ISSN (Online): 2583-648X

IJIRID

International Journal of Ingenious Research, Invention and Development

An International, High Impact Factor, Double-Blind Peer-Reviewed, Open-Access, Multidisciplinary Online Journal

www.ijirid.in

Volume 5 | Issue 1 | February 2026

Research on Real Time Energy Monitoring with IoT

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Abstract: *Now-a-days the number of electricity consumers is increasing to a great extent. It became a hard task in handling and maintaining the power as per the growing requirements. Presently maintenance of the power is also an important task as the human operator goes to the consumer's house and produces the bill as per the meter reading. If the consumer is not available, the billing process will be pending and the human operator again needs to revisit. Going to each and every consumer's house and generating the bill is a laborious task and requires a lot of time. It becomes very difficult especially in the rainy season. To address these issues, the "Real-Time Energy Monitoring with IoT" paper focuses on developing a smart, efficient, and user-friendly system for monitoring and controlling electrical loads in real time. Using the ESP32 microcontroller as the central controller, the system integrates three relays to switch three bulbs both manually and remotely via an IoT server, ensuring flexible operation. It incorporates a current sensor and a ZMPT101B voltage sensor to continuously measure electrical parameters, while an electric meter accurately records total energy consumption. A button on the dashboard allows users to generate a comprehensive Power Monitor report, detailing energy usage in kWh, corresponding bill amount, voltage, current, and power. This system not only enables real-time load control and energy monitoring but also provides insights for efficient energy management and cost tracking, demonstrating the practical application of IoT in smart home and energy-saving solutions.*

Keywords: Artificial Intelligence, Reinforcement Learning, Student Performance Prediction.

I. INTRODUCTION

India is the third largest producer of electricity in the world and fourth largest in electricity consumption. Power generation capacity in India is surplus and infrastructure for supplying electricity to all needy people is lacking. To develop the infrastructure, the government of India launched a scheme called "Power for all". The electricity sector in India is dominated by coal, fossil fuels. The government only increases renewable energy. For leading a comfortable life, electricity is the vital requirement and is to be properly used and managed. At present, a human operator from the electricity board visits the resident and takes readings from the energy meter and produces a bill for corresponding energy consumption for each month manually.

The increasing demand for energy efficiency and cost-effective electricity management has made real-time monitoring of power consumption a critical aspect of modern homes and industries. Traditional energy meters provide only cumulative consumption data, which does not allow users to make timely decisions about load management or detect abnormal power usage. Integrating Internet of Things (IoT) technology with energy monitoring enables intelligent systems to collect, process, and analyze electrical parameters continuously, offering users detailed insights into their energy consumption

 DOI 10.5281/zenodo.19405417

patterns. Such systems not only facilitate remote monitoring but also provide opportunities for predictive maintenance and energy conservation.

This paper presents a practical implementation of a smart energy monitoring system that combines automation with IoT-based analytics. By continuously capturing electrical parameters such as voltage, current, and power, the system allows for precise measurement and management of energy usage. Users can control loads remotely or manually, and detailed reports provide actionable information for optimizing energy consumption and reducing costs. The approach demonstrates how IoT can transform conventional energy management practices into proactive, data-driven solutions, making electricity usage more transparent, efficient, and sustainable.

II. LITERATURE REVIEW

[1] Omkar Natu, Prof. S.A.Chavan, et al. Streetlight being the major source of light against the darkness of the night. The street light ensures safety in urban and rural areas and increases the visibility of the roadways. As a result of rapid and modern infrastructure development a new innovative technology is needed in the energy sector. A GSM based smart light improves the efficiency by using timed controlled switching of street lights, which automatically turn On/Off according to the needs. The major advantage of these systems is that they are less costly to implement, also they are highly scalable. The author has put forth a solution for the smart lighting system. Through a single touch energy can be controlled and it is more eco-friendly.

[2] Nikhil. N. Patil, et al. They stated that the presented system in the paper will replace the traditional meter reading method with a GSM based smart energy metering system using IOT. The sensed units automatically send on cloud generating using IOT. It is a very efficient and low cost system because this model reduces the miscommunication between the user and the controller. An efficient systematic approach is used for the design to acquire accurate measurements for the energy meter. The prevention of malpractice, it gives an accurate accounting of units".

