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Internet of things (IoT) based monitoring system for hybrid powered E-bike charging station

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ABSTRACT

The internet of things (IoT) has become an important foundation in the development of web-based and remote technologies. In the implementation of renewable energy in hybrid E-bike systems, IoT-based monitoring system integration has made a significant contribution to monitoring activities. One of the latest innovations in the development of IoT in E-bike systems is the application of power prediction and the coulomb counting method to estimate the charging time for a battery with a capacity of 200 AH, so that users can know the time needed to charge the battery efficiently. The IoT E-bike system is designed with user data display and monitoring features via the website, such as data on voltage, current, light intensity, battery percentage, power prediction, and prediction of the resulting battery charging time. Experimental results were obtained during the battery charging period, increasing the battery percentage from 50.43% (10 volts) to 71.769% (11.3 volts) in 4.5 hours with a battery charging charge of 153,866.4 C.

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1. INTRODUCTION

To reduce the increasing use of conventional energy and the dominance of fossil fuels in the transportation sector, E-bikes are becoming an increasingly vital, environmentally friendly solution [1]-[3]. Previous research reviewed the design and planning of electric vehicle charging stations for applications in the campus environment as the basis for research, and subsequent development on a hybrid continuity system that combines solar power plants and grid/PLN power grids for E-bike charging stations. This system utilizes solar energy during the day and automatically switches to PLN's power source when the storage battery runs out. By using automatic transfer switches, the transition between the two energy sources is carried out without interruption, with a focus on the charging control components for electric vehicles and the efficiency of the battery management system [4]-[6]. Recent research into the latest technological innovations that allow users to monitor the charging process via the website provides an important breakthrough in the development of E-bike charging [7], [8].

Online access to energy charging information provides flexibility for users to manage and optimize power usage on the E-bike. This system not only functions as a monitoring tool but also as an active step in reducing dependence on conventional energy by choosing a more environmentally friendly resource in the form of solar cells [9], [10]. The integration of the hybrid energy system with an automatic transfer switch as an alternative backup is also a development in system continuity [11]. In further development, the electric vehicle charging station system is integrated with current and voltage sensors using an Arduino Uno as a microcontroller and an Ethernet Shield Uno as an internet connection. However, the disadvantages in terms of cost and data management encourage the more economical use of the ESP8266 to process data from serial monitors to the website [12]-[14]. In this research, the ESP8266 was combined with the Arduino Mega2560. The website interface has the advantage of displaying data about usage levels, batteries, and power used, with support for storing data on the website [15], [16]. Allows access to previous data history. This research presents an electric vehicle charging station monitoring system designed using Arduino Mega2560 with the addition of ESP8266 for data transfer to the website [17], [18] along with the predicted charging time [19], [20].

Experiments carried out to test system performance include testing the delay in sending data to the web, comparing the percentage of errors in measuring sensor readings, predicting battery charging times at electric bicycle charging stations, and predicting battery charging at electric bicycle charging stations using the column counting method [21]-[25]. The development of IoT-based electric bicycle charging station technology contributes to monitoring and managing renewable energy parameters and the parameters of electric bicycle charging station components. With an internet connection and integration with a web server, information about renewable energy parameters, conventional energy, voltage, battery current, battery charging time, and power predictions based on sunlight intensity can be accessed in real-time, making it easy for users to manage and monitor electric bike charging stations. All this information is displayed on a web server connected to the internet, which can export data logger files from the website. In addition, another advantage is that the algorithm embedded in the system can find out the amount of power produced when the charging station is used, so that the data results can be used to streamline users in terms of charging time, and precise battery charging time.

2. METHOD

This research focuses on a monitoring system that is integrated between the hybrid-powered E-bike charging station and the website. The latest in the study is adding a prediction of the charging time and prediction of the power generated by the solar panel to charge the battery at a hybrid-powered E-bike charging station into an internet of things (IoT)-based monitoring system. This study aims to improve previous research. In the method chapter, the design form of the IoT monitoring system and the coulomb counting method. The coulomb counting method contains the calculations used for the basic algorithm that is fed into the monitoring system.

2.1. Design of the IoT monitoring system

Figure 1 describe the overall block diagram regarding input, process, and output for the IoT monitoring system at an electric bicycle charging station. In the input section, there is the source section hybrid, which includes renewable energy (solar panels) and PLN grid source [11]. In the process section, there are processing components from renewable energy solar panels in the form of solar charger controllers, batteries, inverters, and switches between solar panel sources and PLN grid source. PLN grid source the input components and data processes that are connected to the monitoring system are indicated by arrows.

