Advanced Metering Infrastructure [AMI] using IoT

Riya Lewis, Mamatha S., Savan S Tilva, Shama Maimoona
Department of Computer Science,
Srinivas Institute of Technology, Mangalore, Karnataka, 574143

Abstract:- Advanced Metering Infrastructure (AMI) is a system that enables the collection and analysis of energy consumption data in real-time. With the integration of Internet of Things (IoT) technologies, AMI has evolved into a more sophisticated and efficient solution for managing energy resources. This abstract provides an overview of AMI using IoT, highlighting its key components, benefits, and challenges. AMI using IoT leverages a network of smart meters equipped with IoT sensors to monitor and transmit energy consumption data. These smart meters are capable of measuring and recording energy usage at regular intervals, providing a granular view of consumption patterns. The collected data is then transmitted to a central server or cloud-based platform through wireless communication protocols such as Wi-Fi, cellular networks, or Low-Power Wide Area Networks (LPWAN).The integration of IoT in AMI brings numerous advantages. Firstly, it enables real-time monitoring of energy consumption, allowing utilities and consumers to gain insights into usage patterns, identify energy-saving opportunities, and make informed decisions regarding energy management. Secondly, AMI using IoT facilitates remote meter reading, eliminating the need for manual meter reading and reducing operational costs. Additionally, it enables faster detection and resolution of faults or abnormalities, improving overall system reliability and reducing downtime. However, implementing AMI using IoT also presents certain challenges. One significant challenge is the security and privacy of data transmitted over the IoT network. Measures must be in place to ensure the confidentiality, integrity, and authenticity of the data, as well as protect against unauthorized access and cyber threats. Another challenge is the scalability of the system, as large-scale deployments require robust infrastructure and network management capabilities to handle the high volume of data generated by a multitude of connected devices.In conclusion, AMI using IoT offers a promising solution for effective energy management. By leveraging IoT technologies, it enables real-time monitoring, remote meter reading, and improved fault detection. However, addressing security concerns and ensuring scalable infrastructure are critical for the successful implementation and widespread adoption of AMI using IoT in energy management systems.

Keywords:- *AMI (Advanced Metering Infrastructure) ,IoT (Internet of Things) ,Smart Grid ,Smart Meter ,Energy Management ,Real-time Monitoring ,Data Analytics ,Cloud Computing ,Wireless Communication ,Sensor Networks*

I. INTRODUCTION

AMI (Advanced Metering Infrastructure) is a two-way communication technology used to collect detailed metering data across the utility's service business. AMI is often automated, allowing for real-time, on-demand interrogations of metering endpoints.AMI is a network of sensors, Smart Meters, and software that allows end users to monitor and control utilities including water, gas, and electricity. AMI systems allow for the real-time measurement and display of time-specific data, which, when combined with remote control capabilities, can help businesses and homes reduce overhead expenses and manage resource consumption more precisely. To prevent tampering with data and control capabilities, AMI must be used in conjunction with modern security solutions. This is significant because the data provided by an AMI system frequently determines both direct billing and operational decisions.

II. OBJECTIVES

The key objectives of AMI using IoT include:

- Accurate and timely data collection: IoT-enabled smart meters can collect meter readings at regular intervals, providing accurate and up-to-date data on energy consumption, which helps utilities in billing, forecasting, and load management.
- Real-time monitoring and control: AMI using IoT allows utilities to monitor energy usage in real-time, detect anomalies or issues promptly, and remotely control meters, enabling efficient load management and response to emergencies or outages.
- Enhanced operational efficiency: IoT-enabled smart meters automate data collection, reducing the need for manual meter reading and associated operational costs. This improves the overall efficiency of utility operations, including billing, customer service, and asset management.
- Improved customer service: With real-time access to their energy consumption data, customers can make informed decisions about their energy usage, leading to potential energy savings. Additionally, IoT-enabled smart meters can enable faster fault detection and resolution, leading to improved customer satisfaction.
- Optimized energy distribution: AMI using IoT provides utilities with detailed insights into energy usage patterns, helping them optimize energy distribution and identify areas for energy conservation, load balancing, and demand response programs.

