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Design And Development of Electricity Use Management System of Surabaya State Shipping Polytechnic Using Decision Tree Method

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ABSTRACT Electrical energy has become a primary need in society, including in the field of education. This is related to the number of electrical equipment used to support teaching and learning activities. However, this is not directly proportional to the students' awareness of the importance of saving energy. From this, the authors create a management system for the use of electric power, which aims to save electricity consumption by limiting the use of electrical loads. In this system, the method used is a decision tree; the goal is to limit and set priorities for the use of electrical loads. When three classes are ON at the same time, there will be a reduction in the electrical load. In this system, there is a website for monitoring and changing the automatic or manual mode. The manual mode is used to control the electrical load according to the status entered on the website. While the automatic mode regulates the use of electrical loads by controlling the ON or OFF conditions using a schedule that has been made, the website also monitors current, voltage, power, energy, and usage costs. The system has been tested with automatic and manual modes for monitoring data on the website. It has data updates every 10 minutes. The system has also been tested by scheduling using a decision tree and compared with scheduling without using a decision tree. From the test results for a day, it can be concluded that the system created is able to save electricity consumption. This is reinforced by a decrease in energy use of 1,17 kWh and a cost of Rp. 1.116.

INDEX TERMS Electrical Energy, Decision Tree, IoT, Load Management, NodeMCU

I. INTRODUCTION

The use of electrical energy is closely related to the basic needs of all levels of society, where it is based on the progress of the development of electrical equipment technology and the level of consumption of electrical energy that continues to increase. The fact is that since 2015 the use of national electricity consumption has shown an increasing trend, reaching 910 kWh/capita, this figure continues to increase until 2019 by 1,084 kWh/capita, and the latest data based on the Ministry of Energy and Mineral Resources reached 1,142 kWh/capita in 2020. In Indonesia, in particular, the use of electrical energy is carried out with a prepaid system, in which the public is required to purchase a certain amount of electric pulses to obtain electrical energy. The tool used to distribute electrical energy is a kWh meter; through this tool, the distribution of electricity can run.

Along with the increase in the use of electrical energy, it can have an impact on wasting electrical energy. In the education sector, waste of electrical energy usually occurs due to excessive use due to forgetting to turn off electrical equipment after use and lack of awareness of students or students on efforts to save electrical energy, so that it can be detrimental to the state. Another condition that can occur is the risk of accidents in the form of short circuits, where the increasing amount of consumption of electrical equipment and excessive current loads are the driving factors for this risk. A number of efforts that continue to be encouraged to overcome these conditions are by monitoring and controlling the use of electrical energy so that there is a need for management of the use of electrical energy.

Based on this, we can determine the electrical power load that will be used at a certain time, and the electrical load can be turned on or off automatically according to a schedule that has been made with electrical power usage management. In the research that has been done (Juwita et al., 2018), namely the management of household electric power use using the

Greedy algorithm, this research already has a schedule for the electrical load, but there has been no reading about the cost of usage and control using PLC which in terms of costs tends to expensive. Subsequent research has been carried out (Nugraha et al., 2019) namely a monitoring and control system for household electricity consumption, this research has no scheduling of electrical loads and for electrical loads it is only limited to three tools. Further research has been conducted (Tanjung et al., 2016) namely the determination of household electrical power using the decision tree method, this research is to determine the amount of household electrical power using the decision tree method.

From some of the supporting literacy above, the author makes a tool to complement the shortcomings of previous research, namely in the form of designing a management system for using electricity at the Surabaya State Shipping Polytechnic using the decision tree method. Based on some of the things above related to the waste of electrical energy, this system was created with the aim of saving the use of electrical energy and controlling the use of electrical loads according to the classroom usage schedule so as to reduce the waste of electrical energy due to negligence of students.

In this system the decision tree method is used to limit the electrical load used when many classes have concurrent schedules, then the electrical load used will be reduced. This method is used because it makes it easier for the system to control and determine load priorities that are ON or OFF when multiple class schedules are used simultaneously. So that it is expected to make the work of the system easier.

