KIGALI INDEPENDENT UNIVERSITY ULK

SCHOOL OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE

P.0 Box: 2280 KIGALI

BILL PREDICTION AND POWER FACTOR MEASURING WITH SMS ALERT

Case study: LIBREVILLE (GABON)

Done by: KONGA Stingger Dohrveen

Roll number: 202110705

Supervisor: Mr. RUTARINDWA Jean Pierre

Dissertation Submitted in Partial Fulfillment of the requirements for the award of Bachelor's Degree in Computer Science.

Kigali, October 2024

Declaration

I, KONGA Stingger Dohrveen, hereby declare that this work entitled "Bill Prediction and Power Factor Measure with SMS Alert "Submitted in partial fulfilment of the requirement for the award of Bachelor's degree in computer science, is my original work and has not been presented for other University

Student Name...

Date...

Signature...

Approval

This dissertation entitled “BILL PREDICTION AND POWER FACTOR MEASURE WITH SMS ALERT’’ has been done under my supervision and submitted for examination with my approval.

Supervisor Name: …………………………………….

Date: ………/………/…………….

Signature: ……………………….

Dedication

With Genuine Gratitude,

We dedicate this Research Project

To my parents and Siblings,

To all my friends and relatives

To All Lecturers and my colleagues at ULK.

Acknowledgement

First and foremost, I would like to acknowledge and thank God for providing me with the strength, wisdom, and guidance throughout this research journey.

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Abstract

Energy is the driving force that runs the world. The current influence of energy is growing faster, and people are finding different ways to explore this energy. IoT is popular nowadays. The importance of the Internet of Things in the current energy management system can be explained by a practical example. This converts to IoT in general terms of energy management systems and then converts energy prediction and power factor monitoring. The power factor measurement system is used to monitor the consumed power factor, and the energy bill is a prediction of the cost amount used. Personalized energy bill prediction provides real-time energy bill predictions for us. This system can support a new approach to energy conservation, which uses real-time data and analysis to guide decisions about energy use. Different time frames can be selected depending on one's personal characteristics.

Keyword: IoT (Internet of Things) Systems, Bill Prediction, Power Factor, Power Factor Measure, SMS Alert System, Sending Data to ESP8266, Data storage.

CHAPTER ONE: GENERAL INTRODUCTION

1.1 Introduction:

In many countries, including Gabon, managing electricity consumption effectively is a significant challenge. Consumers often face unexpected high bills due to a lack of awareness about their electricity usage. Industries also struggle to identify which equipment consumes the most power and which is most efficient. This report highlights the growing demand for energy-efficient solutions and the need for advanced systems to monitor and predict electricity consumption [1]. To address these issues, our project, Bill Prediction and Power Factor Measuring with SMS Alert**,** aims to provide real-time monitoring and bill predictions, sending timely SMS alerts to help both households and industries manage their electricity consumption more effectively, leading to better cost savings and regulatory compliance.

1.2 Background of the problem:

In many countries, including Gabon, managing electricity consumption effectively is a significant challenge. Consumers often face unexpected high bills due to a lack of awareness about their electricity usage. Industries also struggle to identify which equipment consumes the most power and which is most efficient. To address these issues, our project, Bill Prediction and Power Factor Measuring with SMS Alert**,** aims to provide real-time monitoring and bill predictions, sending timely SMS alerts to help both households and industries manage their electricity consumption more effectively, leading to better cost savings and regulatory compliance. Focuses on real-time energy usage monitoring and bill prediction using IoT technology with GSM-based alerts [9].

Globally, managing electricity consumption is a significant challenge. With the increasing reliance on electronic devices, households and industries worldwide face rising electricity bills. Many consumers lack the tools and knowledge to track their electricity usage effectively, leading to inefficiencies and higher costs. This report emphasizes the importance of modernizing electricity systems, including the use of smart meters and advanced monitoring technologies [2]. Inconsistent power supply and varying energy prices across regions exacerbate the issue, making it difficult for consumers to anticipate their monthly bills. The growing demand for energy-efficient solutions highlights the need for advanced systems to monitor and predict electricity consumption. Also, due to the growing trend of modern technology, electricity is the main energy source in human life. It has been revealed that as many as 76% of electricity users in Indonesia are still using electric meters with low technology and can only be read manually. This is despite PLN being a State-Owned Enterprise with an obligation to convert electrification in Indonesia into a smart electricity network that uses a system called Automatic Meter Reading (AMR).

The author has a keen interest in learning about electrical systems and how to monitor electric power. In the past year, we learned about electronic radio signals and now we want to make modifications in 2019 to increase the accuracy level of electrical energy monitoring in the Arduino UNO Board Circuit and GEDENYA Emon-monitor based on SMS notifications.

For residents of Forowerado City, who predominantly rely on state electricity, they are still using analog Energy Meters or Kilowatt Hour Meters.

In many developing regions, the problem of electricity management is even more pronounced. Sub-Saharan Africa, for instance, experiences frequent power outages and fluctuations in energy supply. This article reviews the current state of energy efficiency in developing countries, including the challenges and opportunities for improving energy management [4].

This instability not only affects residential consumers but also disrupts industrial operations, leading to economic losses. Limited access to modern energy management tools and a lack of consumer awareness further contribute to inefficient electricity usage. Governments and utilities in these regions are increasingly exploring digital solutions to help consumers better manage their energy consumption and reduce costs [2]

Locally, in Gabon, the challenges of electricity management are particularly acute. Many households and businesses receive unexpectedly high electricity bills due to poor tracking and management of their consumption. This report provides an overview of Gabon's energy sector, including the challenges and opportunities for improving electricity management [7]. There is a significant gap in consumer knowledge about which devices consume the most power and how to optimize usage. Industries face similar issues, struggling to identify high-consuming equipment and improve energy efficiency. Additionally, bill prediction measures are often not in compliance with local regulations, leading to further complications. As Gabon [7] continues to develop rapidly, there is a growing need for effective solutions to manage electricity consumption, reduce costs, and ensure regulatory compliance. The proposed project, Bill Prediction and Power Factor Measuring with SMS Alert**,** aims to address these local challenges by providing real-time monitoring and predictive insights, empowering consumers with the knowledge and tools to manage their electricity usage more effectively [8].

1.3 Problem Statement

With the current ways of processing and handling energy, more money and resource are wasted, where it uses too much electricity over the month and unable to have a strict control of the currents they are using or not able to know which device is adaptable for their electrical meter. This research aims to design and implement a bill prediction system using SMS alert.

1.4 Objective of project:

1.4.1 General objective

The general objective of this research is to design and implement bill prediction and power factor measuring system using the SMS alert.

1.4.2 Specific objectives

Considering the problems listed above, the specific objectives of this project are:

i. To develop a predictive model for electricity bills by designing a circuit of the system.

ii. To measure the power factor of a household.

iii. To set up an automated SMS alert system that will send alerts to users based on predefined triggers.

iv. To Enable energy efficiency and cost savings that alert users to potential inefficiencies.

1.5 Research Questions:

i. What data is required to develop an accurate predictive model for electricity bills?

ii. What software and hardware components are necessary for a continuous power monitoring system?

iii. What criteria and predefined triggers will be used to send SMS alerts to users?

iv. What strategies will be implemented to identify potential inefficiencies in electricity usage?

1.6 Scope of the project

The scope of this project entails the development and implementation of an electricity management system in Gabon. The objective is to develop a system that predicts monthly electricity bills based on real-time and data being measuring and a digital platform that streamlines the process of predicting bill amount, power factor status, and alerts for high consumption and poor power factor.

1.6.1 Content scope

The bill prediction and power factor measure with SMS alert encompasses various aspects to facilitate a streamlined and transparent process. The content scope is:

System Architecture and Design which is a system that will identify and document user requirements, including desired features and functionalities, define technical requirements such as data collection frequency, and storage needs. Also, for that system we will design the overall system architecture, including hardware, software, data flow, and integration points. Data collection and integration which is an installation and configuration of a smart meters are need to capture the real-time electricity consumption data and deploy power factor meters to continuously monitor the power factor of the electrical system. Bill prediction can develop and perform calculation for predicting monthly electricity bills. Develop operations for continuous power factor measurement and analysis and define acceptable power factor thresholds and implement real-time monitoring. User interface development develop a web portal that can users can access for knowing their data, and ensuring cross-platform accessibility. Implement features for setting alert thresholds, viewing detailed reports, and managing user preferences. SMS alert system integrate with an SMS gateway service to enable automated alert notifications. Configure the system to send SMS alerts based on predefined triggers (e.g., high predicted bills, poor power factor, abnormal consumption patterns). Detail reports generate comprehensive reports on electricity usage, cost predictions, and power factor analysis. Allow users to download and share reports for further analysis or record-keeping.

1.6.2 Geographical scope:

The geographical scope will focus in Gabon considering its socio-economic contexts, regulatory environment and electrical infrastructure.

Data collection, analysis and recommendations will pertain to electrical power consumption within the boundaries of Gabon.

1.6.3 Time scope:

Effective electricity consumption management is a global challenge, with consumers and industries facing rising bills and inefficiencies due to a lack of proper tools for tracking and managing usage. In developing regions like Sub-Saharan Africa, these issues are exacerbated by frequent power outages, energy supply fluctuations, and limited access to modern energy management solutions. In Gabon, the problem is particularly acute, with households and businesses often receiving unexpectedly high electricity bills due to poor tracking and management practices. This highlights a pressing need for better awareness and tools to manage electricity usage efficiently, ensure regulatory compliance, and ultimately reduce costs.

1.7 Project methodology

Project methodology refers to a systematic approach or framework that outlines the processes, activities, and guidelines to be followed during the execution of a project. Here in our project we are going to use documentation as tools of data collection, SSADM which stand for Structure Systems Analysis and Design Method as the system analysis and design method, and agile model as the software development methodology.

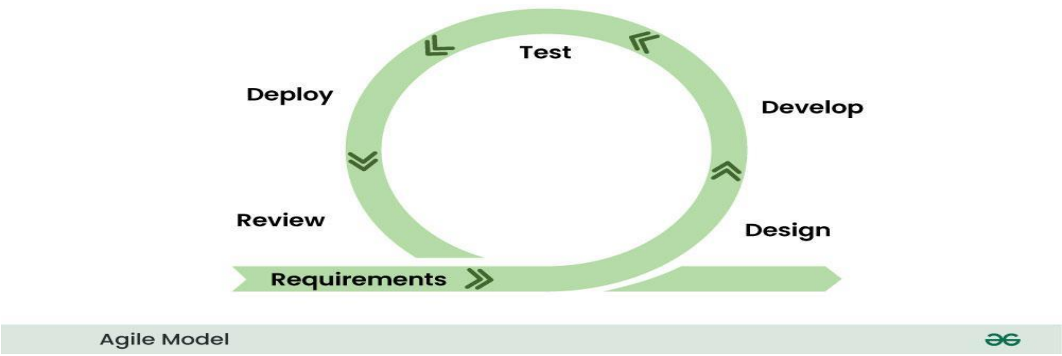


Figure 1. 1: AM.

1.8 Significance of the project

The bill prediction and power factor measure with SMS alert project is of significant interest due to several key reasons:

1.8.1 Personal interest

As an individual, there are several personal interests in the bill prediction and power factor measure with SMS alert project. Financially, we can reap rewards through project contracts, potential employment opportunities, or even by turning the system into a commercial product or service. Technology and Innovation**:** we are fascinated by the integration of advanced technologies such as smart metering, predictive analytics, and real-time monitoring systems. Exploring how these technologies can be applied to optimize energy usage and improve efficiency is personally rewarding.

Problem Solving**:** Addressing challenges related to energy consumption, billing accuracy, and power factor management requires innovative solutions. Finding efficient ways to predict bills accurately and monitor power factors effectively is intellectually stimulating.

User Empowerment**:** Enabling consumers to have better control over their energy usage through real-time alerts and predictive insights empowers them to make informed decisions. This aspect of empowering individuals through technology resonates with personal values of transparency and empowerment.

Learning and Growth**:** Engaging in a project that involves complex data analytics, system integration, and real-time monitoring provides opportunities for continuous learning and professional growth. The dynamic nature of the project allows for acquiring new skills and knowledge in emerging technologies. The completed project becomes a powerful addition to their portfolio, showcasing their ability to handle intricate projects and drawing potential clients or employers. Additionally, they can explore diverse career avenues, including roles in government, construction, or technology companies.

In summary, the personal interest in this project stems from a combination of technological fascination, problem-solving opportunities, impact on efficiency and sustainability, personal growth, community benefits, and ethical considerations. These factors collectively make the bill prediction and power factor measure with SMS alert project not only professionally rewarding but also personally meaningful.

1.8.2 Institutional interest

The institutional interest in the bill prediction and power factor measure with SMS alert project revolves around several key aspects that are beneficial for organizations and institutions involved in energy management, utilities, and technological innovation:

Enhanced Customer Satisfaction: Utility companies and energy providers are keen on improving customer satisfaction. Providing accurate bill predictions and real-time alerts regarding power factor helps in meeting customer expectations and enhancing overall service quality.

Operational Efficiency: Implementing predictive analytics and real-time monitoring systems allows utility companies to optimize their operations. This includes better planning for energy distribution, load management, and resource allocation based on actual consumption patterns.

Cost Reduction: By accurately predicting bills and monitoring power factor, institutions can reduce operational costs associated with billing disputes, inefficient energy usage, and penalties due to low power factor. This leads to improved financial management and profitability.

In conclusion, the institutional interest in the bill prediction and power factor measure with SMS alert project lies in improving customer satisfaction, enhancing operational efficiency, and reducing costs in the energy sector. These factors collectively contribute to the institutional success and long-term sustainability of organizations involved in energy management and utilities.

1.8.3 Public interest

The bill prediction and power factor measure with SMS alert project holds significant public interest due to several key reasons that benefit individuals, communities, and society as a whole:

Consumer Empowerment: Providing consumers with accurate bill predictions and real-time alerts about their energy usage and costs empowers them to manage their finances more effectively. This transparency fosters trust between consumers and energy providers.

