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Using IOT Technology to Design and Implement a Cost-Optimized Energy Metre System

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Abstract

The obvious growth in power bill expenditures is one of the most significant factors impacting the lifestyle and economy of all countries throughout the world. Customers lose money as a result of excessive energy depletion. Furthermore, the high cost of electricity as a result of excessive consumption may lead to a major quarrel between the user and the electrical distribution providers. The lack of an energy usage monitoring system aggravates the situation. As a result, it became important to build an energy consumption monitoring technique capable of estimating daily usage and providing it to clients in an easy-to-understand format. The purpose of this study is to create and deploy a low-cost energy metre system utilising internet of things (IoT) technologies. This is a warning to customers to take precautionary measures to help reduce the increase in their power bills. This system was created using the TINKERCAD programme and the Arduino Integrated Development Environment (IDE). Furthermore, system deployment and testing have been accomplished, and the desired outcomes have been thoroughly examined and achieved. The system has worked flawlessly and adequately. It is also simple, quick, and convenient to use.

***Keywords:** Internet of Things (IOT), Energy Meter System, Integrated Development Environment (IDE), TINKERCAD program*

INTRODUCTION

Electricity is widely acknowledged as one of the most important sources of human development and progress. Furthermore, one of the most serious difficulties affecting society's lifestyle and the economy in all nations throughout the world is the astonishing rise in energy expenses (Yousif et al., 2020). Power consumption is rising due to inefficient resource usage, which causes the depletion of superfluous energy sources, resulting in financial losses for governments and users (Saini, D. K., 2021). Furthermore, a rise in power tariffs as a result of excessive use might spark a major conflict between customers and electrical distribution corporations. Many various prior literary works are gathered to be reviewed and evaluated in order to get key project information, summarise them into the core components necessary, and find the best techniques that can be employed in the system's implementation.

According to a study done by Kewal et al. (2018), the contemporary era's rising need for power. Furthermore, many industries, such as agriculture, healthcare, and domestic needs, demand the utilisation of energy. The financial cost of power rises as the population grows, as does the demand for electrical equipment. Furthermore, consumers' incapacity to limit their energy consumption is a major issue that must be addressed in order to decrease energy depletion and financial losses. This system contains additional criteria, such as eliminating energy theft and metre manipulation, which can result in considerable economic losses. This research also aims to develop a gadget that assists individuals in managing power in order to reduce wasteful depletion and money waste, which can result in considerable financial losses. (Pooja et al., 2016) performed research demonstrating the function of electricity in people's everyday lives as well as the need of preserving it in order to establish an economically conscious society in the field of electricity.

Customers should also keep track of their energy consumption to minimise waste. This study aims to assist consumers in managing their energy use. Customers may monitor their power use through the Internet by using an IoT-based power metre. As a result, the Internet of Things is laying the groundwork for device-to-Internet connection. Furthermore, standard power metres put in houses have a number of drawbacks, including the simplicity with which energy theft can occur due to the meter's lack of a control mechanism.

Furthermore, the typical billing method, which needs the employee to visit each house and collect the bills, is inefficient and time consuming.

Aneesh et al. (2017) conducted a study that revealed increasing customer complaints against energy employees as well as a lack of trust among them as a result of high power bills, which caused a host of economic issues. Furthermore, an intelligent power metre should be constructed to monitor daily units in order to assist clients in understanding why their rates are growing.

Customers, regardless of whether they are aware of energy depletion or energy theft in their houses, will remedy their electrical difficulties once they understand why. As a result, addressing this issue is critical in order to minimise energy depletion and financial losses. In this study, the smart power metre, which monitors and regulates energy use, is utilised to monitor and manage energy consumption.

Birendra kumar et al. (2017) explored the difficulties that consumers and meter-reading employees may have as a result of the old ways for receiving power bills. To obtain the electricity bill, the person reading the power metre must visit all of those residences. This task is worthless since it is difficult and time-consuming. As a consequence, a smart energy metre is required, which calculates electricity bills and delivers them to both power and customers through the internet. This smart metre will also solve a number of issues, such as metre reading mistakes by workers, which result in increased power bill rates. It will also raise customer awareness about energy saving and help to prevent energy depletion.

The purpose of this study is to create and deploy a low-cost energy metre system utilising internet of things (IoT) technologies. This is a warning to customers to take precautionary measures to help reduce the increase in their power bills.

METHOD & MATERIALS

In this study, we explored the installation of an efficient energy metre system based on IoT technology. The circuit flow diagram of the energy metre monitoring system is shown in Figure 1 to emphasis the system components and their connections.

