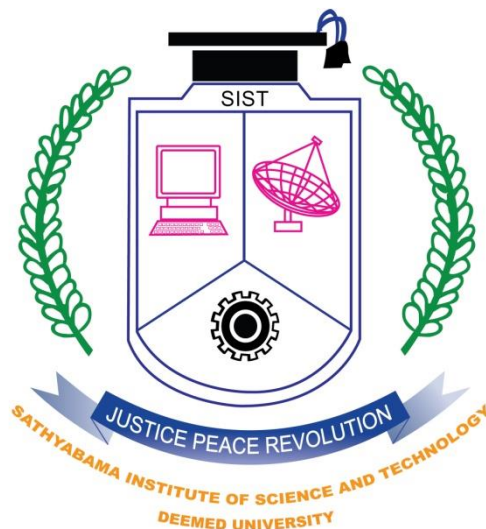


# **IOT-BASED PREPAID SMART METERING AND MONITORING SYSTEM**

Submitted in partial fulfillment of the requirements for the award of  
Bachelor of Engineering Degree in Electrical and Electronics Engineering

by

**SHANTANUKUMAR - ( 39140050 )  
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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING  
SCHOOL OF ELECTRICAL AND ELECTRONICS**

# **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC**

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**APRIL 2023**



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**BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of **SHANTANU KUMAR** (Reg. No. 39140050) and **SUNEEL** (Reg. No. 39140059) who carried out the project entitled "**IOT-BASED PREPAID SMART METERING AND MONITORING SYSTEM**" under our supervision from November 2022 to April 2023.

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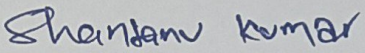
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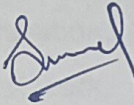
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## DECLARATION

We **SHANTANU KUMAR** (Reg. No. 39140050) and **SUNEEL** (Reg. No. 39140059) hereby declare that the Project Report entitled “**IOT-BASED PREPAID SMART METERING AND MONITORING SYSTEM**” done by us under the guidance of **Dr. W. ABITHA MEMALA** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1. 

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DATE: 26/04/2023

PLACE:

SIGNATURE OF THE CANDIDATES

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We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

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## **ABSTRACT**

IoT-based applications are becoming more popular and provide effective solutions for many real-time problems. In this project, real-time monitoring and a prepaid system for energy monitoring system are proposed. A solution is a cheap and easy-to-implement and manage energy monitoring system for our daily usage of electric power. In order to overcome human errors, manual labor and cost reducing in energy consumption with more efficiency for the power management system, in this project, we focus mainly on IoT prepaid energy monitoring. The proposed design is to implement a very low-cost wireless sensor network and protocol for smart energy and a web application capable of automatically reading the unit and sending the data automatically for the power users to view their current energy meter reading. By using this system, the users will be aware of the electricity usage in his/her home to reduce the power wastage and cost of consumption. And also we can set the monthly unit limit from web application to restrict the over usage. The system consists of a digital energy meter, ESP8266 Wi-Fi module and web applications for management system. load entered into the energy meter and shown on the IOT. Energy meter supplies a current, and a current sensor measures the load before sending an SMS to the user's phone. The ESP8266 Wi-Fi module will be embedded into the meter and implement the TCP/IP protocol for the communications between the meter and the web application.

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## LIST OF SYMBOLS AND ABBREVIATIONS

| ABBREVIATIONS | FULL FORM                               |
|---------------|-----------------------------------------|
| IOT           | Internet Of Things                      |
| $\mu$ C       | Micro Controller                        |
| NO            | Normally Open                           |
| NC            | Normally Closed                         |
| COM           | Common                                  |
| LCD           | Liquid Crystal Display                  |
| LED           | Light Emitting Diode                    |
| POT           | Potentiometer                           |
| SMPS          | Switch Mode Power Supply                |
| GSM           | Global Service for Mobile Communication |
| AMR           | Automatic Meter Reading                 |

# CHAPTER 1

## INTRODUCTION

### 1.1 GENERAL

Internet of Things (IOT) has revolutionized the way in which the people interact with the world around us. IOT technology has also brought about a significant change in the way the energy consumption is monitored. In energy sector, IOT based prepaid smart metering and monitoring systems play a key role. These systems offer several benefits such as accurate billing and real-time monitoring. The various aspects of IOT-based prepaid smart metering and monitoring systems and their impact on the energy sector are discussed. IOT-based prepaid smart metering and monitoring systems are designed to measure the energy consumption of households or businesses in real-time. These systems use advanced sensors like LDR sensor. LDR (Light Dependent Resistor) sensor, also known as a photo resistor, is a type of electronic component that is sensitive to light. It is made of a semiconductor material that changes its resistance when exposed to light. When the light falls on the LDR sensor, the resistance of the material decreases, and when the light is removed, the resistance increase. Communication technologies like GSM module and Wi-Fi module is used to provide accurate readings of energy consumption. The data collected by these systems is sent to a central server or cloud-based platform i.e. IOT page where it is analyzed to track energy consumption and provide alerts for low balances using GSM module sent SMS to the user mobile phones. In this project prepaid aspect is introduced to pay in advance for the energy they consume. Therefore the need of manual meter reading and billing is avoided. This helps consumers to manage their energy consumption more efficiently. The system can be topped up online via IOT page making it more convenient for users.

Smart metering and monitoring systems are considered an integral part of the modernization of the power grid. They are essential for efficient energy management and sustainable development, as they allow for the effective monitoring and control of energy usage in residential, commercial, and industrial settings. By integrating IOT technology into these systems, consumers can have access to real-time data on their energy usage, allowing them to

make informed decisions about when they used energy. Additionally, IOT-based prepaid smart metering and monitoring systems can enable utilities to better manage the energy grid, leading to increased efficiency and cost savings. In summary, the integration of IOT technology into prepaid smart metering and monitoring systems has the potential to revolutionize energy management, making it more efficient, sustainable, and cost-effective. IOT-based prepaid smart metering and monitoring systems have numerous benefits that make them an attractive solution for both consumers and utilities. For consumers, these systems provide greater control over their energy consumption, allowing them to make informed decisions about when they used energy. For utilities, IOT-based prepaid smart metering and monitoring systems provide real-time data on energy usage, enabling them to better manage the energy grid and reduce energy waste. Moreover, these systems can facilitate the integration of renewable energy sources into the grid, such as solar or wind power, and help balance supply and demand. Overall, IOT-based prepaid smart metering and monitoring systems are a key component of the smart grid, enabling the efficient and sustainable management of energy resources. With the increasing demand for energy and the need for sustainable development, the adoption of these systems is expected to grow rapidly in the coming years.

## **CHAPTER 2**

### **LITERATURE SURVEY**

#### **2.1 LITERATURE SURVEY**

IoT-based Prepaid Energy Metering System for Smart Homes by A. Kumar et al. (2021)  
This research paper proposes an IoT-based prepaid energy metering system for smart homes. The proposed system uses a Raspberry Pi as a gateway device to connect the smart meters to the cloud. The system allows consumers to monitor their energy consumption in real-time and make payments in advance. The results of the study show that the proposed system is efficient and effective in reducing energy consumption and costs.

IoT-based Prepaid Smart Metering System for Sustainable Energy Management by S. Saranya et al. (2020)  
This research paper presents an IoT-based prepaid smart metering system for sustainable energy management. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows consumers to monitor their energy consumption and make payments in advance. The results of the study show that the proposed system is effective in reducing energy consumption and costs.

An IoT-Based Prepaid Electricity Billing System for Smart Cities by A. Kumar et al. (2019)  
This research paper proposes an IoT-based prepaid electricity billing system for smart cities. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows consumers to monitor their energy consumption and make payments in advance. The results of the study show that the proposed system is effective in reducing energy consumption and costs.

An IoT-Based Prepaid Energy Metering System for Industrial Applications by R. Elanchezhian et al. (2018)  
This research paper proposes an IoT-based prepaid energy metering system for industrial applications. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows consumers to monitor their energy consumption and make payments in advance. The results of the study show that the proposed system is effective in reducing energy consumption and costs.

IoT-Based Prepaid Energy Metering System for Rural Electrification by S. S. Akbar et al. (2017) This research paper presents an IoT-based prepaid energy metering system for rural electrification. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows consumers to monitor their energy consumption and make payments in advance. The results of the study show that the proposed system is effective in reducing energy consumption and costs.

IoT-based Prepaid Smart Metering System for Energy Efficiency in Buildings by Y. Zhang et al. (2021) This research paper proposes an IoT-based prepaid smart metering system for energy efficiency in buildings. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows building managers to monitor energy consumption and allocate energy budgets to tenants. The results of the study show that the proposed system can effectively reduce energy consumption and improve energy efficiency in buildings.

A Survey on Prepaid Energy Metering Systems for Residential Buildings by S. Al-Shahrani et al. (2020) This survey paper provides an overview of prepaid energy metering systems for residential buildings. The paper reviews the different types of prepaid energy metering systems, including token-based systems, smart card-based systems, and mobile payment-based systems. The paper also discusses the benefits and challenges of prepaid energy metering systems and provides recommendations for future research.

