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DEPARTEMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

OPTION OF ELECTRICAL TECHNOLOGY

FINAL YEAR PROJECT:

DESIGN AND IMPLEMENTATION OF THE SIMULATION OF AN AUTOMATIC POWER CONSUMPTION DETECTING SYSTEM

Submitted in Partial Fulfilment of the Academic Requirements for the Award of an Advanced Diploma (A1) in Electrical Technology

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DECLARATION A

I, BOUANGA MOUBOUNAMOUBOU MAYOMBO SARAH 202150066 herebey declare that this research study is my original work and has not presented for a degree or any other academic award in any university or Institution of Learning. No part of this research should be reproduced without the author consent or that of ULK Polytechnic Institute.

Student name: BOUANGA MOUBOUNAMOUBOU MAYOMBO SARAH

Signature: ……

Date: ……

DECLARATION B

I confirm that the work reported in this research project was carried out by the candidate under my supervision and it has been submitted with my approval as the UPI supervisor.

Name: ENG TUYISHIMIRE APPOLINAIRE

Signature: ……..

Date:…….

DEDICATION

I dedicate this work to my GOD my creator, my source of motivation, my most trusted confidant. Absolutely, I also dedicate all my efforts and struggles of the educational life to my dear parents and my sister (MOUBOUNAMOUBOU LOLA) who have confidence in me and have given me what is necessary to be where I am today. They taught me to follow the path of truth, justice and honesty. I do not forget my supervisor ENG TUYISHIMIRE APPOLINAIRE who provided valuable support for the completion of this project and all those who love and care about me.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to all these individuals for mentoring and supporting me in completing this project.

My supervisor, ENG TUYISHIMIRE APPOLINAIRE for providing me with invaluable insights and direction.

Our HOD, ENG KARIKURUBU EMMANUEL for fostering an environment of learning and creativity within our school.

To my parents, their constant encouragement, patience and understanding have been the pillars of my success.

I am grateful to my friends who contributed ideas and perspectives that enriched the project.

Thank you everyone for shaping this project and enhancing my learning experience.

ABSTRACT

Technology has emphatically expanded proficiency across various sector. We can now do more tasks quicker than expected since the gig is presently faster and more exact. Also, it's plays a pivotal role in enabling effective energy management. Effectively, a prerequisite for optimizing energy efficiency is monitoring the energy consumption. In this project, our main objective is to facilitate the consumer to efficiently use the power source from the power grid in order to have an electricity bill that corresponds to its consumption. The system use a microcontroller-based architecture, using the ESP8266 NodeMCU for real-time data processing and communication. The power consumption is measured using the PZEM-004T sensor, which accurately tracks voltage, current, power, and energy usage in an AC circuit. The system is designed to automate the detection of excessive power utilization and to provide alerts when power consumption exceeds predefined limits (30W). The core of the system includes three relays that control the activation and deactivation of connected three electrical loads, based on the real-time power consumption data. The relays automatically switch off one load when excessive consumption (over 30W) is detected, thus improving energy efficiency and reducing the risk of overloading the circuit. The system also integrates a magnetic sensor to detect the state of power supply and manage the switching processes accordingly. Furthermore, a buzzer is incorporated to signal abnormal conditions, especially when the power consumption exceed 30W. Here we can see the real-time reading on the LCD (16×2) attached with our hardware and on the phone precisely on the Blynk application which represent the IOT tools we used. Furthermore, this application allow us to switch off and on loads through the phone. By providing real-time feedback on energy usage, the system helps users optimize power consumption and reduce energy costs. The simulation, conducted using proteus software, demonstrates the feasibility and effectiveness of the system in managing loads automatically, ensuring safety, and improving energy efficiency.

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LIST OF ACCRONYMNS AND ABREVIATIONS

IOT: Internet Of Things

LCD: Liquid Crystal Display

PLC: Programmable Logical Controller

ADC: Analog to Digital Conversion

ROI: Return On Investment

DSP: Digital signal processors

IDE: Integrated Drive Electronics

AC: Alternating Current

DC: Direct Current

W: Watt

KWh: Kilowatt-hour

MCU: Microcontroller Unit

RMS: Root mean square

NC: Normally close

NO: Normally open

V: Voltage

A: Ampere

VCC: Positive voltage supply

CHAPTER ONE: GENERAL INTRODUCTION

1.0 Introduction

Energy consumption is the total amount of energy required for a given process and is measured in kilowatt hours (kWh). [1]Monitoring energy consumption in households is a fundamental tool for achieving efficient and responsible management of this resource. This practice in our homes saves money because people will familiarize with the concept of electricity and be able to reduce their consumption themselves by adopting good habits. Thus, the electrical measuring device used in general is the energy meter, which is used to record Electrical Energy Consumed over a specified period of time in terms of units. And nowadays, we distinguish traditional energy meters and Iot energy meters which have more intelligent functions, allowing users to remotely monitor, manage and analyse energy consumption. [2] The IOT based energy meters are accessible on commercial area but, the North America is leading the adoption and some parts of Africa are cautiously adopting smart meters, though they face frequently financial challenges. So to make it more accessible to Africans, I decided to orient my project in this direction. Thus, with the device I will build, we will be able to read the power consumption of each devices on the system directly but also on the phone by using the IOT. Here we can see the live real-time reading on the LCD attached with our hardware and on the phone without forget that in the case we have a high energy consumption the Buzzer will make a sound for signalling.

1.1 Background of the study

Technology has changed the way humans interact with all across the world today. Electricity is one of the most brilliant creations in human history. Most of the things we see are powered by electricity in some shape or another. Many people are not familiar with the notion of electricity. For such folks, electricity is as simple as turning on the switch, waiting for the device to start working, and then turning off the switch. When the power goes off, the significance becomes clear. The movement of electrical power or charge is referred to as electricity. Electricity is both a fundamental component of nature and one of the most extensively used types of energy.

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We use electricity as a secondary energy source since it is created by converting primary energy sources such as coal, natural gas, nuclear energy, solar energy, and wind energy into electrical power. Electricity rates can very often increase. Prices changes mainly reflect fluctuations in energy demand, generation source availability, fuel costs, and power plant availability. Summer prices are often the higher because more expensive generation sources are introduced to match the increasing demand. As a result, ordinary people are forced to pay exorbitant prices for power. As a result, we must monitor their daily energy use in order to conserve energy and money.

1.2 Problem Statement

Nowadays to purchase electricity became easily compared to the past days, but managing how the power will be used and controlled for discovering how it is obviously being used was hard to find out. This is how people can sometime paid more than what they are supposed to pay for electricity and also they are not able to easily detect some problem on the system which can increase the energy consumption.

1.2.2 General objectives

The main objective is to design and implement an automatic power consumption detecting system to monitor and manage the energy consumption.

