

Powering Tomorrow: Innovation in Smart Energy Metering and Management

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Abstract - To address the escalating demand for electricity due to population growth and increased reliance on electrical energy, it is imperative to modernize the electrical infrastructure. Leveraging Internet of Things (IoT) technology can revolutionize energy consumption and distribution across various scenarios. This study primarily concentrates on enhancing the electrical system through automatic billing, power card services, theft detection, power optimization, and providing users with pertinent energy consumption data. The IoT-based smart energy meter system comprises three key elements: a controller, Wi-Fi connectivity, and theft detection mechanisms. Whenever an anomaly like theft or malfunction occurs, the theft detector sensor identifies the issue and responds accordingly. The controller plays a pivotal role in maintaining the functionality of all components. By integrating energy meters with the internet through IoT, human involvement in electricity management is minimized. The proposed IoT-based meter reading system is designed to continually monitor meter readings, enabling service providers to disconnect power sources in case of non-payment of monthly bills. Moreover, it ensures accurate meter readings and prevents billing errors while reducing the need for human intervention

Key Words: internet of things (IoT), smart energy meter, automatic billing, theft detection.

1. INTRODUCTION

In the pursuit of sustainable living and responsible energy consumption, the Smart Energy Meter project emerges as a beacon of innovation. Built upon the foundation of the NodeMCU development board and harnessing the power of IoT technology, this project aims to revolutionize the way we monitor and manage electricity usage. By providing real-time insights and actionable data, the Smart Energy Meter empowers users to make informed decisions, optimize consumption, and contribute to a greener future. The Smart Energy Meter project integrates hardware and software components to create a comprehensive energy monitoring system. Through the deployment of sensors and modules, the

device captures data on electricity consumption, temperature, and humidity, among other parameters. This data is then processed and analysed in real-time, allowing users to visualize their energy usage patterns and identify areas for improvement. With seamless connectivity to the internet, users can access their energy consumption data remotely, enabling proactive management and optimization of energy usage. The primary objective of the Smart Energy Meter project is to empower individuals and organizations with the tools they need to monitor, manage, and reduce their electricity consumption. By providing real-time visibility into energy usage patterns, the project aims to raise awareness and promote responsible energy practices. Additionally, the scalability and versatility of the Smart Energy Meter make it suitable for a wide range of applications, from residential homes to commercial buildings and industrial facilities. Ultimately, this project seeks to not only enhance energy efficiency but also contribute to a more sustainable and environmentally conscious society. This document shows the suggested format and appearance of a manuscript prepared for SPIE journals. Accepted papers will be professionally typeset. This template is intended to be a tool to improve manuscript clarity for the reviewers. The final layout of the typeset paper will not match this template layout.

2. LITERATURE REVIEW

The literature surrounding smart energy meter systems is crucial for contextualizing the innovative use of technology, such as in monitoring and managing energy consumption. This project emphasizes efficiency and user-friendliness, employing sensors to collect voltage and current values. By storing data in a database, it enables user and utility company access.

This paper advocates employing Internet of Things (IoT) technology to manage energy consumption and distribution effectively. The focus includes automatic billing, power card functionality, theft detection, power

optimization, and providing relevant energy consumption information to users. The IoT-based smart energy meter system consists of a controller, Wi-Fi connectivity, and a theft detection device. The theft detector sensor identifies errors or theft, triggering appropriate responses. By connecting energy meters to the internet through IoT, human intervention in electricity maintenance is eliminated. The proposed system continuously monitors meter readings, allowing service providers to disconnect power if consumers fail to pay the monthly bill. This approach enhances meter reading efficiency, prevents billing errors, and reduces the need for human involvement

3. PROPOSED SYSTEM

The envisioned smart energy meter system constitutes advancement in energy measurement, poised to redefine the landscape of consumption monitoring. At its core, this innovative system promises to deliver real-time and precise data on energy usage, providing consumers with unprecedented insights into their consumption patterns. Notably, it goes beyond mere data provision by empowering customers to comprehend and manage their energy costs effectively, fostering a culture of informed energy consumption. Moreover, the system pledges to contribute significantly to grid reliability through its ability to promptly detect and address issues, enhancing the overall resilience of the energy infrastructure. A key feature of the proposed system is its implementation of effective demand response programs, strategically designed to curtail peak energy demand. This not only optimizes energy utilization but also aligns with sustainability goals by mitigating stress on the grid during periods of heightened demand. In tandem with these functionalities, paramount importance is placed on safeguarding the privacy and security of customer energy consumption data. Stringent measures are envisaged to ensure that sensitive information remains protected, aligning the deployment of smart meters with the highest standards of privacy and cybersecurity. Furthermore, the system introduces a paradigm shift in utility operations by seamlessly integrating remote service management capabilities. This transformative aspect streamlines utility processes, offering a host of benefits including enhanced operational efficiency, cost savings, and resource optimization. In essence, the proposed smart energy meter system emerges as a comprehensive solution, addressing not only the immediate need for real-time data and effective cost management but also contributing to the broader goals of grid reliability, sustainability, and secure energy management practices

4. METHODOLOGY

The arrangement of the prototype based on the review of the literature review to gather its application. The voltage and current sensor measures the energy consumption. To analyze a program written which computes the energy consumption of the building. Program for bill calculation and tariff slab changes are programmed into the controller. Using the Wi-Fi module, the collected and processed data can be stored locally or uploaded to the cloud. The device connects to the cloud and smartphone via Blynk. The blynk will be used in the smartphone for communication and real-time monitoring which is user interface

5. SYSTEM DESIGN

The primary objective is to develop a sustainable solution for addressing the real-time energy monitoring, manage and its consumption in residential and commercial buildings.

