.86	63.63
Monday, 6/9/2021	54.01	96.6	80.84
Tuesday, 7/9/2021	41.35	66.61	80.93
Wednesday, 8/9/2021	43.91	67.35	73.41
Thursday, 9/9/2021	38.41	54.38	70.62
Friday, 10/9/2021	36.76	75.1	72.35

From the first day of charging until the tenth day, the largest use of electrical energy is in the third pump, with the use of 731.06 Wh. After that, the largest use of electrical energy is the second pump, with the use of 718.83 Wh. And the smallest use of electrical energy is the first pump, with used electrical energy of 409.52 Wh.

3.1.2. The Eleventh to the Twentieth Day

The results of measuring electrical energy without using a control on the eleventh day to the twentieth day can be seen in Table 2.

Table 2. Usage Amount the Eleventh to the Twentieth Day

Day	Pump 1	Pump 2	Pump 3
	Usage Amount (Wh)		
Saturday, 11/9/2021	47.13	65.34	86.23
Sunday, 12/9/2021	38.84	81.01	70.64
Monday, 13/9/2021	34.64	59.23	75.84
Tuesday, 14/9/2021	41.21	84.98	71.18
Wednesday, 15/9/2021	33.47	68.6	70.42
Thursday, 16/9/2021	51.33	60.86	88.74
Friday, 17/9/2021	61.29	56.3	65.81
Saturday, 18/9/2021	45.64	68.64	74.84
Sunday, 19/9/2021	39.55	58.96	58.52
Monday, 20/9/2021	33.33	60.94	56.66

From the eleventh day to the twentieth day of charging (Table 2), the largest use of electrical energy was at the third pump, with a usage of 718.88 Wh. After that, the largest use of electrical energy is the second pump, with the use of 664.86 Wh. And the smallest use of electrical energy is the first pump, with used electrical energy of 426.43 Wh.

3.1.3. Twenty-first to Thirtieth Day

The results of measuring electrical energy without using a control on the twenty-first to the thirtieth day can be seen in Table 3.

Table 3. Usage A1mount the Twenty-First to the Thirtieth Day

Day	Pump 1	Pump 2	Pump 3
	Usage Amount (Wh)		
Tuesday, 21/9/2021	52.89	70.18	76.52
Wednesday, 22/9/2021	47.91	52.33	84.04
Thursday, 23/9/2021	38.53	91.06	63.32
Friday, 24/9/2021	29.91	68.51	64.49
Saturday, 25/9/2021	33.92	63.1	75.86
Sunday, 26/9/2021	41.54	54.89	70.88
Monday, 27/9/2021	52.96	63.63	50.71
Tuesday, 28/9/2021	47.1	66.83	76.82
Wednesday, 29/9/2021	36.73	86.76	58.99
Thursday, 30/9/2021	36.53	71.86	64.71

On the twenty-first to the thirtieth day of charging (Table 3), the largest use of electrical energy was in the second pump, with a usage of 750.08 Wh. After that, the largest use of electrical energy is the third pump, with the use of 686.34 Wh. And the smallest use of electrical energy is the first pump, with used electrical energy of 418.03 Wh.

3.2. Electrical Energy Measurement Results Using the Control System

3.2.1. Day One to Day Ten

The results of measuring electrical energy using controls on the first day to the tenth day can be seen in Table 4.

Table 4. Usage Amount Day One to the Tenth Day

Day	Shelter 1	Shelter 2	Shelter 3
	Usage Amount (Wh)		
Monday, 1/11/2021	28.56	71.09	49.79
Tuesday, 2/11/2021	28.24	63.50	42.96
Wednesday, 3/11/2021	35.96	64.11	61.04
Thursday, 4/11/2021	28.51	57.39	51.28
Friday, 5/11/2021	41.03	63.49	49.19
Saturday, 6/11/2021	35.78	57.40	42.71
Sunday, 7/11/2021	28.14	63.27	56.78
Monday, 8/9/11021	42.13	56.07	49.84
Tuesday, 9/11/2021	35.54	64.54	56.40
Wednesday, 10/11/2021	42.72	63.87	58.44

From the first day of charging until the tenth day (Table 4), the largest use of electrical energy was in filling the second tub, with a usage of 624.74 Wh. After that, the largest use of electrical energy is filling the third tub with the use of 518.43 Wh. And the smallest use of electrical energy is filling the first tub with used electrical energy of 376.81 Wh.

3.2.2. The Eleventh to the Twentieth Day

The results of measuring electrical energy using controls on the eleventh day to the twentieth day can be seen in Table 5. From the eleventh day until the twentieth day, the largest use of electrical energy was in filling the third tub, with a usage of 565.54 Wh. After that, the largest use of electrical energy is filling the second tub with the use of 539.60 Wh. And the smallest use of electrical energy is filling the first tub with used electrical energy of 424.34 Wh.

