ISSN (p) : 2407-1323
ISSN (e) : 2442-4404
DOI : https://doi.org/10.25124/jett.v11i1. 7282
| Vol. 11 | No. 1 | Halaman: 16 - 25
JETT Jurnal Elektro Telekomunikasi Terapan Juli 2024

DESAIN DAN IMPLEMENTASI SISTEM INFORMASI MONITORING PENGGUNAAN DAYA LISTRIK DENGAN FITUR *MAP MODELLING* UNTUK MENDUKUNG PROGRAM *GREENCAMPUS* DI UNIVERSITAS TELKOM

DESIGN AND IMPLEMENTATION OF ELECTRIC POWER USAGE MONITORING INFORMATION SYSTEM WITH MAP MODELLING FEATURES TO SUPPORT THE GREENCAMPUS PROGRAM AT TELKOM UNIVERSITY

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Abstrak
Universitas Telkom (Tel-U) adalah salahsatu institusi pendidikan yang mempunyai komitmen dalam menjalankan program Green Campus. Dalam menjalankan program Green Campus ini, ada standar pemeringkatan yang diikuti oleh kampus Universitas Telkom yaitu UI Greenmetric. Salahsatu standarnya adalah terkait dengan energi dan perubahan iklim, dimana didalamnya terkait Dengan penggunaan listrik didalam kampus. Dan pada tahun 2023, penggunaan listrik di kampus masih tinggi serta belum adanya perangkat monitoring dari penggunaan listrik ini. Pada penelitian ini telah dibuat perangkat monitoring berupa sistem informasi monitoring penggunaan daya listrik dengan menggunakan *map modelling*. Penelitian ini dilakukan untuk gedung Selaru Universitas Telkom. Sistem informasi ini menggunakan *website* menampilkan hasil pengukuran penggunaan listrik yang dikirimkan oleh *microcontroller* melalui *google firebase* sebagai penyimpan *database* selanjutnya akan diproses untuk mengahasilkan citra berbentuk pemodelan peta dari gedung. Sistem Informasi monitoring penggunaan listrik ini mempunyai respon delay website menerima data dari alat sebesar 0,19 detik. Sistem informasi ini sudah berhasil menampilkan warna Gedung berdasarkan penggunaan konsumsi listrik yang didapatkan berdasarkan hasil pengukuran.

Kata kunci: ***Electrical Power Consumption, Website, Monitoring***

Abstract
Telkom University (Tel-U) is an educational institution that is committed to running the Green Campus program. In carrying out this Green Campus program, there is a ranking standard that is followed by the Telkom University campus, namely UI Green metric. One of the standards is related to energy and climate change, which relates to electricity use on campus. And in 2023, electricity use on campus will still be high and there will be no monitoring devices for this electricity use. In this research, a monitoring device has been created in the form of an information system for monitoring electrical power usage using map modeling. This research was conducted for the Selaru building at Telkom University. This information system uses a website to display the results of electricity usage measurements sent by the microcontroller via Google Firebase as database storage which will then be processed to produce an image in the form of a map modeling of the building. This electricity usage monitoring information system has a response delay for the website receiving data from the device of 0.19 seconds. This information system has succeeded in displaying building colors based on electricity consumption obtained based on measurement results.

Keywords : ***power electric consumption, website, monitoring***

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1 . INTRODUCTION

Electricity use on campus is very different from electricity use in housing in general. Electrical power on campus is relatively large in use because it supports a lot in the implementation of lecture activities in class and practical activities in the laboratory. Several factors that influence the value of electricity consumption on campus are influenced by: (1) The amount of equipment used, such as practical equipment in laboratories, room lighting, computers and other equipment for lecture and practical activities; (2). Length of use of electrical equipment, the average length of use of electrical equipment on campus is relatively longer; (3). Use of equipment that is efficient in consuming electricity; (4). Campus community habits in using equipment; (5). The use of increasingly sophisticated technology connected to the internet (Internet of Things) can affect electricity consumption because these devices may continue to operate in standby mode or be connected online.

To be able to manage electricity consumption well, many universities have adopted energy-saving practices, such as using energy efficient equipment, turning off equipment that is not in use, utilizing smart lighting systems, and choosing renewable energy sources to minimize environmental impacts. from electricity consumption. In fact, several universities have built solar power plants that can be used directly through a hybrid system. However, there are still many who have not implemented energy management properly and sustainably.