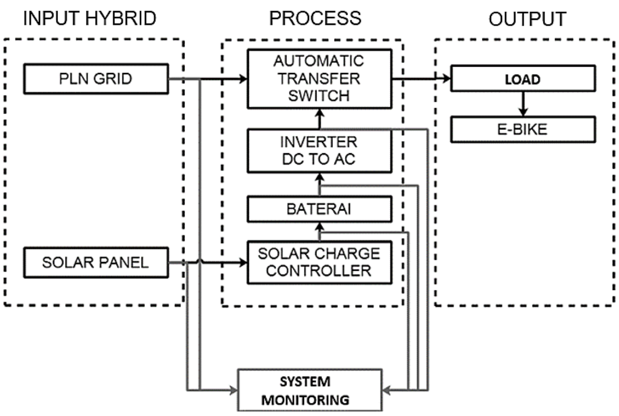

Figure 1. Block diagram of the IoT monitoring system at the hybrid-powered E-bike charging station

Figure 1 shows the block diagram of the IoT monitoring system which is described in more detail in Figure 2. Arduino Mega functions as a control center connected to several sensors to collect data. Connected sensors include a BH1750 lux sensor to measure light intensity, an ACS712 DC current sensor to measure direct current, a DC voltage sensor to measure direct voltage, and two PZEM sensors to monitor electrical parameters in alternating current (AC). After the Arduino Mega collects data from the sensors, the data is then processed and sent to the NodeMcu ESP8266 device. Next, the data is sent via a router network connected to the internet and stored in the webserver database. The data collected by this system is then displayed directly on a website. On this website, users can see the data that has been collected and processed in detail.

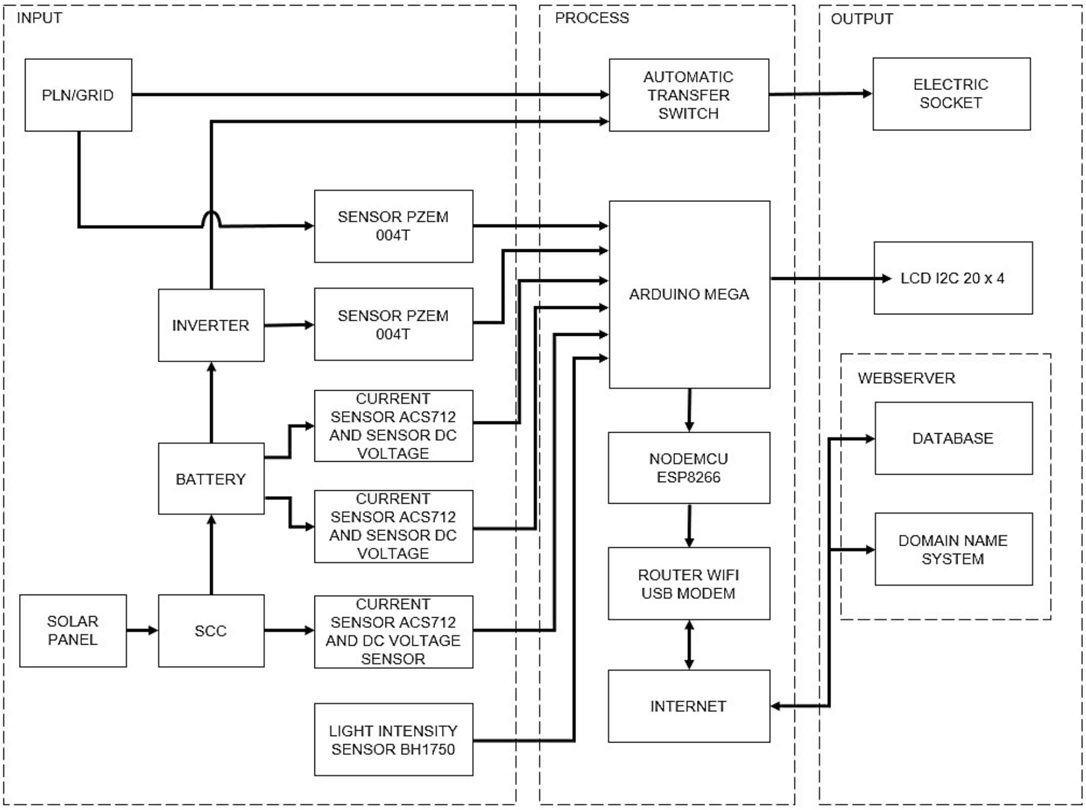

Figure 2. Schematic process of receiving and sending data on the monitoring system at the hybrid-powered E-bike charging station