Table 5. Usage Amount the Eleventh Day to The Twentieth Day

Day	Shelter 1	Shelter 2	Shelter 3
	Usage Amount (Wh)		
Thursday, 11/11/2021	42.55	48.96	49.24
Friday, 12/11/2021	56.35	57.33	63.72
Saturday, 13/11/2021	42.71	50.21	56.26
Sunday, 14/11/2021	42.51	56.16	57.24
Monday, 15/11/2021	35.54	57.77	49.21
Tuesday, 16/11/2021	42.49	49.77	57.20
Wednesday, 17/11/2021	35.13	56.44	63.80
Thursday, 18/11/2021	49.56	56.05	56.55
Friday, 19/11/2021	42.28	50.15	62.99
Saturday, 20/11/2021	35.21	56.77	49.33

3.2.2. Twenty-first to Thirtieth Day

The results of measuring electrical energy using the control on the twenty-first to the thirtieth day can be seen in Table 6. On the twenty-first to the thirtieth day of charging, the largest use of electrical energy is in filling the second tub with usage of 590.18 Wh. After that, the largest use of electrical energy is filling the third tub with the use of 553.23 Wh. And the smallest use of electrical energy is filling the first tub with used electrical energy of 433.55 Wh.

Table 6. Usage Amount the Twenty-First to the Thirtieth Day

Day	Shelter 1	Shelter 2	Shelter 3
	Usage Amount (Wh)		
Sunday, 21/11/2021	42.76	71.28	49.77
Monday, 22/11/2021	35.00	56.77	56.94
Tuesday, 23/11/2021	42.71	49.55	56.66
Wednesday, 24/11/2021	42.40	56.53	49.87
Thursday, 25/11/2021	43.11	64.80	56.12
Friday, 26/11/2021	35.61	49.91	63.62
Saturday, 27/11/2021	49.19	56.52	56.91
Sunday, 28/11/2021	57.49	56.55	49.71
Monday, 29/11/2021	42.59	64.78	64.32
Tuesday, 30/11/2021	42.68	63.49	49.32

3.3. Electrical Energy Comparison Analysis

1. First Shelter

Analysis of the comparison of electrical energy in the first shelter can be seen in Fig. 4. The use of electrical energy in the first tub without using the control shows instability in the resulting curve with a total amount of electrical energy usage of 1253.99 Wh for 30 days. Meanwhile, the use of electrical energy using the control on the same tub shows a stable curve with a total amount of 1234.70 Wh for charging electrical energy for 30 days.

2. Second Shelter

Analysis of the comparison of electrical energy in the second shelter can be seen in Fig. 5. The use of electrical energy in the second tub without using the control shows instability in the resulting curve with a total amount of electrical energy usage of 2072.83 Wh for 30 days. Meanwhile, the use of electrical energy using the control on the same tub shows a stable curve. Only 2 times, this charging experienced a surge in electrical energy, namely 9.97 Wh and 9.63, with a total number of charging electrical energy of 1754.52 Wh for 30 days.