Cost Savings: Helping consumers optimize their energy usage based on predictive insights can lead to significant cost savings on utility bills. This is particularly beneficial for households and businesses looking to reduce expenses.

Environmental Sustainability: By promoting energy efficiency and monitoring power factor, the project contributes to reducing overall energy consumption. This translates into lower carbon emissions and environmental impact, supporting global sustainability goals.

Public Awareness: The project raises public awareness about energy conservation practices and the importance of maintaining a high-power factor. It educates consumers about the impact of their energy usage on the environment and encourages responsible energy behavior.

Public Health**:** Efficient energy management can indirectly contribute to public health by reducing pollution and greenhouse gas emissions associated with energy production.

1.9 Limitations of the project

While the bill prediction and power factor measure with SMS alert project offers substantial benefits, it also faces several limitations and challenges that need to be considered:

Data Accuracy and Availability: The accuracy of bill predictions and power factor measurements heavily relies on the quality and availability of data from smart meters or other monitoring devices. Inaccurate data inputs can lead to unreliable predictions and alerts.

Dependency on Infrastructure: The project's effectiveness depends on the availability and reliability of energy infrastructure, including smart meters and communication networks. Poor infrastructure in some areas can hinder data collection and transmission.

Technological Challenges: Implementing and maintaining advanced technologies such as predictive analytics and real-time monitoring systems require technical expertise and investment in infrastructure. This can be a barrier for smaller utility providers or regions with limited resources.

Cost of Devices: While implementing can be think as easy thing for users, cost of the devices can cause a big challenge of it. In fact, electronic components need to be taken preciously due to their conductivity with electricity, and specially their capacities because any wrong fixation between them can damage them.

1.10 Organization of the project

This study contains four chapters:

First Chapter entitled “general introduction” provide the basic information on the research project and the motivation behind the choice of this topic, the problem statement, project methodology used for data collection, the objectives of the project, the scope of the study and the results expected from this study.

Second Chapter titled “literature review” where we define the concepts and the domain terms, describe the environment of the system, the technics that will be used by the system solution and of how a new system will operating. Also, in this chapter keys words used in the system are defined.

The third chapter called System analysis and design where all logical concept of the new system, and describe its UML and the design aided by the use case diagrams, sequence diagram, activity diagram, database diagram, data dictionary diagram, and architectural diagrams.

The fourth chapter system implementation will show technical realization of the application, technologies used, presentation of the new system using screenshots and brief descriptions. and software requirements, development and deployment.

The project will be ended with conclusions and recommendations of the project.

CHAPTER TWO: LITERATURE REVIEW

2.0. Introduction:

A literature review is an essential component of academic research that provides a comprehensive overview and critical evaluation of existing scholarly works, theories, and findings relevant to a specific research topic or question. It serves as a foundation for the research and helps to establish the context, significance, and gaps in knowledge that the current study aims to address.

The primary objective of a literature review is to demonstrate the researcher's understanding of the existing body of knowledge and to identify the most important and pertinent studies related to their research area. By examining a wide range of published works, including journal articles, books, conference papers, and other academic sources, the literature review aims to synthesize and analyze the findings, methodologies, and theoretical frameworks of previous research.

2.1. Definitions of Concept/ Terminologies.

In the context of this project, the following key concepts related to online Taxation management are defined:

Bill: An itemized statement of money owed for goods or services supplied [19].

Prediction: A forecast or estimation about a future event or trend based on current data or analysis.

Bill Prediction System: Bill prediction management deals with applying a method that can predict energy bills on a daily basis. This allows customers to estimate their energy consumption and make decisions regarding utility management. In the Bill Prediction System, two forecasts can be made using regression analysis [18].

Load Forecast: This refers to forecasting the load of energy that will be used in the future. It is used to determine the future load and make decisions regarding energy efficiency. Load, measured in wattage, represents the power or energy used by customers [21].

Energy Forecast: This refers to forecasting the amount of energy consumed within a particular time for a given date. This forecast is more accurate in predicting energy bills because the billing cycle may vary from one customer to another [21].

IoT: Internet of Things (IoT) refers to a network of everyday devices, appliances, and other objects equipped with computer chips and sensors that can collect and transmit data through the internet [19].

Power Factor: Power factor (PF) is a dimensionless number between 0 and 1 used to measure the efficiency of converting electrical power into useful work output [20]. Poor power factor means that you're using power inefficiently. This matters to companies because it can result in: heat damage to insulation and other circuit components, reduction in the amount of available useful power, a required increase in conductor and equipment sizes. Finally, a low power factor increases the overall cost of a power distribution system because it requires a higher current to supply loads [41]. The power factor (PF) ranges from 0 to 1, and different ranges indicate varying levels of efficiency in power usage:

- **PF = 1 (or 100%):**

Description: Perfect efficiency; all power is being used effectively.

Cost Implication: Most cost-effective; no penalties from utilities.

- **0.9 ≤ PF < 1:**

Description: Good efficiency; the system is using power effectively with minimal losses.

Cost Implication: Generally acceptable; low likelihood of penalties.

- **0.8 ≤ PF < 0.9:**

Description: Moderate efficiency; some losses in the system.

Cost Implication: May incur penalties depending on utility provider policies.

- **0.5 ≤ PF < 0.8:**

Description: Poor efficiency; significant losses in the system.

Cost Implication: Higher likelihood of penalties; increased electricity costs due to inefficiencies.

- **PF < 0.5:**

Description: Very poor efficiency; most of the power is reactive and not doing useful work.

Cost Implication: Very costly; significant penalties from utilities, potentially leading to increased costs and inefficient operation.

SMS Alert: A text message sent to a mobile device to notify the recipient of important information, such as updates, warnings, or reminders[20].

Channel Relay: A relay is an electrically operated switch. Many relays use an electromagnet to operate a switch mechanically, but other operating principles, such as solid-state relays, are also utilized Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal [38].

PZEM-004T: PZEM-004T is an electronic module that functions to measure: Voltage, Current, Power, Frequency, Energy and Power Factors. With the completeness of these functions / features, the PZEM-004T module is ideal for use as a project or experiment for measuring power on an electrical network such as a house or building [39].

Energy Meter: An electricity meter, electric meter, electrical meter, energy meter, or kilowatt-hour meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device over a time interval [40].

Arduino microcontroller: Arduino microcontrollers will serve as the hardware platform for implementing the bill prediction and power factor measurement with SMS alert system, providing flexibility and customization options for integrating various sensors and actuators. Also, Arduino technology is an open-source [40] platform comprising a microcontroller board and development environment, allowing users to create interactive electronic projects easily. It offers simplicity, flexibility, and accessibility for users of all skill levels, enabling a wide range of applications in areas such as robotics, home automation, and wearable devices.

ESP8266: The ESP8266 is a low-cost Wi-Fi microcontroller, with built-in TCP/IP networking software, and microcontroller capability, produced by Espresso Systems in Shanghai, China [40].

Optocoupler: An opto-isolator (also called an optocoupler, photocoupler, or optical isolator) is an electronic component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 25 kV/μs [40].

GSM Module: A GSM module is a device that allows electronic devices to communicate with each other over the GSM network. GSM is a standard for digital cellular communications, which means that it provides a platform for mobile devices to communicate with each other wirelessly. The GSM module is a specialized device that enables a device to send and receive data over the GSM network. The GSM network is an essential component of modern communication systems. It is a standard used by mobile devices to communicate with each other wirelessly. The GSM network provides a reliable and secure platform for communication, which makes it a preferred choice for many applications [40].

2.2. Review of Related Literature:

Bill prediction and power factor measuring using SMS Alert have become increasingly popular due to their convenience and efficiency. Several studies have focused on aspects such as data collections, circuit system, and system functionality as stated in the above specific objectives [22].

A predictive model for electricity bills leverages historical consumption data, weather information, and other relevant factors to forecast future electricity usage and costs. These models employ various machine learning algorithms, such as regression analysis, time series forecasting, and neural networks, to predict consumption accurately. Key steps in building such a model include data collection, feature engineering, model selection, and training and validation processes. The model's performance is measured using evaluation metrics like Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R-squared values. By understanding and anticipating consumption patterns, users can better manage their electricity usage and potentially reduce costs. Additionally, these models can help utility companies improve load forecasting and optimize resource allocation, leading to enhanced grid stability and efficiency. Also, Real-time energy monitoring is essential for accurate bill prediction. Smart meters and IoT-based sensors play a critical role in providing the necessary data. In their research, McKenna et al. (2012) emphasize the need for continuous monitoring to provide users with up-to-date energy usage information, which enhances the accuracy of bill predictions. The integration of real-time sensors has revolutionized energy management systems, allowing for dynamic bill predictions that adapt to real-time usage [23].

Power factor is an important parameter in power systems, representing the efficiency with which electrical power is converted into useful work. A power factor closes to 1 indicates efficient energy usage, while a lower power factor indicates inefficiency, leading to higher energy costs. Power factor measurement has been extensively studied in the context of industrial and commercial energy management. Power factor correction is critical to reducing electricity costs, particularly for industrial consumers. Farhangi et al. (2010) describe how power factor measurement can help industries reduce reactive power consumption, thereby lowering their energy bills. This is particularly relevant in systems where motors, transformers, and other inductive loads are predominant [24].

An automated SMS alert system can notify users about their electricity consumption, potential inefficiencies, and cost-saving opportunities. This system integrates with predictive models to send timely alerts based on consumption forecasts. Key components of the system include an SMS gateway service like Twilio or Nexmo, mechanisms to trigger alerts when certain thresholds are met, and personalization of messages based on individual user patterns and preferences. By receiving real-time notifications, users can take immediate actions to prevent high consumption and manage their energy usage more effectively. Furthermore, the system can provide users with tips on energy-saving practices and recommend the best times for using high-energy appliances, thereby encouraging more sustainable consumption habits [25].

Enabling energy efficiency and cost savings involves monitoring consumption patterns, identifying inefficiencies, and suggesting corrective actions. This can be achieved by using smart meters and IoT devices to track real-time electricity usage, analyzing data to detect anomalies or equipment inefficiencies, and recommending corrective actions such as load balancing, using energy-efficient appliances, or scheduling high-energy tasks during off-peak hours. Additionally, educating users on best practices for energy conservation can further enhance efficiency. By maintaining a high-power factor and reducing electricity costs, users can achieve significant savings and contribute to sustainable energy use. The implementation of energy management systems can also aid in achieving these goals by providing comprehensive insights and control over energy consumption in both residential and commercial settings [26].

2.3.2 What is BPPFMSA?

Bill prediction, power factor measurement, and SMS alerts offers a comprehensive approach to energy management. Bill prediction systems help users anticipate future costs, while power factor measurement ensures that energy is used efficiently. SMS alerts provide real-time notifications, empowering users to make informed decisions about their energy consumption. As IoT technology continues to evolve, the combination of these three components will become increasingly important in promoting energy efficiency and reducing operational costs. Further research into the optimization of these systems could yield even more effective energy management solutions for both residential and industrial applications [27].

The System handles power consumption and prediction of future expenses for the users to have a positive and minimal monthly expense.

i. Sends real-time SMS notifications to users.
ii. Informing them about predicted costs.
iii. Potential inefficiencies.
iv. Providing tips for energy savings.

CHAPTER THREE: SYSTEM ANALYSIS AND DESIGN.

3.1. Introduction

With the growing importance of efficient energy management, the need for systems that help users monitor and control their electricity consumption is becoming increasingly critical. The advent of Internet of Things (IoT) technology, coupled with real-time data analytics, has led to the development of systems that provide comprehensive energy insights to users. One such system integrates bill prediction, power factor measuring, and SMS alert mechanisms to ensure that users stay informed about their energy consumption patterns and overall efficient.

3.2.2. Problem of the Current System:

The current system faces some problem such as administration challenges which is weak institutional capacity and governance issues hinder effective bill management by the administration, wastage of funds more money is being wasted, during our daily life. Also, lack of integration in current energy management systems.

3.3. Analysis of the new System:

3.3.1. Introduction:

The new system will improve the traditional methods of electrical management through the below discussed importance and features as well.

Implementing bill prediction in Gabon can the system sends real-time SMS notifications to users, informing them about predicted costs, potential inefficiencies, and providing tips for energy savings. This enables users to manage their electricity usage proactively and reduce their bills by taking timely corrective actions. The digital nature of the bill prediction system allows for greater scrutiny of financial transactions, making it more difficult for individuals and businesses to evade paying their bills. By detecting and deterring bill payment evasion, a bill prediction system can contribute to a more equitable system and increase government income.

3.3.2. System Requirements:

The system requirements for a new bill prediction in Gabon would need to consider various factors to ensure its effectiveness, efficiency, and usability. Here are some key system requirements:

3.3.2.1. functional Requirements:

These define what the system should do in terms of specific functionalities or features it must possess to meet user needs and stakeholder objectives. Below are the functional requirements for a bill prediction and power factor measure with SMS alert system.

In term of hardware the System will sense the current, voltage, power, energy, and power factor with the help of the energy meter and sensor(PZEM-004T) and with those values sensed will help us for the prediction of the bill. Also, in that system we will integrate the GSM model for sending required messages with is user.

The system will have a user authorization process that requires users to log in using a username and password.

The system can store all the information and retrieve them.
The user will be able to logout after they finished using system.
The system will allow the users to view and print the bill for power bill.
The system will allow admin to view and make decisions.

3.3.2.1. Nonfunctional Requirements:

These specify the criteria that characterize how well the system performs its functions, including aspects such as security, reliability, performance, usability, scalability, and compliance.

Security: All passwords that are generated or accepted must be stored in a database in an encrypted form.
User friendly: The system must be user friendly, understandable and easy to use
Privacy: The system shall be able to protect the user's privacy
Availability: The system should be available to all user 24 hours
Performance: The system must have a quick performance and should be able to respond requests in a reasonable amount of time.
Accessibility: Users can access their results from any location (as long as they are within a network service reception area).
Recoverability: The system should be able to recover from any disturbance.
Environmental: The system should be able to run on an android operating system.

3.3.3. Function diagram:

A function diagram for an online bill prediction management system typically includes various components and their interactions to illustrate how the system operates.