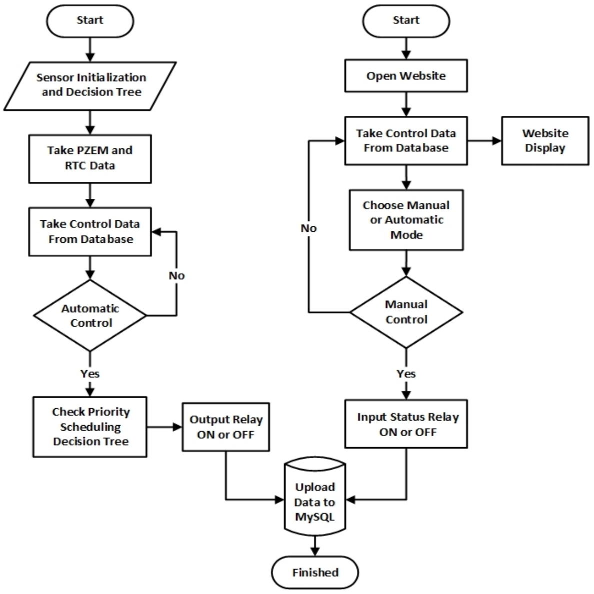

FIGURE 1. **System Work Flowchart**

II. MATERIAL AND METHODS

A. THE SYSTEM DESIGN

Below is a flowchart diagram of the system.

At this stage there is a system workflow in the form of a chart containing the processes carried out by the system. This stage aims to determine the performance of the tool made. There are 2 flows in this system, namely with automatic and manual control. For the system to work automatically, the use of all electrical loads is used according to the schedule that has been made. As for the system work manually, the use of electrical loads is regulated through the website by entering the relay status on the website.

B. ELECTRICAL LOAD DATA

The data collection stage was carried out to determine what electrical loads were used in this study, according to the loads in the classrooms used as shown in TABLE 1.

TABLE I
ELECTRICAL LOAD DATA

No	Electrical Load	Room
1	Lamp 1	M-106
2	Lamp 2	
3	Lamp 3	M-107
4	Lamp 4	M-108
5	AC	

C. CALCULATION OF BASIC ELECTRICITY RATES

This calculation is used to determine the reading of electricity costs in accordance with the basic tariff groups provided based on the Minister of Energy and Mineral Resources No. 28 of 2016. The formula for calculating costs for the social commercial doctoral class can be seen in this equation.

$$\text{Block WBP} = K \times P \times 735 \quad (1)$$

$$\text{Block LWBP} = P \times 735 \quad (2)$$

Description:

K = Price comparison factor of WBP and LWBP according to the load characteristics of the local electricity system (1.4 K 2), determined by the Board of Directors of PT Perusahaan Listrik Negara (Persero)

P = Multiplier is social commercial (1,3)

WBP = Peak Load Time (17.00-22.00)

LWBP = Outside Peak Load Time

Because the scheduling used is outside the peak load time, only one formula is used, namely LWBP Block

$$\text{LWBP} = 1.3 \times 735 = 955.5 \quad (3)$$

D. DECISION TREE METHOD

In this system, the decision tree method is used as an automatic limitation of load usage, when all three classrooms are on at the same time. Then the electrical load of each room will be reduced to reduce power consumption.

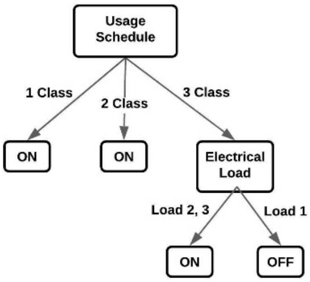

FIGURE 2. Decision Tree

So when the load is used on the schedule there are 1 or 2 classes that are used simultaneously then the load will all light up, but when 3 classes are used simultaneously there will be a reduction in the load in the form of lights, the purpose is to limit the use of electrical power so that it can save electrical energy.
From the decision tree, it can be made into a rule, namely:
IF usage schedule=1 class THEN load 1,2 and 3 ON
IF usage schedule=2 class THEN load 1,2 and 3 ON
IF usage schedule=3 class THEN load 1 OFF & load 2,3 ON

E. HARDWARE DESIGN

At this stage, hardware is made, namely by combining components into one tool that is used to support the work of the tool made. Below is a series of components that have been combined. The power supply is a relay voltage source, Arduino, and buck converter. While the buck converter is built using a NodeMCU voltage source. Arduino is programming to run sensors and actuators and retrieve data from sensors, later the data received by Arduino will be sent to the NodeMCU. Furthermore, the NodeMCU will be sent to the database via the internet and the data will be displayed on the website. Below is a picture of the hardware design.