- Sustainability and environmental impact: By providing real-time data on energy consumption, AMI using IoT can promote energy conservation, enable better load management, and support the integration of renewable energy sources into the grid, contributing to sustainability and reducing the environmental impact of energy consumption.

III. LITERATURESURVEY

Literature survey is the documentation of a comprehensive review of the published and unpublished work from secondary sources data in the areas of specific interest to the researcher. It is important for gathering the secondary data for the research which might be proved very helpful in the research. The literature survey can be conducted for several

reasons. The literature review can be in any area of the business. Below are the few papers referred.

A. A Low Cost Smart Meter Network for a Smart Utility

In this paper a low cost solution for the real-time energy management in a smart grid is presented. It provides several power meters, that continuously monitor connected loads communicating with a Data. Through the implemented web server, the users can remotely control their consumption using a web browser. From them it stems that the proposed Smart Meter network can be easily installed in a home and in an industrial grid with the possibility to monitoring the various loads through a local friendly user interface or the remote web server. In our project, apart from this, we are also using some sensors to detect the fire, smoke and temperature that alerts the user in the sense of descry.

B. Design, Implementation, and Deployment of an IOT Based Smart Energy Management System

In this paper, the smart meter measures a wide range of electrical variables for example current, voltage, frequency, power and power factor. These variables are recorded at a specific time and the granularity of recording of the data differs from few minutes to few hours depending upon the requirements. The frequent data recording provides a comprehensive insight of the events and allows to gain a better understanding of the load usage patterns. In our project, we implement Machine Learning concept to plot the load usage and also to predict the monthly electricity bill with the help of recorded data set having the electrical variables. The smart meter in this paper initiate alerts and notifications in case of any electrical parameter deviating from the standard limit. These alerts are helpful in the identification and elimination of system deficiencies and power losses leading to efficient load management, fault analysis and load profiling. In our project, we use relay sensor that help the consumer to reduce the electricity bill by detecting when the consumer exceeds the sanctioned load and once the maximum demand exceeds the sanction load, immediately it will reset power supply so the MD penalty charges are saved.

C. Energy Monitoring Using LoRaWAN-based Smart Meters and oneM2M Platform

In this paper, we have proposed a novel and scalable real-time energy monitoring system employing LoRaWAN enabled smart meters and a oneM2M service platform. A novel format was used for the LoRaWAN PDU that contained46 bytes of payload denoting values of phase currents and voltages, frequency, power factor, and power and energy consumption related information. The data accumulated over the four months of deployment can be analyzed to detect faults, minimize power loss and reduce energy consumption, and can be used for visualization purposes. This deployment can be scaledup to 100 energy meters in the future, without the need for additional infrastructure. An Inter-working Proxy Entity (IPE) can be incorporated instead of a proxy server, to seamlessly transfer decoded packet information to the oneM2M platform.

D. Effective Energy Consumption Scheduling in Smart Homes

The DMES device, through daily electricity consumption scheduling, has been shown in this work as a device that can be used to ensure that consumers do spend on electricity bills within a desired limit. Consequentially, it would help both the utility provider and the customers towards better energy savings, financial savings, planning and budgeting for a more reliable and sustainable.

E. Real-Time Smart Meter With Embedded Web Server Capability

In this paper a smart energy meter network is presented with the aim to obtain a low-cost device for a sustainable use of electrical energy. The master microcontroller, called data aggregator, acquires information about the single load via CAN Protocol. It was implemented a web server that , in addition to acquiring the several parameters, updates daily the energy price: with this information it calculates the amount of the billing and is able to make decisions for an use efficient of the energy such as to disconnect a single load or to decide its time of use. The users can locally control their consumption through the display of the data aggregator and remotely using a web browser.

IV. PROPOSEDMETHODOLOGY

A proposed methodology for AMI using IOT can include steps such as sensor deployment, data acquisition, data processing, and system optimization. This methodology can aim to enable efficient energy consumption and provide accurate billing for consumers while also reducing carbon emissions.