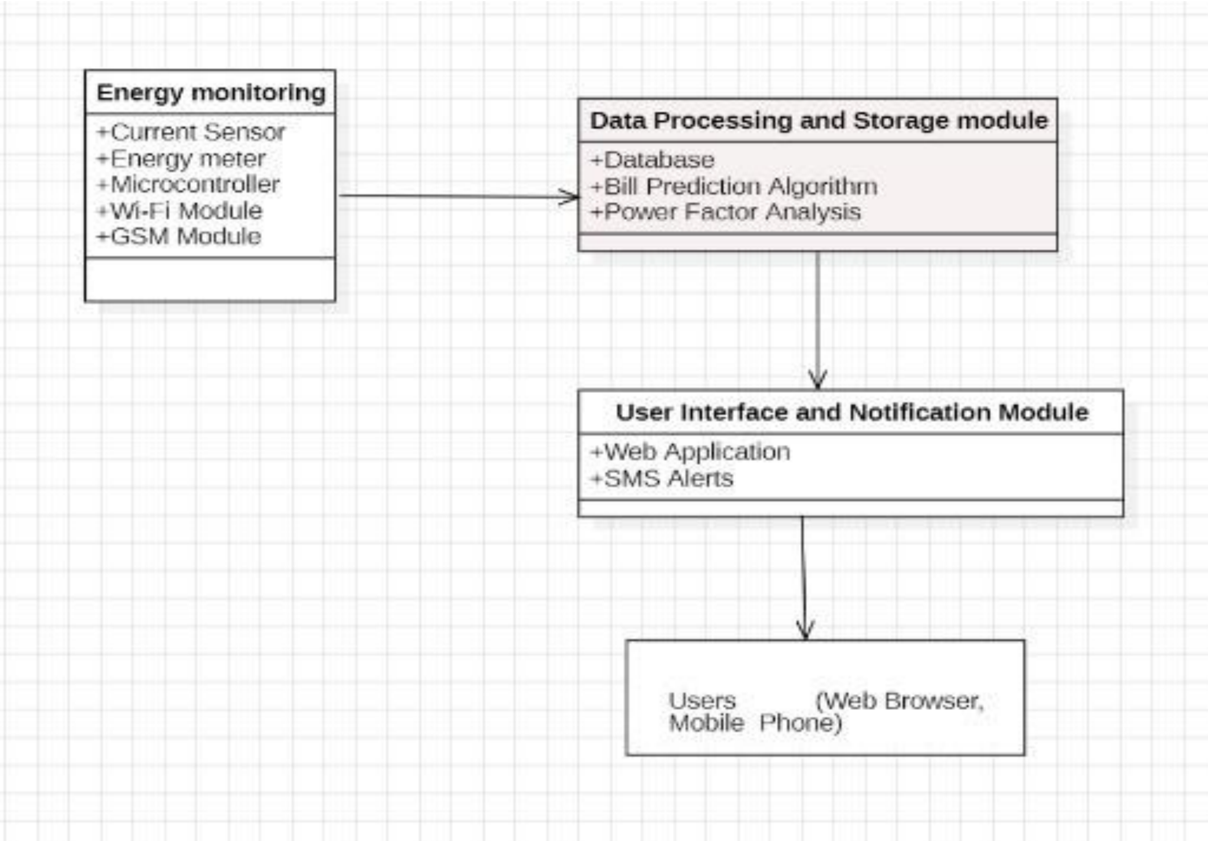


Figure 3. 1: Function Diagram.

3.3.4 Software Development methodology:

Figure 3. 2: Agile Methodology.

i. Evaluation and Monitoring:

- Deploy the system to a pilot group of users
- Collect data on prediction accuracy and user engagement
- Monitor power factor improvements resulting from alerts
- Track SMS delivery rates and user response to alerts
- Gather feedback on system usability and usefulness
- Analyze impact on energy consumption patterns
- Identify any technical issues or performance bottlenecks
- Assess system scalability and reliability

ii. Strategy for Optimization:

- Analyze data from the evaluation phase to identify areas for improvement
- Refine prediction algorithms based on actual vs. predicted bills
- Optimize power factor measurement accuracy and alert thresholds
- Enhance user interfaces based on feedback
- Develop strategies to increase user engagement with the system
- Plan for scaling the system to handle more users and data
- Create a roadmap for additional features (e.g., appliance-level monitoring)
- Establish a process for continuous model training and improvement

iii. Application and Design Together with Client:

- Collaborate with utility companies and end-users to define system requirements
- Design predictive algorithms for bill estimation
- Plan power factor measurement and analysis methods
- Create user interfaces for bill prediction and power factor monitoring
- Design SMS alert system (triggers, message content, frequency)
- Develop data flow diagrams for the entire system
- Create mockups and prototypes for client feedback
- Iterate on designs based on client input and technical feasibility

iv. Application Construction Implementation and Testing:

- Develop core system components (data collection, processing, prediction modules)
- Implement machine learning algorithms for bill prediction
- Create power factor measurement and analysis software
- Integrate SMS gateway for alert system
- Develop user interfaces for web and mobile platforms
- Conduct unit testing for individual components
- Perform integration testing of the entire system
- Carry out user acceptance testing with a sample group of consumers
- Test accuracy of bill predictions and power factor measurements
- Verify SMS alert system functionality under various scenarios

v. Mapping Processes to Determine the Starting Point ('Actual State'):

- Analyze current billing systems and their accuracy
- Assess existing power factor measurement methods
- Evaluate current communication methods for alerts (if any)
- Gather data on user energy consumption patterns
- Identify pain points in current billing and power factor management
- Collect information on existing hardware (smart meters, sensors)
- Survey potential users about their needs and preferences
- Review regulatory requirements for billing and power factor standards

3.3.4.2. System Design Methodology:

Structured Systems Analysis and Design Method (SSADM) is a systems approach to the analysis and design of information systems. It uses a systematic and disciplined methodology, breaking down systems development into stages that include feasibility study, requirements analysis, design, implementation, and testing. SSADM emphasizes thorough documentation and detailed modeling techniques to ensure that the final system meets user requirements and is delivered on time and within budget. It is particularly useful for large, complex projects where a structured approach can help manage risks and ensure quality.

SSADM utilizes several key tools for system development. Data Flow Diagrams (DFDs) illustrate the flow of data within a system, showing how data is processed through inputs and outputs. Entity-Relationship Diagrams (ERDs) model data entities and their relationships, providing a clear view of the system's data structure. A Data Dictionary serves as a centralized repository of information about data, including its meaning, relationships, origin, usage, and format, ensuring consistency across the project.

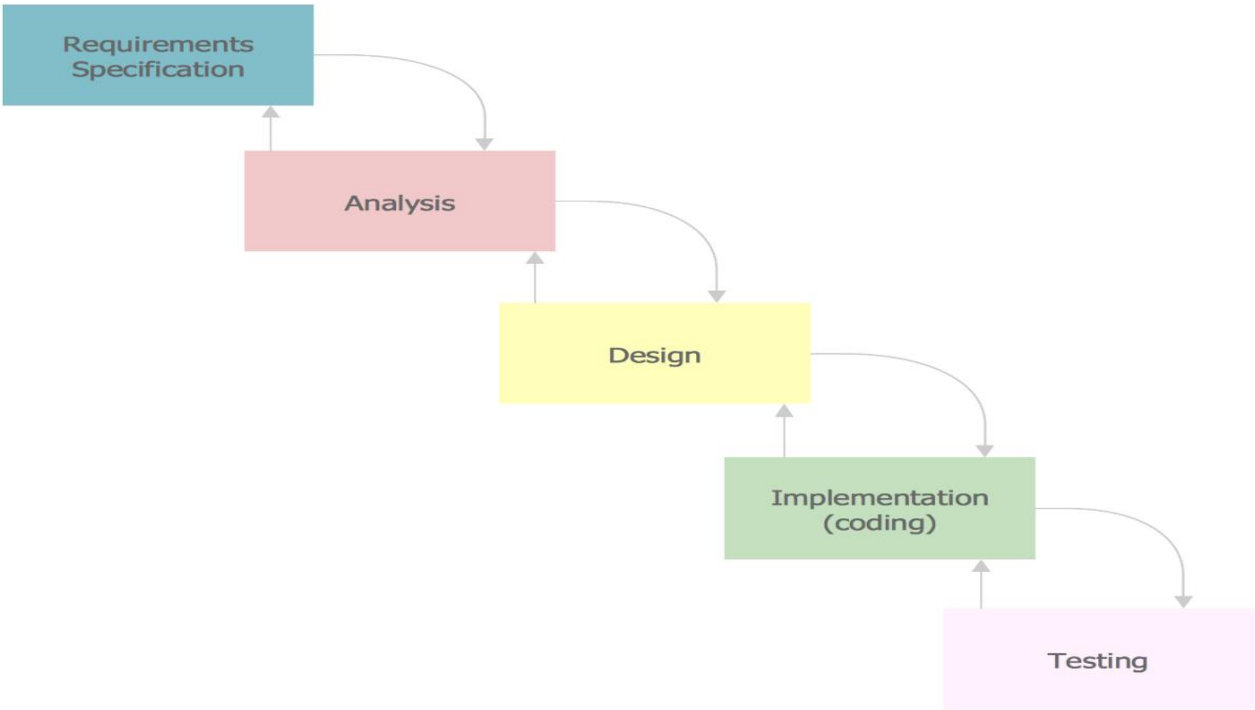


Figure 3. 3: SSADM Method.

3.3.4.3. Data collection Techniques:

Refer to the methods and procedures used to gather data for research or analysis purposes.

Documentation

This technic permitted the research to consult books, reviews, class notes and web page related to online electrical bill prediction and power factor measuring with SMS alert management systems.

i.Dataflow diagram (Level0)

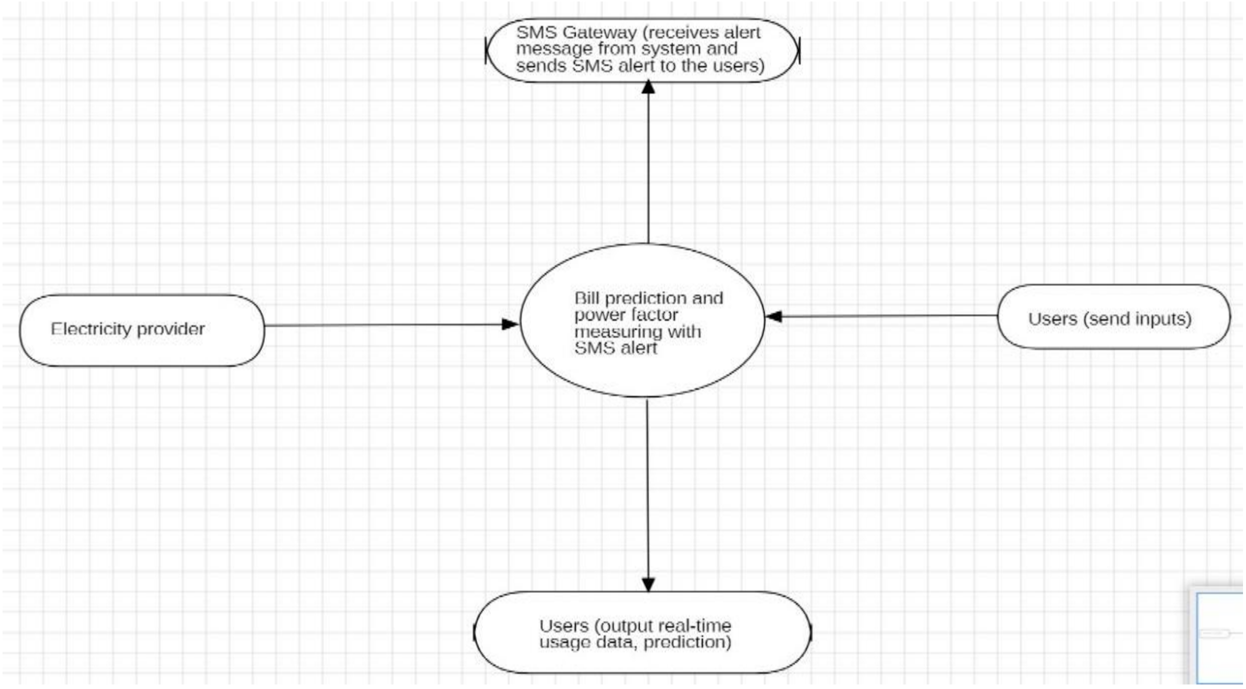


Figure 3. 4: Level 0 of Dataflow Diagram.

ii.Dataflow diagram (Level1)

The image bellow is a level one data flow diagram that outlines a process for monitoring energy usage and providing feedback.

External Entities: Here they are 3. Let start by the first one which is the user specifically the end-user of the electricity service, following by the electricity provider which is the company supplying electricity, and the last one of the external entities are telecom provider which are the companies providing SMS services.

Main Processes: the main processes are following by the meter reading which is in charge of collecting electricity usage data, payment processing which is in charge of handling recharge through SMS. Also, we have the bill prediction which is forecasted future bills based on usage patterns, the bill prediction is follow by the power factor measurement that monitors power quality. The last two of the main processes are the alert generation and SMS handling, while the first one creates alerts based on various triggers other manages sending and receiving SMS messages.

Data Store: For the storage, as we know database will store all relevant system data.

Key Data Flows: User provides electricity usage data and recharge/top-up information, Meter Reading process collects consumption data and stores it in the Database. Payment Processing handles recharges and updates the Database, Bill Prediction uses historical data to forecast bills, Power Factor Measurement analyzes usage data for power quality, Alert Generation creates messages based on bill predictions and power factor data, SMS Handling manages communication with the Telecom Provider to send alerts to the User. Payment Processing and Bill Prediction provide balance updates and forecasts to the User, Power Factor Measurement sends power quality information to the Electricity Provider.

This Level 1 DFD provides a more detailed view of the system's internal processes while still maintaining a clear overview of how data flows between these processes, the external entities, and the data store.