Table 1. Sensors connected to components

Component	Data						
	Voltage	Current	Power	LUX	Status	KWh	frequency
Solar panel	√	√		√			
Solar charger controller	√	√					
Battery- inverter	√	√					
Grid PLN	√	√	√		√	√	√
Inverter	√	√	√		√	√	√

The data recorded in this system includes various measurements carried out by installed sensors, such as readings on solar panel components, solar chargers, batteries, PLN power sources, and inverters. Table 1 is a summary of information regarding sensors connected to components processed by the Arduino Mega device, sent via the Node MCU device, and displayed on the website. In the solar panel section, a voltage sensor is installed to monitor the voltage produced by the sun, an ACS712 current sensor to measure the current supplied from the solar panel to the solar charger controller, and a BH1750 sensor to measure solar intensity (lux), which is used for power prediction. In the solar charger controller section, install the ACS712 voltage and current sensor to monitor the voltage and charging current to the battery. At the battery output to the inverter, voltage and current sensors are installed to monitor the energy output to the inverter. The PLN grid and inverter sections are each equipped with sensors for voltage, current, power, kwh, system frequency, and system activation status, whether they are active or not. Apart from that, they are also equipped with connected load conditions. These data are displayed on web Figure 3, namely the monitoring system for electric bicycle charging stations.

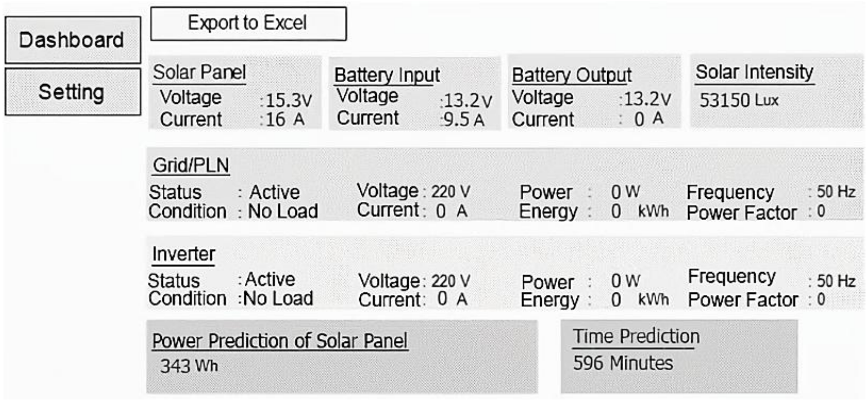

Figure 3. Website display of E-bike charging station monitoring system

2.2. Coulomb counting

The coulomb counting method is a method that allows containing a set of information (coulomb) or charging the battery by estimating the state of the charger (SOC) when the battery is in a discharged state and in a charging state. Therefore, state of charge (SOC) estimation makes it possible to support the prediction of storage battery charging of electric bicycle charging systems in research on power monitoring systems in internet of things (IoT)-based E-bike charging stations and is new in research [19], [20], [26].

SOC(t0) is state of charger in (1) state of charge (SOC) is the percentage of battery charge; SOC(t_0) is the percentage of the battery during initial conditions. C_{rated} is the capacity of the charge I_b is the charging current of the battery and Iloss is the current consumption of the battery.

$$SOC = SOC(t_0) + \frac{1}{C_{rated}} \int_{t0}^{t0+\tau} (I_b - I_{loss}) dt \quad (1)$$

In (2) V_{oc} is equilibrated OCV, V_{tr} is Voltage during measurement, Kv is constant from the V_{tr}-V_{oc}.

$$V_{oc} = V_{tr} \pm Kv \quad (2)$$

In (3) Q_{OUT} is the charge that increases when the charging time, Δi is the change in current on charge and T is the time in seconds.

$$Q_{OUT} = \Delta I \times T \quad (3)$$

In (4) and (2) is then included in the equation $C_{battery}$ or battery charge. $C_{battery}$ full in this section is the total charge value of the battery.

$$C_{battery} = \left(\frac{Q_{out}}{C_{batrery\ full}} \times\ 100\% \right) \quad (4)$$