1.2.3 Specific objectives

1. To monitor energy consumption by displaying the consumption of each device on the LCD display and through the phone using IOT.
2. To allow the client to switch off and on a lamp or other device sometime in order to manage the consumption using the IOT.
3. To allow the consumer to follow the consumption on the phone or on the system directly.
4. To allow people to know the bare minimum to better manage their electricity consumption.

1.3 Research Questions

1.3.1 Why we need to monitor our energy consumption?

1.3.2 How IOT can help energy managers with effectively using technology to manage energy?

1.3.3 How IOT can facilitate life of people about the energy consumption?

1.4 Scope of project

With IOT, we could learn your energy usage habits and adjust your energy usage accordingly, further reducing your energy bills. Predictive maintenance: Smart meters will be able to help to detect potential issues before they become major problems, allowing for more efficient and cost-effective maintenance.

This project based on IOT can provide real-time data on energy consumption, allowing users to monitor and optimize their energy consumption.

Cost-effective: Because they can connect to the internet via Wi-Fi, it's can be a cost-effective solution to send energy usage data.

Real-time monitoring: The system can be linked to an internet-based monitoring system, allowing consumers to track their energy consumption in real time via a user-friendly mobile app and website.

Overall, it's can provide a more efficient and cost-effective method of monitoring and optimizing energy consumption, as well as extra capabilities such as the detection. Iot based power monitoring system can provide a range of benefits in Rwanda, including improved accuracy, real-time monitoring, increased efficiency and cost savings.

1.4.1 Content scope

The research project focus on IOT-based power monitoring system, for helping people like student who are leaving alone and also far from their home country to manage well the energy budget of the month and help them to develop good habit about the energy consumption.

1.4.2 Time scope

For carrying out this research on simulation of an automatic power consumption detecting system took me four months from May to August 2024.

1.5 Significance of the Study

1.5.1 Personal

As a result, as student of Electrical technology and the project researcher, I have put what I have learned since the first year into practice, giving me a basic idea of what I might accomplish and how I could improve to assists workers to reduce the effort to provide and be more efficient through management of energy consumption from their client. This system will help me to improve my ability, knowledge, experience in implementing different automated system, it can assist me to shift my academic skills into the real world by job creation and it will give me money and solve community problems.

1.5.2 Institutional interest

To help big institutions about energy bill through management of energy consumption.

1.5.3 Public interest

Other researchers will benefit from this effort since they can use it as a reference in their research reports if they come across data that is relevant to their work, this project is also useful to the general, etc.

1.6 Organization of project

This final project is organized in five chapters:

Chapter one deals with the background, problem statement, objectives, Research Questions, Importance of the study, Scope and Limitation of the Project and organization of the study.

Chapter two gives a brief literature review about theoretical, review of the past studies, conceptual framework, critical review, and summary.

Chapter three shows Research design.

Chapter four explains different results obtained during design and implementation of project.

Chapter five makes the conclusions through the results obtained and gives recommendations for furthered research work. At the end, a list of references is provided.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter is a written overview of major writings and other sources on the topic.

2.1 Concepts, Opinions, Ideas from Authors/Experts

The concept of devices based on the Internet of Things (IOT) has garnered significant attention from experts and authors in various fields, including energy management, smart technologies, and sustainability. [3]Internet of Things technology has become one of the most popular technological concepts, especially with the rapid developments in the internet field. IOT is the process of equipping machines and objects with sensors, allowing them to communicate with each other via the Internet or Local Area Network (LAN) (Kılınç, 2020). As the Internet changes global human-to-human contact, IoT aims to innovate in human-to-machine and machine-to-machine communication. Advances in cloud computing, integrated networks, high-speed internet, and 4G / 5G internet protocols have enabled the internet to penetrate almost every corner of our physical space. This means that more and more objects can be integrated over the internet (Qazi, 2019).According to a study by Juniper Research (2020), the number of IoT devices connected to each other “almost tripled” from 13.4 billion in 2015 to 38 billion in 2020. Concerning IOT on the energy management where we will focus in our research, implementing IOT energy meters can lead to substantial cost savings for both consumers and businesses by identifying and reducing unnecessary energy use. R. Kavitha and Dr. R. S. D. Wahidabanu, in their research, highlight that the adoption of IoT-based energy meters results in a quick return on investment due to the reduction in energy costs and improved operational efficiencies. IOT energy meters can predict potential failures in electrical systems by analyzing usage patterns and detecting anomalies. Michael Legatt, an expert in smart grid technologies, states, "Predictive maintenance enabled by IOT energy meters helps in proactively addressing issues, thus avoiding costly downtime and extending the lifespan of equipment. IoT energy meters play a crucial role in the development and functioning of smart grids by providing detailed data on energy consumption and generation. Dr. Massoud Amin, a leading figure in smart grid innovation, mentions, The integration of IoT-based energy meters with smart grids facilitates better demand response, grid stability, and efficient energy distribution.

[3]

These meters empower consumers by giving them detailed insights into their energy consumption, enabling them to make informed decisions. In their work on consumer behaviour and smart meters, Darby and Pisica note, IoT energy meters foster a more engaged and energy-conscious consumer base by providing transparency and control over energy use.

2.2 Theoretical perspectives

For monitoring the energy, we generally use an energy meter known as an electricity meter, which measures the amount of electrical energy consumed by a residence, business, or an electrically powered device. Understanding the theoretical perspective of an energy meter involves delving into various scientific and engineering principles that underpin its operation and design. Faraday's Law of Electromagnetic Induction states that a change in magnetic field within a closed loop induces an electromotive force (EMF) in the wire. In traditional electromechanical energy meters, this principle is used to generate a rotating magnetic field that moves a disk proportionally to the amount of electricity used. The rotating disk in electromechanical meters interacts with magnetic fields generated by the current flowing through the coils. This interaction produces a torque that is proportional to the power consumption. Modern digital energy meters use Analog-to-Digital Conversion (ADC) to convert the analog signals (current and voltage) into digital signals that can be processed by microcontrollers or digital signal processors (DSPs).

Modern smart meters use various modulation and encoding techniques for reliable data transmission over power lines, wireless networks, or other communication media. Standard communication protocols (e.g., Zigbee, WI-Fi, PLC) are used for secure and efficient data exchange between the meter and the utility company. Statistical Analysis and Metering Algorithms, Statistical methods are used to analyze consumption patterns and detect anomalies or potential fraud. Algorithms predict future energy usage based on historical data and usage patterns. But we can find some error Analysis Understanding the sources of error in measurement, such as temperature variation, component aging, and electromagnetic interference, is crucial for designing accurate energy meters. Regular calibration ensures that the meter maintains accuracy over time. This involves comparing the meter's readings with a known standard and making necessary adjustments. About economic and Regulatory Perspectives, understanding different billing structures (e.g., time-of-use pricing, tiered rates) and how meters implement these calculations.

Meters must comply with national and international standards, such as IEC and ANSI, which dictate performance, accuracy, and safety requirements.