An IoT-Based Prepaid Energy Metering System for Electric Vehicle Charging Stations by W. Wang et al. (2019) This research paper proposes an IoT-based prepaid energy metering system for electric vehicle charging stations. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows EV owners to monitor their charging usage and make payments in advance. The results of the study show that the proposed system can effectively manage the demand for electric vehicle charging and reduce the load on the grid.

A Comparative Study of IoT-Based Prepaid Energy Metering Systems for Smart Grids by L. Yu et al. (2018) This research paper provides a comparative study of IoT-based prepaid energy metering systems for smart grids. The paper compares the performance of different prepaid energy metering systems, including token-based systems, smart card-based systems,

and mobile payment-based systems. The paper also discusses the challenges and opportunities of implementing prepaid energy metering systems in smart grids.

An IoT-Based Prepaid Energy Metering System for Microgrid Applications by J. Kim et al. (2017) This research paper proposes an IoT-based prepaid energy metering system for microgrid applications. The proposed system uses a wireless sensor network to connect the smart meters to the cloud. The system allows microgrid users to monitor their energy consumption and make payments in advance. The results of the study show that the proposed system can effectively manage the energy consumption of microgrid users and improve the stability and reliability of the microgrid.

## **2.2 PROBLEM IDENTIFICATION**

1. One problem is the security and privacy of the system. IoT devices are often vulnerable to cyber attacks and hacking, and if the smart meters and monitoring system are not properly secured, they could be compromised. This could lead to fraudulent usage or data theft, which could result in financial losses for both consumers and utility companies.
2. Another problem is the interoperability of the system. Different smart meters and monitoring devices may use different communication protocols, making it difficult to integrate them into a single system. This could limit the scalability and flexibility of the system and make it more difficult to adopt and maintain.
3. A third problem is the cost of the system. The development and installation of an IoT-based prepaid smart metering and monitoring system can be expensive, especially for small and medium-sized utility companies. This could make it difficult for them to compete with larger companies that have more resources and funding.
4. Lastly, there is the issue of user adoption and acceptance. Consumers may be resistant to the idea of using a prepaid smart metering system, especially if they are used to traditional post-paid billing. This could result in low adoption rates and limit the effectiveness of the

## **2.3 SCOPE OF THE PROJECT**

The scope of the project is to develop an IOT-based prepaid smart metering and monitoring system that addresses the problems identified in traditional energy metering and billing systems. The system will enable real-time monitoring of energy usage and provide consumers with detailed information about their energy consumption patterns.

The project involves the design and development of hardware and software components for the smart metering and monitoring system. The hardware components include the smart meter, installed at the consumer's premises and collect data on energy usage. The software component includes a user interface that enable the consumers to view their energy usage data and manage their prepaid energy accounts.

The system incorporates IOT technology, allowing for the collection and transmission of real-time data on energy consumption. This will enable utilities to better manage the energy grid and balance supply and demand. In addition, the system will allow for the integration of renewable energy sources into the grid, such as solar or wind power.

The project involves testing and validation of the system to ensure its reliability and accuracy. The system is tested under different conditions to ensure that it can handle varying levels of energy consumption and can operate in different environments.

The project's ultimate goal is to develop a reliable and efficient IOT-based prepaid smart metering and monitoring system that enables consumers to manage their energy consumption effectively and utilities to manage the energy grid efficiently. The system is designed to be scalable, allowing for its deployment in a range of residential, commercial, and industrial settings.

## **2.4 OBJECTIVE**

The objective of the IOT-based prepaid smart metering and monitoring system project is to develop a reliable and efficient energy management system that addresses the problems of traditional energy metering and billing systems. The specific objectives of the project include:

- Providing consumers with real-time data on their energy consumption: The system will enable consumers to monitor their energy consumption in real-time, allowing them to adjust their usage patterns and make informed decisions about their energy consumption.
- Enabling utilities to manage the energy grid more efficiently: The system will provide utilities with real-time data on energy consumption, enabling them to balance supply and demand and reduce energy waste.
- Encouraging sustainable energy usage: The system will enable the integration of renewable energy sources into the grid, such as solar or wind power, and incentivize consumers to use energy more sustainably.
- Providing transparency and control for consumers: The system will provide consumers with detailed information on their energy consumption patterns and enable them to manage their prepaid energy accounts effectively.
- Reducing operational costs for utilities: The system will automate the metering and billing process, reducing operational costs for utilities and improving their overall efficiency.

The ultimate goal of the project is to develop an IOT-based prepaid smart metering and monitoring system that is scalable, cost-effective, and user-friendly. By achieving these objectives, the project will contribute to the development of a more sustainable and efficient energy management system.

## **2.5 METHODOLOGY**

The methodology for the IOT-based prepaid smart metering and monitoring system project will involve several phases. First smart meters will be installed at homes and any place. Then like simple energy meter it will also record the usage of energy but with more accuracy. Wi-Fi module is programmed in a way that exactly as usage of the energy smart meter records the energy usage and send the usage data to the IOT page for monitoring by the user. User can

access the energy usage on IOT page in real-time with respect to date and exact time. GSM module is also there to send the information about the low balance of the smart meters. GSM module is used to send SMS to the user on their respective registered phone number. It will alert the user for low balances and as well as no balance. If there will be no recharge in the smart meter then power will go off automatically. User can recharge the smart meter using IOT page provided by the user.

## **CHAPTER 3**

### **PROJECT DESCRIPTION**

#### **3.1 EXISTING SYSTEM**

The existing system for energy metering and billing typically involves the installation of mechanical or electronic meters at consumers' premises. These meters measure the amount of energy consumed by the consumer and send the data to the utility company for billing purposes.

However, the existing system has several limitations and challenges. First, the system does not provide real-time information on energy consumption, making it difficult for consumers to adjust their usage patterns and manage their energy consumption effectively. Second, the system is prone to errors, leading to inaccurate billing and disputes between consumers and utilities. Third, the system does not incentivize sustainable energy usage or the integration of renewable energy sources into the grid.

Moreover, the existing system requires significant resources and time for meter reading, data processing, and billing, leading to high operational costs for utilities. The system is also vulnerable to tampering and fraud, which can lead to revenue losses for utilities.

Overall, the existing system for energy metering and billing is limited in its functionality, efficiency, and sustainability. To address these challenges, there is a need for a more advanced and integrated system that incorporates IOT technology, prepaid billing, and real-time monitoring of energy consumption.

#### **3.2 ADVANTAGES OF EXISTING SYSTEM**

1. **Reliability:** The existing system has been used for many years and has been proven to be reliable in accurately measuring energy consumption and generating bills.
2. **Familiarity:** Consumers and utilities are familiar with the existing system, which has been used for decades. This familiarity can make the transition to a new system more challenging.
3. **Low initial cost:** The initial cost of installing mechanical or electronic meters is relatively low, making it an affordable option for utilities.

4. Easy to maintain: The existing system is relatively easy to maintain, with mechanical meters requiring little to no maintenance.
5. Compatibility: The existing system is compatible with most types of energy sources, including traditional and renewable sources.

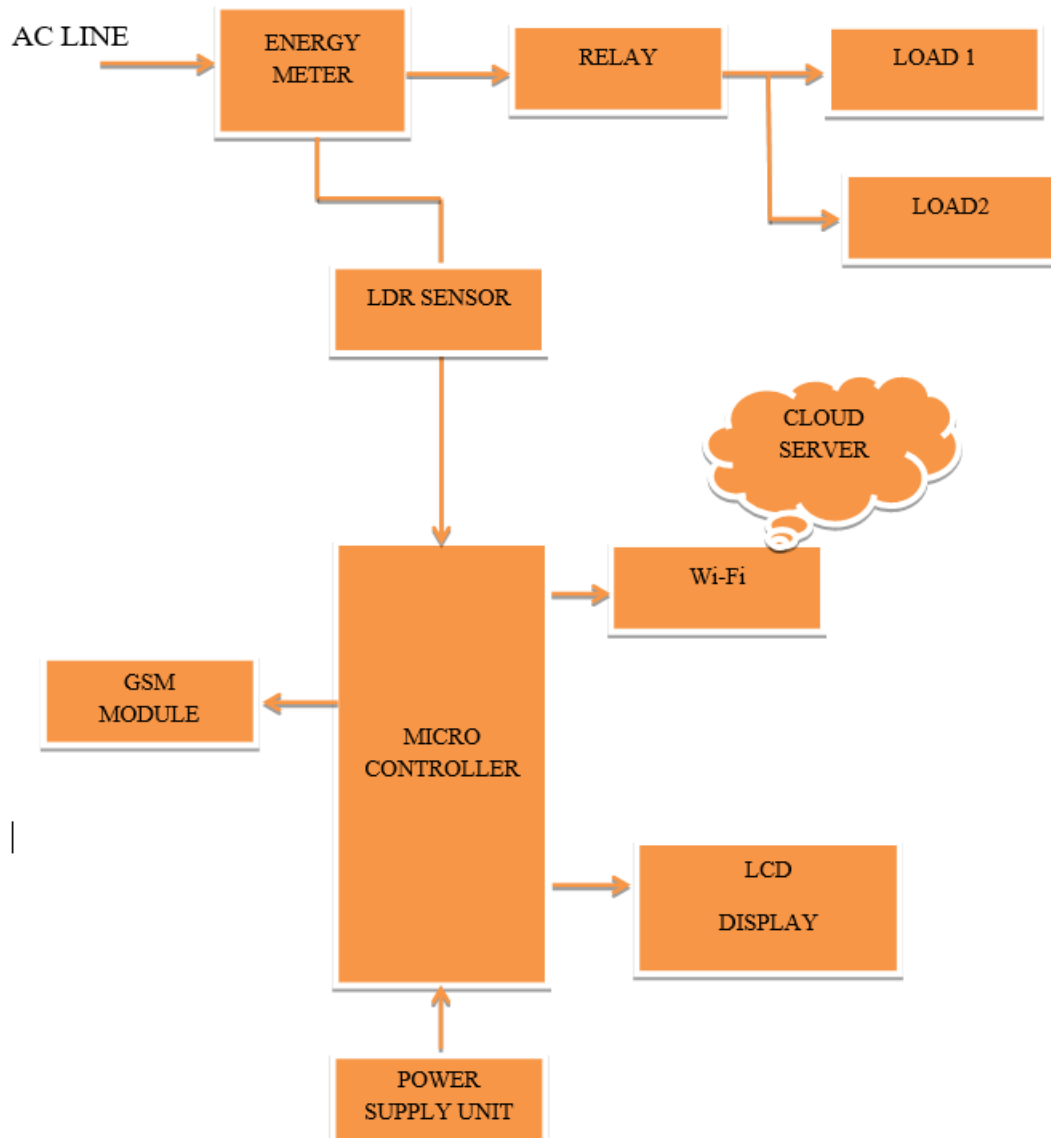
### **3.3 DISADVANTAGE OF EXISTING SYSTEM**