Energy management is a topic that is always interesting to discuss, where this includes planning and operating energy production and consumption units. One of the first steps for an effective energy cost control program is an assessment of energy consumption and energy use patterns [2,3]. Electrical resources in the campus environment are one of the most basic needs for carrying out learning and teaching activities, both for lecture activities in class and practical activities in the laboratory. Electricity is a very limited resource and the costs are quite high, so it is necessary to take savings and efficiency measures in the use of this electricity.

Monitoring energy use is one of human efforts to maintain the availability of energy on earth, so that excessive energy use can be avoided and the use of energy will be more efficient [3]. For this reason, in this research a monitoring device system was created in the form of an information system for monitoring electrical power usage using map modeling.

2 . BASIC THEORY AND DESIGN SYSTEM

2 .1 Basic Theory

2.1.1 Internet of Things

The internet of things (IoT) is a network of physical devices that can transfer data to each other without human intervention. IoT allows businesses to monitor, manage and automate their operations more efficiently and with more control [7] .

2.1.2 Electric Current

Electric current is an electrical movement that occurs due to electrons moving from one point to another in an electrical circuit per unit time. The unit of measurement for electric current is Coulomb/second or Ampere [13]. The difference in voltage or potential between two points in a conductor causes electric charges to move in the conductor. This movement is called electric current. Electric current moves from points with high voltage to points with low voltage.

2.1.3 Electrical Voltage

Voltage is the difference in electric potential between two points in an electrical circuit which is measured in volts (V). This quantity shows the potential energy of the electric field which causes electricity to flow in an electrical conductor. Electric voltage makes negatively charged objects move from low voltage terminals to high voltage terminals. As a result, the direction of conventional electric current in an electrical conductor flows from high voltage to low voltage [11]. Kirchoff's Second Law states that the total voltage (potential difference) in a closed circuit is zero, so the formula can be written as follows:

$$V_{total} = V_1 + V_2 + V_3 + \cdots + V_n \quad (1)$$

2.1.4 Google Firebase

Firebase is a service from Google that helps application developers create applications. Google Firebase offers user authentication (with email and password), storage (for storing files) and cloud messaging (for sending notifications) features [6] . Apart from that, it also offers a real-time NoSQL database feature with a JSON (Java Script Object Nation) data structure that is easily accessible via web code in hybrid applications. To create an application, you need storage media in the form of a database that can be accessed from the server side using server-based programming languages such as PHP and ASP. The hybrid application will send a request to the server which is then forwarded to the database to create, read, update or delete data.

2.1.5 JSON

JSON is an ideal format for data exchange, easy for humans to write and easy for computers to understand. JSON is in text format with a general programming language and is not tied to a language. JSON can use the programming languages C, C++, C#, Java, JavaScript, Perl, Python, and others. JSON can store data in arrays and these arrays will be stored in keys. Using JSON usually involves encode and decode functions. The encode function will convert the array into a format that can be read as a JSON array. The decode function will retrieve the value of the variable in JSON array format [9]

2.1.6 HyperText Markup Language (HTML)

The standard commonly used to display web pages is HTML. HTML is an internet standard defined and regulated by the World Wide Web Consortium (W3C). HTML was created by Caillau TIM and Berners-lee Robert when they worked at CERN in 1989 (CERN is a high energy physics research institute in Geneva). HTML is a markup language used to create web pages, display various information in internet web browsers and simple hypertext formatting written in ASCII format files to produce an integrated display. In other words, files created in word processing software and saved in normal ASCII format become web pages with HTML commands [15].

2.1.7 JavaScript

JavaScript is an interpreted programming language that is widely used to make static web pages into dynamic and interactive pages. JavaScript is a very mature programming language and can work together with HTML documents, throughout the history of the internet this language was the first scripting language for the web. This language is a programming language that provides extra capabilities to the HTML language by allowing the execution of commands on the user side, namely on the browser side rather than on the web server side [15].

2.1.8 Bootstrapping

Bootstrap is a CSS framework that makes it easy to design websites and web applications. This framework has HTML and CSS-based design templates for typography, forms, buttons, navigation and other interface components, as well as optional JavaScript extensions. Bootstrap is CSS built with LESS, a pre-processor that provides the flexibility of regular CSS[15].