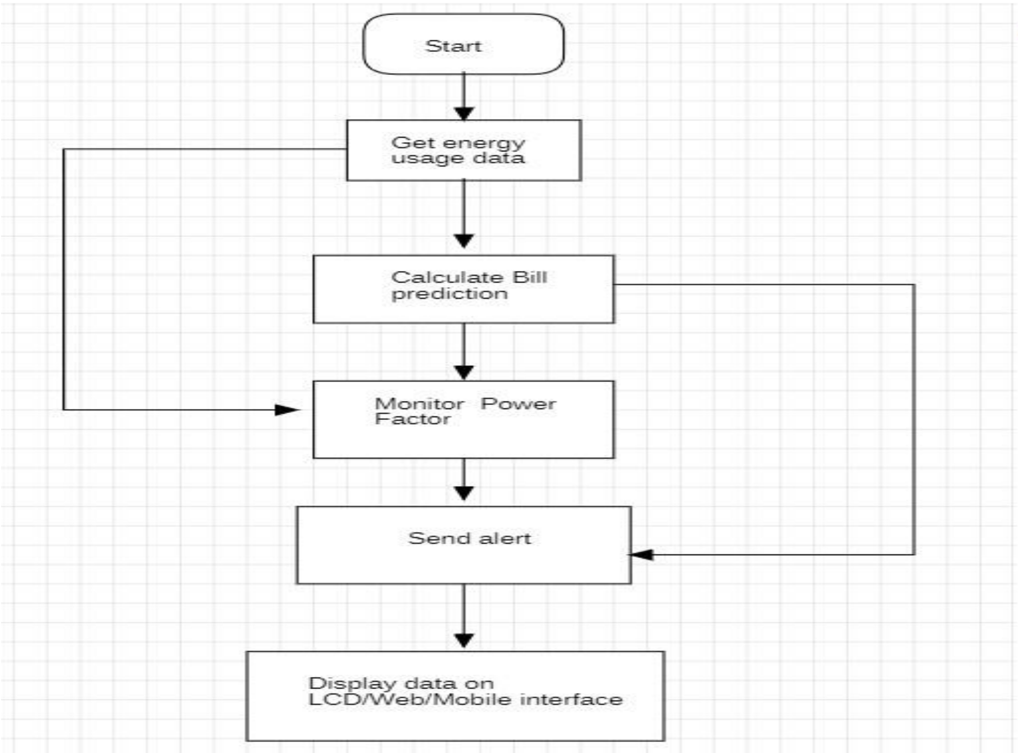


Figure 3. 5: Level 1 of Dataflow Diagram.

iii.Entity Relationship Diagram (ERD)

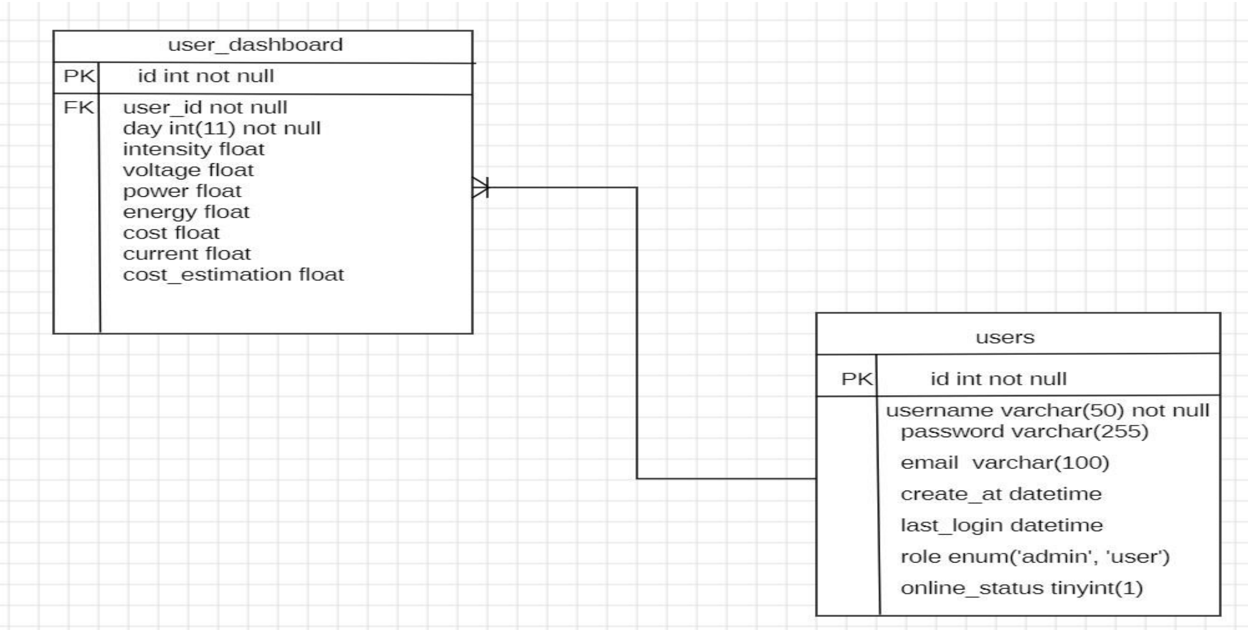


Figure 3. 6: Entity Relationship Diagram(ERD)

iv.System Circuit:

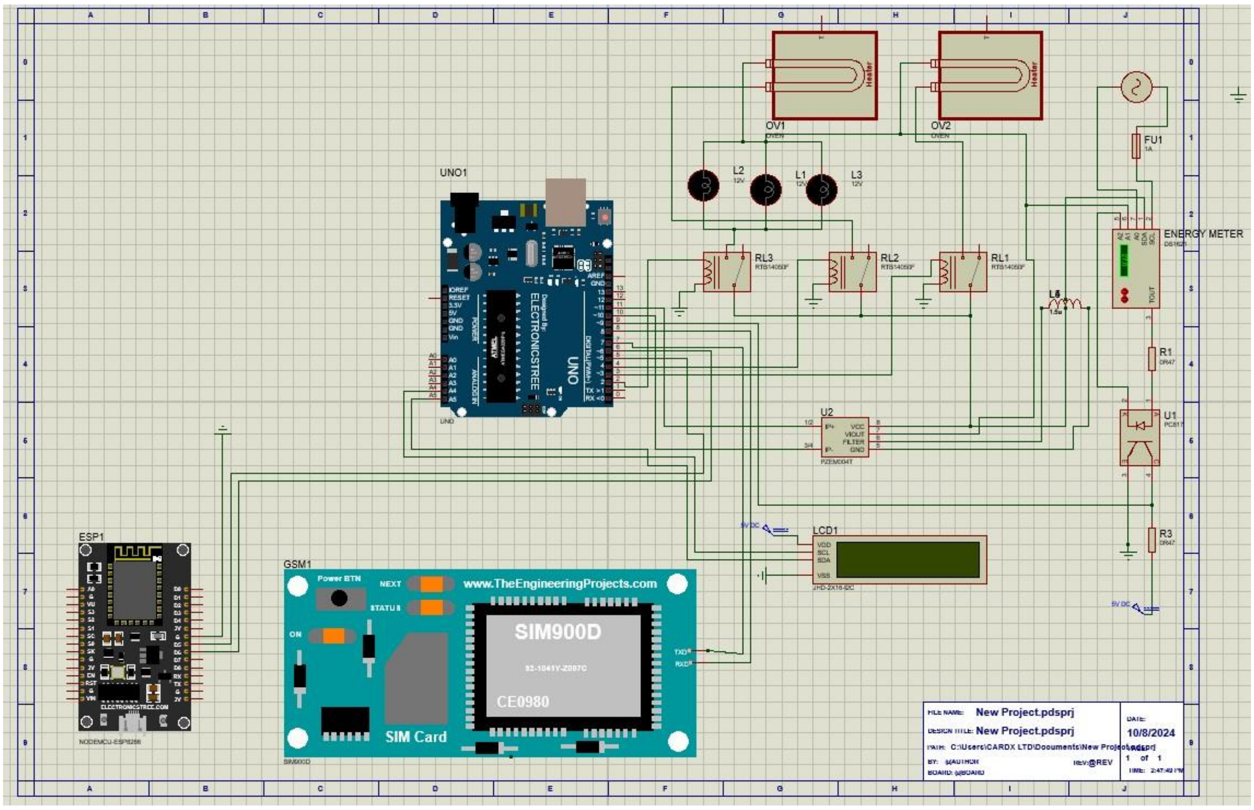


Figure 3. 7: Circuit diagram

v. Data dictionary

User table

Table 3. 1: User table.

Name	Type	Extra
id	int(11)	Primary key
username	varchar(50)	
password	varchar(255)	
email	varchar(100)	
created_at	datetime	
last_login	datetime	
role	enum(‘admin’,’user’)	
online_status	tinyint(1)	

User_dashboard table

Table 3. 2: User_dashbord Table.

Name	Type	Extra
id	int(11)	primary key
user_id	int(11)	
day	int(11)	
current	float	
voltage	float	
power	float	
Power_factor	Float	
cost	float	
Current_estimation	float	
cost_estimation	float	
date	DATE	
time	TIME	

CHAPTER FOUR: SYSTEM IMPLEMENTATION.

4.1. Implementation and Coding:

The implementation of Bill prediction and power factor measuring with SMS alert involves developing a hardware for measuring data and handling the message alert. That hardware part will be connected each other and communicate together through a code. Also, backend logic for data processing, frontend interfaces for user interaction, and robust security measures. Backend technologies, such as frameworks for handling data and business logic, are utilized. Frontend frameworks are employed for creating user interfaces. The system's codebase comprises API routes for various functionalities like user registration, bill prediction, and reporting. Testing ensures reliability, while deployment involves hosting backend services and frontend on platforms. Ongoing maintenance includes updates, security patches, and user support to ensure smooth operation.

4.1.1. Introduction:

Electricity usage leads to complexity and mistakes in billing. Monitoring and controlling it manually is time-consuming and unreliable. Wireless monitoring reduces complexity. A unique design using a microcontroller records power consumption. A relay interrupts supply during high consumption to protect the user from excess charges. The number of electric machines has increased, making monitoring difficult. A digital energy meter, microcontroller, and modem are needed to measure and send data. Mobile-based wireless automation controls the motor. This system is proposed for large farms and controls appliances to limit load and reduce excess charges.

An electricity billing is a digital platform designed to streamline and simplify the process of the knowing the power that has been consumed for individuals, and businesses. It enables users to file their electricity, track billing records, generate reports, and ensure compliance with electricity consumption through an intuitive online interface. This microcontroller system typically involves backend development for handling data processing and logic, frontend development for user interfaces, IoT for measuring data, and robust security measures to safeguard sensitive information. By leveraging technology, bill prediction and power factor measuring with SMS alert system aims to improve efficiency, accuracy, and transparency in electricity processes, ultimately facilitating better financial management for users.

4.1.2. Description of Implementation tools and technology:

Implementing an electrical consumption system involves utilizing a range of tools and technologies. IoT relies on devices to help us to sense the external entities, backend development typically relies on frameworks for handling data and business logic, while frontend interfaces are built using frameworks for user interaction. Robust security measures are essential throughout. Testing ensures reliability, and deployment is facilitated by hosting platforms. Ongoing maintenance involves updates, security patches, and user support to ensure operational efficiency.

4.1.2.1. Hardware implementation:

4.1.2.1.1 Components Used

The primary hardware components used in the system are:

- Arduino Uno: The central microcontroller that manages the entire system.
- ESP8266: For wireless communication with the web server.
- PZEM-004T: For sensing the current, voltage, power factor.
- Energy meter: For the usage of power and units.
- GSM: For the remote command of the controller
- Optocoupler: For stepping down of the AC electrical source
- 3-Channel Relay Module: Used to control the lighting circuits.
- LED Bulbs: Represent the lighting system to be controlled.
- Breadboard and Jumper Wires: For creating connections between components.

4.1.2.1.2 Hardware Setup

The hardware setup involves connecting the components according to the system circuit diagram.

- Arduino Uno: Acts as the central processing unit for the system.
- ESP8266: Connected to the Arduino's serial communication pins (5 and 6) for receiving commands came from Arduino.
- PZEM-004T: Connected with Arduino using pins (9 and 8) for sending the value sensed from the source.
- Energy meter: Connected with the optocoupler with pin (1 and 2)

- GSM: Connected to the Arduino's serial communication pins (Tx and Rx) for receiving and sending command with Arduino and user
- Optocoupler: Connected with Arduino to receive the data came from the energy meter
- 3-Channel Relay Module: Connected to the digital pins of the Arduino to control the switching of the LED bulbs.
- LED Bulbs: Connected to the relay module which is in turn controlled by the Arduino.

Connections:

ESP8266 Module:

- VCC to 5V on Arduino
- GND to GND on Arduino
- D5 to 5 on Arduino
- D6 to 6 on Arduino

PZEM-004T Sensor:

- VCC to 5V on Arduino
- GND to GND on Arduino
- TXD to 11 on Arduino
- RXD to 10 on Arduino

GSM Module:

- VCC to 5V on Arduino
- GND to GND on Arduino
- TXD to 7 on Arduino
- RXD to 8 on Arduino

Relay Module:

- IN1 to D9 on Arduino
- IN2 to D3 on Arduino

- IN3 to D4 on Arduino
- LED Bulbs: Connected to the relay output terminals.