1. Limited functionality: The existing system does not provide real-time information on energy consumption, making it difficult for consumers to monitor and manage their energy usage effectively.
2. Inaccuracy: The existing system is prone to errors, leading to inaccurate billing and disputes between consumers and utilities. Mechanical meters can also become less accurate over time.
3. Lack of incentives: The existing system does not incentivize sustainable energy usage or the integration of renewable energy sources into the grid.
4. Operational costs: The existing system requires significant resources and time for meter reading, data processing, and billing, leading to high operational costs for utilities.
5. Vulnerability to tampering and fraud: The existing system is vulnerable to tampering and fraud, leading to revenue losses for utilities.

### **3.4 PROPOSED SYSTEM**

The proposed system is an IOT-based prepaid smart metering and monitoring system that addresses the limitations of the existing energy metering and billing systems. The proposed system consists of smart meters that measure energy consumption in real-time and send the data to a central server for processing and billing. The system also allows for prepaid billing, where consumers can top-up their energy credit before consumption, and the meter automatically deducts the energy consumed from the credit balance.

### 3.5 BLOCK DIAGRAM OF PROPOSED SYSTEM



**Figure 2.1 Block Diagram**

The figure 2.1 shows that the direct AC supply is given to the smart energy meter. Relay and LDR sensor is directly connected to the smart energy meter. With LDR sensor microcontroller is connected and with the microcontroller GSM module and Wi-Fi module and LCD display is connected. With relay loads are connected. LDRs (Light Dependent Resistors)

can be used as a sensor to detect the presence or absence of light in the surrounding environment. LDR sensor can be used in several ways like to detect tampering etc. Microcontroller NodeMCU is a programmed like Arduino board. Relays are used for safety of the loads. GSM module is used for sending and receiving the usage of the energy on the mobile phones and Wi-Fi module is used for updating energy usage on the IOT page.

### **3.6 ADVANTAGES OF PROPOSED SYSTEM**

The proposed system has several advantages over the existing system, including:

1. Real-time monitoring: The proposed system provides real-time information on energy consumption, allowing consumers to adjust their energy usage patterns and manage their energy consumption more effectively.
2. Accuracy: The proposed system is more accurate than the existing system, reducing the risk of billing errors and disputes between consumers and utilities.
3. Incentives for sustainable energy usage: The proposed system provides incentives for sustainable energy usage and the integration of renewable energy sources into the grid. Consumers can be rewarded for reducing their energy consumption and using renewable energy sources.
4. Cost-effective: The proposed system is more cost-effective than the existing system, reducing operational costs for utilities and improving revenue collection.
5. Security: The proposed system is more secure than the existing system, with smart meters that are difficult to tamper with and prevent fraud.

### **3.7 CONSTRAINTS IN THE PROJECT**

There can be several constraints in the implementation of an IOT-based prepaid smart metering and monitoring system. Here are some of the most common ones:

1. Budget constraints: Developing an IOT-based system can be expensive, and the cost of implementing prepaid smart metering and monitoring systems can be a significant barrier for small and medium-sized utility companies.
2. Technical challenges: IOT-based systems require a robust and reliable network infrastructure for data transmission and communication. The development and maintenance of such infrastructure can pose technical challenges and require significant resources.
3. Privacy and security concerns: IOT devices and systems are vulnerable to cyber threats and hacking. The sensitive data transmitted and stored in the system can pose privacy and security concerns, making it essential to have robust security measures in place.
4. Regulatory compliance: The deployment of IOT-based prepaid smart metering and monitoring systems requires compliance with regulatory requirements and standards. Utility companies must adhere to relevant regulations and obtain necessary certifications before implementing the system.
5. Resistance to change: The introduction of new technology and systems can face resistance from consumers who may not be familiar with the technology or prefer traditional methods.

### **3.8 ENGINEERING STANDARDS**

IEEE standards are a set of technical guidelines and specifications developed by the Institute of Electrical and Electronics Engineers (IEEE) to ensure consistency, interoperability, safety, and quality in the design, manufacturing, and operation of engineering systems and products. Here are some of the key IEEE standards that may apply to IOT-based prepaid smart metering and monitoring systems:

1. IEEE 802.11 - Wireless Local Area Network (WLAN) standards: This standard specifies the protocols and procedures for wireless communication, which is essential for IOT devices and systems.
2. IEEE 802.15.4 - Wireless Personal Area Network (WPAN) standards: This standard defines the specifications for low-rate wireless personal area networks, which can be used for low-power IOT devices.

3. IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems: This standard provides guidelines for interconnecting distributed energy resources, such as solar panels and wind turbines, with electric power systems.
4. IEEE 2030.5 - Standard for Smart Energy Profile Application: This standard provides specifications for the interoperability and communication protocols of smart grid devices, such as smart meters.
5. IEEE 1888 - Standard for Ubiquitous Green Community Control Network Protocol: This standard provides specifications for a communication protocol for smart grid systems that facilitate demand response and energy management.

Adherence to these and other relevant IEEE standards is essential for the successful development, implementation, and operation of IOT-based prepaid smart metering and monitoring systems. These standards ensure that the system is safe, reliable, interoperable, and consistent with industry best practices, providing benefits to both consumers and utility companies.

### **3.9 TRADE – OFF**

Trade-offs are inevitable in the design, development, and implementation of IOT-based prepaid smart metering and monitoring systems. These trade-offs involve the consideration and balancing of various factors, such as cost, performance, reliability, and user experience. Here are some common trade-offs in the context of IOT-based prepaid smart metering and monitoring systems:

**Cost vs. Performance:** The cost of implementing IOT-based prepaid smart metering and monitoring systems can be a significant barrier for small and medium-sized utility companies. Therefore, trade-offs must be made between the cost of implementing the system and the expected performance and benefits.

**Data Collection vs. Privacy:** IOT-based systems generate vast amounts of data, which can be valuable for optimizing energy usage and reducing costs. However, this data can also pose privacy concerns for consumers. Thus, trade-offs must be made between data collection and privacy protection.

Reliability vs. Complexity: IOT-based systems involve multiple interconnected devices and systems, which can increase complexity and potential points of failure. Therefore, trade-offs must be made between the reliability of the system and the complexity of the system.

User Experience vs. Functionality: IOT-based systems must be user-friendly and intuitive to use. However, user experience trade-offs may need to be made for increased functionality and advanced features.

Compatibility vs. Security: IOT-based systems require compatibility between devices and systems, which can increase the risk of cyber threats and hacking. Thus, trade-offs must be made between compatibility and security measures.

Effective management of trade-offs requires a comprehensive understanding of the system requirements and stakeholder needs, as well as careful planning, testing, and iteration throughout the development and implementation process.

## **CHAPTER 4**

### **SIMULATION DETAILS**

#### **4.1 DEVELOPMENT SETUP**

The development setup for an IOT-based prepaid smart metering and monitoring system can be broken down into several steps:

1. **Define System Requirements:** The first step is to define the system requirements, including functional and non-functional requirements. This includes identifying the scope of the system, the data to be collected, the features required, and the performance characteristics.
2. **Select Hardware Components:** Once the system requirements are defined, the hardware components required to build the system can be selected. This includes selecting IOT devices, networking components, and servers.
3. **Select Software Components:** Software components required to build the system can be selected based on the system requirements. This includes selecting the operating system, middleware, and application software.
4. **Develop Software Applications:** Once the software components are selected, the software applications required to collect, process, store, visualize, and analyze the data collected by IOT devices can be developed.
5. **Develop Hardware Prototypes:** Hardware prototypes can be developed to test the integration of IOT devices, networking components, and servers.
6. **Integrate Hardware and Software:** Hardware and software components can be integrated to ensure compatibility and to test the system's functionality.
7. **Test and Validate:** The integrated system can be tested and validated to ensure it meets the system requirements, is reliable, and scalable.
8. **Deploy the System:** Once the system is tested and validated, it can be deployed in the field.