IOT involves the network of physical devices, vehicles, home appliances, and other items embedded with sensors, software, and connectivity, allowing them to connect and exchange data. This connectivity can occur without human intervention, leading to a highly integrated system. Sensors and Actuators are the primary data-gathering components, detecting changes in the environment and acting upon to various communication protocols (e.g., Wi-Fi, Bluetooth, and Zigbee) enable devices to transmit data. Cloud computing and edge computing platforms process the massive amount of data generated. Applications and dashboards that allow users to interact with the IOT system. Thus using IOT devices for energy management is the ability to monitor and control energy consumption in real time. With all devices connected to the web, businesses and individuals can actively track their energy consumption and make better-informed decisions to adjust their consumption patterns.

2.3 Related study

This part explains related projects on what we are doing. Here we choose the health monitoring system and a GSM based prepaid Electricity Energy Meter using Arduino.

Health Monitoring System is a sophisticated application of IoT technology designed to enhance personal health management. [4]It involves the use of wearable devices and sensors that continuously gather health-related data such as heart rate, blood pressure, body temperature, and activity levels. This data is then transmitted to a centralized platform where it can be analyzed to provide insights. The into the user's health status, detect anomalies, and even predict potential health issues before they become serious. Users can access their health metrics in real-time through mobile apps, enabling them to make informed decisions about their lifestyle and seek medical advice when necessary. For healthcare providers, this system offers a tool for remote patient monitoring, improving the efficiency of care and allowing for timely interventions. The Health Monitoring System is a testament to how IOT can revolutionize personal healthcare, promoting preventive medicine and personalized health management.

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Prepaid Electricity Energy Meter is one of the best concepts for the current electricity payment system. In this system, you can recharge the device and update the balance as we do on our mobile phones. [5]By sending a simple SMS, you can recharge the electricity balance through this system. [6]It can also disconnect the home power supply connection if there is a low or zero balance in the system. And this system will read the energy meter readings and automatically send some updates to the user's mobile phone like low balance alert, cut off alert, resume alert and recharge alert. The Anti-Theft Alert can also be detected when someone tries stealing the meter by opening the lid. So, let us see how we can build this project.

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CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter demonstrate different techniques used in time of collecting data and analyzing them in order to find out the real data concerning to this project. This chapter highlight data collection and data analysis, study design and problem with limitation of the study.

3.1 Research design

The research design refers to the overall strategy and analytical approach that you have chosen in order to integrate, in a coherent and logical way, the different components of the study, thus ensuring that the research problem will be thoroughly investigated. For this project of IoT-based power monitoring system, the overall architecture is composed of hardware part and software part in general. Concerning the hardware part, as principal component we have Node MCU (ESP8266), Sensor (PZEM-004T), Led Screen, Relay module (3 channel), Loads and Adapter. For the software part we have Arduino for coding and BLynk application as IOT. For designing this project I will make first the connection between the all hardware component, secondly I will arrange parameter to be sure that the code write on Arduino will be well transfer on the ESP8266, thirdly I will write the code then transfer it on the ESP8266 and finally I will put information on the blink application and start testing the project.

3.2 Research Population

The research population, also known as the target population, represents the group of individuals or entities you aim to study or collect data from. Certainly, when designing a research project on an energy meter for monitoring power consumption, defining the research population is crucial. Thus for this project I choose 5 Residential Users.

Description: Homeowners or renters using electricity in their residences.

Purpose: To understand the energy consumption patterns in households, identify peak usage times, and evaluate the effectiveness of the energy meter in reducing consumption.

Sampling Method: Random sampling of households across different socio-economic backgrounds, dwelling types (apartments, single-family homes, etc.), and geographical locations.

Sampling Method: Cluster sampling based on the type of institution and geographical distribution.

The research population for this project includes a diverse group of energy users, but I decide to be focus on the one above, ensuring comprehensive insights into the effectiveness of the energy meter. This approach helps in developing targeted strategies for energy conservation and efficient energy management.

3.3 Sampling procedure

For Residential Users, about the total number of households in the target area, we assume a population of 5 households. I decided to be focused on apartments (student's apartments), people who are living alone. Located in the campus area.

3.4 Research Instrument

3.4.1 Choice of the research instrument

This project is a revolutionary technology that has the potential to transform the way we consume power. By providing real-time monitoring and control of energy consumption, it can help users to reduce their energy usage, save money, and promote sustainable energy consumption. Thus for having this result, it's crucial to perform well the research work as the research instruments which can significantly benefit researchers by improving research design, data collection, data analysis, and the overall quality of research findings. So, between the all research instruments we choose the questionnaire.

The purpose of this research instrument it's to gather information on energy usage patterns, awareness, and attitudes towards energy conservation from different user groups. Concerning the structure, we have some examples of question.

What type of dwelling do you live in? (Apartment, Single-family home, other (please specify))

On average, how many hours per day do you use electricity?

During which time of the day do you usualy use the most electricity?

Are you conscious of your daily energy consumption?

Do you practice any energy-saving measures? (e.g., turning off lights when not in use, using energy-efficient appliances)

How would you rate your overall experience with the energy meter?

What benefits have you observed from using the energy meter?

Do you have any suggestions for improving the energy meter?

3.4.2 Validity and Reliability of the Instrument

For a research instrument, such as an IOT based power consumption detecting system, it's crucial to ensure both its validity and reliability. These two concepts are fundamental to the quality and credibility of your research findings. Validity is the extent to which a questionnaire accurately measures its intended purpose. It can be content, construct, or face valid. Content validity ensures the questionnaire covers all aspects of the concept being measured, while construct validity assesses if it accurately measures theoretical IoT constructs. Face validity checks if the questionnaire appears to measure what it is supposed to. Reliability refers to the consistency of the questionnaire, with methods such as internal consistency, test-retest reliability, and inter-rater reliability.

3.5 Data Gathering Procedures

Data gathering is a crucial phase of a research project, involving the systematic collection of information to answer research questions, test hypotheses, and evaluate outcomes. Data gathering for an IOT based power monitoring system involves multiple steps and components to ensure accurate, real-time monitoring and analysis of energy consumption. We have Hardware Components as sensors to measure voltage, current, power factor, and energy consumption. Microcontroller Serves as the brain of the meter, processing sensor data. And our choice is ESP8266. Communication Module Enables connectivity to the internet (Wi-Fi).

As Software Components, Custom code running on the microcontroller to read sensor data and handle communication.