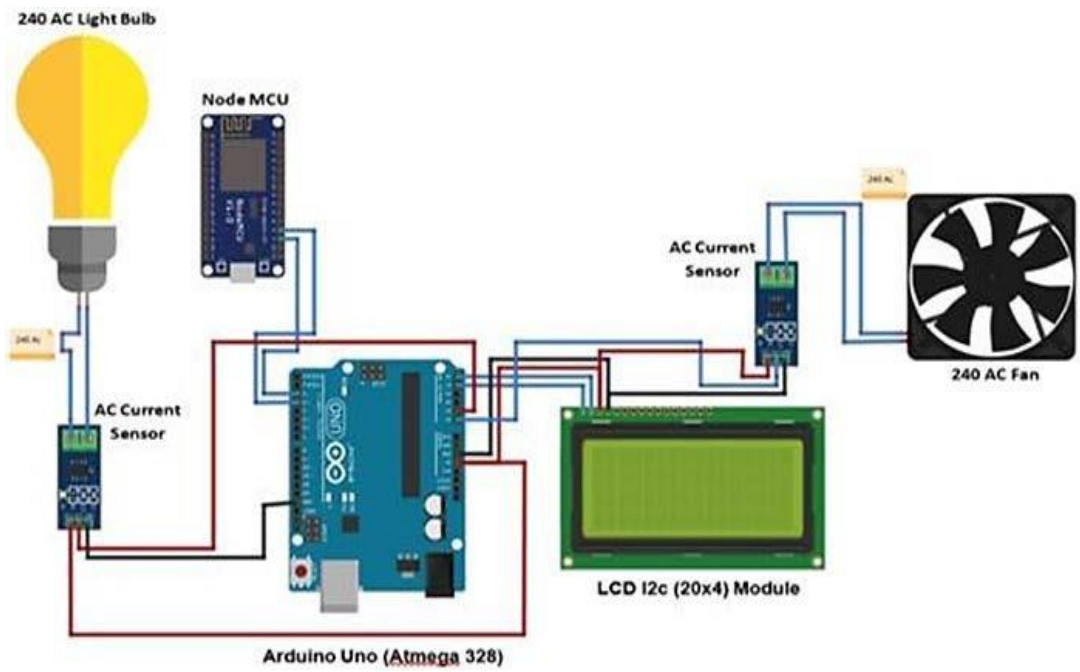

Figure 1: Circuit flow Diagram

The major purpose of this system is to design and deploy a low-cost energy metre system that uses Internet of Things (IoT) technology to allow users to monitor energy metre readings via IoT.The operation of the energy consumption monitoring system is dependent on the design of a system that includes the following devices: collection.

ESP8266 Node MCU

The Node MCU is an Internet of Things platform. It has a Wi-Fi gadget that allows it to connect to the Internet and communicate with other systems. As a result, this platform is ideal for all Internet of Things applications. The Node MCU is the central processing unit (CPU) of the smart energy metre system; it manages all of the system's components and links them to form an integrated system. It performs a variety of duties, including as mathematical and logical computations, as well as coding, analyzing, and decoding all incoming data. The Node MCU contains 8 numeric pins for input and outputactivities, as shown in Figure 2. (Components101, 2019).

Arduino Uno

Response Figure 3 depicts the Arduino Uno, an open-source electrical system. It is a miniature computer system contained on a single chip. The Arduino is a critical component of this system since it reads and analyses sensor data to power the whole system. It features six analogue input ports for sinusoidal signals. It features 16 digital data input/output pins. PWM is utilised on six of the sixteen digital input and output pins (PWM). A USB cable, a battery, or an AC/DC converter can power it. The Arduino Uno has a working voltage of 5 volts and a current of 20 mA. The Arduino Uno software is compatible with both Macintosh and Windows operating systems, making it superior to other microcontrollers that exclusively support Windows. The Arduino Uno is utilised in this study because of its remarkable features, which include:

- The performance quality
- Small size.
- Cheaper than other microcontrollers (Basma, A. et al, 2019).