The specific development setup will depend on the requirements and constraints of the project, including factors such as scalability, cost, and security. Effective management and integration of

these components and tools are crucial for successful development, testing, and deployment of the IOT-based prepaid smart metering and monitoring system.

## **4.2 SOFTWARE DEVELOPMENT**

Software development for IOT-based prepaid smart metering and monitoring systems involves designing, developing, testing, and deploying software applications and systems that control, manage, and analyze the data collected by IOT devices. This includes developing software applications for data collection, processing, storage, visualization, and analysis. Software development may involve using programming languages such as Python, Java, or C++, and development environments such as Eclipse, Visual Studio, or PyCharm. Agile development methodologies, such as Scrum or Kanban, can be used to ensure the software development process is iterative and collaborative, with regular testing and feedback loops.

Both software and hardware development must be integrated and tested to ensure the IOT-based prepaid smart metering and monitoring system is reliable, scalable, and effective. Collaboration between hardware and software development teams is essential to ensure compatibility and to troubleshoot any issues that may arise during the development process. Regular testing, validation, and quality assurance must be conducted to ensure the final product meets the system requirements and user needs.

## **4.3 ARDUINO PROGRAMMING CODE**

```
#include <ESP8266WiFi.h>

#include <ESP8266HTTPClient.h>

#include <WiFiClient.h>

#include <ArduinoJson.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);
```

```

const char* ssid    = "IOT";

const char* password = "12345678";

const char* serverName = "http://IOTcloud22.in/2255_energy/post_value.php";


int unit = 0, val, n = 5;

WiFiClient client;

HTTPClient http;


int len;

int c = 0, a = 0;

int cnt = 0;

void setup() {

    lcd.init();

    lcd.backlight();

    lcd.setCursor(0, 0);

    lcd.print(" SMART PREPAID ");

    lcd.setCursor(0, 1);

    lcd.print(" ENERGYMETER ");

    delay(2000);

    pinMode(D5, OUTPUT);

```

```

pinMode(D6, OUTPUT);

Serial.begin(9600);


WiFi.begin(ssid, password);


Serial.println("Connecting");

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

    Serial.print(".");

    delay(500);

}

Serial.println("");

Serial.print("Connected to WiFi network with IP Address: ");

Serial.println(WiFi.localIP());

digitalWrite(D5, LOW);

delay(2000);

sending_to_db();

lcd.clear();

}


void loop() {

    val = analogRead(A0);

    Serial.println(val);

```

```

lcd.setCursor(0, 0);

lcd.print("UNIT: ");

lcd.print(unit);

// va++;

if (val > 400 ) {

    unit = unit + 1;

    Serial.println(unit);

//    va=0;

    sending_to_db();

}

if (cnt == 0 && unit == n - 2) {

    digitalWrite(D6, HIGH);

    delay(500);

    digitalWrite(D6, LOW);

    delay(500);

    digitalWrite(D6, HIGH);

    delay(500);

    digitalWrite(D6, LOW);

    while (a < 2) {

        alertsms();

        a++;

```

```

    }

    a = 0;

    cnt = 1;

}

if (unit >= n)

{

    digitalWrite(D5, HIGH);

    while (a < 2) {

        offsms();

        a++;

    }

    a = 0;

    c = 0;

    cnt = 0;

    while (c == 0) {

        getdata();

    }

}

}

```

```
void alertsms() {  
  
    lcd.setCursor(0, 1);  
  
    lcd.print("SMS SENDING.....");  
  
    delay(1000);  
  
    Serial.println("AT\r");  
  
    delay(2000);  
  
    Serial.println("AT+CMGF=1\r");  
  
    delay(1000);  
  
    Serial.println("AT+CMGS=\"+918579811744\"\r");  
  
    delay(1000);  
  
    Serial.println("***PLEASE CHECK YOUR RECHARGE IS LOW***");  
  
    Serial.println("***RECHARGE IMMEDIATELY***");  
  
    delay(1000);  
  
    Serial.println((char)26);  
  
    delay(1000);  
  
}
```

```

void offsms() {

    lcd.setCursor(0, 1);

    lcd.print("SMS SENDING.....");


    delay(1000);

    Serial.println("AT\r");

    delay(1000);

    Serial.println("AT+CMGF=1\r");

    delay(1000);

    Serial.println("AT+CMGS=\"+918579811744\"\r");

    delay(1000);

    Serial.println("****PLEASE CHECK YOUR RECHARGE IS FINISHED****");


    Serial.println("****PLEASE RECHARGE****");


    delay(1000);

    Serial.println((char)26);

    delay(1000);

}

void sending_to_db()

```

```

{
    if (WiFi.status() == WL_CONNECTED)
    {
        http.begin(client, serverName);

        http.addHeader("Content-Type", "application/x-www-form-urlencoded");

        String httpRequestData = "&value1=" + String(unit) + "";

        // Serial.print("httpRequestData: ");

        // Serial.println(httpRequestData);

        int httpResponseCode = http.POST(httpRequestData);

        if (httpResponseCode > 0) {

            Serial.print("HTTP Response code: ");

            Serial.println(httpResponseCode);

        }

        else {

            Serial.print("Error code: ");

            Serial.println(httpResponseCode);

        }

        http.end();

        delay(900);

    }

    else {

```

```

    Serial.println("WiFi Disconnected");

}

}

void getdata()

{

    if (WiFi.status() == WL_CONNECTED) {

        //HTTPClient http; //Object of class HTTPClient

        http.begin(client, "http://IOTcloud22.in/2255_energy/light.json");

        int httpCode = http.GET();

        //Check the returning code

        if (httpCode > 0) {

            // Parsing

        }

    }

    StaticJsonDocument<256> doc;

    DeserializationError error = deserializeJson(doc, http.getString());

    Serial.println(http.getString());

    if (error) {

        Serial.print(F("deserializeJson() failed: "));

        Serial.println(error.f_str());
    }
}

```

```

    return;

}

//StaticJsonDocument<256> doc;

//    deserializeJson(doc, json);

//    auto error = deserializeJson(doc, json);

if (error) {

    Serial.print(F("deserializeJson() failed with code "));

    Serial.println(error.c_str());

    return;

}

```

```

String light = doc["light"]; // "on"

// Extract values

//Serial.print(F("Response:"));

//Serial.println(light);

if (light == "on" && c == 0)

{

    n = n + 5;

    digitalWrite(D5, LOW);

    c = 1;

    delay(3000);

```

```

    }

    // if (light == "off")

    // {

    //

    //   digitalWrite(D5, HIGH);

    // }

    http.end(); //Close connection

    //Serial.println(flag);

    delay(1000);

}

```

#### 4.4 WORKING ROLE OF THE PROTEUS

The Arduino Integrated Development Environment (IDE) is an open-source software application that is used to program Arduino microcontrollers. The IDE provides a user-friendly interface that enables users to write, compile, and upload code to Arduino boards. The Arduino IDE is available for Windows, Mac OS X, and Linux operating systems and can be downloaded for free from the Arduino website.

The Arduino IDE includes a text editor with syntax highlighting, code completion, and error highlighting features, which help users write error-free code. The IDE also includes a compiler that translates the code into machine-readable instructions that can be executed by the Arduino board.

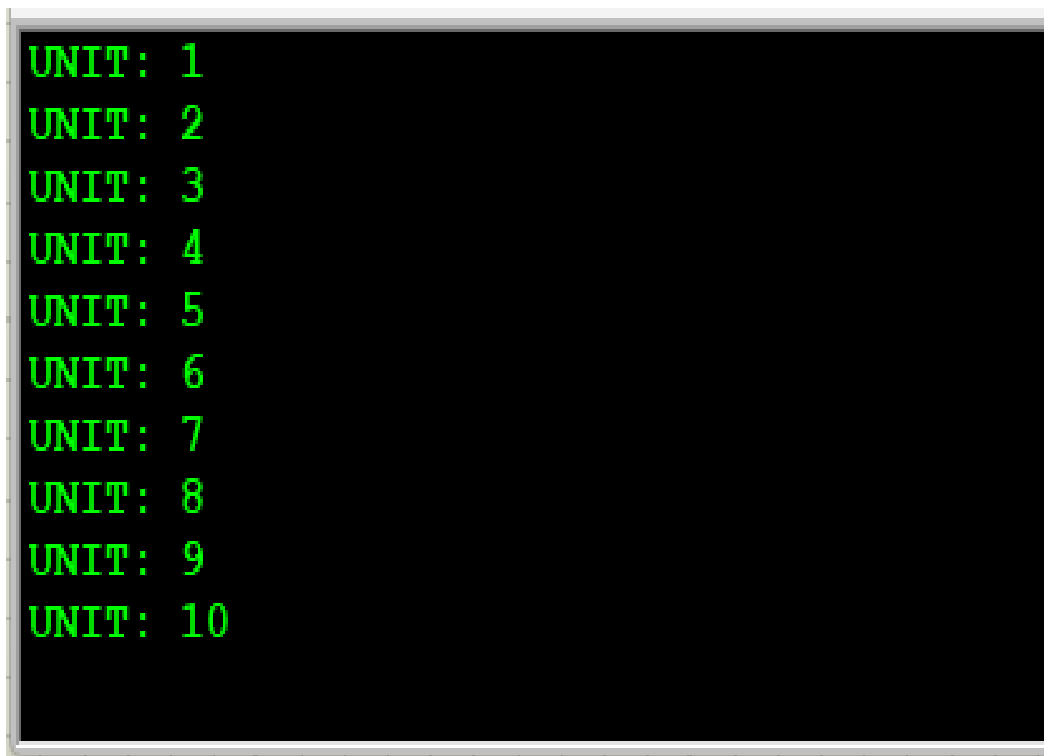
The Arduino IDE supports several programming languages, including C, C++, and Arduino-specific programming language. The IDE includes libraries, which provide pre-written code that can be used to interface with various sensors and actuators. The IDE also supports

third-party libraries, which can be downloaded and installed to extend the functionality of the Arduino board.