2.2 System Design

2.2.1 System Design Flowchart

This research designs an information system for monitoring electrical power usage that uses Firebase as a database. This information system has a monitoring feature for electrical power

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consumption which comes from the voltage and current flowing when the device is connected to the sensor and sent via the internet to Firebase. The goal is that electrical power usage can be monitored and controlled remotely, because it can be accessed using the internet network. The following is a flow diagram of the system design of the application created:

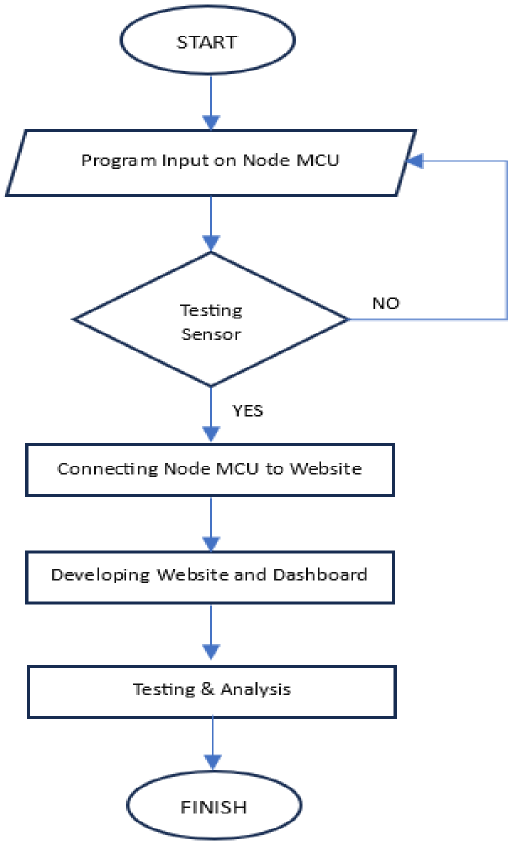

Figure 1. System Design Flowchart

Figure 1 explains the flowchart for designing an information system for monitoring electrical power usage using map modeling, with the following stages:

- In the first stage of system design, a program is created which is then input into the Node MCU to set the voltage sensor and current sensor.
- In the second stage of system design, before implementing the sensors on the Node MCU, the sensors will be tested or also known as the sensor calibration process. At this stage the sensor will measure the amount of current and voltage and then compare it with a standard measuring instrument that functions as a calibrator, namely a multimeter. Sensor and multimeter measurement data will be recorded and then compared. If the value from the sensor and multimeter measurements has a small percentage error value, it will proceed to the next stage.
- After completing sensor testing, the next stage is to create a website and at the same time connect to the website. The website that is built will be connected to hardware, namely a collection of sensors and a microcontroller in the form of a Node MCU. The sensors will measure the current and voltage values from the electricity distribution panel which are then connected via the internet to the Firebase database and will be displayed on the website. The software is also connected to Google Firebase. Google Firebase is a Mobile Apps Developer like Firebase real-time Database. The measured current and voltage will be processed to be sent with an output in the form of electrical power values, then sent to Firebase for processing and then sent to the connected website page. On the website page, you can see the current amount of electrical power consumption.

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2.2.1 System Block Diagram

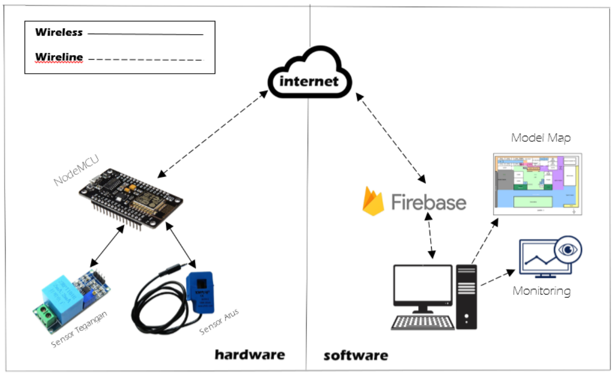

Figure 2. System Block Diagram

Figure 2 shows that the information system for monitoring electrical power usage using map modeling consists of two parts, namely the hardware and software parts.