Table 4. 1: Pin Connections

Component	Arduino Pin
ESP8266 D5	5
ESP8266 D6	6
Relay IN1	9
Relay IN2	3
Relay IN3	4
GSM TX	7
GSM RX	8
PZEM-004T Tx	11
PZEM-004T Rx	10

Connection of the relay to the bulbs:

The common (COM) terminal for the relay was connected to a 240V supply and looped to the other three relays. Normally, an open terminal was connected to one terminal of the bulbs while the other was connected to the Neutral from the supply. The setup below shows the connection between the relay and the bulbs:

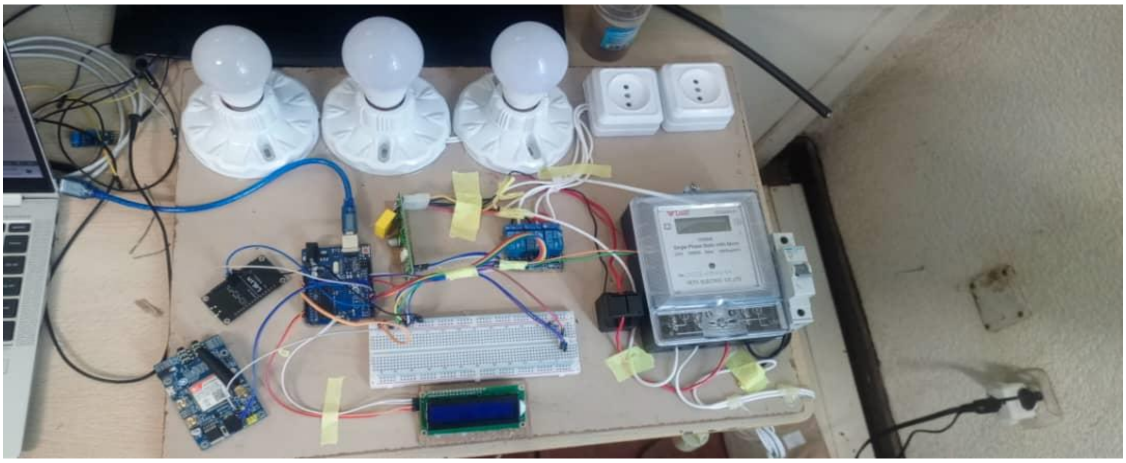


Figure 4. 1: Connection of the system.

When the Arduino is connected and the code is running the GSM will send a message of to the user and if there no unit in the Energy meter the user needs to send to the GSM the message to charge the energy meter as it is in the code (Rw1, Rw2, Rw3, Rw4, …). After recharging the Energy meter, the current will flow in the circuit and the relay module which powered by Energy meter and command by Arduino will close the circuit to switch on the lamps. The relay module is connected to the LED bulbs and socket by wiring each to a relay channel. The relay module itself is commanded by the Arduino, with VCC and GND pins connected to the Arduino's 5V and GND pins, respectively. Control signals are sent from the Arduino to the relay module through digital pins (e.g., Digital Pin 9 to IN1, Digital Pin 3 to IN2, etc.). When the Arduino sends a signal to a specific relay input pin, the corresponding relay channel closes its circuit, allowing current to flow and turning the connected LED bulb and socket on or off. When the current flow in the circuit the PZEM004T which is connect with the lamps, Arduino and Energy meter will be in charge of measurement of the current, voltage, power, energy, and power factor. During that all this process the user can ask for the data and power factor by sending GSM an SMS such as D or Data for data and P for power factor. If user send D or Data, the feedback will be Unit and Price as the figure bellow:

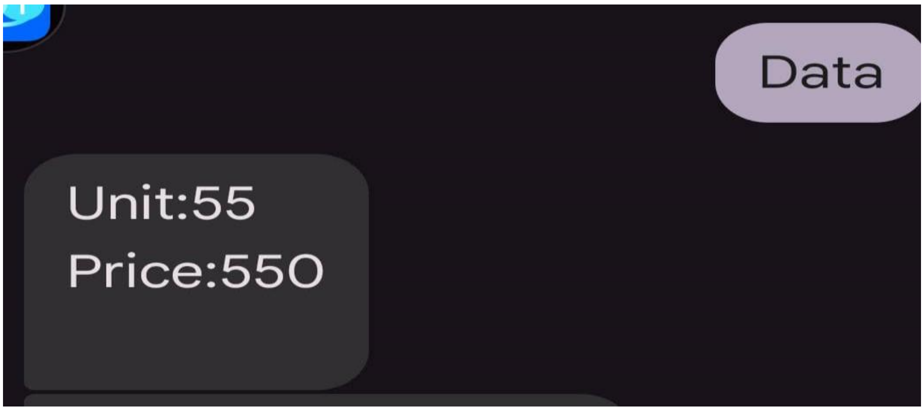


Figure 4. 2: data sms

If the user sends P the feedback will be description and cost implication depending on the value of power factor(pf):

If pf = 1: Description will be perfect efficiency and cost implication will be no penalties.

If pf >= 0.9: Description will be good efficiency and cost implication will be low likelihood of penalties.

If pf >= 0.8: Description will be moderate efficiency and cost implication will be may incur penalties.

If pf >= 0.5: Description will be poor efficiency and cost implication will be significant penalties.

Let precise here when we talk about the penalties, we are referring about the augmentation of the energy consumption. Also, when the energy will almost be over mean when it will reach 5 and less than 5 the alert message should be send to the user to prevent him for recharging is power and when the energy will be over means equal zero the message will tell the user that the energy reach 0 and he need to recharge it.

4.1.2.2. Server-Side tools:

Server-side tools facilitate the implementation of various functionalities on the backend of an electrical consumption system. These tools include frameworks and libraries tailored for tasks such as data processing, business logic handling, and API development. These tools enable developers to efficiently build robust backend systems capable of managing tax-related data and operations effectively.

4.1.2.2.1. MySQL:

MySQL is a popular relational database management system that can be highly beneficial for an electrical consumption system business. In the context of an electrical consumption system:

- **Data Storage:** MySQL can efficiently store various types of tax-related data, such as user information, financial records, tax filings, and reports [28] [29].
- **Data Security:** MySQL provides robust security features, including user authentication, access control, and encryption, ensuring sensitive tax data remains protected from unauthorized access [28].
- **Data Integrity:** MySQL supports transactions and data integrity constraints, such as foreign key relationships and unique constraints, ensuring the accuracy and consistency of tax data stored in the database [28].
- **Scalability:** MySQL is scalable, allowing the electrical consumption system to handle a growing volume of data and Tax payers over time without compromising performance [29].
- **Performance:** MySQL is known for its speed and performance, enabling efficient querying and retrieval of tax data, which is crucial for generating reports and processing tax filings promptly [29].

- **Integration:** MySQL can easily integrate with other technologies and frameworks used in the electrical consumption system's backend, such as Node.js, Django, or Spring Boot, facilitating seamless data exchange and system interoperability [29].
- Overall, MySQL serves as a reliable and robust data management solution for an electrical consumption system business, helping ensure data security, integrity, scalability, and performance [29].

4.1.2.2.2. PHP

PHP, a server-side scripting language, can play a crucial role in an electrical consumption system.

- **Dynamic Web Content:** PHP allows for dynamic generation of web content, facilitating the creation of interactive user interfaces for tax filing, reporting, and account management [30] [31].
- **Form Processing:** PHP can handle form submissions, validating user input and processing tax-related data submitted through online forms [30] [31].
- **Database Interaction:** PHP can interact with MySQL or other database systems, enabling the retrieval, storage, and manipulation of tax data stored in databases [30] [31].
- **User Authentication:** PHP can implement user authentication and authorization mechanisms, ensuring secure access to tax-related functionalities based on user roles and permissions [31].
- **Integration with External Services:** PHP can integrate with external services such as payment gateways or third-party APIs for additional functionalities like online tax payments or data retrieval [30].
- **Scalability and Performance:** PHP can be optimized for performance and scalability, ensuring that the electrical consumption system can handle increasing user loads and data volumes efficiently over time [30] [31].

In summary, PHP provides the necessary tools and functionalities for building robust, dynamic, and scalable web applications for electrical consumption system.

4.1.2.2.3. Xampp:

XAMPP is a cross-platform web server solution package that includes Apache, MySQL, PHP, and Perl. In the context of an electrical consumption system:

- **Local Development:** XAMPP provides an easy-to-install bundle for setting up a local development environment on a developer's machine. This allows developers to work on electrical consumption system features and functionalities offline [32].
- **Server Environment**: XAMPP includes Apache as a web server, MySQL as a database management system, and PHP as a server-side scripting language. These components collectively provide the necessary infrastructure for developing and testing electrical consumption system applications [32].
- **Database Management:** XAMPP's MySQL component enables developers to create and manage databases for storing tax-related data, such as user information, financial records, and tax filings [32].
- **PHP Development:** XAMPP's PHP component allows developers to write server-side code for implementing electrical consumption system functionalities, such as user authentication, form processing, and database interaction [32].
- **Testing and Debugging:** XAMPP facilitates testing and debugging of electrical consumption system applications in a local environment before deployment to a production server, ensuring smooth operation and identifying issues early in the development process [32].
- In essence, XAMPP simplifies the setup of a development environment for building electrical consumption system applications, providing the necessary server infrastructure and tools for efficient development and testing [32].

4.1.2.3. Client-Side tools:

These client-side tools collectively contribute to creating intuitive, interactive, and visually appealing interfaces in electrical consumption system applications, enhancing user engagement and satisfaction.

4.1.2.3.1. HTML:

HTML, being a markup language, utilizes tags to define the structure of web pages, including headers, paragraphs, lists, and links. By organizing content into semantic elements, HTML facilitates accessibility, search engine optimization, and proper rendering across different devices and browsers [33].

4.1.2.3.2. CSS:

CSS, as a styling language, allows developers to specify the visual presentation of HTML elements, thereby influencing factors such as color schemes, typography, margins, and positioning. Through the application of CSS rules, electrical consumption system interfaces can achieve consistency, branding alignment, and improved user experience [33] [37].

4.1.2.3.3. Bootstrap:

Bootstrap, a front-end framework, furnishes developers with a library of pre-designed CSS and JavaScript components tailored for creating responsive and mobile-friendly interfaces in electrical consumption system applications. By leveraging Bootstrap's ready-made components and grid system, developers can expedite development processes, streamline design consistency, and ensure compatibility across various devices and screen sizes, consequently minimizing development overhead [34] [37].

4.1.2.3.4. JavaScript:

JavaScript empowers electrical consumption system applications with dynamic and interactive capabilities, including client-side form validation, real-time data manipulation, and asynchronous communication with the server. By harnessing JavaScript's functionality, electrical consumption system interfaces can deliver enhanced user experiences, fostering smoother interactions and more responsive interfaces, ultimately improving overall usability and satisfaction for bill user [35].

4.1.2.3.5.IDE:

IDEs (Integrated Development Environments) are comprehensive software tools that streamline the development process for electrical consumption system applications. They offer features such as advanced code editing, project management, debugging tools, integrated terminals, code refactoring, code analysis, and plugin ecosystems. IDEs enhance developer productivity, code quality, and collaboration, providing a unified environment for efficient electrical consumption system development [36].

4.1.2.4. Local Development Environment

4.1.2.4.1The Arduino IDE

It is a local application that runs on a user's computer, allowing them to write, compile, and upload code to their Arduino board. It does not have the capability to receive requests or serve data to external clients. Use Cases

The Arduino IDE is commonly used for writing and debugging Arduino code, compiling and uploading code to Arduino boards, managing libraries and dependencies for Arduino projects, and providing a user-friendly interface for beginners and experienced developers alike.

In the case of Server-Side Integration the Arduino IDE is not a server-side tool, it can be used in conjunction with server-side technologies to create more complex projects. For example, an Arduino project can send data to a server using the Ethernet or Wi-Fi libraries, and the server can then process and store the data. However, the Arduino IDE itself is not responsible for serving requests or managing data in these scenarios.

4.1.3. Screenshots:

Screen shots and source code play pivotal roles in software development for electrical consumption systems:

Screen Shots: Visual representations of user interfaces, functionalities, and system behavior, aiding in communication, documentation, and user feedback. Screen shots provide stakeholders with tangible insights into the electrical consumption system's appearance and functionality, facilitating collaboration and decision-making throughout the development process.

Source Code: The foundation of electrical consumption system development, comprising structured instructions written in programming languages like JavaScript, Python, or Java. Source code defines the logic, behavior, and functionality of the electrical consumption system, enabling developers to implement features, handle data, and ensure system reliability. It serves as the blueprint for the electrical consumption system's operation and is essential for debugging, testing, and maintaining the software.

4.1.3.1. System Visualization:

Visual representations of user interfaces, functionalities, and system behavior, aiding in communication, documentation, and user feedback. Screen shots provide stakeholders with tangible insights into the electrical consumption system's appearance and functionality, facilitating collaboration and decision-making throughout the development process.

4.1.3.1.1. BPPFMSA General System Dashboard:

This is the home page of the **BPPFMSA** Website where he users and admin of the system can login

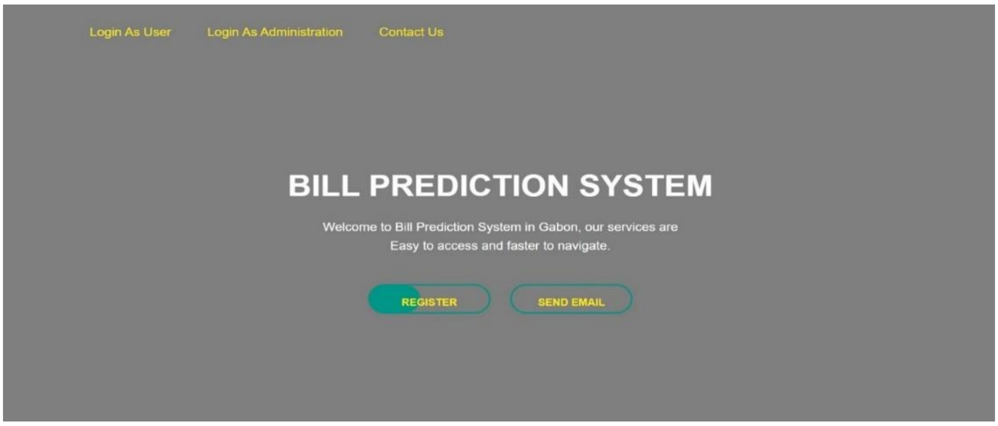


Figure 4. 3: The main interface.

4.1.3.1.2. Xampp Control Panel:

This helps in managing and monitoring the Xammp components and the software package of as well.