One of the key features of the Arduino IDE is its ability to easily upload code to the Arduino board. The IDE includes a serial monitor that allows users to send and receive data to and from the board. The IDE also includes a bootloader, which enables the board to be programmed over a serial connection.

Overall, the Arduino IDE is a powerful and user-friendly tool that enables users to program Arduino microcontrollers, even without a deep understanding of programming. Its intuitive interface and extensive library of pre-written code make it an ideal platform for beginners to get started with embedded programming.





```
UNIT: 1
UNIT: 2
UNIT: 3
UNIT: 4
UNIT: 5
UNIT: 6
UNIT: 7
UNIT: 8
UNIT: 9
UNIT: 10
```

**Figure 4.2: Output**

Figure 4.2 shows the usage of the energy used by the user in smart meter on while simulating on the proteus. It shows the 10 units is used. After the use of every 10 units power will go “Off” and send the SMS to the user to recharge the smart meters immediately.

Proteus is a powerful software tool used for designing and simulating electronic circuits. The software is widely used by engineers, designers, and students for circuit design and simulation, PCB layout, and microcontroller simulation. Proteus is developed by Lab center Electronics and is available in two versions, Proteus Professional and Proteus Design Suite.

The working role of Proteus involves the following:

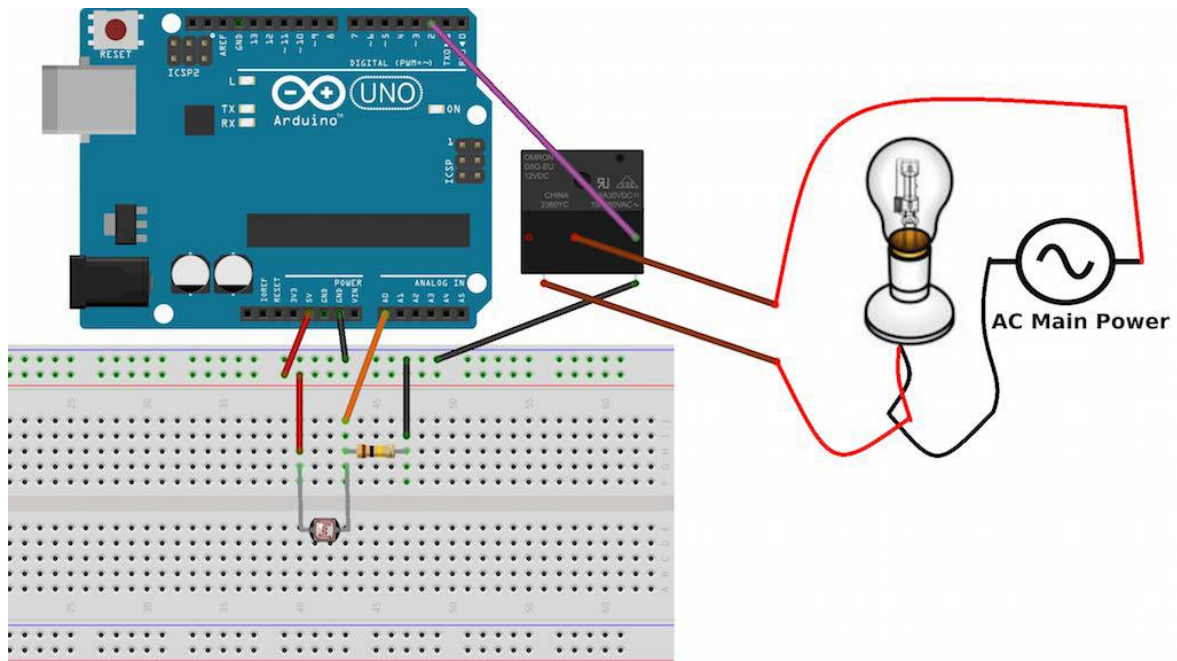
- **Circuit Design:** Proteus enables users to design electronic circuits using a schematic capture tool that includes a library of components such as resistors, capacitors, transistors, and ICs. Users can drag and drop these components onto the schematic editor and connect them using wires.

- **Simulation:** Once the circuit is designed, Proteus can simulate the circuit to test its functionality. Proteus uses SPICE (Simulation Program with Integrated Circuit Emphasis) to simulate electronic circuits. The simulation feature allows users to test and verify the design before building the physical circuit.
- **PCB Layout:** Proteus also provides a PCB (Printed Circuit Board) layout tool that enables users to convert the circuit schematic into a physical circuit board. The PCB layout tool allows users to place the components on the board, route the traces, and generate Gerber files for manufacturing.
- **Microcontroller Simulation:** Proteus includes a microcontroller simulation feature that enables users to simulate the behaviour of microcontrollers such as Arduino, PIC, and AVR. Users can write and upload code to the virtual microcontroller and simulate its behaviour within the circuit.

Overall, Proteus plays a critical role in the design and development of electronic circuits. Its schematic capture, simulation, PCB layout, and microcontroller simulation features provide a comprehensive solution for designing, testing, and verifying electronic circuits before building them physically. Proteus is widely used in the electronics industry and academia, and its user-friendly interface and extensive library of components make it an ideal tool for beginners and professionals alike.

## **4.5 TESTING**

Testing is a critical phase in the software development life cycle that ensures that the software or system meets the intended requirements and specifications. The testing phase involves executing the software or system with the intent of identifying defects, errors, and other issues that may impact the quality and performance of the software.



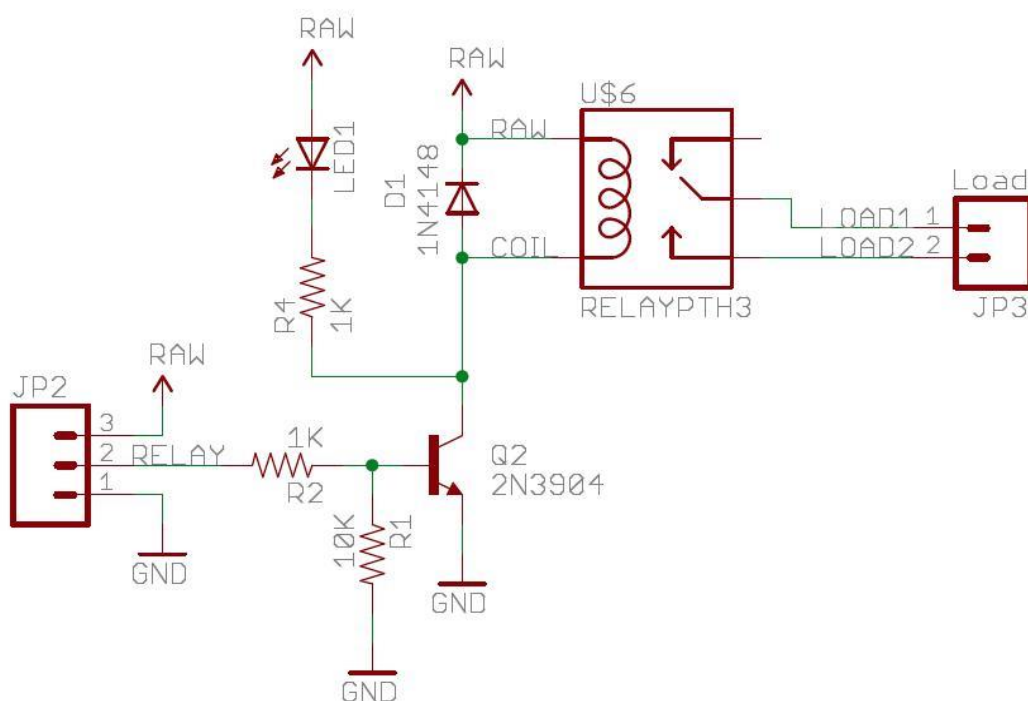
**FIG:4.3 TESTING**

There are several types of testing, including:

- **Unit Testing:** Unit testing is a type of testing that is performed at the code level. It involves testing individual units or modules of the software to ensure that they are functioning as intended.
- **Integration Testing:** Integration testing is a type of testing that is performed to test the interaction between different units or modules of the software. The objective of integration testing is to identify defects that may arise due to the integration of different components.
- **System Testing:** System testing is a type of testing that is performed to test the entire software or system as a whole. The objective of system testing is to ensure that the software or system meets the intended requirements and specifications.
- **Acceptance Testing:** Acceptance testing is a type of testing that is performed to test the software or system against the customer's requirements and specifications. The objective of acceptance testing is to ensure that the software or system meets the customer's expectations.