A. Methodology

The methodology for AMI (Advanced Metering Infrastructure) using IoT (Internet of Things) involves several stages. The first stage involves the selection of hardware components and sensors for collecting data from the meters, which are then connected to a gateway device. The gateway device transmits the data to the cloud for processing and analysis.

In the next stage, data analytics tools are used to process and analyze the data, which is then presented in a meaningful way through visualization tools. This helps in identifying patterns and anomalies, and provides insights into energy usage patterns of the customers.

The third stage involves the implementation of demand response programs, which enable customers to modify their energy usage patterns in response to pricing signals or other incentives. This helps in reducing energy consumption during peak periods and improves the overall efficiency of the grid.

The final stage involves the implementation of a feedback mechanism, which enables customers to view their energy consumption patterns and take steps to reduce their energy consumption. This feedback mechanism can be provided through a mobile app or a web portal.

Overall, the methodology for AMI using IoT involves the integration of various hardware components, data analytics tools, demand response programs, and feedback mechanisms to enable utilities to monitor and optimize the energy consumption patterns of their customers.

B. Hardware Components

Table 1: Hardware Components

Sl no	**Name**
1.	Esp32 microcontroller
2.	Liquid-crystal display (LCD)
3.	I2c
4.	Current sensor
5.	Voltage sensor
6.	Relay
7.	Dc load
8.	Button

C. Circuit Diagram

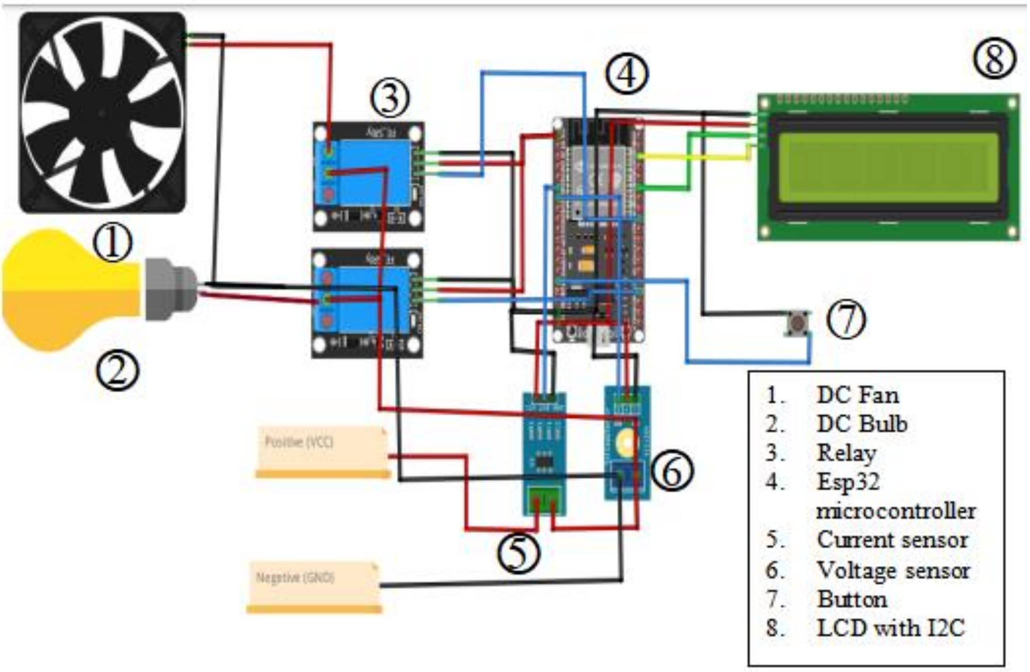

Fig. 1: Circuit Diagram

We utilized Fritzing software to generate the circuit design shown above. The components used include a relay, a voltage sensor, a current sensor, an ESP32, a fan, a light, and a converter, all of which are combined in the exact needed form to provide the desired output. We created the Circuit diagram shown above using the Fritzing programme. The components utilized include a relay, a voltage sensor, a current sensor, an ESP32, a fan, a light, and a converter, all of which are combined in the exact needed form to produce the desired output.