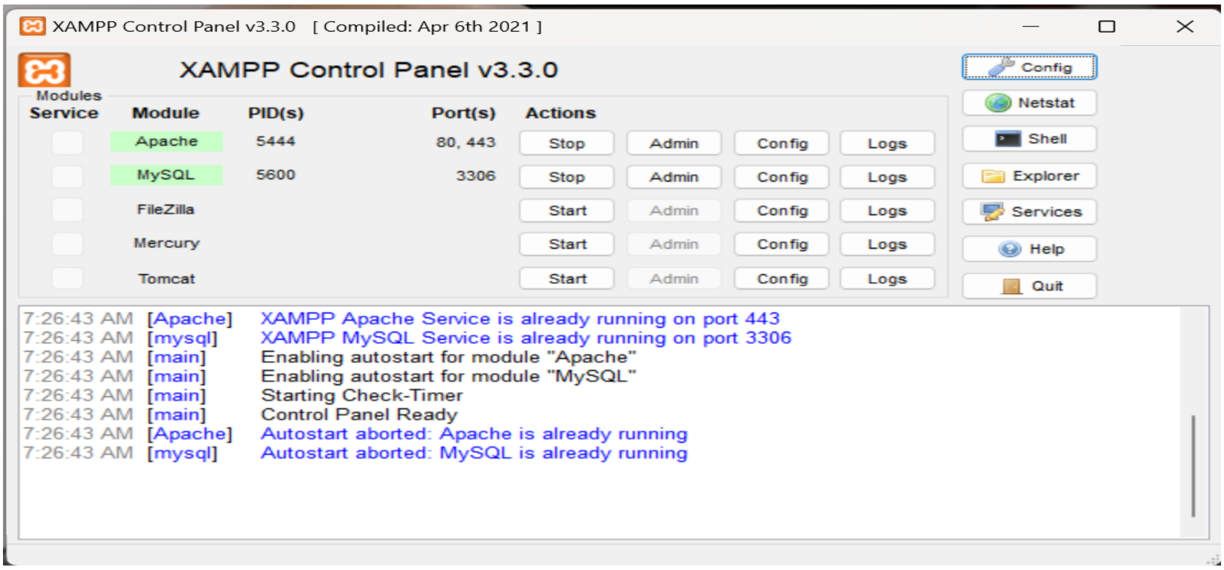


Figure 4. 4:Xampp Control Panel

4.1.3.1.3. Xampp Localhost Dashboard:
This is where you can download the Xampp set up.

Figure 4. 5: Xampp Local Host Dashboard

4.1.3.1.4. User Login Page:

This is where the users can login and also to sign up as a new user. It also directs the user to help change his password.

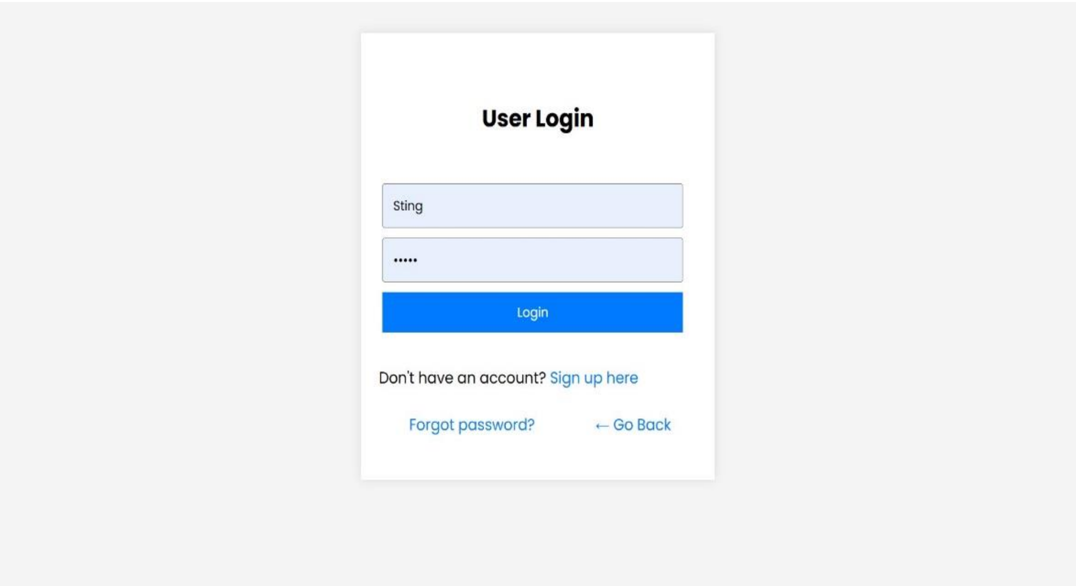


Figure 4. 6:User login.

4.1.3.1.5. User Sign up Page:

This is where the users and admin sign up and register in order to use the system

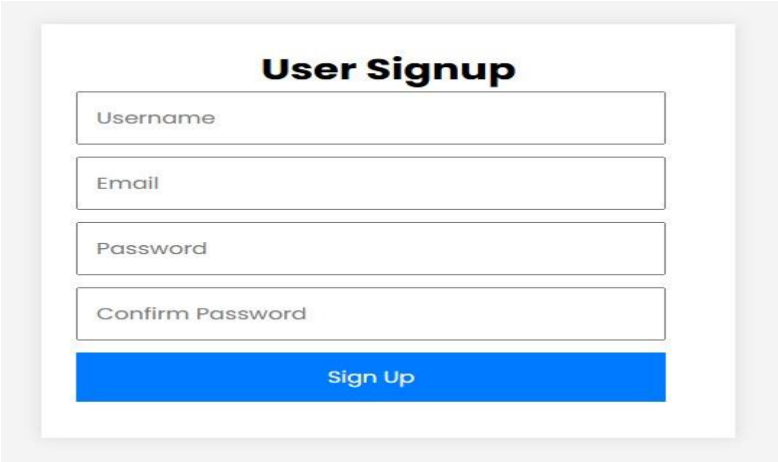


Figure 4. 7: User signup.

4.1.3.1.6. User Dashboard:

This is an interface that user can predict his bill.

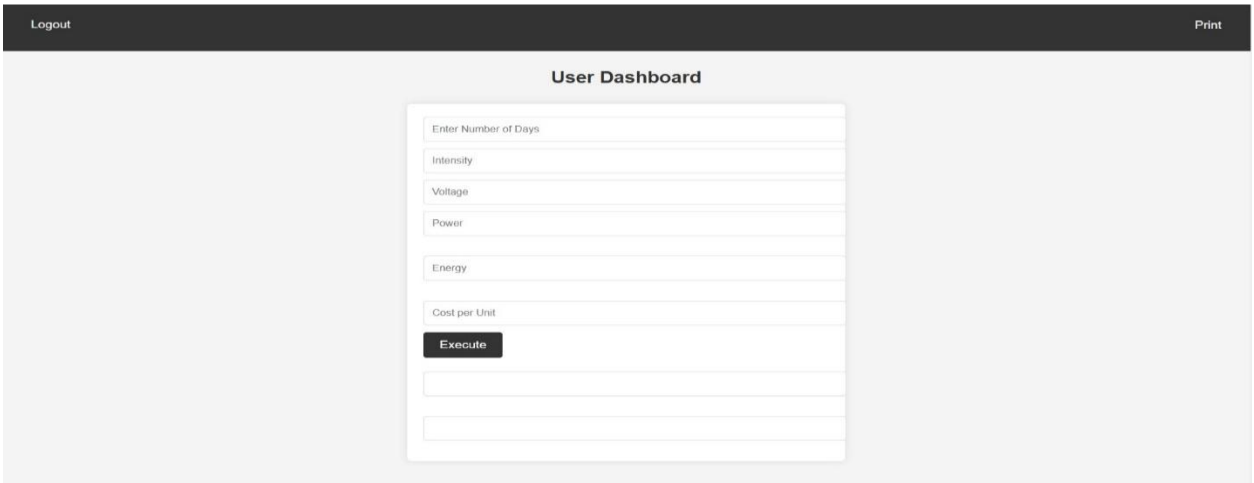


Figure 4. 8: User dashboard.

4.1.3.1.7. Contact us Form:

This is where you can reach out to the tax management authority and get assisted

Figure 4. 9: Contact us.

4.1.3.1.8. Admin Login:

This is the login interface used for admin.

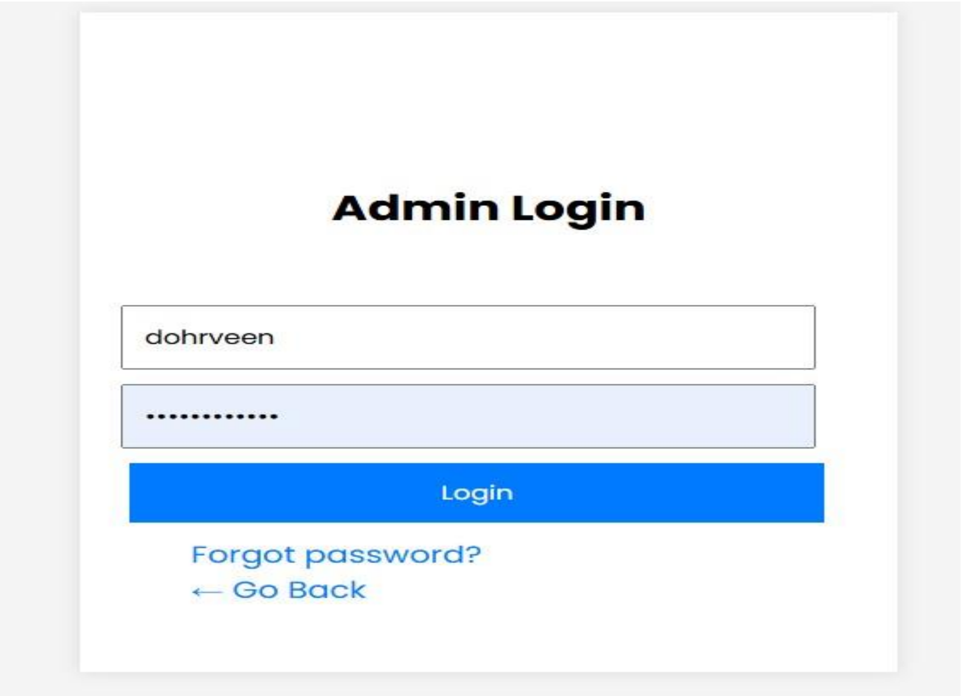


Figure 4. 10: Admin login.

4.1.3.1.9. Admin Dashboard:

Here and admin can view user activities, know how many users there are in the system, add and remove users, and see his profile.

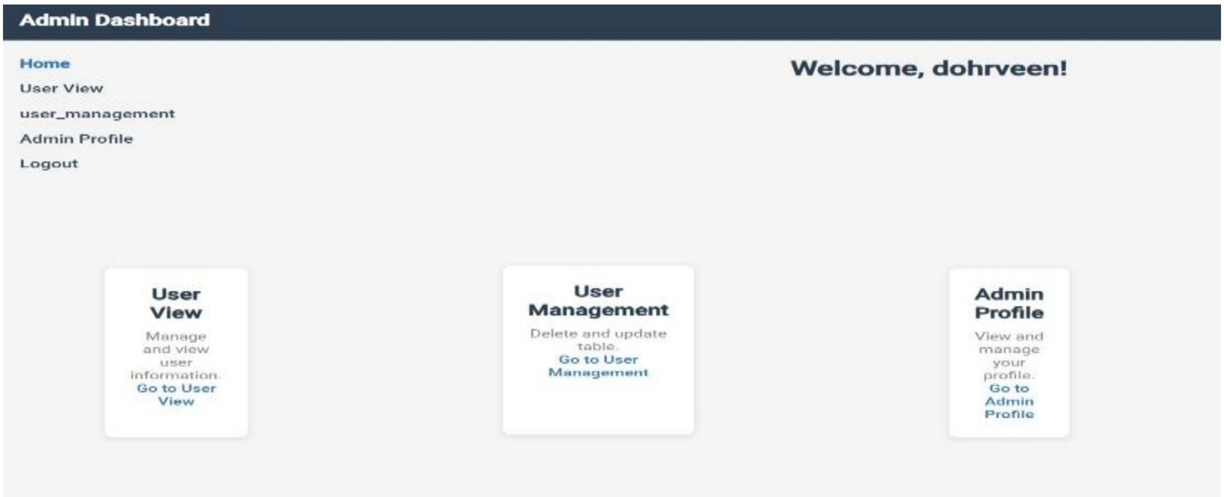


Figure 4. 11: Admin dashboard.

4.1.3.1.10. User View:

This is where admin can see the activities of users.