- **Performance Testing:** Performance testing is a type of testing that is performed to test the performance of the software or system under different load conditions. The objective of performance testing is to identify performance-related issues such as response time, throughput, and scalability.
- **Security Testing:** Security testing is a type of testing that is performed to test the security of the software or system. The objective of security testing is to identify security-related issues such as vulnerabilities and threats.

Overall, testing plays a critical role in ensuring the quality and reliability of the software or system. The testing phase helps to identify defects and issues that may impact the performance and functionality of the software, enabling developers to fix these issues before releasing the software to the end-users.



**Figure 4:4 Circuit Diagram**

Figure 4:4 shown , A relay is an electromechanical switch which is activated by an electric current. A single relay board arrangement contains driver circuit, power supply circuit and isolation circuit. A relay is assembled with that circuit. The driver circuit contains transistors for switching operations. The transistor is use for switching the relay. An isolation circuit prevents reverse voltage from the relay which protects the controller and transistor from damage. The input pulse for switching the transistor is given from the microcontroller unit. It is used for switching of a single device.

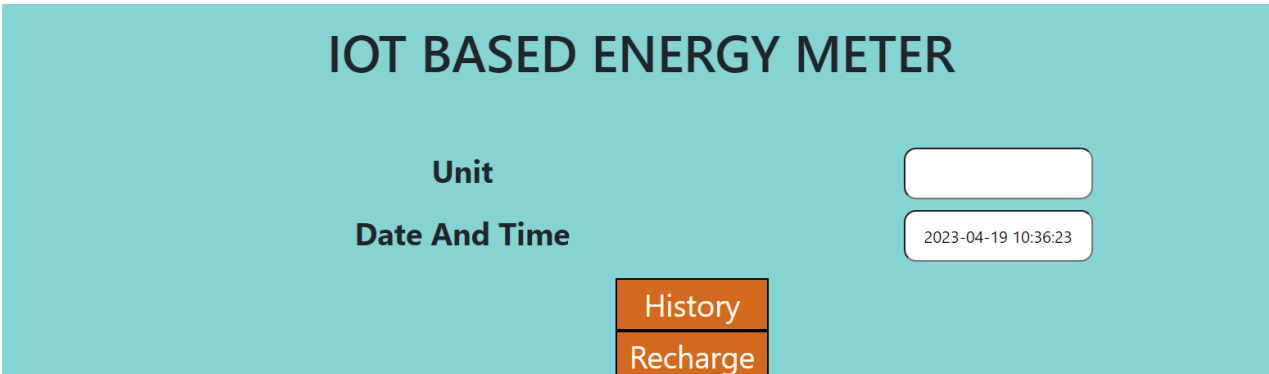


Figure 5.5 Recharge Page

Figure 5.5 shows the recharge page of smart energy meter where user can recharge their smart meters according to their usage and as well as can monitor the real-time energy usage of the user on that IOT page

## **CHAPTER 5**

### **RESULT AND DISCUSSION**

#### **5.1 CONCEPT EXPLANATION**

A concept is an abstract idea or general notion that represents something that is complex or difficult to define in concrete terms. It is a mental construct that helps us to understand, categorize, and communicate information about the world around us. Concepts are an essential part of human cognition, and they play a critical role in our ability to reason, learn, and communicate.

Concepts can be formed through a variety of ways, including direct experience, observation, and language. For example, we may form a concept of a tree by directly experiencing a tree in the environment, observing other people interacting with trees, or learning about trees through language and communication. Once a concept is formed, we can use it to categorize and organize information about the world, make predictions, and communicate with others.

Concepts can be organized into hierarchies, with more general concepts at the top and more specific concepts at the bottom. For example, the concept of "animal" is a more general concept than "dog," which is a more specific concept. The hierarchy of concepts helps us to understand the relationships between different concepts and to make sense of complex information.

Concepts are used in a variety of domains, including science, mathematics, language, and culture. In science, concepts such as gravity, energy, and atoms are used to explain natural phenomena. In mathematics, concepts such as numbers, geometry, and algebra are used to solve problems and make calculations. In language, concepts such as grammar, syntax, and vocabulary are used to communicate ideas and information. In culture, concepts such as identity, tradition, and values are used to define and understand social and cultural practices.

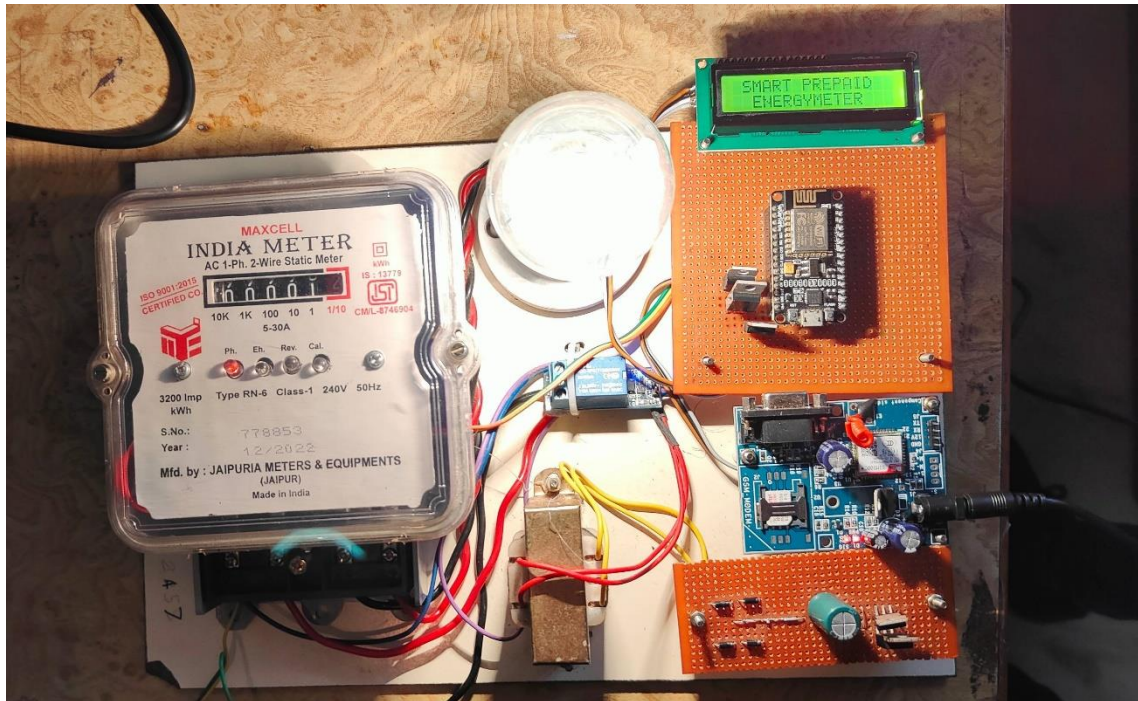
Overall, concepts play a crucial role in our ability to understand and interact with the world around us. They help us to organize and communicate information, make predictions, and solve problems, and they form the foundation of our knowledge and understanding of the world.

## 5.2 WORKING OF IOT-BASED PREPAID SMART METERING AND MONITORING

The IOT-based prepaid smart metering and monitoring system is designed to provide a more efficient and convenient way of measuring and managing electricity consumption in homes and businesses. Here's how it works:

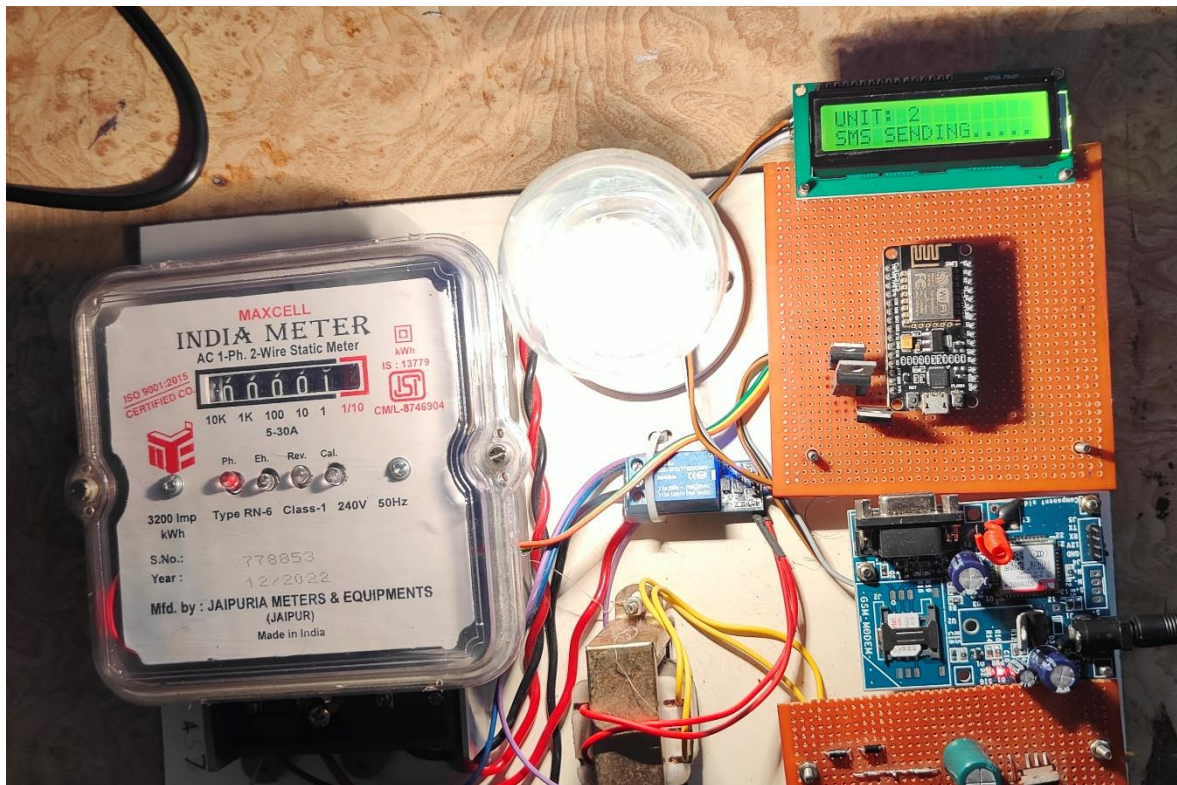
- **Smart Meter Installation:** A smart meter is installed at the user's location, which is connected to the internet and communicates with the utility company's server. The smart meter measures the electricity consumption in real-time and sends the data to the server.
- **Prepaid System:** The system uses a prepaid model, where the user purchases a certain amount of electricity credits in advance, which is then loaded onto their account.
- **User Interface:** The user can access their account information and monitor their electricity consumption through a web-based interface or a mobile application.
- **Real-Time Monitoring:** The system provides real-time monitoring of the user's electricity consumption and sends alerts to the user when their account balance is low.
- **Automatic Disconnection:** When the user's electricity credits are exhausted, the system automatically disconnects the electricity supply until the user purchases more credits.
- **Online Payment:** Users can easily purchase more electricity credits online using a variety of payment methods such as credit cards, online banking, and mobile wallets.
- **Analytics and Reports:** The system generates analytics and reports on the user's electricity consumption, which helps the user to identify areas where they can reduce their consumption and save on electricity bills.

Overall, the IOT-based prepaid smart metering and monitoring system provides a convenient, efficient, and cost-effective way of managing electricity consumption, reducing wastage, and promoting sustainability.



**Figure :5.1: The Prototype Model**

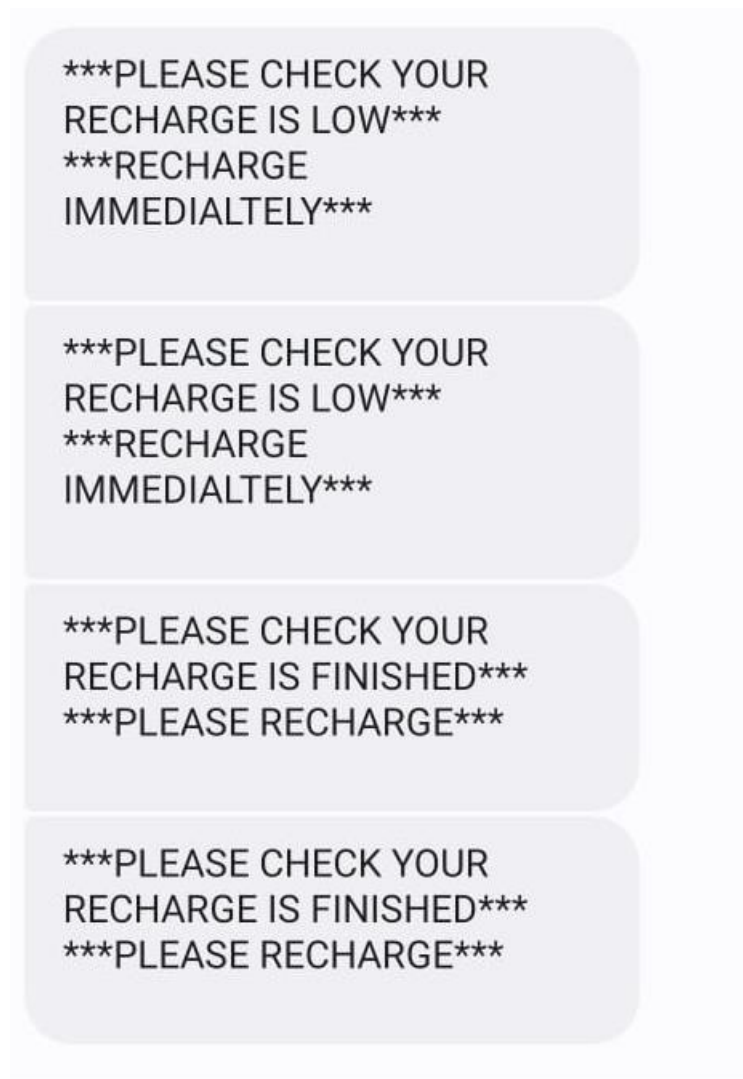
Figure 5.1 Shows the prototype of smart energy meter when it initializes the smart energy meter.



**Figure 5.2: Usage Notification**

Figure 5.2 Shows the units used and sending SMS to user on every defined usage.

Defined usage means if limit is set to 5 units then after every 5 units used the smart energy meter will send SMS to the user mobile phones. Here in this case the limit is set to the 2 units. And after every 2 units used the GSM module will send notification to the user.



***Figure 5.3: SMS Notification***

Figure 5.3 Shows the user side mobile phones SMS interface. On usage they will get notified through the SMS.

| S.no | Unit | Date And Time       |
|------|------|---------------------|
| 1    | 5    | 2023-03-31 14:14:17 |
| 2    | 4    | 2023-03-31 14:13:58 |
| 3    | 3    | 2023-03-31 14:13:40 |
| 4    | 2    | 2023-03-31 14:13:21 |
| 5    | 1    | 2023-03-31 14:13:03 |

**Figure 5.4 Energy Usage Data On IOT Page**

Figure 5.4 Shows the real time usage on IOT page. User can access the page provided by the supplier and can access the data they have used in entire usage and can find when and how much energy used in specific period of the time.

### 5.3 HARDWARE DESCRIPTION

#### 5.3.1 ARDUINO NODEMCU

The Arduino NodeMCU is a development board that combines the functionalities of the popular Arduino Uno board and the ESP8266 Wi-Fi module. The ESP8266 Wi-Fi module is a low-cost Wi-Fi chip that provides Wi-Fi connectivity to devices.

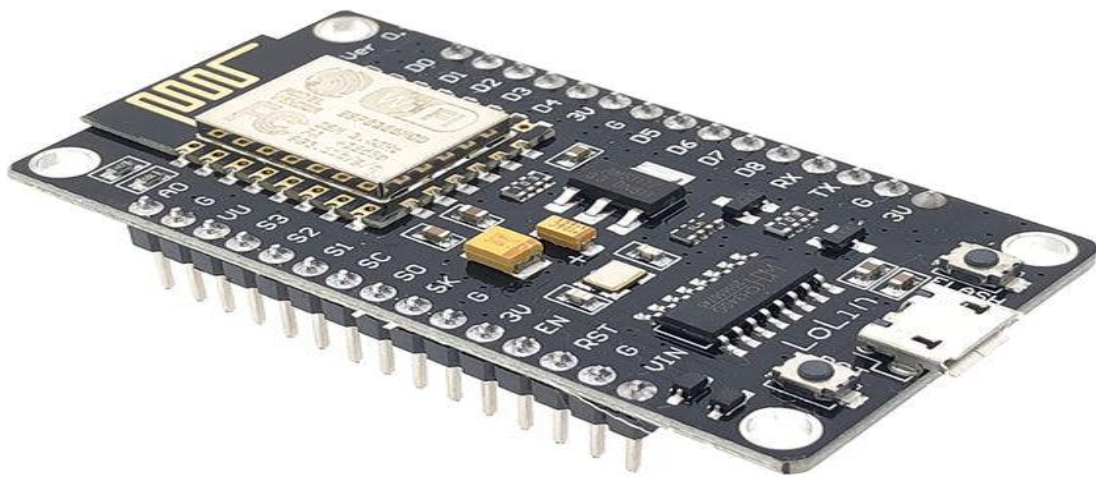
The NodeMCU board is compatible with the Arduino Integrated Development Environment (IDE) and can be programmed using the Arduino programming language. It provides a simple and easy-to-use platform for developing Wi-Fi-enabled projects using the Arduino framework.

The NodeMCU board features a microcontroller, which is the brain of the board, and a built-in Wi-Fi module. It also includes a USB interface for power and programming, as well as various pins for connecting sensors, actuators, and other devices.

The NodeMCU board can be used to create a wide range of projects, including IOT devices, home automation systems, weather stations, and more. It provides a powerful and

flexible platform for developing connected devices and enables developers to easily connect their projects to the internet.