D. Current Calculation

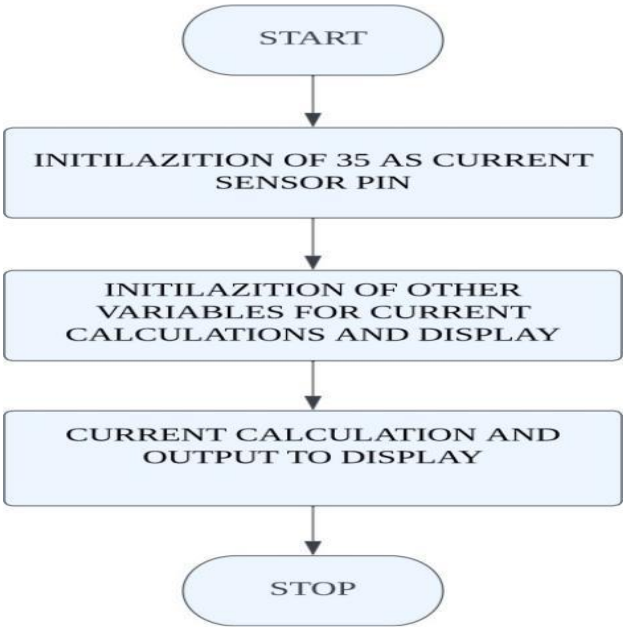

Fig. 2: Current Calculation Flowchart

- *STEPS:*
  - Start, In ESP32 Analog pin 35 is used to sense the proportional current value.
  - Then the proportional current value is divided by 1024 and multiplied by 5000.
  - Then it is Divided by (adcVoltage - offsetVoltage) / sensitivity).
  - To get the voltage value that is needed.
  - Stop.

E. Voltage Calculation

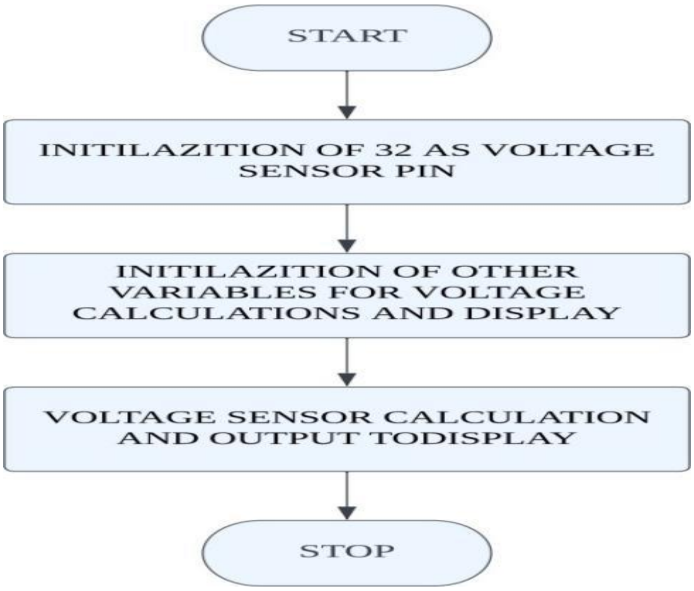

Fig. 3: Voltage Calculation Flowchart

- *STEPS:*
  - Start the device, In ESP32 Analog pin 32 is used to sense the proportional voltage value.
  - Then the proportional value is multiplied by 5 and divided by 1024.
  - Then it is Divided by (R1/R1+R2).
  - To get the voltage value that is needed.
  - End it is Stopped.