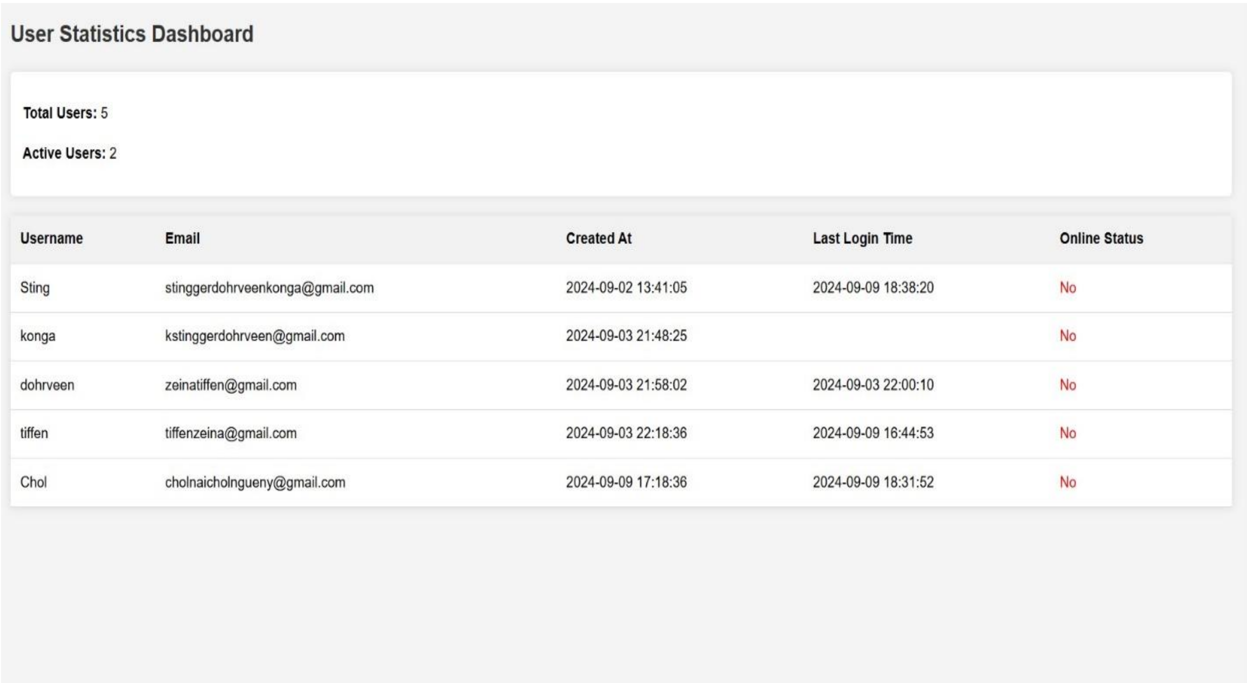
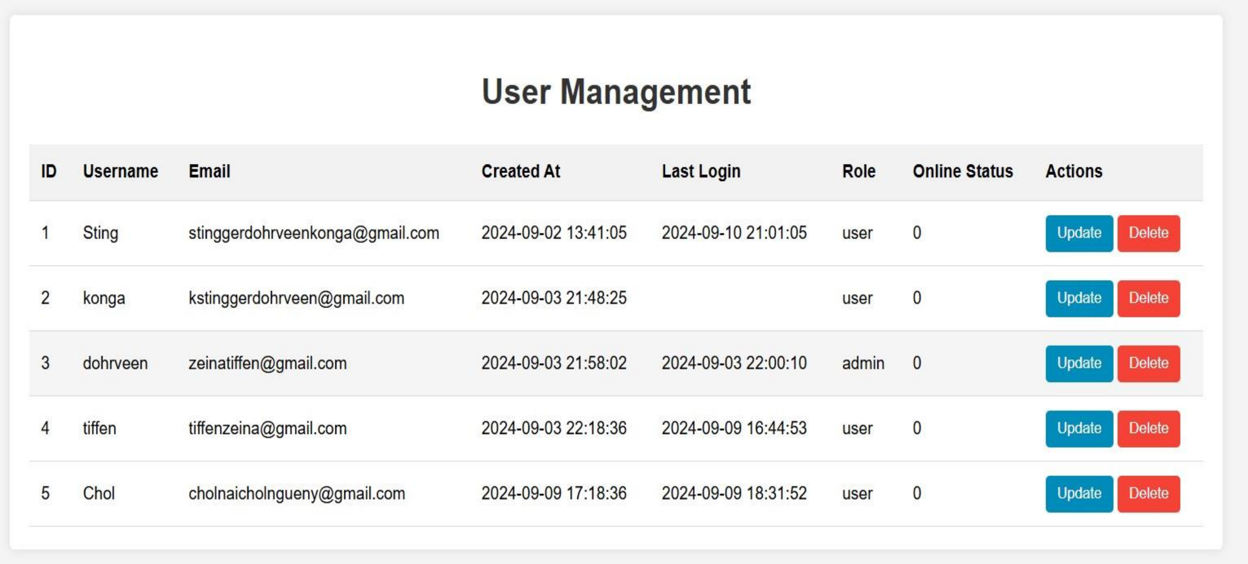


Figure 4. 12: User view.

4.1.3.1.11. User Management:

Here you can manage all the registered users and know their details as an admin.



User Management

ID	Username	Email	Created At	Last Login	Role	Online Status	Actions
1	Sting	stinggerdohrveenkonga@gmail.com	2024-09-02 13:41:05	2024-09-10 21:01:05	user	0	Update Delete
2	konga	kstinggerdohrveen@gmail.com	2024-09-03 21:48:25		user	0	Update Delete
3	dohrveen	zeinatiffen@gmail.com	2024-09-03 21:58:02	2024-09-03 22:00:10	admin	0	Update Delete
4	tiffen	tiffenzeina@gmail.com	2024-09-03 22:18:36	2024-09-09 16:44:53	user	0	Update Delete
5	Chol	cholnaicholngueny@gmail.com	2024-09-09 17:18:36	2024-09-09 18:31:52	user	0	Update Delete

Figure 4. 13: User management.

4.1.3.1.12 Admin Profile:

Here you can see the admin profile.

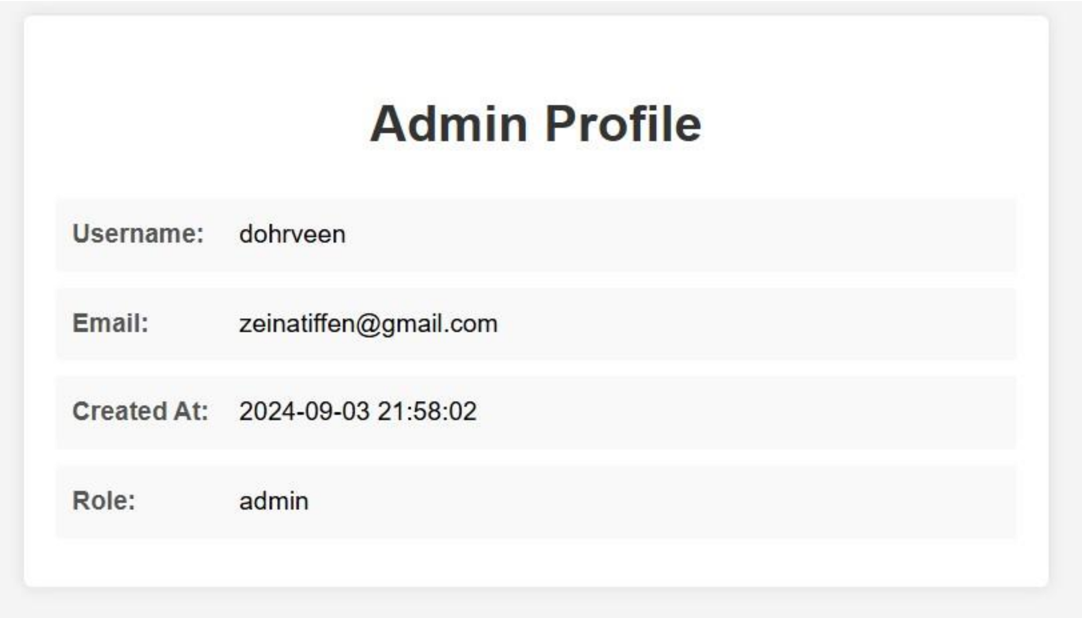


Figure 4. 14: Admin profile.

4.1.4. Source Codes:

Is the human-readable version of a computer program written in a programming language. It's the set of instructions that a programmer writes to tell a computer what to do.

Source code is like a recipe for a computer, detailing step-by-step how to perform bill. It's written in a language that both humans and machines can understand, serving as the blueprint for software development.

4.2. Testing:

Is the process of evaluating a software application or system to identify any discrepancies between expected and actual outcomes? It involves running the software under controlled conditions to discover bugs, defects, or errors, ensuring that the software meets specified requirements, functions correctly, and delivers the desired user experience. Testing helps to improve the quality, reliability, and performance of software products before they are deployed to Users.

4.2.1. Introduction:

In the realm of software engineering, testing plays a pivotal role in ensuring the reliability, functionality, and quality of software products. It involves the systematic examination of software components or systems to identify and resolve defects, errors, or bugs before deployment. Through a series of controlled conditions and test cases, software testers aim to validate that the software meets specified requirements, functions as intended, and delivers a satisfactory user experience. Testing encompasses various techniques, including unit testing, integration testing, system testing, and acceptance testing, each serving a unique purpose in the software development lifecycle. Ultimately, the goal of testing is to enhance the overall quality and performance of software products, thereby minimizing risks and maximizing user satisfaction.

4.2.1.1. Objectives of Testing:

- Identify defects, errors, and bugs in the software.
- Validate that the software meets specified requirements.
- Ensure the functionality, reliability, and performance of the software.
- Minimize risks associated with software deployment.
- Improve the overall quality and user satisfaction of the software product

4.2.2. Bill Prediction Testing Output:

Test Case: CalculateBill ()

This test case checks the functionality of the CalculateBill () method in the Bill Prediction System.

Test Input:

Table 4. 2: Bill prediction.

Enter the number of day/days	input
Intensity	displayed
Voltage	displayed
Power	displayed
Energy	displayed
Cost per unit	displayed
Current Estimation	output
Cost estimation	output

Result: The current and Cost estimation depending on the numbers of days we inputted and energy.

4.2.3. Integration Test Case:

Message of welcome to the System.

Test Step:

The welcome message should be sent to the user mobile phone.

Expected Outcome:

Welcome to Libreville Meter Service.

Result: Pass

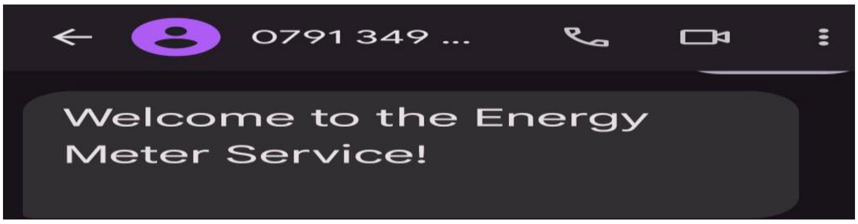


Figure 4. 15: SMS of welcome

4.2.4. Integration Test Case:

Message of Data to the System.

Test Step:

The D should be sent to the user mobile phone.

Expected Outcome:

Unit: value.

Price: value.

Result: Pass

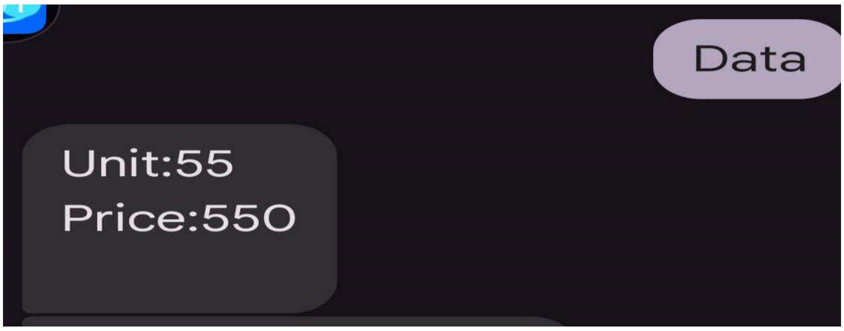


Figure 4. 16:datasms

4.2.5. Integration Test Case:

Message of Power factor to the System.

Test Step:

The P should be sent to the user mobile phone.

Expected Outcome:

Pf: value.

Result: Pass

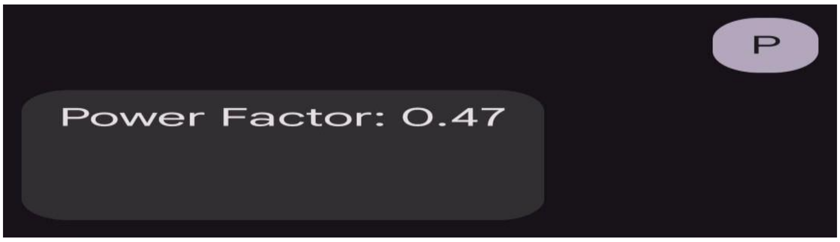


Figure 4. 17:sms of power factor

4.2.6. Integration Test Case:
User Authentication Integration.

Verify that the user authentication module integrates correctly with other system components.

Test Steps:

1.Enter valid username and password.

2.Click on the login button.

Expected Outcome:

User successfully logs in and gains access to the user dashboard system.

Actual Outcome:

User authentication module integrates seamlessly with the system, allowing Tax payers to log in without issues.

Result: Pass

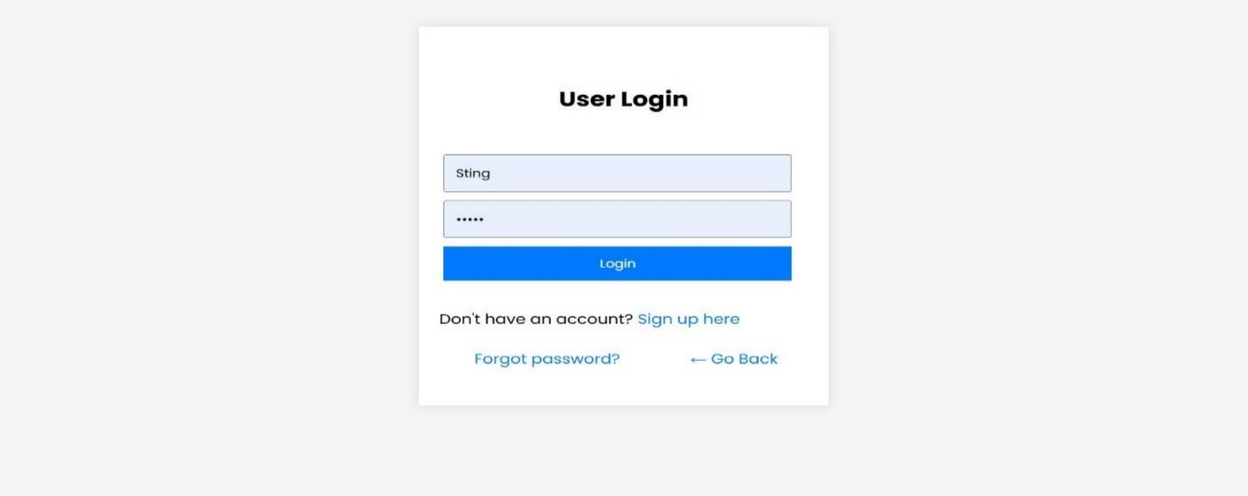


Figure 4. 18: User login.