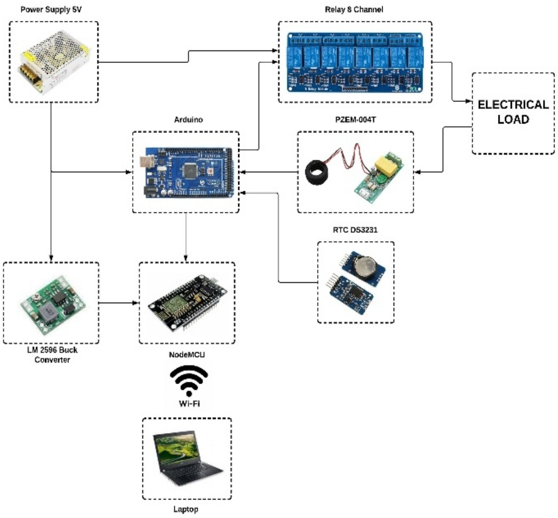

FIGURE 3. Hardware Design

The components used for hardware design include NodeMCU, Arduino Nano, PZEM-004T, RTC DS3231, Power Supply 5V, Buck Converter, Modul Relay 8 Channel, Relay AC, terminal block and socket. below is the physical form of the hardware that has been completed, which later the load will be connected to the hardware

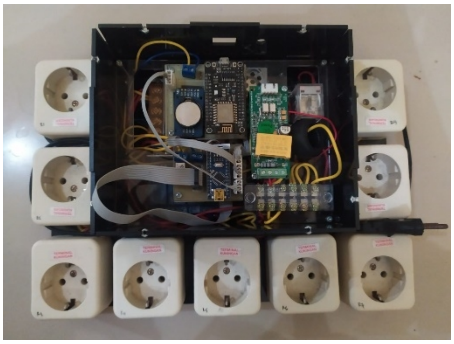

FIGURE 4. Hardware Design

F. SOFTWARE DESIGN

At this stage, software design is carried out using the website as a place to display data from sensors and control electrical loads using actuators.

FIGURE 5. Software Design

From the picture above is a website display that shows data from sensors, namely current, voltage, power, energy, usage costs and graphs of kWh usage.

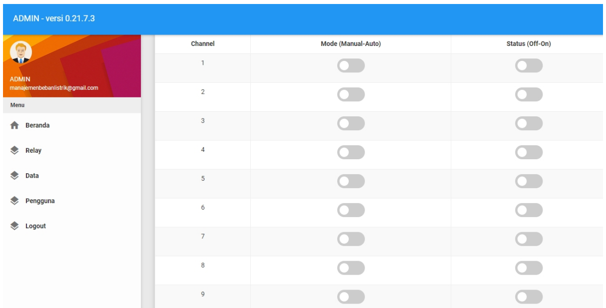

FIGURE 6. Software Design

From the picture above is a website display that is used to change the mode to control the electrical load automatically according to a schedule or manually by changing the relay status on the website.

III. RESULT

The results of testing the whole system, automatic mode according to schedule and manual mode according to status on the website. evaluate the suitability of electricity cost readings and the application of the decision tree method

A. MANUAL MODE TESTING

In manual mode testing, control ON and OFF on the relay via the website. The goal is to turn on the electrical load manually or outside of the schedule that has been made, this works when there are activities outside of the schedule.

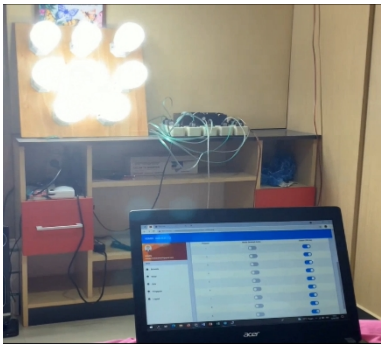

FIGURE 7. **Manual Mode Testing**

From the picture above, it is known that when the status on the website is in the ON position, the electrical load is on, while when the status on the website is in the OFF position, the electricity load is off.