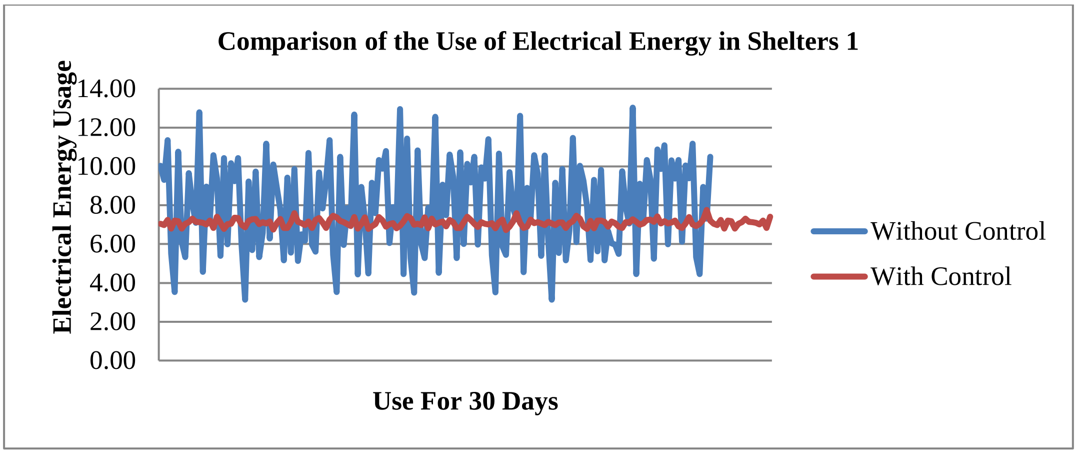

Fig. 4. The Comparison of Electrical Energy in the First Shelter

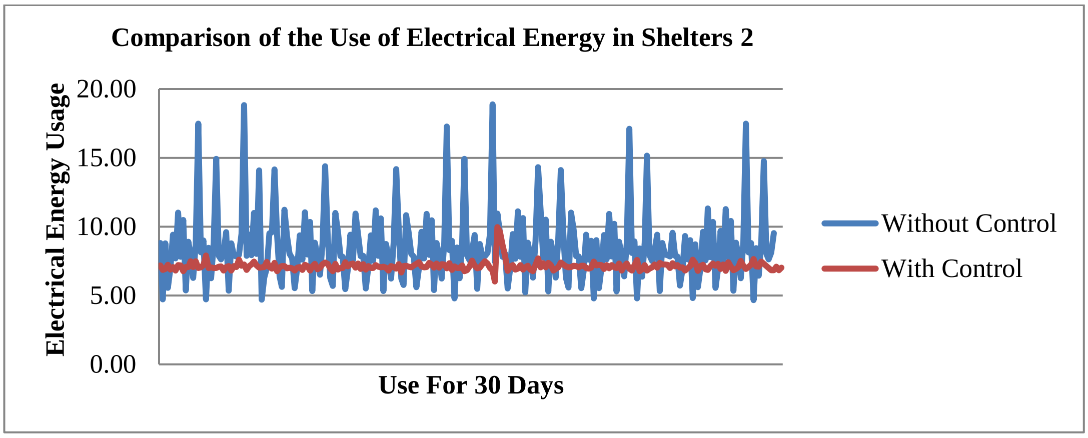

Fig. 5. The Comparison of Electrical Energy in the Second Shelter

3. Third Shelter

Analysis of the comparison of electrical energy in the third shelter can be seen in Fig. 6. The use of electrical energy in the third tub without using the control shows instability in the resulting curve with a total amount of electrical energy usage of 2136.27 Wh for 30 days. Meanwhile, the use of electrical energy using the control on the same tub shows a stable curve. In charging, electrical energy had increased by 10.11 Wh and 9.61 Wh at the twenty and twenty-first charging. Then up again by 9.90 Wh. So that the total amount of electrical energy charging is 1644.12 Wh for 30 days.

3.4. Electrical Energy Efficiency

To determine the efficiency of electrical energy in this water pump, a measurement of electrical energy was conducted between a system that does not use control and a system that uses control. Thus, obtained a comparison of the use of different electrical energy. Table 7 is electrical energy efficiency.

Table 7. Electrical Energy Efficiency

Day	Electrical Energy Efficiency					
	Without Control (Wh)			With Control (Wh)		
	Shelter 1	Shelter 2	Shelter 3	Shelter 1	Shelter 2	Shelter 3
1-10	405.44	718.83	731.06	376.81	624.74	518.43
11-20	426.43	664.86	718.88	424.34	539.60	565.54
21-30	418.02	689.15	686.34	433.55	590.18	553.23
Total	5459.01			4626.42		

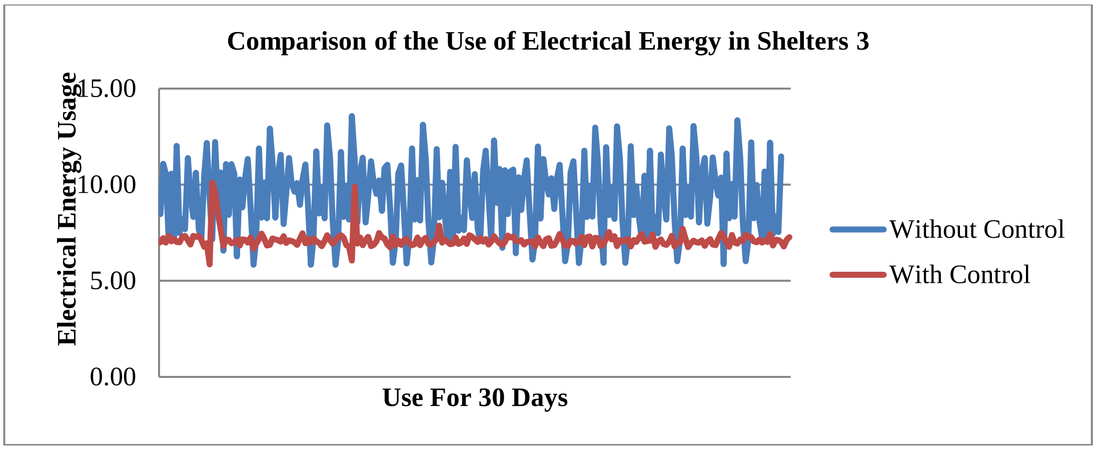

Fig. 6. The Comparison of Electrical Energy in the Third Shelter

Based on Table 7, data obtained that the use of electrical energy without control at the water pump is as much as 5459.01 Wh. While the water pump using the control system requires as much as 4626.42 Wh of electrical energy. From the two results of the use of electrical energy, the efficiency of electrical energy can be obtained as follows