F. *Flow of the Project*

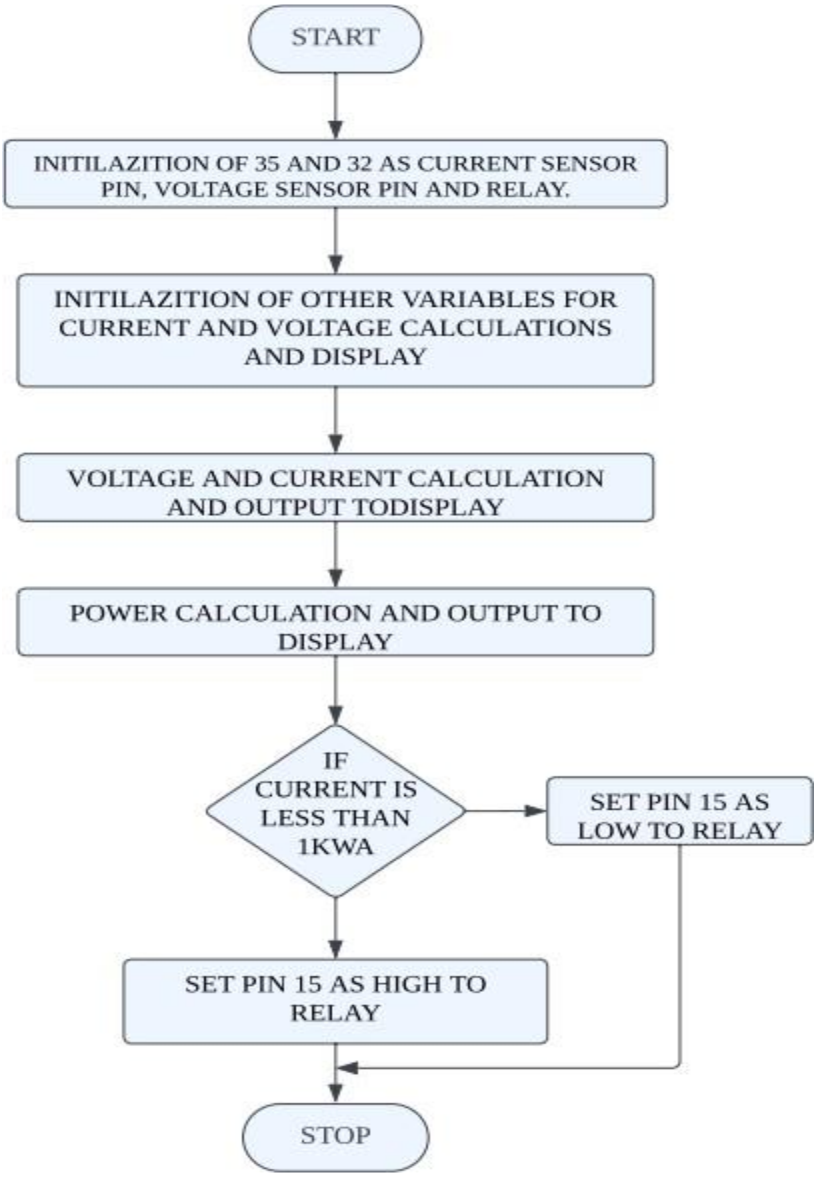

Fig. 4: Complete Program Flowchart

➢ *STEPS:*

- Start, initializing 35 as current sensing pin and 32 as voltage sensing pin.
- Initializing other variables for voltage calculations, current calculations and display.
- Voltage calculation and current calculation display.
- Power calculation from obtained current and voltage values.
- Check for the condition is current is less then 1KWA.
- If the value of current is more than 1KWA then set pin no 15 as low to relay or if the value of current is less than 1KWA then then set pin no 15 as high to relay.
- Stop.