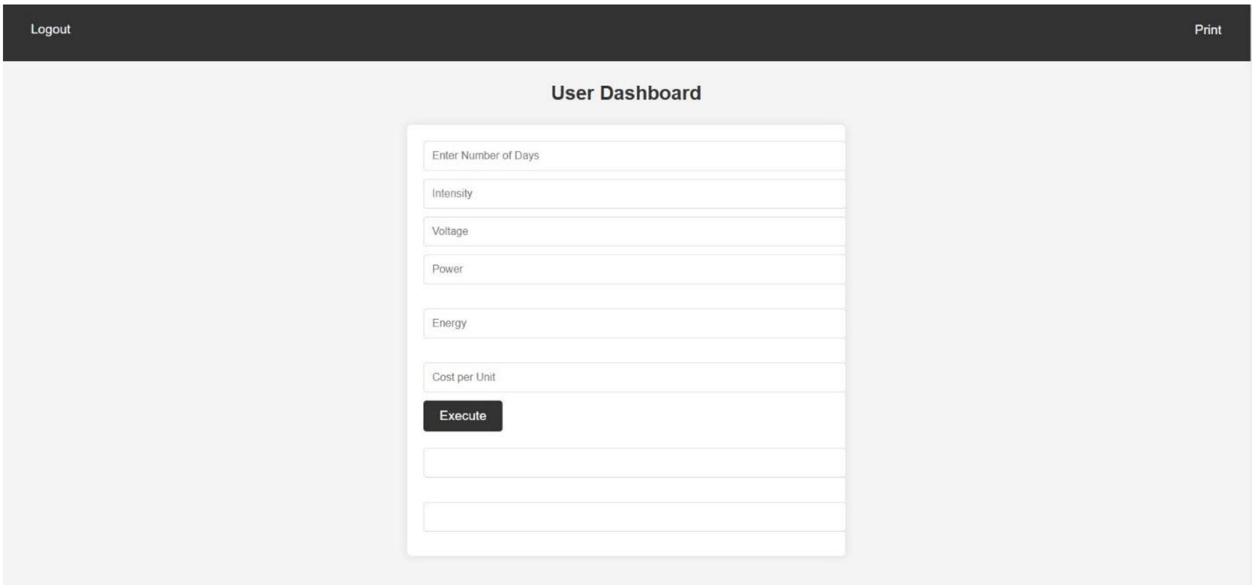


Figure 4. 19: User dashboard.

4.2.7. Functional and System Testing:

4.2.7.1. Test Case:

User Registration Functionality

Verify that Users can register for an account in the system.

Test Steps:

- ✓ Navigate to the sign-up page.
- ✓ Enter valid user information.
- ✓ Click on the sign-up button.

Actual Outcome:

Registration process successfully registers Users and allows them to log in with their credentials.

Figure 4. 20: User signup.

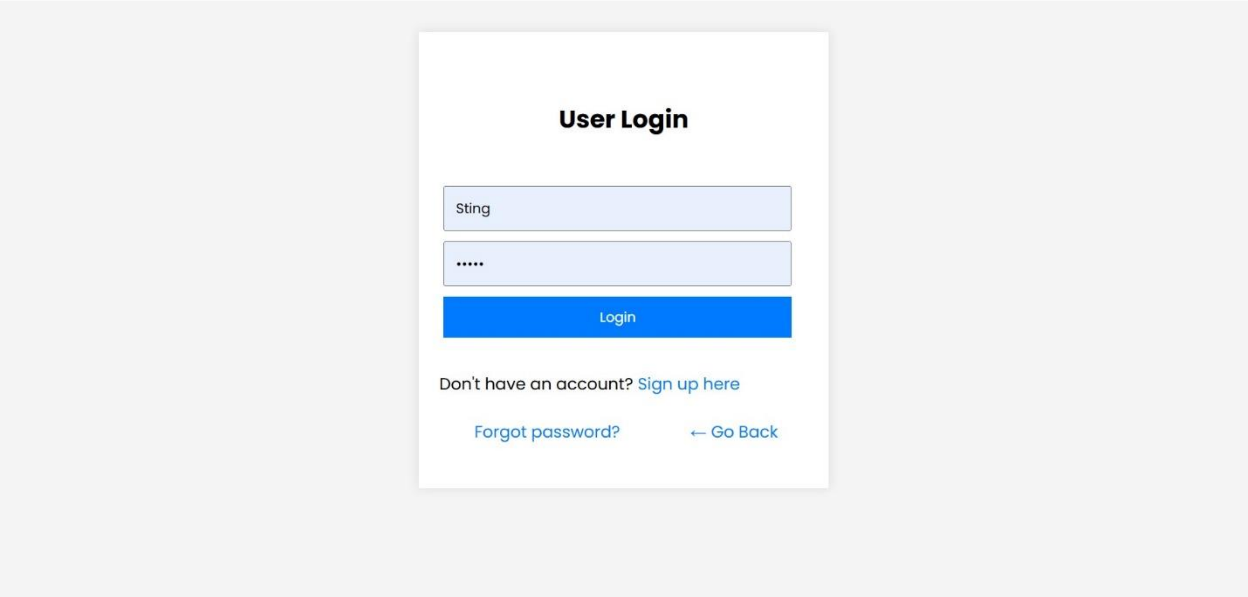


Figure 4. 21: User login.

Result: Pass

These figures show how user by clicking on signup button after inputted his information will directly come up to the login page and fill that page.

4.2.8.1. Test Case:

Bill Prediction

Verify that the system accurately predict bill based on user input.

Test Steps:

Enter various the numbers of days.

4.2.8.3. Calculate Bill.

Expected Outcome:

Bill is calculated correctly according to predefined days and user input.

Actual Outcome:

Bill prediction results align with expected values for different values of cost and current

Result: Pass

4.2.8.3. System Testing Output:

System testing is typically conducted after integration testing and before user acceptance testing (UAT) in the software development lifecycle.

4.2.8.3.1. Test Case:

User Interface Consistency and Performance Testing.

Verify that the user interface elements are consistent across different pages and functionalities.

Actual Outcome:

User interface elements are consistent and provide a cohesive user experience throughout the system.

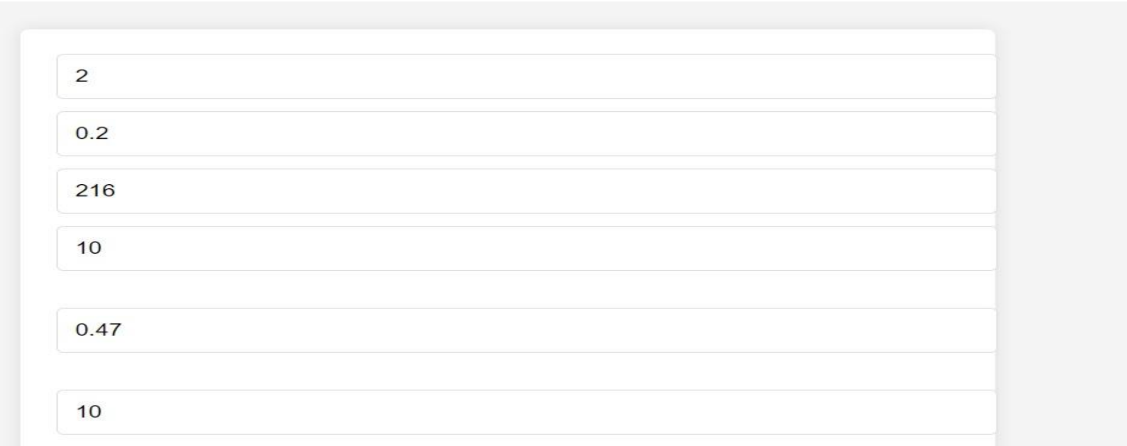


Figure 4. 22:user test

Results

Parameter	Value
Total Energy Consumption	0.48 kWh
Total Cost	RWF4.80
Current Estimation	0.00 Amps
Power Estimation	432.00 Watts
Voltage	216.00 Volts
Power	10.00 Watts
Power Factor	10.00

Figure 4. 23: Test result.

Result: Pass

CONCLUSION AND RECOMMENDATIONS

Conclusion

The aim of this project is to predict the electricity bill and control the excessive usage of power factor correction for house monitoring through SMS and a reporting system. The conclusion of this research work is that the system successfully predicts the electricity bill using a mathematical equation. In addition, this system also successfully identifies under and over power factor conditions that are continuously monitored and controlled by the power factor correction device using the mobile phone interface. To achieve a complete model, a programming and interfacing experiment has been conducted on house monitoring for two months, and the results can be accessed through the user account interface. A reporting section has been implemented in this system that sends an alert message to the user's mobile phone if an over power factor condition is identified by the power factor control device using the mobile phone interface. To enhance the energy efficiency of the building, uninterrupted testing and improvement are required.

Recommendations

I would like to recommend the government of Gabon to think of this system and try to implement it in real life, for it is easy for all the process involves in IoT building, in billing and registering in the Bill prediction and power factor measuring with SMS alert system. This will reduce energy consumption, and money. It will make life much easier for people and organizations for their electrical system. This system is scalable and can be updated by including other features and functionalities.

In concluding this work, I would like to explicitly say that the Bill prediction and power factor measuring with SMS alert system approval and analysis system works. I would also like to suggest any other person wishing to improve this research by adding functionalities to go for it and improve our services.

Future work

Due to the constraints and limitations in this study, the future work is discussed in this section. This project serves as a foundation for future work and it is open-ended. Numerous features can be added during the next phase of the project, as mentioned as follows: the power quality can be measured, allowing users to know and understand the condition of power in their living spaces. If there are any malfunctions, the system will send an alert to users. Implement provisions to interface the microcontroller with PLC for industrial applications. Add voice alert messages. In addition, a real-time clock, interrupts, and interrupt service routines will be implemented efficiently for this project. Also, the theft alert system can be adding on the energy meter. In term of web application, a better application can be used to communicate directly with the ESP8266.

Source Codes:

Is the human-readable version of a computer program written in a programming language. It's the set of instructions that a programmer writes to tell a computer what to do.

Source code is like a recipe for a computer, detailing step-by-step how to perform tasks. It's written in a language that both humans and machines can understand, serving as the blueprint for software development.

1.Arduino code:

```
#include <EEPROM.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>
#include <PZEM004Tv30.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);
SoftwareSerial GSM(8, 7);
PZEM004Tv30 pzem(10, 11);

#define RELAY_1 9
#define RELAY_2 3
#define RELAY_3 4
#define pulse_in 2

// Using smaller data types
volatile uint8_t pulse = 0;
long total_unt = 7; // Total units
int price = 0;
long price1 = 0;
const int Set = 10;

const char phone_no1[] = "+250791349870";
const char phone_no2[] = "+250724121961";

unsigned long lastSerialPrint = 0;
```

Figure 5. 1: Arduino code1

```
    initGSM();
    sendSMS(phone_no1, "Welcome to Libreville Energy Meter!");
    Read();
}

// Initialize GSM module
void initGSM() {
    initModule("AT", "OK", 1000);
    initModule("ATE1", "OK", 1000);
    initModule("AT+CPIN?", "READY", 1000);
    initModule("AT+CMGF=1", "OK", 1000);
    initModule("AT+CNMI=2,2,0,0,0", "OK", 1000);
}

void loop() {
    float voltage = pzem.voltage();
    float current = pzem.current();
    float power = pzem.power();
    float energy = pzem.energy();
    float pf = pzem.pf();

    if (millis() - lastSerialPrint >= 30000) {
        Serial.print("Voltage: "); Serial.print(voltage, 1); Serial.println(" V");
        Serial.print("Current: "); Serial.print(current, 1); Serial.println(" A");
        Serial.print("Power: "); Serial.print(power, 1); Serial.println(" W");
```

Figure 5. 2: Arduino code2

2.User Registration and Login:

```
<?php
require 'db_connection.php';

if ($_SERVER['REQUEST_METHOD'] == 'POST') {
    $username = $_POST['username'];
    $email = $_POST['email'];
    $password = $_POST['password'];
    $confirm_password = $_POST['confirm_password'];

    // Check if passwords match
    if ($password !== $confirm_password) {
        $error = "Passwords do not match!";
    } else {
        // Hash the password for security
        $hashed_password = password_hash($password, PASSWORD_DEFAULT);

        // Insert new user into the database
        $query = "INSERT INTO users (username, email, password, role) VALUES (?, ?, ?, 'user')";
        $stmt = $conn->prepare($query);
        $stmt->bind_param('sss', $username, $email, $hashed_password);

        if ($stmt->execute()) {
            $success = "User registered successfully! You can now login.";
```

Figure 5. 3:code1.

```
                header('Location: login.php');
            } else {
                $error = "Error: " . $stmt->error;
            }
        }
}
?>

<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>User Signup</title>
    <link rel="stylesheet" href="styles.css">
</head>
<body>
    <form method="POST" action="signup.php">
        <h2>User Signup</h2>
        <?php if (isset($error)): ?>
            <p class="error"><?php echo $error; ?></p>
        <?php endif; ?>
        <?php if (isset($success)): ?>
```

Figure 5. 4:code2.

3.User Dashboard code:

```
<header>
    <a href="logout.php" class="btn">Logout</a>
    <button onclick="printReport()" class="btn">Print</button>
</header>
<h2>User Dashboard</h2>
<form method="POST" action="user_dashboard.php" id="formcontent">
    <input type="number" id="day" name="day" placeholder="Enter Number of Days" required>
    <input type="number" name="intensity" placeholder="Intensity" required>
    <input type="number" name="voltage" placeholder="Voltage" required>
    <input type="number" name="power" placeholder="Power" required>
    <input type="number" id="energy" name="energy" placeholder="Energy" required>
    <input type="number" id="cost" name="cost" placeholder="Cost per Unit" required>
    <button type="submit" onclick="submit()">Execute</button>
    <div id="cost"><input type="text" id="cost_estimation" name="cost_estimation" readonly></div>
    <div id="energy"><input type="text" id="energy_estimation" name="energy_estimation" readonly></div>
</form>

<script>
function printReport() {
    var printContents = document.getElementById('formcontent').innerHTML;
    var originalContents = document.body.innerHTML;
```

Figure 5. 5: code3.

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