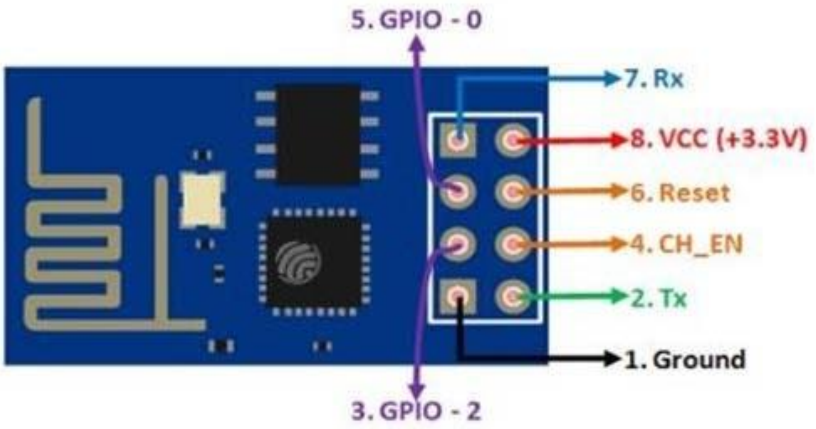

Figure 2: Pin out of the ESP8266

Figure 3: Arduino Uno

ACS712 Current Sensor

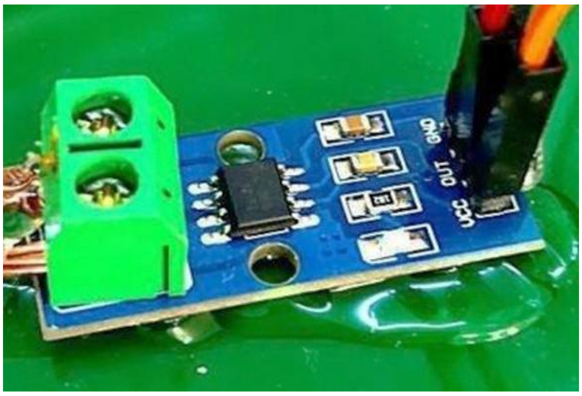

Figure 5: ACS712 Current Sensor

The Response ACS712 Current Sensor measures electrical current and is used in devices that require it. Depending on whether the gadget is analogue or digital, this sensor provides a signal. Furthermore, in this application, current sensors are utilised to monitor the current in specific devices such as a fan and a light bulb. As illustrated in Figure 4, each current sensor has two input slots, one of which is linked to the node MCU and the other to the device whose current must be measured, either the fan or the bulb (Components101, 2019).

Designing the Software

The Atmega 328-powered Arduino Uno is an open-source electrical system. It interfaces with other devices such as the Arduino Node MCU, ACS712 Current Sensor, AC Fan, AC Light Bulb, and LCD I2C (20x4) using the programming techniques required by the Arduino Integrated Development Environment, which was used to construct this system. In addition, the system code is written in the simplified C++ language, which was created specifically for system code. Furthermore, the IDE application makes it easy to develop and download Arduino board instruction codes, as well as swiftly run them in the programme assigned to them by the Windows operating system. In addition, as shown in Figure 5, the programme icon is uploaded to the node MCU, which then transfers the data to the IOT Blynk platform through the Wi-Fi module. For the creation of the energy metre monitoring system, the IOT BLYNK platform was used. This platform is intended to aid in the creation and design of IOT-related activities. The smart energy metre system is also created with the TINKERCAD simulation tool for simplicity of system modelling as well as speed and accuracy (Diygeeks.org, 2019).

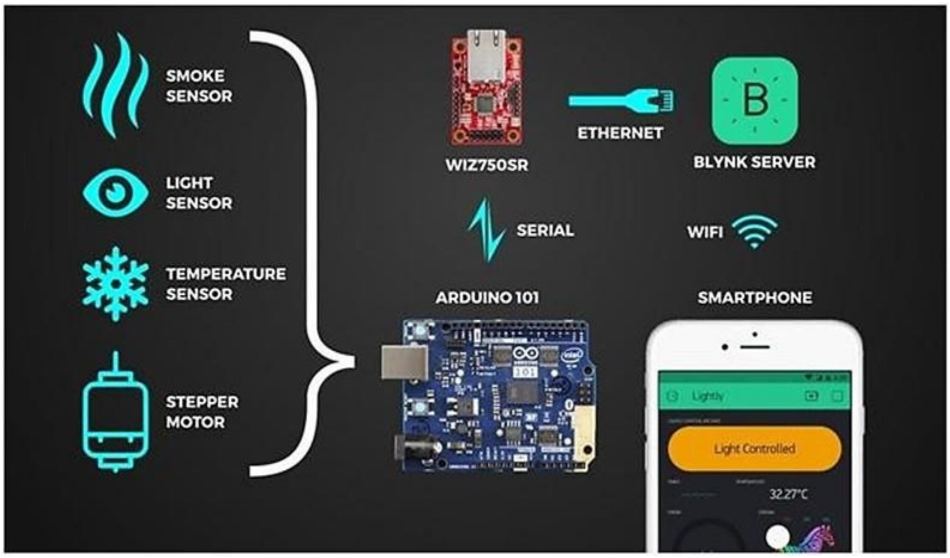

Figure 5: IOT BLYNK platform.