From (4) to obtain the percentage, the formula P_r is a prediction of the charging time, Q_{total} is the total charge of the battery, dan Q_{input} is the charge that enters the battery or the prediction of the charging time that can be seen in (5).

$$P_r = \left(\frac{Q_{total}}{Q_{input}} \right) \quad (5)$$

To find the battery charging duration can be calculated by (6).

$$Charging\ duration\ =\ Total\ charging\ time -\ length\ of\ running\ charging\ time \quad (6)$$

To find the power produced, you can use (7).

$$Power\ Prediction\ =\ Intensity \times 0.0086 \times solar\ panel\ area \quad (7)$$

3. RESULTS AND DISCUSSION

In the study, an experiment was carried out by loading 2 electric bicycles with a load of 7.3 amperes for each electric bike. The time obtained to discharge the battery to a voltage of 10 volts is about 24,442 seconds. To calculate the remaining charge from the battery discharge using (3), the generated charge is obtained. the remainder of the discharge is about 356,850 C.

$$Q_{OUT} = 14.6\ A \times 24{,}442\ second$$
$$= 356{,}850\ C$$

Then, from the remaining charge, the remaining battery capacity is left, using (4).

$$C_{battery} = \left(\frac{Q_{out}}{C_{batrery\ full}} \times 100\%\right)$$
$$C_{battery} = \left(\frac{356{,}850}{720{,}000} \times 100\%\right)$$
$$= 50.4\%$$

Where the original capacity of the battery is 50.4% of the 100% capacity of 200 AH, then to determine the predicted battery charging time, what is needed is to calculate the remaining charge divided by the average current received from the solar panel to the solar charger controller, which is 9.5 A when converted to 9.5 C.

$$P_r = \left(\frac{356{,}850\ C}{9.5\ C}\right)$$
$$= 626.05\ Minutes \approx 626\ Minutes$$

So, from the Pr formula, the total charging time is 626 minutes. Each longer charging time will reduce the predicted duration of charging time. For more details on the charging prediction process and correlation to charging time predictions, see subsection 3.1.

3.1. Power prediction vs real power

In the prediction test for the power produced by solar panels using an approach to lux light intensity which is converted to watts/m^2 for the area of the solar panel. The experiment was carried out at 10.00 AM by comparing the energy value of the power from the test results and predictions calculated every 30 minutes to see the accuracy of the prediction power against the test power. At 10.30 AM, the test power was 253.98 Wh and the prediction power was 343 W. The value obtained from the BH1750 sensor had an error percentage of up to 25% and at peak conditions at 12.00 PM the error ratio reached 50.82%. In Figure 4. analysis of the prediction method for power systems that use solar panels with a prediction method based on solar intensity from the BH1750 lux sensor, there is a significant difference between the power measured directly from the solar panels and the predicted power. The data shows that the predicted power tends to be higher than the measured power at each test time interval. The causes of this difference include, among other things, the accuracy of the prediction model which is not yet optimal, fluctuations in the intensity of sunlight received by the solar panels, and errors in measurements or predictions.

3.2. Power management of battery capacity

The power supplied from the solar panels influences the increase in battery percentage from the start of charging to the end of charging. From the data obtained on Figure 5, the battery charging test started at 10.00 AM with a battery percentage of 50.438%. On test runs every half hour, the change in battery percentage is recorded along with the power supplied to the battery. The use of 2×100 watt solar panels produces a charge of 340,295.2 C from 10.00-10.30 AM. The total charge generated from 10.00 AM-14.30 PM is 153,866.4 C or the equivalent of an increase in battery percentage of 21.33% during the charging period and the total power used during charging is around 2,173.74 Watts.

3.3. Effect of increasing SOC percentage on battery capacity (AH)

Battery percentage (%) and battery capacity (AH) have a relationship with each other, which can be seen in Figures 6 and 7, where the electrical charger increases with the incoming charge based on the current charge capacity of around 720,000 minus the outgoing charge, then divided by the charging time. In conditions after discharging the battery, charging is carried out with an initial percentage of 50.43% and a capacity of 100.87 AH. With the increase in charge without loading after discharge, the charging will be at a maximum in the battery percentage graph, and the battery capacity in AH will be linear and tend to increase. The experiment was carried out until 14.30 PM, resulting in a battery increase of 71.769%, where the battery capacity in AH reached a value of 143.54 AH.