3.6 Data Analysis and interpretation

System analysis is a problem-solving technique that decomposes a system into its component Pieces for the purpose of studying how well those component participle of work and interact to accomplish their purpose. It is driven by the business concerns of system owners and system Users. Hence, it addresses the Data, Process and interface building blocks from system owners and system users perspectives. And for interpreting the results of this project, we used various tools. Firstly, we have the Arduino IDE where the code was written, secondly we used the Liquid Crystal Display(LCD) for real-time display of the energy and power consumption. Thirdly, the Wi-fi to receive data from the microcontroller (ESP8266) which will be interpret on the mobile phone by the blynk application that we upload on it. Finally, we used also the software proteus, it helps to build and test circuits along with the code before moving to physical prototyping. Those are some of the principal tools we used for interpreting the results.

3.7 Ethical considerations

To ensure the security and effectiveness of an IoT-based energy meter, it is crucial to consider several moral considerations. These include confidentiality of information, information security, straightforwardness, client independence, and legitimate compliance. Customers should be informed about the purpose and usage of their information, and encryption strategies should be implemented to prevent unauthorized access. Clear communication about the purpose and usage of the information should be provided, and clients should have control over their data. Additionally, consideration of intellectual property rights and energy-efficient materials should be taken into account.

3.8 Limitations of the study

In Rwanda, the electricity usage is very high as in many country in the world. And there is no such system that can take the reading on its own. [7]Energy meter monitoring and keeping track of energy consumption is generally done manually. This process is quite complex; it

[7]

sometimes produces few problems due to human errors. The problems such as retaking reading may cause, but the bigger problem is in case of big apartment. In these apartments as there are a number of residents and everyone is having an Energy Meter, the number of meters is also high. These meters are connected in matrix form. So, it is quite difficult for both the electricity board and the consumer to identify their own meter. Also for the consumer to know his daily use of electricity, has to go to the meter and check for the readings, which makes this stuff a bit annoying. So, automating this process will be very useful. This will allow user to monitor reading by the internet access. This automated system is such designed that it can access the Energy Meter of every consumer directly without any human intervention. It will take the reading itself and will display it using server. Automated system will provide unit consumed and disconnect device consuming more. This also will be useful for the smart city programmer undertaken by government. This project is presenting the IOT based power consumption device. This system will help creating a transparent and a consumer-friendly environment.

CHAPTER FOUR: DESIGN AND IMPLEMENTATION OF THE SIMULATION OF AN AUTOMATIC POWER CONSUMPTION DETECTING SYSTEM

4.0 INTRODUCTION

This chapter covers the system analysis which describes the process that focus on the analysis of existing system, requirement specification, and the overall architecture of the new system. In addition, system analysis helps the researcher in understanding and identifying the user and system requirements of proposed system as well as how to design and model the proposed system in order to come up with a working solution.

4.1 CALCULATIONS

For this project, we can include various calculations to monitor and analyze energy consumption. Here are some key calculations to consider:

a- Energy Consumption (kWh):

Energy (kWh) = power (in kW) ×time (in hours)

b- Power Factor:

$$\text{Power Factor} = \frac{\text{Real power(W)}}{\text{Apparent power(VA)}}$$

This indicates the efficiency of the power usage.

c- Active Power (P):

This is the real power consumed by electrical devices, calculated as the product of the RMS values of voltage (V) and current (I) and the cosine of the phase angle (φ) between them.

$P=Vicos(\phi)$.

d- Reactive Power (Q):

This is the power that oscillates between the source and the reactive components (inductors and capacitors) in the system, calculated as

Q=Visin (ϕ)

e- Apparent Power (S):

This is the product of the RMS values of voltage and current without considering the phase angle, calculated as

S=V×I.

f- Cost Calculation:

Cost = Energy consumption (kWh) ×Rat

g- Voltage and Current Analysis:

- RMS Voltage:

$$Vrms = \sqrt{\frac{1}{T}\int_0^T v(t)^2\,dt}$$

- RMS Current:

$$I\,(rms) = \sqrt{\frac{1}{T}\int_0^T I(t)^2\,dt}$$

Including these calculations can provide comprehensive insights into energy usage, efficiency, and potential cost savings, making your IOT energy meter project valuable for both consumers and energy providers.

4.2 Drawing

Concerning drawing we will have three principal and for the first one which is a block diagram, it [8]is a graphical representation of a system, project, or scenario. It provides a functional view of a system and illustrates how the different principal elements of that system interlink. Engineers, in particular, use block diagrams to model the elements of a system and understand how they are all connected.

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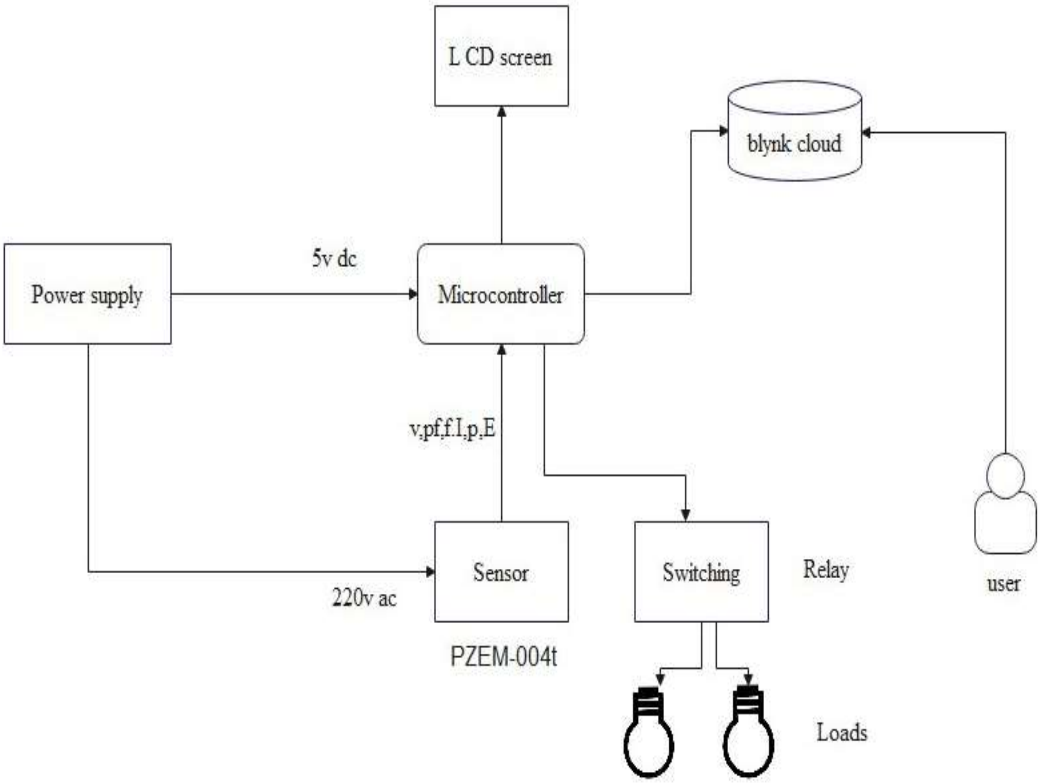

Figure 4. 1.Block diagram

For the second drawing, we have a flowchart define as a graphical aid, designed to visualize the sequence of steps to be followed throughout the project management process. Once your process flow has been developed, it will guide the primary phases of any future projects, from start to finish.