B. OVERALL TOOL TESTING WITHOUT DECISION TREE

In this test, monitoring is carried out using a Tuesday schedule, with the electrical load in ON conditions in 3 different classes, namely at:
M-106 : 07.50 – 11.30 and 12.10 – 15.50
M-107 : 07.50 – 11.30 and 14.00 – 15.50
M-108 : 07.50 – 11.30 and 12.10 – 15.50
some samples of test data can be seen in TABLE 2.

TABLE 2
TEST RESULTS WITHOUT DECISION

No	Time	Current (Ampere)	Voltage (Volt)	Power (Watt)	Energy (kWh)
1	08.00	7,35	219,3	1619,5	0,269
2	08.10	7,35	219,5	1621,2	0,271
3	08.20	7,35	218,4	1619,7	0,270
4	08.30	7,36	219,6	1620,5	0,271
5	08.40	7,37	219,3	1621,3	0,271
6	08.50	7,36	219,6	1620,5	0,271
7	09.00	7,36	218,7	1620,4	0,271
8	09.10	7,34	218,6	1620,4	0,270
9	09.20	7,32	219,5	1619,2	0,269
10	09.30	7,33	220,1	1620,1	0,270

Based on all the data that has been obtained. The results of the electrical load test without a decision tree show that the total energy use is 10,63 kWh and the reading of the usage cost is Rp. 10.156. Below is the result of testing the system on the website display.

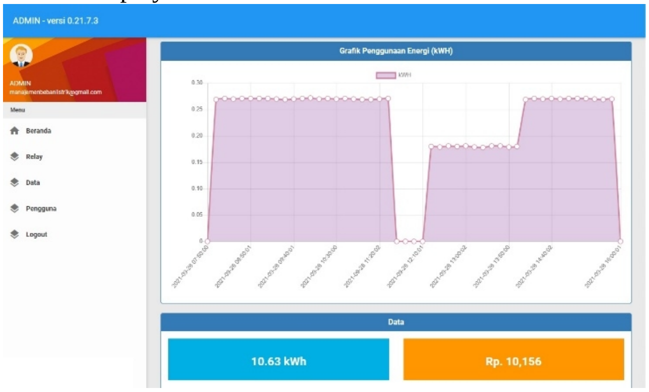

FIGURE 8. **Test Results Without Decision Tree**

C. OVERALL TOOL TESTING WITH DECISION TREE

This test uses a schedule on Tuesday, the electrical load is scheduled and the priority of the use of the electricity load will be determined from the schedule; when three classes are used simultaneously, there will be a load that is turned off. Some of the schedules that have been determined are as follows:
M-106 : 07.50 – 11.30 and 12.10 – 15.50
M-107 : 07.50 – 11.30 and 14.00 – 15.50
M-108 : 07.50 – 11.30 and 12.10 – 15.50
some samples of test data can be seen in **TABLE 3**.

TABLE 3
TEST RESULTS WITH DECISION

No	Time	Current (Ampere)	Voltage (Volt)	Power (Watt)	Energy (kWh)
1	08.00	6,35	218,8	1396,1	0,232
2	08.10	6,33	219,4	1395,5	0,231
3	08.20	6,35	218,9	1395,7	0,232
4	08.30	6,34	218,5	1395,6	0,232
5	08.40	6,36	219,4	1396,2	0,233
6	08.50	6,33	221,3	1394,8	0,231
7	09.00	6,34	220,6	1396,3	0,233
8	09.10	6,35	219,2	1395,5	0,232
9	09.20	6,33	219,6	1396,4	0,233
10	09.30	6,35	218,4	1395,6	0,234

The test results by reducing the use of electrical loads using a decision tree show that the total energy use is 9,46 kWh and the reading of the usage cost is Rp. 9.040. Below is the result of testing the system on the website display.