PROPOSED SYSTEM IMPLEMENTATION

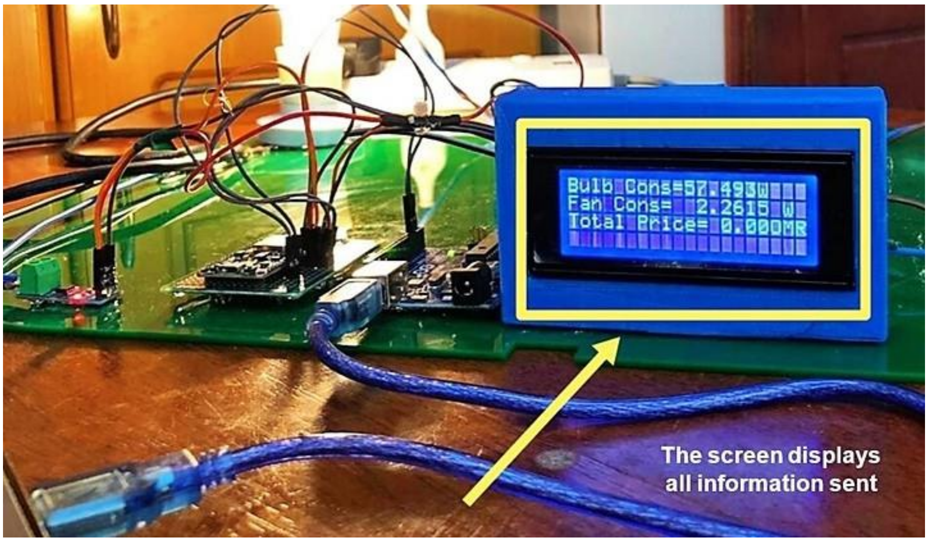

Figure 6: System implementation

As illustrated in Figure 6, the smart energy metre is built by connecting important components such as the node MCU, Arduino Uno-based Atmega 328 microcontroller, ACS712 current sensor, AC fan, AC light bulb, and LCD I2C. (20x4). The Arduino Integrated Development Environment generates system code, which is subsequently uploaded to the Arduino to carry out system commands. Two current sensors are utilised in this system: one to detect the current in the AC light and the other to measure the current in the AC fan. Each current sensor has two input slots, one for the device whose current is being measured and one for the Arduino Uno slot, which utilises the ATmega 328. Furthermore, another Arduino type, Node MCU, has been released; it operates in accordance with the instructions sent by the Arduino UNO to the IOT BLYNK App through the Wi-Fi unit. As a result, the Arduino Uno, which employs the Atmega 328, is linked to the Arduino Node MCU in order to transmit data to the selected software through the Internet. In addition, the Arduino Uno is linked to an I2C (20x4) LCD screen that displays current measurements. The Arduino Uno (Atmega 328 in this case) and Arduino Node MCU work together as the core system that connects all the devices; hence, they are regarded as the system's heart and for device communication. Additionally, because the Arduino Uno is a microcontroller with the Atmega 328 as a data processor, the system programming code is loaded onto it and transferred to the Arduino Node MCU. As a result, all essential data is sent to the BLYNK platform via the Wi-Fi unit in the Node MCU, which is specifically intended to show system statistics such as power and pricing. Furthermore, the energy metre data is promptly monitored.

Proposed System Testing

This section will describe how to test the proposed system to ensure that the calculations and data analysis results are valid (Yousif&Saini, 2020).