[3] Dr. Adithya Tiwary, Manish Mahato, Mohit Tripathi, Mayank Shrivastava, Matnak Kumar Chandrol, Abhitesh Chidar, et al. Proposed design and implementation of an Innovative Internet of Things based on smart energy meters. This model describes its design along with its working. It will make the leading to be handy and measure the energy consumption accurately. Here the energy wastage is reduced and also brings awareness among all.

[4] Ashna K, et al. Involves development of smart energy meter.it is used for monitoring the energy usage of different applications and providing other features like advanced billing system and high accuracy. Meter can control energy supply and usage of energy based on load requirement and measure cost power consumed. Consumers get a clear idea about his usage & cost.

[5] Sujatha, M. S., et al. In this paper, a powerful GSM network is designed to send data from one network to another network. Any change in parameters of transmission is sensed to protect the entire

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transmission and distribution. rigid, reliable and robust communications like GSM technology instead of many communication techniques used earlier. This enhances speed of communication with distance independenncy. This technology saves human life from this electrical danger by providing the fault detection and automatically stops the electricity to the damaged line and also conveys the message to the electricity board to clear the fault. An Embedded based hardware design is developed and must acquire data from electrical sensing system.

[6] Syed Assra Shah, et al. They proposed a system that replaces a regular electricity meter with a hall sensor and ESP8266 interfaced with Arduino UNO to transmit data. Data collected from various households and sent directly to the Arduino UNO module. From the Arduino UNO module, data transfer to Arduino YUN module through ESP 8266 Ethernet shield. From Arduino YUN module data stored at temboo cloud. Users can access the data from Temboo cloud. Therefore the server uses the details of the user and can retrieve it using their Id. Regular updates from the server are sent to users through SMS or email.
Electricity bill generated every month and sent to the user. If the user doesn't pay the bill, the electricity connection is automatically interrupted using a relay switch. Here the hall sensor senses the amount of current that is consumed using current sensing theory. The phase wire is passed through the hole of the hall sensor. When current passes through phase wire, it is measured from a magnetic field generated. Therefore potential differences are referred to as a hall voltage.
The advantage of hall sensors is that they measure the current without breaking the system. Per capita power consumption is rapidly increasing with increasing population. When users are concerned about electricity bills and power consumption, there are high chances for reducing per capita power consumption. This system increases privacy and will reduce health hazards compared to previous systems.

[7] Jayant. P. Pawar, et al. They presented a system based on ZigBee technology. Consumer side consists of an energy meter, microcontroller, LCD display, voltage sensor, ZigBee module and power supply unit. Micro controller continuously monitors the energy meter. When the user tempers the meter, theft is detected then a meter tampering signal sent to the microcontroller via optocoupler. Theft signal display at LCD display at consumer side. The microcontroller directly interfaces with the ZigBee module. The theft signal sent to the server side through the ZigBee module LCD displays energy consumption in units, power status, theft status, monthly bill. The Electrical side consists of a ZigBee module and personal computer system. Monthly bill status will be sent with the help of the "send bill" button. If theft is detected, power is switched off with the help of the "cut-off" button. Power supply can be restored using the "Restore" button. This communication takes place wireless via the ZigBee module.

[8] Shubham Pahurkar, et al. In this paper, an IOT Based electricity bill generation technology is presented. It is used to gather information from energy meters and transfer it to the database. Database analyzes this information for billing purposes. Energy is stored in the chemical form. Using

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kernel programming, reading will be taken from the energy meter. Kernel programming will give battery status and is sent to the server through Gateway. At the server side the calculated bill will be sent to the customer through browser and GPRS Gateway. This system avoids human intervention in electric bill generation.
If the user gets wrong information he has to visit the electricity board for correction. These errors are avoided by taking reference of meter reading and sending details to the server and maintaining the database at real-time. This system avoids use of paper and provides fast meter reading. Here we take laptop batteries for reference.

[9] O. Homa Kesav, B. Abdul Rahim, N. et al. In this paper the design presents a new method for avoiding high construction & maintenance cost in the existing system. The system is designed in such a way that if the consumer is unable to pay the bill the power connection may be disconnected automatically from the remote server. The ARM 7 based hardware system consists of a processor core board & the peripheral board. The embedded C language is used as a programming language in this system.

[10] Abhinandan Jain, Dilip Kumar, Jyoti Kedia et al. presented a paper which represents the development of fully automated energy metres which have capabilities like remote monitoring & controlling energy metres. Automatic meter reading (AMR) system continuously monitors the energy meter & sends data on request of service provider through SMS. It saves huge amounts of human labor.