$$\frac{(\text{Without Control} - \text{With Control})\ \text{Wh}}{\text{With Control Wh}} \times 100\% \tag{1}$$

$$\frac{(5459.01 - 4626)\ \text{Wh}}{5459.01\text{Wh}} \times 100\% \tag{2}$$

$$\frac{832.59\text{Wh}}{5459.01\text{Wh}} \times 100\% = 15\% \tag{3}$$

By obtaining an electrical energy efficiency of 15% after using the control system, of course, the operational costs on the electricity bill will be reduced so that it will benefit the rented owner.

3.5. Electrical Energy Consumption Limit

This limit on the use of electrical energy aims to reduce excessive use by people who contract with Yulihamri. With this system of limiting the use of electrical energy, the contracting person will save more on the use of electrical energy because there is a maximum limit for the use of electrical energy. The amount of electrical energy consumption before using the control system for 30 days can be seen in the Table. 8.

Table 8. Electrical Energy Consumption Limit

Day	**Water Pump 1**	**Water Pump 2**	**Water Pump 3**
		Amount of Usage (Wh)	
1-10	405.44	718.83	731.06
11-20	426.43	664.86	718.88
21-30	418.02	689.15	686.34
Total		5459.01	

From Table 8, the amount of electricity consumption for 30 days is obtained. So that the maximum limit for the use of electrical energy in Yulihamri's rental is limited to 5459.01 Wh. If the use of electrical energy exceeds the specified, the system will automatically shut down until the landlord turns it back on.

4. CONCLUSION

In testing the measurement of electrical energy without using a control, it was found that the use of electrical energy was 1253.99 Wh with 157 charging times for 30 days at the first pump. While in the second pump, the use of electrical energy is 2072.83 Wh with 243 charging times for 30 days. And in the third pump, the total use of electrical energy is 2136.27 Wh with 228 charging times for 30 days. In testing the measurement of electrical energy using the control system, it was found that the use of electrical energy was 1234.70 Wh with 174 charging times for 30 days at the first shelter. While in the second shelter, the use of electrical energy was 1754.52 Wh with 246 charging times for 30 days. And in the third shelter, the total use of electrical energy is 1644.12 Wh with 231 charging times for 30 days. The electric energy efficiency of the water pump before using the control system and after using the control system is 15%.

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BIOGRAPHY OF AUTHORS

Antonius Rajagukguk was born in Medan, North Sumatra, Indonesia. and joined the University of Riau as a lecturer in 1997. He earned his B.S. Bachelor of Electronic Engineering from Atma Jaya, Catholic University, Jakarta, Indonesia, in 1993 and an M.S. degree from the Sepuluh Nopember Institute of Technology (ITS) Surabaya, in 2005. And received a Doctorate degree in Electrical Engineering at the Sepuluh Nopember Institute of Technology (ITS) in 2019. His research interests include the application of power electronics for grid systems, power quality, and renewable energy. Email: antoniusrajagukguk@gmail.com

Iman Sahrobi Tambunan was born in Bandar Durian April 16, 1999. He became a student at the University of Riau in 2017. He researches microcontrollers, electrical energy, and also energy efficiency. Email: imansahrobi.1304@student.unri.ac.id

Anhar was born in Kijang, Bintan, Kepulauan Riau in April 9, 1976. He spent his education from elementary to senior high school on this island. In 1995, he continued his bachelor's degree in electrical engineering at Universitas Sumatera Utara (USU), Medan, and graduated in 2000. He got a scholarship from the ministry of education in 2005 to pursue his master's degree in the School of Electrical Engineering and Informatics, Institut Teknologi Bandung. To expand his knowledge, he took his Ph.D. level at Brunel University London, UK, and finished in 2019. He is also interested in investigating the performance of Medium Access Control (MAC) and routing protocols in sensor networks, the Internet of Things (IoT), and Wifi. Email: anhar@lecturer.unri.ac.id

Alfian Ma'arif was born in Klaten, Central Java, Indonesia, in 1991. He received the bachelor's degree from the Department of Electrical Engineering, Universitas Islam Indonesia, in 2014, and the master's degree from the Department of Electrical Engineering, Universitas Gadjah Mada, in 2017. Since 2018, he has been a Lecturer with the Department of Electrical Engineering, Universitas Ahmad Dahlan. He is currently an Assistant Professor, since 2020. His research interest includes control systems. He is a member of IEEE and ASCEE. He is the Editor in Chief of International Journal of Robotics and Control Systems. Email: alfian.maarif@te.uad.ac.id