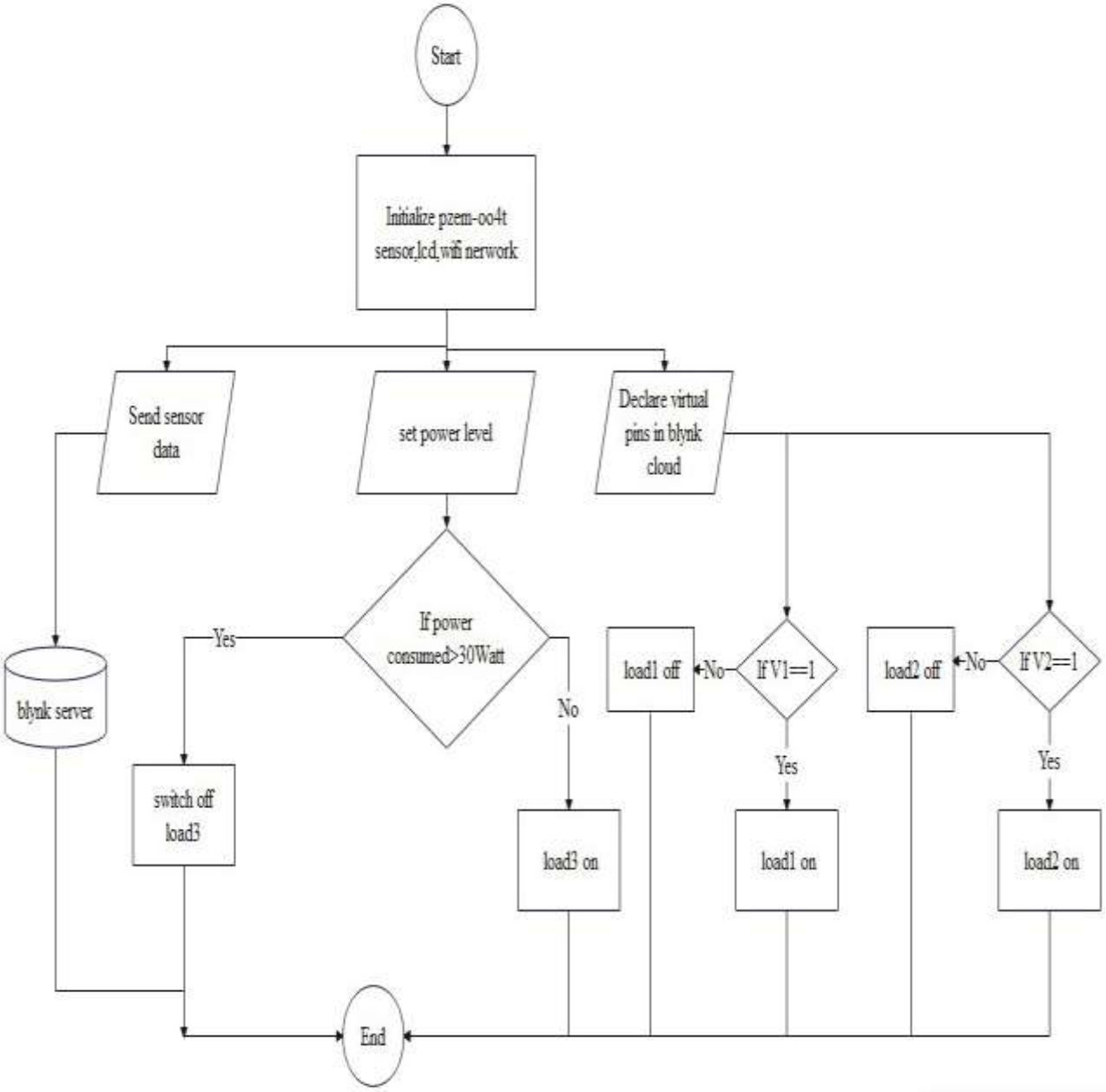

Figure 4. 2.Flow chart

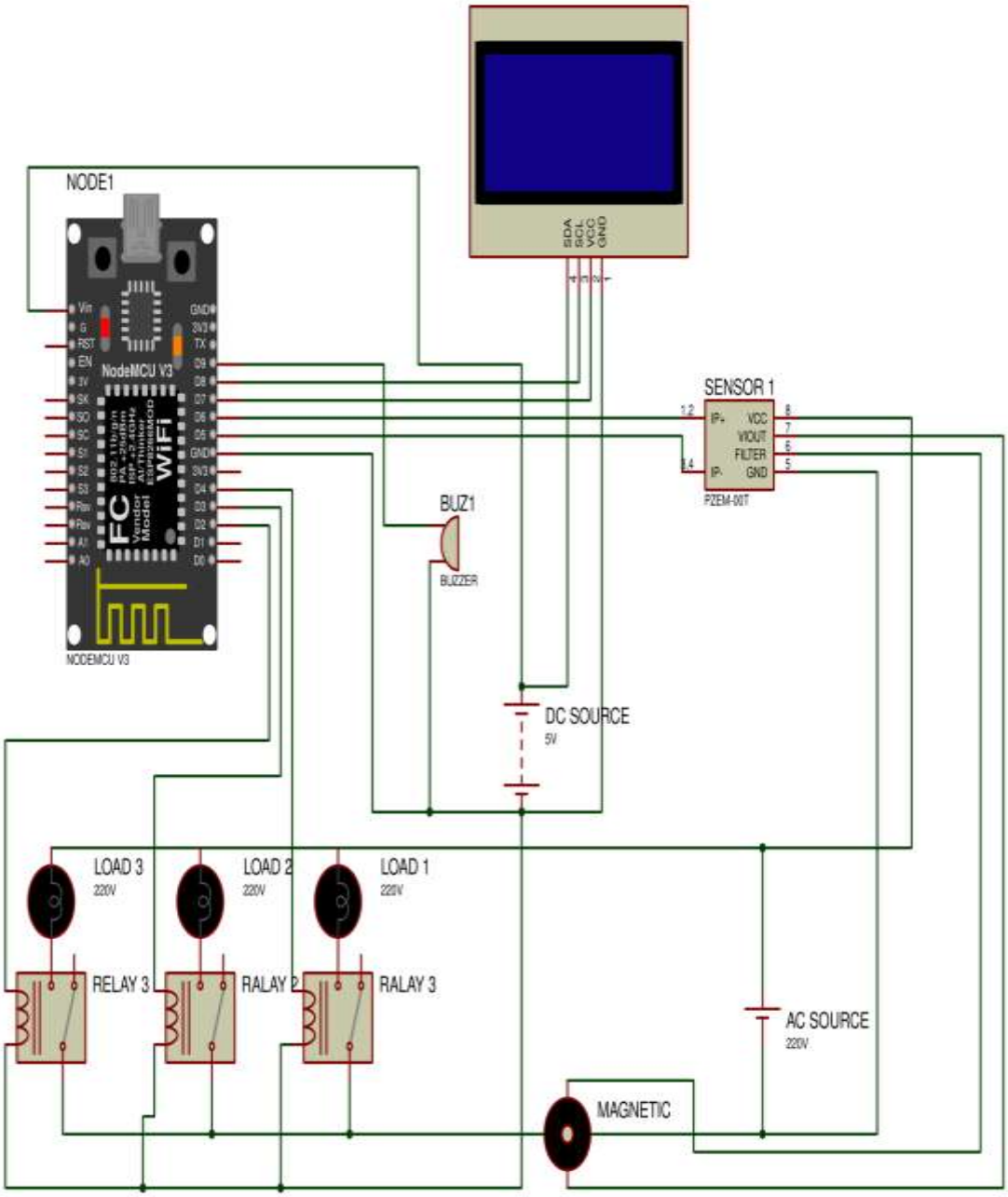

Figure 4. 3.Circuit diagramme

4.3 Specification

This system will use smart sensors and IOT technology to collect data, which will be processed and displayed through a mobile application. Therefore, I would highlight the main component of this project and explain in brief the working principal of each.

4.31 NodeMCU

NodeMCU is an open-source IoT (Internet of Things) platform based on the ESP8266 Wi-Fi module. It provides a microcontroller unit (MCU) with integrated Wi-Fi connectivity, enabling seamless communication and data exchange between devices over a wireless network. There are open source prototyping board designs available for the NodeMCU firmware. This facilitates the data flow to the database.

Figure 4. 4.NodeMCU

4.3.2 LCD 16×2 Display

Liquid Crystal Displays is display device which is used in embedded system applications for displaying various parameters and status of the system. [9]LCD 16x2 is a 16-pin device that has 2 rows that can accommodate 16 characters each. LCD 16x2 can be used in 4-bit mode or 8-bit mode.

Nowadays, we always use the devices which are made up of LCDs such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries to replace the utilization of CRTs. Cathode Ray Comparing LCDs to CRTs, tubes consume a significant amount of power and are both larger and heavier. These gadgets use a remarkably small amount of power and are slimmer.

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The LCD 16x2 operates on the idea of blocking light instead of dissipating it. The word LCD, or liquid crystal display, refers to the pin arrangement and operation of the LCD 16X2 that is covered in this article. It is one type of electronic display module that is utilized in many different circuits and gadgets, such as computers, calculators, mobile phones, and so on. Seven segments and multi-segment light-emitting diodes are the major applications for these displays. The primary advantages of utilizing this module are its low cost, easy programming, animations, and limitless display options for unique characters, special effects, and animations, among other things.

Figure 4. 5.16X2 LCD

4.3.3 PZEM-004T Module