- The hardware section consists of 2 sensors, namely a voltage sensor and a current sensor and 1 microcontroller in the form of a Node MCU. This hardware section will measure electrical power usage data from the electrical distribution panel in the form of current and voltage values. We do not explain this part of hardware design in this journal because it is part of another research. We use the measurement results from testing these devices as input for the monitoring website [1].
- Meanwhile, the software section is creating a monitoring information system in the form of a website that will display real-time electrical power usage data. The data is then processed and displayed using map modeling.

This monitoring information system website will be connected to hardware, namely a series of sensors and a microcontroller in the form of a NodeMCU. This hardware is a device that knows the current and voltage values from the electricity distribution panel which is then connected via the internet to the Firebase database and will be displayed on the website. The software section is also connected to Google Firebase, which is a Mobile Apps Developer. The known current and voltage will be processed so that it is sent with an output in the form of electrical power values, then sent to Firebase for processing and then sent to the website page that has been connected so that on the website page, you can see the amount of electricity consumption that is currently running in real time.

2.2.2 Design of an Electricity Consumption Monitoring Information System

The system created is a website page for monitoring electrical power consumption, where to access the website you are required to log in first. The account used is an admin account that has been registered in the Firebase database. When you have logged in to the website page, the admin can monitor current, voltage and electrical power. There is a parameter that is a benchmark for the maximum power in a room which will be accumulated in value with other rooms on the same floor, so that it can become the total power value for one floor and depicted in the form of a color image. The features you get from this website are monitoring and also adding sensors to the room if you want to install the device again in another room. The monitor can monitor the current conditions of electrical power usage on a floor, whether it is still within reasonable limits or not, monitor the amount of current, voltage and electrical power in the room where the designed equipment has been installed. Map Monitoring, in this feature, the user, in this case the admin, can carry out more detailed monitoring regarding rooms that consume electrical power.

2.2. 3 Usecase Diagrams, Activity Diagrams, and application sitemaps

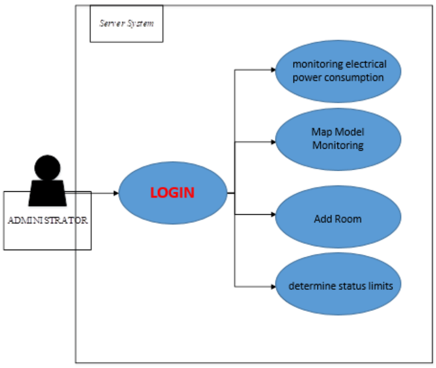

Figure 3. Use case System Diagram

Figure 3 explains the process flow of the application being created, with the following requirements:

1. To be able to become an administrator, you must first log in according to the email and password that you have registered.
2. There are 4 types of monitoring carried out by administrators, namely monitoring electrical power consumption, carrying out *map modeling monitoring*, adding rooms to be monitored, and determining *limit status*.

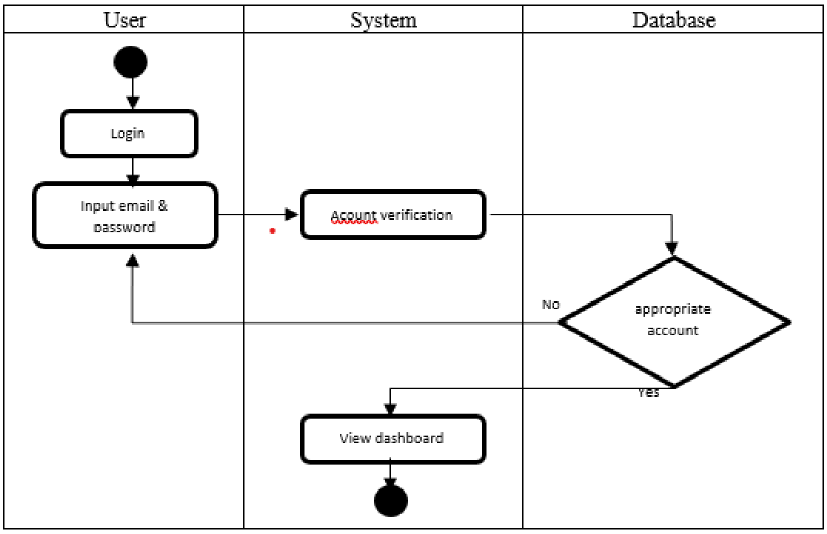

Figure 4. Login Activity Diagram

Figure 4 explains user data access activities. Users are required to log in by entering the registered email and password, after which account verification will be carried out. Once the account is deemed appropriate, you can access the data in the form of a dashboard page.