V. IMPLEMENTATION

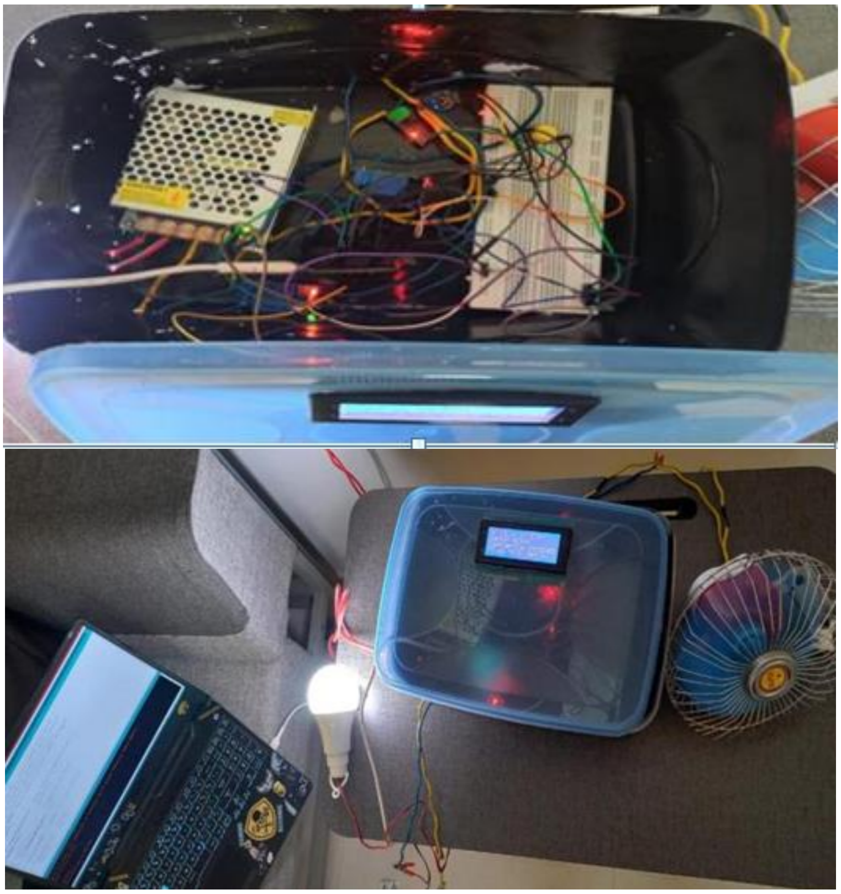

Fig. 5: Initial Project Setup

The above figures shows the initial setup of the project using regulated power supply(RPS) as supply to the setup and DC lamp and DC fan as load.

A. Voltage sensing and observation

➢ *Coding steps:*

- Initializing the voltage variables

```
float VSensorPin = 32;
float adc_avgvalue;
float adc_voltage;
float R1 = 30000.0;
float R2 = 7500.0;
float ref_voltage = 3.62;
float adc_value;
float Voltage;
```

Code For Initializing Voltage Variables

- Declaration of formula for voltage calculation

```
adc_avgvalue = adc_value / 151;
adc_voltage  = (adc_avgvalue * ref_voltage) / 4096.0;
//  adc_voltage = (adc_voltage);
Voltage = (adc_voltage / (R2 / (R1 + R2)));
```

CodeForVoltageCalculation

Display the values calculated on LCD display

```
Serial.println("Input Voltage = " + String(Voltage));
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("ENERGY METER");
lcd.setCursor(0, 1);
lcd.print("V: ");
lcd.print(Voltage, 2);
lcd.setCursor(9, 1);
```

Code For Voltage Display

B. Current sensing and observation

- *Coding steps:*

- Initializing the current variables

```
float CSensorPin = 35;
float CurrentSVal;
float Current;
float CurrentSAvgvalue;
int value;
```

Code for initializing voltage variables

- Declaration of formula for current calculation

```
CurrentSAvgvalue = CurrentSVal / 151;
Current = (((CurrentSAvgvalue * 5.0) / 4096.0) / 0.185) - 18.13;
```

Code for current calculation

- Display the values calculated on LCD display

```
Serial.println("Input Current = " + String(Current));
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("ENERGY METER");
lcd.print("I: ");
lcd.print(Current, 2);
lcd.setCursor(0, 2);
```

Code for current display

C. Power calculation and relay observation

- *Coding steps:*
- Calculation of power by voltage times current

Voltage and current values from the voltage and current sensor are taken they were multiplied to get the power which his given by formula “power=voltage *current”.

```
Power = Current * Voltage;
```