III. METHODOLOGY

The aim of this paper is to develop a smart power metering and load control system that enables remote monitoring, billing, and operation of electrical loads. The proposed system is designed using an ESP32 microcontroller which acts as the central unit to control and monitor all operations.

BLOCK DIAGRAM

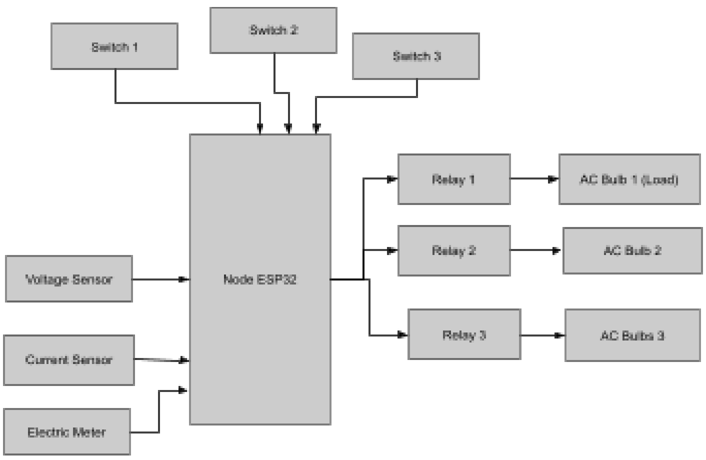

Figure 1 Shows the Block Diagram of the System

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Three relays are connected to the ESP32 for switching three bulbs, where each bulb can be turned ON or OFF either remotely via the IoT server or manually through its respective switch. A current sensor is interfaced to measure the current drawn, while a ZMPT101B voltage sensor is used to measure the supply voltage, and an electric meter is connected to accurately record the total energy units consumed. A button on the dashboard is provided, and upon pressing it, the ESP32 generates a detailed Power Monitor report that includes energy consumption in kWh, bill amount, voltage in volts, current in amperes, and power in watts. The system uses three bulbs as loads.

DESCRIPTION

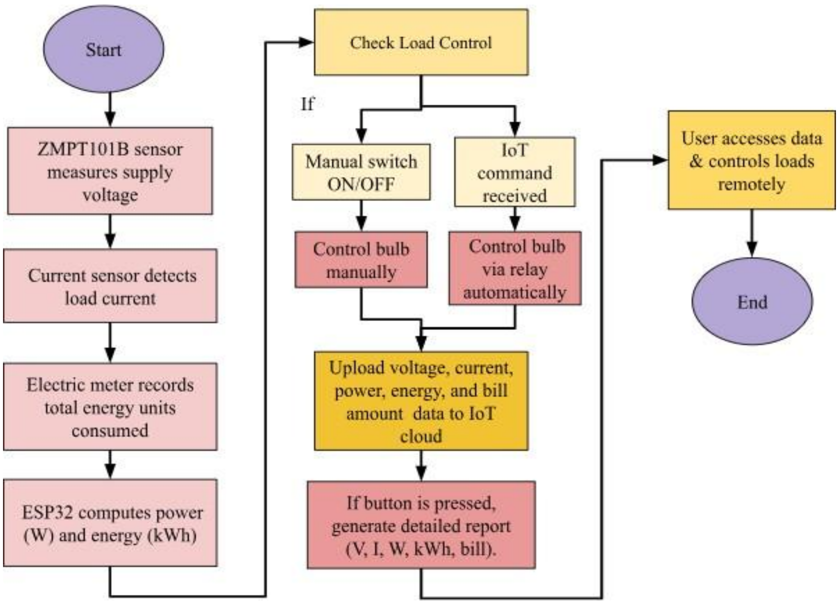

Figure 2 Shows the Flowchart the System

IV. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1. NodeMCU ESP32 Module
2. Relay* 3
3. ZMPT101B Voltage sensor
4. Current Sensor
5. Bulb*3
6. Switch*3
7. Bulb Holder*3
8. Electric Meter

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus

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V. IMPLEMENTATION & RESULT IMPLEMENTATION