3 . RESULTS AND TESTING

3.1 Electrical Power Measurement

This electrical power measurement was carried out in previous research which was carried out by measuring the use of electrical power consumption for 60 minutes on 3 floors, namely the ground floor, 1st floor and 2nd floor. The measurement results are as follows:

Table 1. Power Consumption measurement results

Floor	Room	Power (kVA)	Total Power (kVA)
Basement	Lab	457	957
	LAK	141	
	G4	359	
1st	A1	560	2068
	B3	581	
	B5	927	

Floor	Room	Power (kVA)	Total Power (kVA)
2nd	14	417	1547
	15	492	
	16	638	
3rd	Lab 1	674	1678
	Paintry	292	
	Lab 4	712	

3.2 Website View

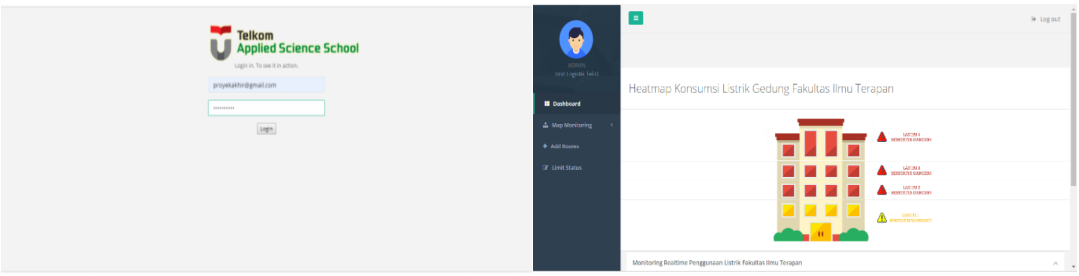

Figure 8. Website appearance

Figure 8 shows the appearance of the electrical power consumption monitoring website. Users must first log in with an account that has been registered with Firebase Authentication to be able to enter this monitoring system. After logging in, the user will be taken to the dashboard page to see the current electricity usage status. Users can see electricity usage indicators by looking at the colors that have determined the maximum and minimum limits for power used, so that users can change the electricity usage limits as desired if they have successfully accessed the website. Also on the dashboard page, users can access other features. The color for each floor is determined based on the results of electrical power consumption measurements. Where for power usage 0kVA - 500kVA is green, 500kVA-1000kVA is yellow, and above 1000kVa is red.

3 .3 System Testing

3.3.1 User Integration Testing with Database

To be able to carry out this test, you must first register user data with Firebase Authentication. The first step taken is authentication testing by the user logging in. Whether the user logs in successfully or not, if they log in successfully they can see the information displayed according to the data in the database. The following is a successful account login display:

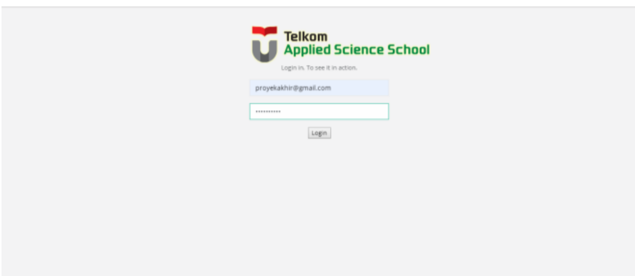

Figure 9. User login page

After the user successfully logs in, the user will be directed to the dashboard page as shown in Figure 10 below:

Figure 10. Dashboard page

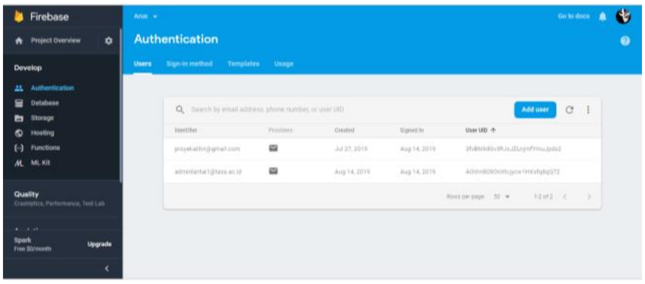

Figure 11. Authentication of user accounts

Figure 1 shows that the process of testing User Integration with the Database can be successful by proving that the user can enter the dashboard menu after successfully logging in.