The PZEM-004T module is a multifunctional sensor module that functions to measure power, voltage, current and energy contained in an electric current. [10]It can measures AC voltage in the range of 80V to 260V, AC current up to 100A with an external current transformer (CT), Calculates active power based on the measured voltage and current and also measures energy consumption over time, providing data on total kilowatt-hours (kWh). Utilizes a UART (TTL) serial interface for data communication, making it easy to connect with microcontrollers like Arduino, ESP8266, or other development boards. Offers a high degree of measurement accuracy, with typical accuracy better than 1%.

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Figure 4.6 PZEM-004T

4.3.4 Arduino IDE software

The Arduino IDE (Integrated Development Environment) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. Is used to write the computer code and upload this code to the physical board. It connects to the Arduino hardware to upload programs and communicate with them.

Figure 4.7 Arduino IDE software

4.3.5 Blynk application

Blynk is a mobile app that allows users to easily create and control Internet of Things (IoT) projects. The app provides a user-friendly interface for connecting and controlling a wide range of devices, including sensors, actuators, and other electronic components. Users can create custom dashboards to monitor and control their IoT projects remotely, as well as set up notifications and alerts for specific events.

The Blynk app also includes a library of pre-built widgets and functions that make it easy for users to quickly add features to their IoT projects without the need for extensive programming knowledge.

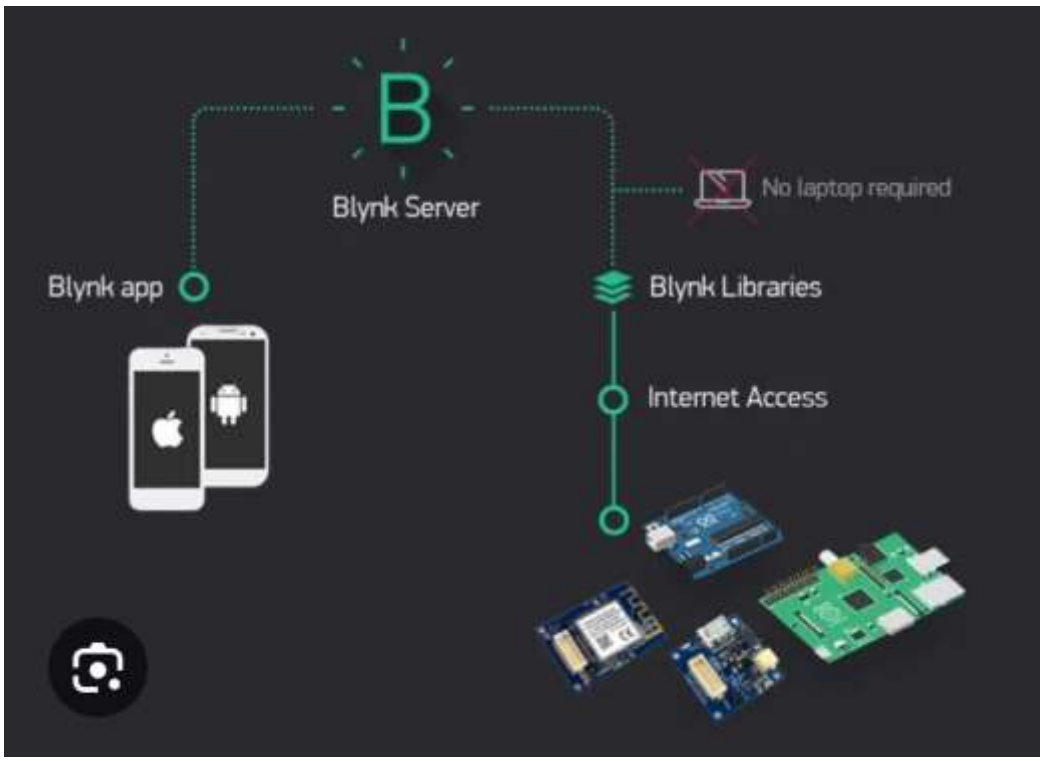

Figure 4.8 Blynk

4.4 Cost estimation

Number of table of figures entries found.	Devices	Specification	Quantity	Unit/Price	Total/Price
1	ESP8266	NODEMCU	1	11000frw	
2	Sensor	PZEM 004T	1	26300frw	
3	LCD display	LCD screen	1	8000frw	
4	buzzer		1	500frw	
5	Relay module	3channel	3	4800frw	
6	Socket outlet	White	2	2000frw	
7	load	Lamp	1	1500frw	
8	Cable for supply	Bleu	1	1000frw	
9	cover	Wood	6	4000frw	
10	Adapter	Charger	1	2500frw	
11	Jumper wire		8	800frw	
Total					59600frw