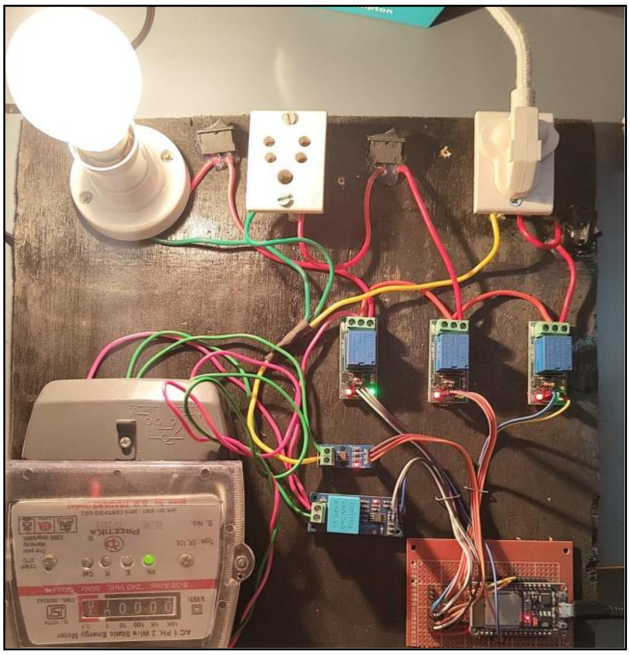

Figure 3 Shows the Experimental Setup of the Proposed System

Using the Node MCU ESP32 microcontroller as the central controller. The three relays operated accurately, allowing each bulb to be switched ON or OFF both manually through physical switches and remotely via the IoT dashboard. The current sensor and ZMPT101B voltage sensor provided stable and correct measurements of load current and supply voltage, enabling the ESP32 to compute power usage effectively.

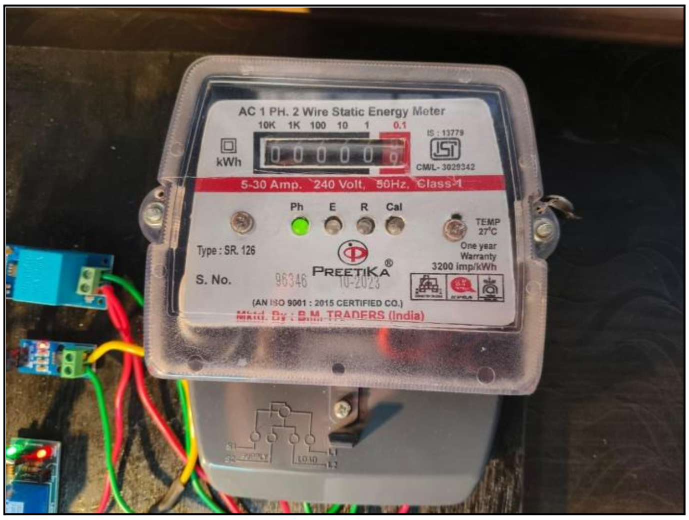

Figure 4 Shows the Energy Meter

 DOI 10.5281/zenodo.19405417

The connected electric energy meter accurately recorded the total units consumed during the operation of the loads, with its mechanical counter clearly increasing in response to real-time power usage. This confirmed that the system's energy calculations matched the actual physical meter readings, proving the reliability of the measurement setup and validating that the energy consumed by the three bulbs was precisely tracked throughout the experiment.

VI. RESULT

The implemented system successfully demonstrated real-time monitoring and control of electrical loads through the IoT platform, providing accurate readings of voltage, current, power, and total energy consumption for all three connected bulbs. The system reliably switched the loads both manually and remotely, confirming proper relay operation and seamless communication with the ESP32. The generated Power Monitor report displayed clear and precise data, including kWh usage and the corresponding bill amount, allowing users to understand their energy consumption instantly. Overall, the results show that the system is effective in enabling smart energy management, remote operation, and transparent billing estimation, making it suitable for practical home and laboratory applications.

VII. CONCLUSION

The Real-Time Energy Monitoring with IoT paper successfully demonstrates an intelligent approach to managing and monitoring electrical loads efficiently. By integrating sensors, relays, and the ESP32 microcontroller with IoT capabilities, the system enables both remote and manual control of devices while providing accurate, real-time data on energy consumption, voltage, current, and power. The generation of detailed Power Monitor reports allows users to track usage patterns, calculate costs, and make informed decisions for energy conservation. This paper highlights the practical benefits of combining IoT technology with smart metering, offering a scalable solution that promotes energy efficiency, cost savings, and enhanced control over electrical systems in residential and small-scale commercial environments.

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