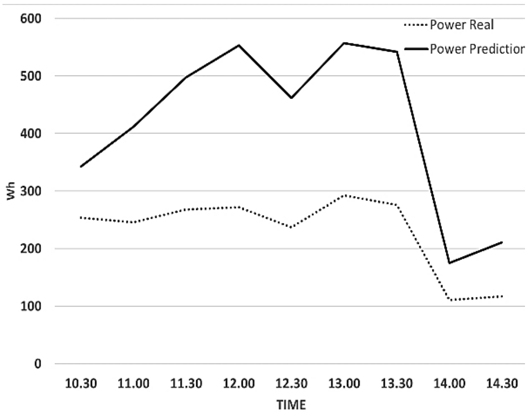

Figure 4. Comparison of real power vs predicted power

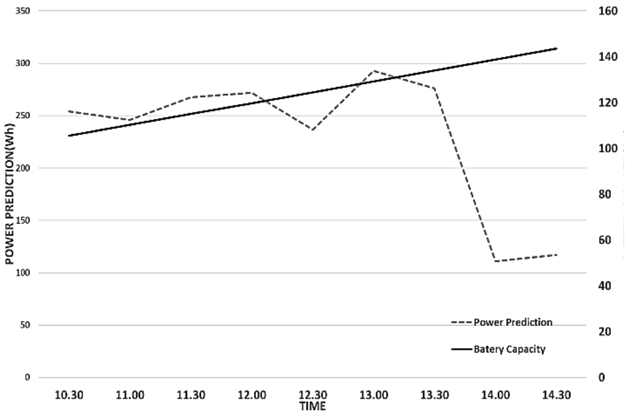

Figure 5. Effect of power prediction on battery capacity

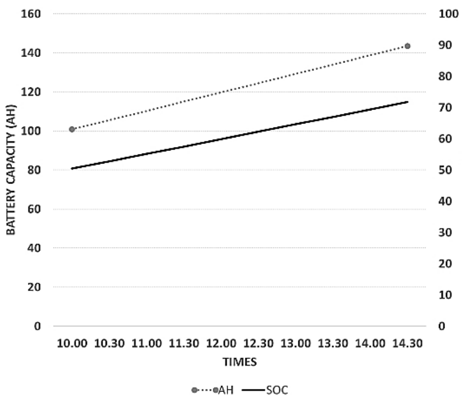

Figure 6. Effect of increasing SOC percentage on battery capacity (AH)

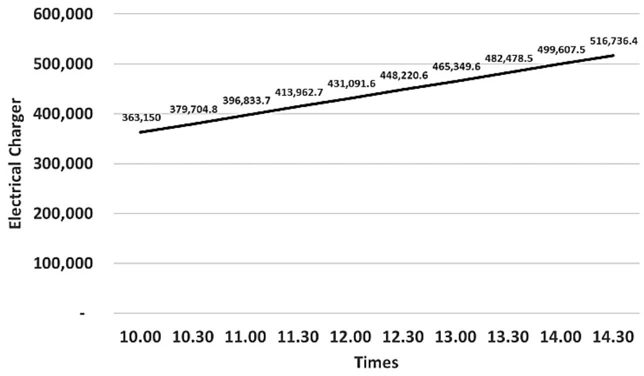

Figure 7. Electrical chargers are generated based on time

4. CONCLUSION

Based on the results of the experiment, the solar panel power prediction method used in the monitoring system based on sunlight intensity using the BH1750 lux sensor at 10.00–10.30 am produced a power prediction value of 343 Wh, while the power calculation result based on the lux value measured using a lux meter was 253.98 Wh. In this study, the coulomb calculation technique was used in the monitoring system as an application method to make a time prediction It was successfully applied to the monitoring system by displaying test data in the form of an initial battery capacity of 50.4% to 100% and a charging time duration of 626 minutes. So that in the results of the power management test on the battery monitoring system with a total battery capacity of 200 AH or 720,000 C, the battery charging process using solar panels was able to generate a significant charge during the battery charging period, increasing the battery percentage from the initial capacity of 50.43% (10 volts) to 71.769% (11.3 volts) within 4.5 hours with a battery charge of 153,866.4 C. The linear relationship between the battery percentage and capacity shows that the battery charging. The battery of solar panels can be carried out efficiently, even if there are fluctuations in the intensity of sunlight. In addition, the power generated by the solar panel also affects the time prediction result, where the more power generated by the solar panel, the faster the charging time prediction, and vice versa; if the power generated is smaller, the predicted charging time will be longer.

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