4.5 Implementation (Optional depending on the project)

For implementing this project, we connect the all hardware part as, sensor, ESP8266, adapter, relay, load… this part wasn't the most complicated. After that we start with the software part, we download the blynk app on the phone and create a new project in blynk then after we install Arduino in the computer and install the ESP8266 board and blynk Library. We create a new sketch and we include the blynk library and ESP8266 Wi-Fi library in the code. After that, we upload the code to ESP8266 by using a cable to connect them. Also on the blynk application we add five virtual pin, three representing the three relay we have on the physical part and two that we represent with the gauge graph for energy and power. Then after we test the project and it's was working.

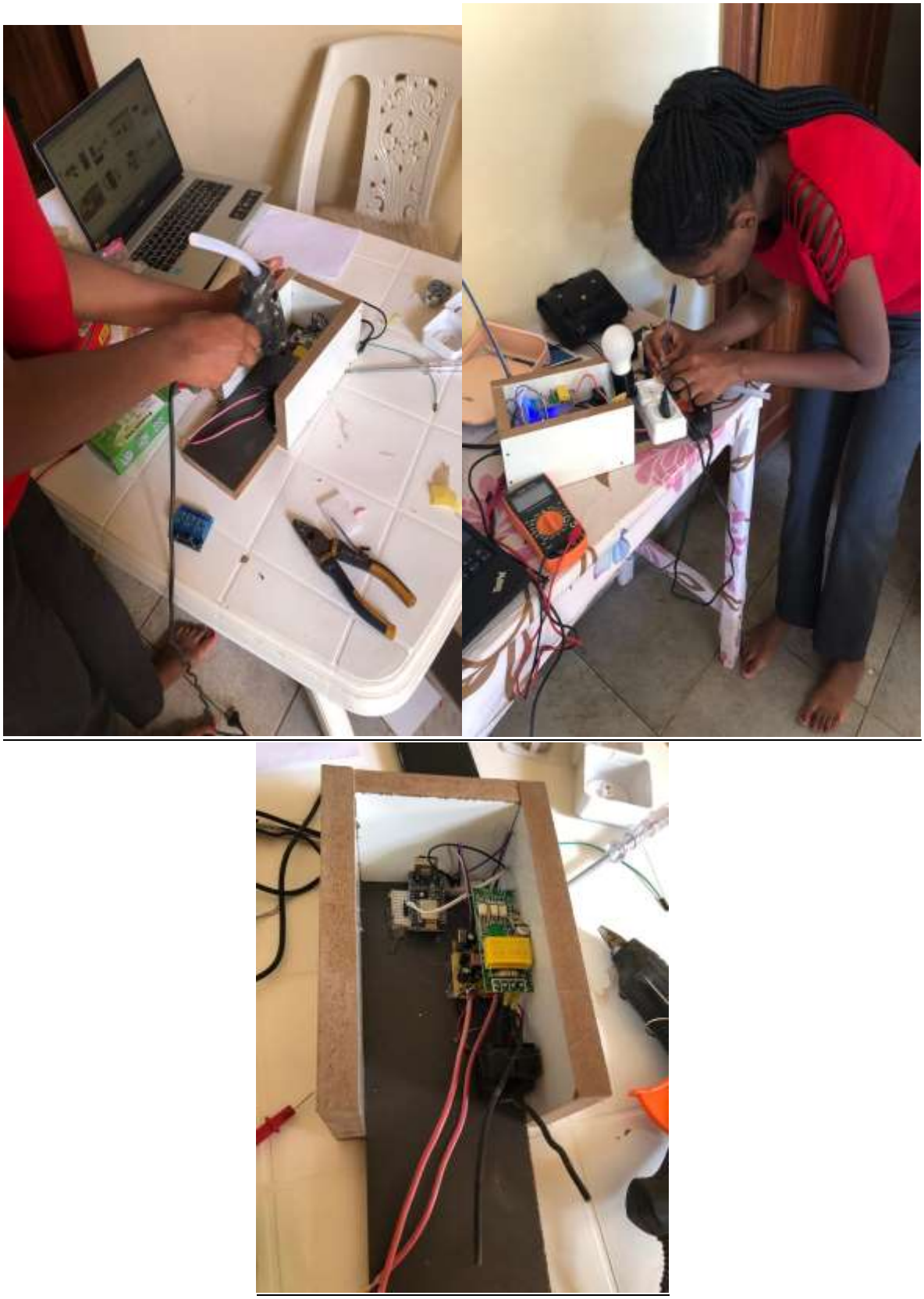

Figure 4. 6.Project figure

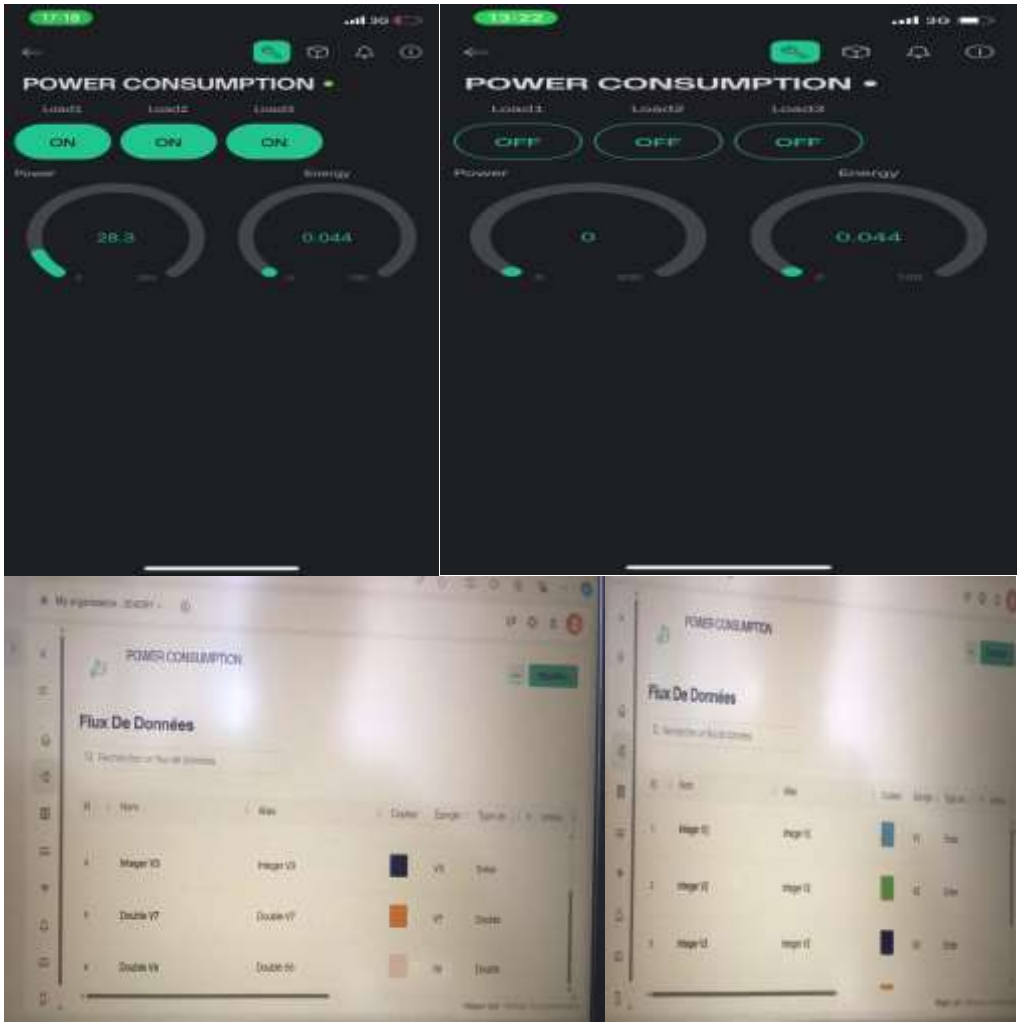

Figure 4. 7.Blink figure

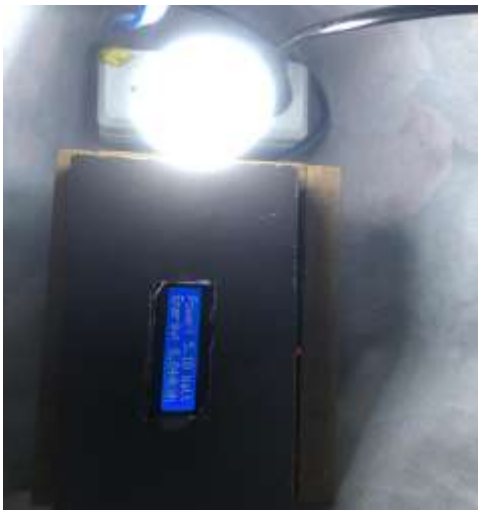

Figure 4. 8.Project in progress

CHAPTER FIVE : CONCLUSION AND RECOMMENDATION

5.0 Introduction

Nowadays, monitor and manage the energy consumption it's essential for industries, businesses and residential users. This project for monitoring the power will help them by providing real-time data and insights that can help identify areas for improvement, reduce energy costs, and increase overall operational efficiency.

5.1 Conclusion

Finally, systems made for monitoring power consumption are helping organizations track their power usage, identify inefficiencies, and make informed decisions to optimize their energy consumption. Effectively, by using power monitoring system, businesses and residential users will save money and they will be able to detect easily and quickly problem related to the electricity conception.

5.2 Recommendations

In general, I recommend to businesses and residential users to consider the importance of having a power monitoring system for having a good management of the consumption, save money and for cultivating good consumption habit.

5.3 Suggestions for further study

Further research could focus on how integrate renewable energy sources to this project (solar energy), exploring advancements in technology that could enhance the capabilities of this power monitoring systems would also be an interesting area for my future study.

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APPENDICES