HARDWARE COMPONENTS TESTING

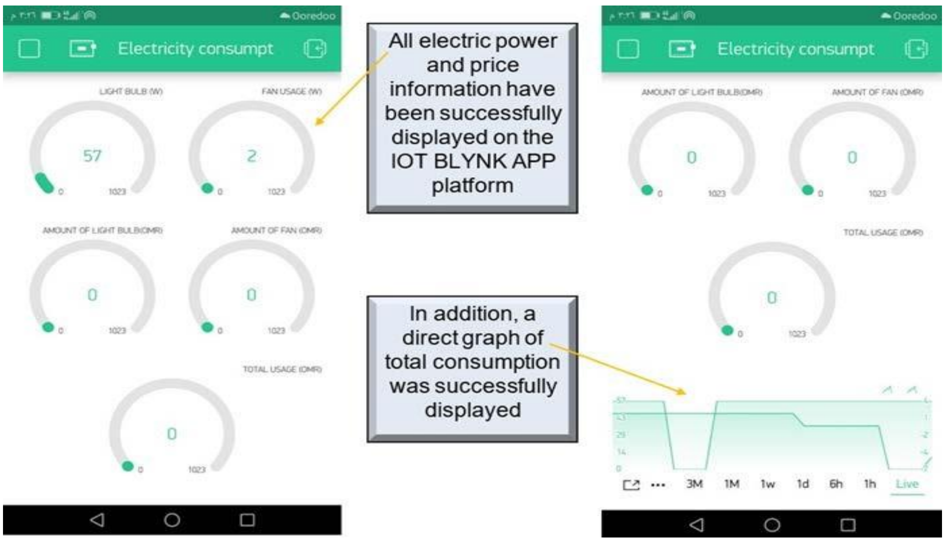

Figure 7: System result of testing

The suggested system test will assess operational efficiency and the speed with which orders are responded to. Furthermore, each device is examined separately many times to confirm that it is completely shown; ultimately, the system is extensively assessed to ensure that the operational efficiency target is accomplished, as illustrated in Figure 7. The Node MCU's Wi-Fi module successfully communicates all relevant information to the BLYNK platform. In addition, the energy metre values may be directly watched. Figure 8 depicts the results of testing an AC light bulb and an AC fan. Lamp and fan current levels are detected using two sensors. Each current sensor captures and transmits data using Wi-Fi modules.

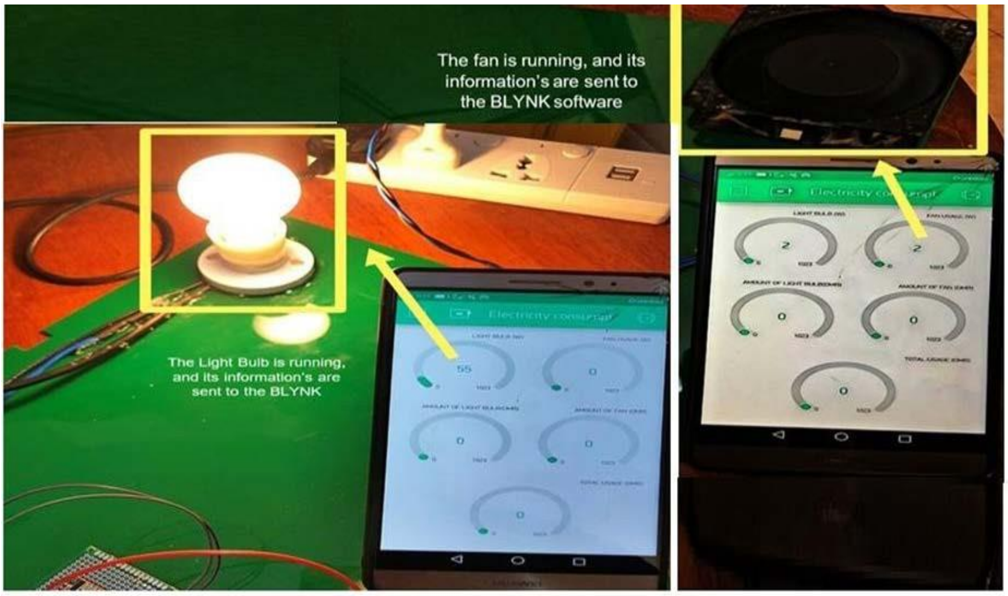

Figure 8: Result of testing AC Light Bulb and AC Fan

Economic Cost Analysis

Table 1: The total cost of the project Hardware components.

No	Item	Qty	Price(OMR)	Total(OMR)
1	NodeMCU	1	4	4
2	ArduinoUno (Atmega328)	1	5	5
3	AC CurrentSensor	2	4	8
4	LCD I2c(20x4)	1	4	4
5	ACLight Bulb	1	2	2
6	AC Fan	1	18	18
Total				41 OMR

Before the project begins, it is critical to determine the economic and technical costs. As a result, the total cost of all components necessary for this system, which may be found on websites, is determined. Furthermore, our research revealed that the procedure is appropriate and affordable. Table 1 shows the entire cost of the project.