3.3.2 Website Integration Testing with Database

This test is carried out to find out whether the features displayed on the website are in accordance with the database that has been created and are running well and correctly.

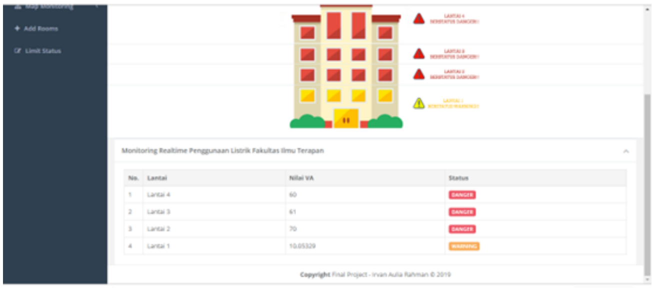

Figure 12. Voltage value data on the website

In Figure 13 you can see that this test was carried out to ensure that users get data from the real-time database that is connected from Firebase to the website. Based on the measurement results, it was found that for floor 1 the status was WARNING because the electricity usage reading was 10 VA, while for floors 2 to 4 the status was DANGER because the reading was above 60 VA.

This value is based on readings obtained from Firebase as follows:

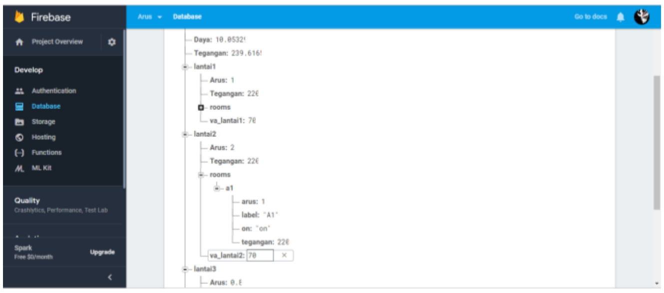

Figure 13. User database integration

3.3.3 Delay Testing

The purpose of Delay Testing is to find out the average time needed to send and receive data in seconds. This test was carried out by measuring the response delay of the website from receiving data from the tool until it appeared on the web in the form of a building coloring simulation dashboard. This test measures from the device to the user. This test uses additional devices to measure time, namely a camera that records the testing process, then uses the Adobe Premiere Pro application to see the time sent from the tool to the website. The application is connected to WiFi (2.4 GHz) with an uplink network speed of 10 Mbps and downlink 5 Mbps. The following is the delay test carried out:

Table 1. Data delivery delay testing

No	Testing	Difference (Seconds)	No	Testing	Difference (Seconds)
1	1st Test	0.12	11	11th Test	0.20
2	2nd Test	0.20	12	12th Test	0.22
3	3rd Test	0.21	13	13th Test	0.18
4	4th Test	0.18	14	14th Test	0.21
5	5th Test	0.30	15	15th Test	0.10
6	6th Test	0.13	16	16th Test	0.20
7	7th Test	0.28	17	17th Test	0.20
8	8th Test	0.20	18	18th Test	0.18
9	9th Test	0.11	19	19th Test	0.20
10	10th Test	0.19	Average		0.19

From table 1 it can be seen that the average sensor data transmission delay to the real time database is 0.19 seconds, so the delay is included in the ITU-T standard, namely 250 ms or 0.25 seconds.

4 . CONCLUSION

a) Electricity consumption monitoring information system with map modeling feature to support green campus management running well, namely by being able to create a modeling map by giving each floor a different color according to electricity usage.
b) This application system was created to carry out remote monitoring with data transmission in 0.25 seconds.
c) The delay for the website receiving data from the tool is 0.19 seconds, which means it meets the ITU-T standard, namely 250 mseconds or 0.25 seconds.
d) Information system regarding real-time electrical power consumption can be displayed after an integrated tool application has been created and based on interviews conducted with users, they provide feedback that this system is needed to be able to monitor current conditions regarding electrical power consumption.

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ISSN (p) : 2407-1323
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