```
#define BLYNK_TEMPLATE_ID "TMPL2XaQ2rujc"

#define BLYNK_TEMPLATE_NAME "POWER CONSUMPTION"

#define BLYNK_AUTH_TOKEN "Q5ljzSsq_tvmXF8J4PdBr_GonNGhBTWE"

//POWER CONSUMPTION

#include <ESP8266WiFi.h>

#include <BlynkSimpleEsp8266.h>

#include <SoftwareSerial.h>

#include <PZEM004Tv30.h>

// Replace with your network credentials

const char* ssid = "iPhone";

const char* password = "sarah123";

#if !defined(PZEM_RX_PIN) && !defined(PZEM_TX_PIN)

#define PZEM_RX_PIN D3

#define PZEM_TX_PIN D4

#endif

WiFiClient client;

 #define PZEM_RX_PIN D3

#define PZEM_TX_PIN D4

SoftwareSerial pzemSWSerial(PZEM_RX_PIN, PZEM_TX_PIN);
```

```
PZEM004Tv30 pzem(pzemSWSerial);

// Relay pins

const int relay1 = D7;

const int relay2 = D5;

const int relay3 = D6;

int buzzer=D8;

void setup() {

  Serial.begin(115200);

  //pzemSerial.begin(9600);

  // Connect to Wi-Fi

  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {

    delay(1000);

    Serial.println("Connecting to WiFi...");

  }

  Serial.println("Connected to WiFi");

  // Initialize Blynk

  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, password);

  // Initialize relay pins as outputs

  pinMode(relay1, OUTPUT);
```

```
  pinMode(relay2, OUTPUT);
  pinMode(relay3, OUTPUT);
    pinMode(buzzer, OUTPUT);
  // Turn off all relays at the beginning
  digitalWrite(relay1, LOW);
  digitalWrite(relay2, LOW);
  digitalWrite(relay3, LOW);
}
void loop() {
  Blynk.run();
  float voltage = pzem.voltage();
  float current = pzem.current();
  float power = pzem.power();
  float energy = pzem.energy();
if (power>30)
{
    tone(buzzer, 10000,500); delay(1000);
  delay(5000);
  digitalWrite(relay1, LOW);
}
```

```
  // Send data to Blynk
  Blynk.virtualWrite(V4, voltage);
  Blynk.virtualWrite(V5, current);
  Blynk.virtualWrite(V6, power);
  Blynk.virtualWrite(V7, energy);
  Serial.print("Voltage: "); Serial.print(voltage); Serial.println("V");
  Serial.print("Current: "); Serial.print(current); Serial.println("A");
  Serial.print("Power: "); Serial.print(power); Serial.println("W");
  Serial.print("Energy: "); Serial.print(energy); Serial.println("Wh");
  delay(2000); // Delay between readings
}
BLYNK_WRITE(V1) {
  int value = param.asInt();
  digitalWrite(relay1, value);
}
BLYNK_WRITE(V2) {
  int value = param.asInt();
  digitalWrite(relay2, value);
}
BLYNK_WRITE(V3) {
  int value = param.asInt();
  digitalWrite(relay3, value);
}
```