Code for power calculation

- Display the values calculated on LCD display

```
lcd.setCursor(0, 2);
lcd.print("P: ");
lcd.print(Power, 2);
lcd.setCursor(9, 2);
```

```
lcd.print("E: ");
lcd.print(Energy, 2);
lcd.setCursor(0, 3);
```

Code for power display

- Controlling the relay unit

```
if (RelayRstVal == 0){
digitalWrite(RelayHPin, LOW);
Serial.println("Hi");
lcd.print("CONSUMPTION in LIMIT");
}
else if (Current > 0.6){
lcd.print("CONSUMPTION EXCEEDED");
digitalWrite(RelayHPin, HIGH);
}
else if ((Current < 0.6) && (RelayHVal == 1)){
lcd.print("Press Rst BUTTON");
}
else{
lcd.print("CONSUMPTION in LIMIT");
}
}
```

Codeforrelaycontrol

```
V: 13.69 I: 2.97
ENERGY METER
CONSUMPTION EXCEEDED
P: 40.68 E: 447.47
```

Fig. 6: Digital display of Power Consumed

VI. CONCLUSION AND FUTURE SCOPE

AMI using IOT has numerous advantages, including increased energy efficiency, reduced costs, and improved system performance. It has the potential to revolutionize the way we consume energy by providing real-time information on energy consumption and optimizing energy usage.In the future, AMI using IOT will continue to evolve, with advances in technology such as edge computing, 5G networks, and AI. These advances will enable AMI to become even more efficient, secure, and scalable. Additionally, the integration of renewable energy sources into the grid will further improve the sustainability of the system. Overall, AMI using IOT is a promising technology with enormous potential to transform the energy sector, and its future looks bright.

REFERENCES

[1.] A"Embedded energy meter – a new concept to measure the energy consumed by a consumer and to pay the bill", by Maitra S, Joint International Conference on Power System Technology and IEEE Power India Conference. pp. 1–8, 2020

[2.] "An Improved Energy and Cost Minimization Scheme for HomeEnergyManagement (HEM) in the Smart Grid Framework", by Md MamunUrRashid Proceedings of 2020 IEEE International Conference onID20327Applied Superconductivity and Electromagnetic Devices Tianjin, China, October 16-18, 2020

[3.] "Energy Meter based Wireless Monitoring SystemusingBlynkApplication via smartphone", by Ammar Othman Faculty of ScienceandTechnology Islamic Science University of Malaysia (USIM) 26-27Sept. 2020

[4.] "Arduino Based Smart Energy Meter using GSM", by HimanshuKPatil, Institute of Technology, Nirma University ID 978-1-7281-1253-4/19/2019

[5.] "IOT Based Smart Energy Meter for Efficient Energy UtilizationinSmart Grid", by Bibek Kanti Barman Electrical Engineering Department. Mizoram University Aizawl, India. 1-2 June 2019

[6.] "Development of IOT Based Smart Energy Meter ReadingandMonitoring System", by A. L. Hanees and M. M. M. Mufassirin, 7thInternational Symposium 2017 (IntSym2017)- SEUSL, 2018.

[7.] "Smart Meter for the IOT", F. Abate , M. Carratù , C. Liguori , M. Ferro, V. Paciello, Proc. of the IEEE Instrumentation and MeasurementTechnology Conference, I2MTC 2018, Houston, TX, USA, May2018.

[8.] S.Bayram and T.S.Ustun, "A survey on behind the meter enegymanagement systems in smart grid," Renew. Sustain. EnergyRev., vol. 72pp. 1208_1232, 2017.

[9.] M. M. Albu, S. Member, S. Mihai, and C. St, "Syncretic Use of SmartMeters for Power Quality Monitoring in Emerging Networks,"IEEETransactions on Smart Grid, vol. 8, no. 1, pp. 485–492, 2017.

[10.] Anvari-Moghaddam, J. C. Vasquez, and J. M. Guerrero, "Loadshifting control and management of domestic microgenerationsystemsfor improved energy efficiency and comfort," in IECON2015-41stAnnual Conference of the IEEE Industrial Electronics Society. IEEE, nov 2016.