5.1. Block Diagram

A detailed block diagram in Fig-1 illustrates its functioning and key components such as relay module, current and voltage sensor (PZEM-004T), NodeMCU ESP8266, I2C module and LCD display (16x2).

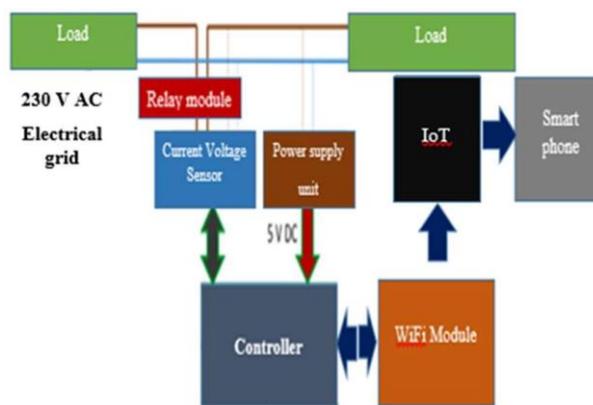


Fig-1: Smart Energy Meter block diagram

This system continuously monitor the real-time parameters through the sensors for monitoring the energy consumption.

- voltage and current sensor: measure power, voltage ,current contained in an electric current.
- nodeMCU: serves a versatile platform for creating IoT projects both hardware and software ,built in Wi-Fi connectivity ,communicate with other devices.
- I2C module: connection with minimal wiring complexity with sensors and display for efficient data exchange.

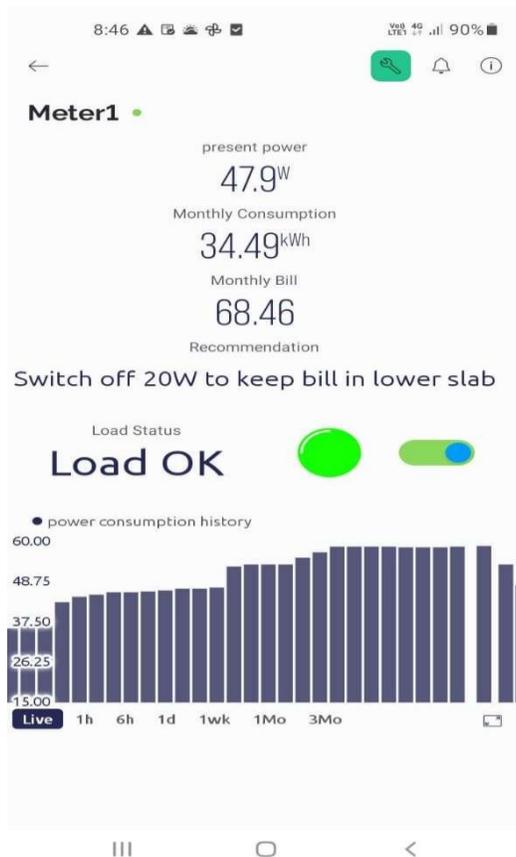
-relay: the 5V relay is an electrically operated, electromagnetic switch that can be used to turn on or off a circuit.

5.2. User interface

The system incorporates with a mobile application "Blynk" for real-time monitoring of energy consumption. This app also allow to visualize present power, monthly consumption ,predicted bill and recommendation or notification based on the slab changes .

5. RESULT

A smart energy meter testing is carried out using Led and filament bulbs .Based on these testing results the consumer can monitor the energy consumption of the load



3. CONCLUSIONS

Smart Energy Meters using IoT, illuminates the profound impact on our energy consumption landscape. The integration of Internet of Things (IoT) technology has ushered in an era of unparalleled efficiency, enabling real-time monitoring and control of energy usage. This innovative approach not only empowers consumers with insights into their consumption patterns but also facilitates seamless communication between devices for optimized energy management. The deployment of Smart Energy Meters contributes significantly to sustainability goals by promoting energy conservation and reducing wastage. The scalability and adaptability of IoT-based systems provide a versatile platform for utilities and consumers alike to embrace a more responsible and eco-friendly energy lifestyle. The seminar highlighted the potential for cost savings, as well as the environmental benefits associated with the implementation of these smart meters.

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Appendix1:Program to the controller

Demonstration purpose bill calculations

0 to 10 units : Rs.1.00 per unit

11 to 25 units : Rs.2.00 per unit

26 to 40 units : Rs.3.00 per unit

41 to 70 units : Rs.4.00 per unit

above 70 units : Rs.5.00 for all unit

Blynk virtual pin listing

V0 : voltage

V1 : current

V2 : power

V3 : predicted monthly consumption

V4 : predicted monthly bill

V5 : load status (OK or OVERLOAD)

V6 : recommendation. (how much Watts need to OFF to reduce bill)