Overall, the Arduino NodeMCU is a versatile and powerful development board that combines the capabilities of the Arduino and the ESP8266 Wi-Fi module, making it an excellent choice for developing Wi-Fi-enabled projects.



**FIG: 5.5 NODEMCU DEVELOPMENT BOARD**

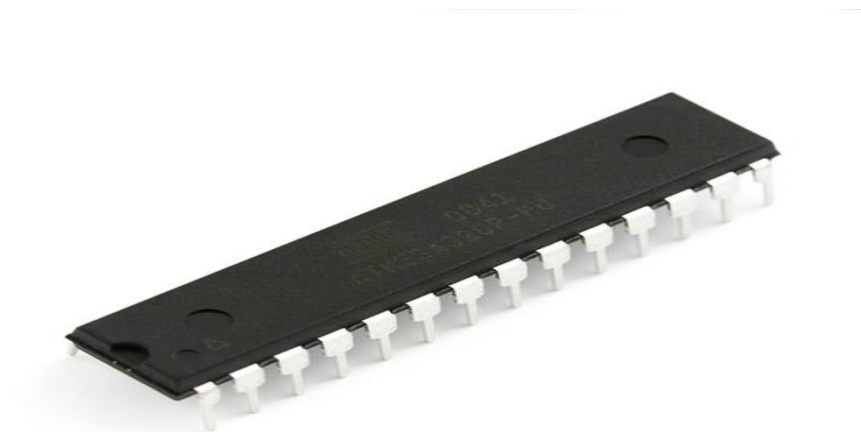
### **5.3.2 ATMEGA328 IC**

The ATmega328 is a microcontroller chip from Atmel Corporation that is widely used in embedded systems, robotics, and other electronic projects. It is the heart of the Arduino Uno board, which is one of the most popular development boards for hobbyists and makers.

The ATmega328 is an 8-bit microcontroller that runs at 16 MHz clock speed and has 32 KB of Flash memory for program storage, 2 KB of SRAM for data storage, and 1 KB of EEPROM for non-volatile storage. It has 23 digital input/output (I/O) pins, six of which can be used for pulse width modulation (PWM), and six analog input pins.

The ATmega328 is a versatile and flexible microcontroller that can be programmed using various programming languages, including C and assembly. It provides a powerful platform for developing embedded systems and can be used in a wide range of applications, including robotics, home automation, and IOT devices.

Overall, the ATmega328 is a popular and reliable microcontroller chip that is widely used in the electronics industry. Its versatility, flexibility, and ease of use make it an excellent choice for developers and hobbyists alike.



**FIG:5.6 ATMEGA328 IC**

### 5.3.3 LCD DISPLAY

LCD (Liquid Crystal Display) is a technology used in displays for electronic devices such as calculators, digital clocks, and other consumer electronics. It uses a liquid crystal material sandwiched between two sheets of glass to display information.

LCD displays work by controlling the orientation of the liquid crystal molecules using an electric field. When a voltage is applied to the electrodes surrounding the liquid crystal material, the molecules align in a particular direction, which either blocks or allows light to pass through the display.

LCD displays are widely used in electronic devices because they are low-power, lightweight, and can display high-quality images and text. They are available in various sizes and configurations, including character displays (e.g., 16x2), graphic displays, and colour displays.

In electronic projects, LCD displays can be used to display various types of information, including sensor readings, messages, and status updates. They are commonly used in combination with microcontrollers such as the Arduino to create projects such as weather stations, home automation systems, and other IOT devices.

Overall, LCD displays are a popular and versatile technology used in a wide range of electronic devices and projects. They provide a simple and effective way to display information and are widely available in various sizes and configurations.



**FIG:5.7 LCD DISPLAY**

#### **5.3.4 LDR SENSOR**

LDR (Light Dependent Resistor) sensor, also known as a photo resistor, is a type of electronic component that is sensitive to light. It is made of a semiconductor material that changes its resistance when exposed to light. When the light falls on the LDR sensor, the resistance of the material decreases, and when the light is removed, the resistance increases.

LDR sensors are commonly used in electronic projects to detect the presence or absence of light. They are often used in streetlights, security systems, and light meters to control the intensity of light or turn the light on and off automatically.

LDR sensors can be easily integrated into electronic circuits and are often used in combination with microcontrollers such as the Arduino to create projects such as light meters, automatic streetlights, and other IOT devices.

Overall, LDR sensors are a useful and versatile component in electronic projects, providing a simple and effective way to detect the presence or absence of light.



***FIG:5.8 LDR SENSOR***

#### **5.3.5 SINGLE CHANNEL RELAY**

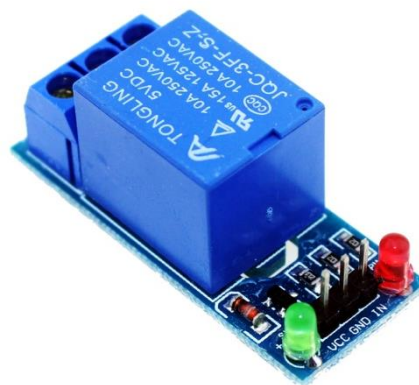
A single-channel relay is a type of electromechanical switch that can be used to control the flow of electrical current in a circuit. It consists of a coil, which, when energized, creates a

magnetic field that pulls a metal armature towards the coil, which closes the contacts of the relay. This allows a separate electrical circuit to be controlled by the relay, without any direct electrical connection between the two circuits.

A single-channel relay is called a single channel because it can control one circuit at a time. It is commonly used in electronic projects to switch on or off high voltage or high current loads such as motors, heaters, lights, and other electrical devices.

Single-channel relays can be controlled by a variety of devices, including microcontrollers such as Arduino, sensors, switches, and other electronic components. They are easy to use and can be integrated into a wide range of electronic projects.

Overall, single-channel relays are a versatile and useful component in electronic projects, providing a simple and effective way to control the flow of electrical current in a circuit.



**FIG:5.9 SINGLE CHANNEL RELAY**

**TABLE 5.1: SYSTEM REQUIREMENTS**

| HARDWARE REQUIRED               | SOFTWARE REQUIRED |
|---------------------------------|-------------------|
| ENERGY METER                    | ARDUINO IDE       |
| LCD DISPLAY                     | EMBEDDED C        |
| NODE MCU (MICROCONTROLLER UNIT) |                   |
| RELAY                           |                   |
| LDR SENSOR                      |                   |
| TRANSFORMER                     |                   |
| WIFI                            |                   |
| GSM MODULE                      |                   |
| LED BULB                        |                   |

## **CHAPTER 6**

### **CONCLUSION AND FUTURE SCOPE**

#### **6.1 CONCLUSION**

In conclusion, the IOT-based prepaid smart metering and monitoring system provides a highly efficient and convenient way of measuring and managing electricity consumption. The system employs a prepaid model and real-time monitoring to provide users with accurate information about their electricity consumption and alerts them when their account balance is low. The system's analytics and reporting features also help users identify areas where they can reduce their electricity consumption and save on bills. IOT-based prepaid smart metering and monitoring system offers a range of benefits over traditional metering systems, including increased transparency, reduced operational costs, improved energy efficiency, and enhanced customer experience. With its potential for further development and expansion, the system has a bright future in the energy sector. As we move towards a more sustainable and efficient energy system, the IOT-based prepaid smart metering and monitoring system has the potential to play a key role in achieving that goal.

#### **6.2 FUTURE SCOPE**

In terms of future scope, there are several areas where the system can be improved or expanded. For instance:

- **Integration with renewable energy sources:** The system can be integrated with renewable energy sources like solar or wind power, allowing users to monitor their usage of both grid and renewable energy.
- **Smart home integration:** The system can be integrated with smart home devices, allowing users to control their electricity consumption and appliances through a single interface.
- **Block chain integration:** The system can be integrated with block chain technology to ensure secure and transparent transactions between users and utility companies.
- **Predictive maintenance:** The system can be enhanced with predictive maintenance features that detect potential faults in the metering and monitoring system and alert users in advance.

- Time-of-use pricing: The system can be integrated with time-of-use pricing, where the cost of electricity varies depending on the time of day. This encourages users to shift their electricity consumption to off-peak hours, reducing the overall demand on the grid.
- Integration with smart grid: The system can be integrated with the smart grid, allowing for more efficient and reliable energy distribution. This also enables users to participate in demand response programs, where they can adjust their electricity consumption during peak hours to help balance the grid.
- Integration with EV charging stations: The system can be integrated with EV charging stations, allowing users to monitor and manage their electric vehicle charging. This can also help utilities manage the load on the grid by incentivizing users to charge their vehicles during off-peak hours.
- Artificial intelligence integration: The system can be enhanced with artificial intelligence and machine learning algorithms, which can help predict future electricity consumption and optimize the grid accordingly. This can also improve the accuracy of the system's analytics and reporting features.
- Integration with other utilities: The system can be expanded to include other utilities like gas and water, providing users with a comprehensive view of their overall utility consumption.

These future scope not only benefits users by providing a more efficient and cost-effective way of managing their utilities, but also benefit utility companies by promoting efficient use of resources and reducing operational costs.

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