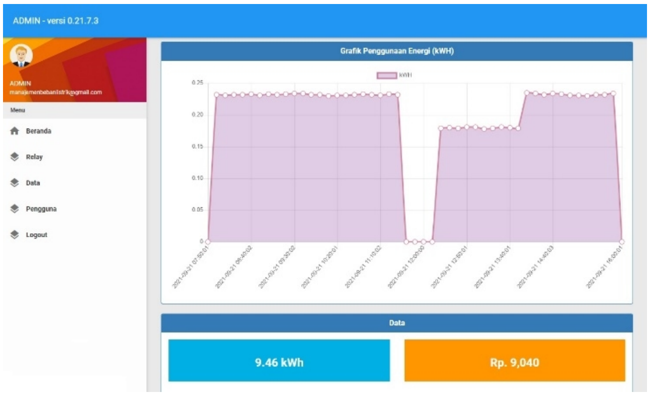

FIGURE 9. Test Results With Decision Tree

D. DATA LOSS TEST

In this test to find out data that was not sent or lost in data transmission. Testing is done by looking at sending data every 10 minutes, whether there is missing data or not. The goal is to determine the level of accuracy of the reading of electrical energy. Below is a data loss test.

No	Tanggal	Arus (A)	Tegangan (V)	Daya (W)	Energi (kWH)
1	2021-09-21 16:00:01	0	219.3	0	0
2	2021-09-21 15:50:01	6.33	218.7	1393.2	0.234
3	2021-09-21 15:40:03	6.33	219.5	1395.6	0.232
4	2021-09-21 15:30:02	6.34	218.6	1394.2	0.232
5	2021-09-21 15:20:01	6.34	219.3	1395.6	0.23
6	2021-09-21 15:10:01	6.31	219.5	1394.7	0.231
7	2021-09-21 15:00:03	6.36	219.1	1395.7	0.231
8	2021-09-21 14:50:02	6.33	218.6	1396.3	0.233
9	2021-09-21 14:40:03	6.32	221.6	1395.6	0.234
10	2021-09-21 14:30:01	6.35	217.9	1394.7	0.232
11	2021-09-21 14:20:01	6.32	217.5	1395.6	0.234
12	2021-09-21 14:10:01	6.36	218.4	1396.4	0.235
13	2021-09-21 14:00:02	4.89	219.2	1079.9	0.179

FIGURE 10. Data Loss Test Results

There is no data loss because all data sent every 10 minutes is already on the website display. This shows that the energy reading level in this system has a high accuracy.

E. COMPARISON TESTING SYSTEM

From these tests, data on energy use and cost readings were obtained. Data from scheduling with decision tree obtained energy use of 9,46 kWh and cost reading of Rp. 9.040, while the scheduling data without a decision tree obtained an energy use of 10,63 kWh and a cost reading of Rp. 10.156. When compared from the two data, the energy use decreased by 1,17 kWh and the usage cost was Rp. 1.116.

IV. DISCUSSION

The test results show that the Arduino microcontroller used can read sensors from the RTC in the form of date and time, Arduino is also able to read PZEM sensors in the form of current, voltage, energy and power. In addition, control and monitoring can be done through the website by sending data using NodeMCU. Testing the accuracy of the data obtained by looking at the data loss test, in this test there is no missing data. System testing related to reading usage costs is in accordance with the calculation and the use of the decision tree method is in accordance with the rules used.

In testing the system using the same schedule, there are differences in the use of electrical energy with the decision tree method. In the scheduling test without a decision tree, it is obtained that the use of electrical energy is greater, this is because the decision tree method is used to reduce the electrical load when the third class schedule is used.

The weakness of this research is that it has not been tested directly in classroom conditions. When compared with previous research (Juwita et al., 2018) namely the design and implementation of electrical power management using a greedy algorithm for home automation, in addition to different test sites in this study there are also cost readings and the website is not only used as monitoring but can control the load. Electricity manually and when compared with research (Nugraha et al., 2019) which is a monitoring and control system for household electricity consumption based on IoT and android, in addition to different test sites in this study, there is also electrical load scheduling and the website is not only used as monitoring but can control the electrical load manually which in previous studies did not exist.

V. CONCLUSION

In this study, the design of a management system for the use of electrical power with parameters of voltage, current, power, energy, and usage costs was carried out. This system uses Arduino as a controller and a website as an interface. NodeMCU is used to send data from Arduino and websites. In addition, this study not only controls the electrical load according to the schedule but can also control it manually through the website. Websites for monitoring have data updates every 10 minutes. Testing is only on a simulation scale.

In the future, this research still needs a lot of development and refinement. Extending the control with additional parameters can increase the practicality of this system. Furthermore, experiments can be carried out in the classroom directly to get more accurate data. Thus, it is possible to test the level of reliability of this system.

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