RESULT AND DISCUSSION

As indicated in Table 2, the energy consumption monitoring system was tested 10 times for each component. Furthermore, all of the above-mentioned components have been tested and proven to be exact and efficient. The Arduino Uno Microcontroller, AC Fan, AC Light Bulb, and LCD 12C (20x4), for example, all passed the test with flying colours since they functioned well and without flaws. The node MCU completed the test with a score of 90%, with a small mistake due to limited internet connectivity in the testing region; thus, this is a high percentage. As indicated in Figure 9, the current sensor passed the test by 80%, and the rate shortfall is most likely caused by a power loss.

Table 2: Tests applied on system components

Tests/ component	Node MCU	ACS712 Current Sensor	Arduino Uno	AC Fan 240	AC Light Bulb	LCD 12c (20x4)
No. of tests applied	10	10	10	10	10	10
No. of tests passed	9	8	10	10	10	10
No. of tests failed	1	2	0	0	0	0
Percentage (%) of tests based	90%	80%	100%	100%	100%	100%
Percentage (%) of tests failed	0%	10%	0%	0%	20%	0%

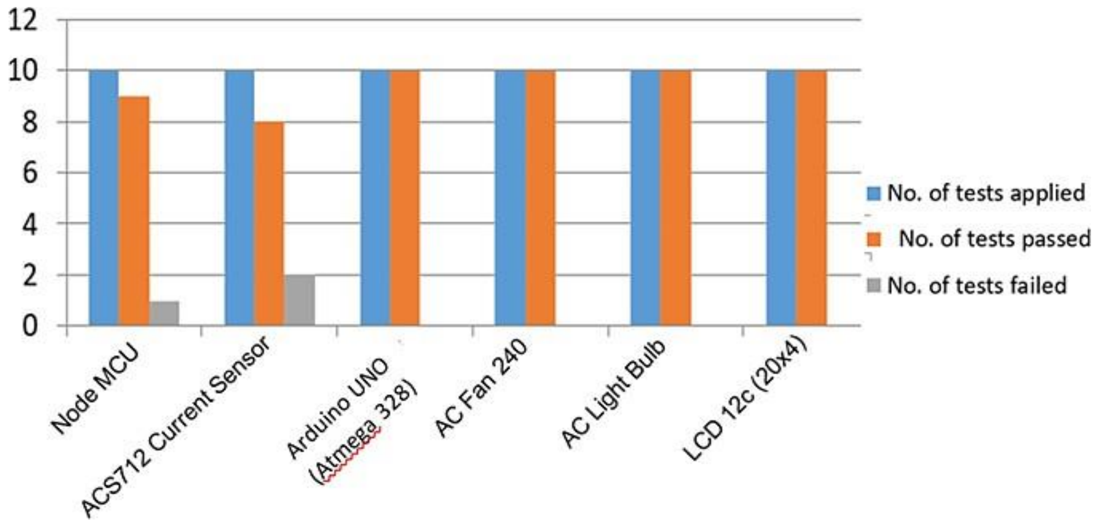

Figure 9: Results of Applying 10 Tests

CONCLUSION

Finally, as previously seen via study, the increased usage of electrical equipment and its many applications has resulted in exorbitant power expenses owing to energy depletion. Power costs climb on a daily basis as the number of electrical equipment increases, resulting in increased daily power demand. The lack of an energy usage monitoring system aggravates the situation. As a consequence, it became important to create an energy consumption monitoring system that can compute daily use and deliver it to clients so that they can understand their energy consumption.

The gadgets for monitoring energy use have been fully implemented by connecting all relevant devices to the system core (Arduino UNO, which uses the Atmega 328). This system utilises a node MCU, an Arduino Uno Microcontroller, an AC Fan, an AC Light Bulb, an LCD I2C (20x4), and an ACS712 Current Sensor to monitor the current of electrical equipment.

The system was programmed using the Arduino Integrated Development Environment (IDE) (IDE). As a result, the system began to function by using current sensors to monitor electrical device currents and passing the data to the Arduino UNO. That was for assessing the data and doing mathematical procedures to estimate the amount of electrical power in watts, which was then converted into a price.

In addition, all vital data was sent to the LCD panel and the Arduino Node MCU, and the data was sent to the BLYNK programme via the Wi-Fi device. As a result, all relevant information was shown on the LCD panel and in the BLYNK application. Furthermore, the system deployment and testing have been accomplished, and the desired objectives have been efficiently obtained. The system has functioned admirably, and it is simple to operate, reliable, and efficient.

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