International Journal of Electrical, Electronics and Computer Systems
ISSN: 2347-2820
Volume 15 Issue 1s (2026) | Pages: 250-255

IoT Based Energy Meter Reading

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Peer Review Information

Type: *Article*
Received: *21 February 2026*
Revised: *23 March 2026*
Accepted: *25 April 2026*
Published: *22 May 2026*

Abstract

An IoT-based energy meter system is an intelligent solution that automatically monitors, records, and transmits energy consumption data through the internet, eliminating the need for manual meter reading. Traditional energy monitoring methods often lead to delays, human errors, and difficulties in identifying energy misuse or power theft. The proposed system improves efficiency by enabling real-time collection and remote accessibility of energy usage information. It typically uses microcontrollers such as Raspberry Pi or ESP8266 integrated with energy measurement modules to capture electrical consumption data continuously. The collected data is then transmitted to a cloud platform or web server, where both consumers and utility providers can monitor usage remotely. This approach supports accurate billing, faster analysis, and better energy management. By automating meter reading and providing real-time access to energy data, IoT-based energy meter systems contribute to smarter, more reliable, and efficient energy monitoring infrastructure.

Keywords: IoT; Smart Meter; Energy Monitoring; Automatic Meter Reading; Cloud Connectivity.

How to Cite This Article

Gate, S., Kumbhar, S., Shinde, K. (2026). Iot based energy meter reading. *International Journal of Electrical, Electronics and Computer Systems*, 15(1s), 250-255.

Introduction

The Internet of Things (IoT) is revolutionizing traditional energy meters by transforming them into smart systems. An IoT-based energy meter reader enables automatic monitoring and data transmission without the need for manual intervention. It uses sensors, microcontrollers, and communication modules to record energy consumption and send the data in real one to web or mobile applications. This approach not only reduces human error and manpower requirements but also improves energy management and monitoring efficiency An

IoT-based energy meter is a smart device that uses Internet of Things (IoT) technology to automatically collect and transmit electricity consumption data over the internet, enabling real remote monitoring, automated billing, energy then detection, and remote load control for both consumers and utility companies.

Literature Review

Arun Singh, K. S. and Dr. Gaayathry K. (2021): This paper presents a smart electricity meter using a NodeMCU for cloud transmission and automatic billing, applicable to industrial and domestic purposes. An IoT-based energy meter using Raspberry Pi is a smart monitoring system that measures real-time electrical parameters (voltage, current, power) and transmits data to a cloud platform for remote monitoring, automated billing, and theft detection.

Arun V S et al. (2020): A review paper on smart energy meters that analyzes the energy consumption and facilitates automatic bill generation, providing remote access to readings. It uses sensors like the PZEM-004T to gather data, with the Raspberry Pi processing and sending it via MQTT to dashboards, often utilizing relays to cut power for unpaid bills. P. S. Sreejith et al. (2022): This paper proposes a low-cost, real-one ARM-based energy management system with a web server for collecting consumption data. Raspberry Pi acts as the central hub, managing data collection from sensors and communicating with the cloud.

IJARCCE.com (2020): Published in the International Journal of Advanced Research in Computer and Communication Engineering, this paper reviews smart energy meters, focusing on automatic bill generation and labor reduction. Uses protocols like MQTT or HTTP to transfer data to platforms such as Thingspeak, Adafruit.io, or custom dashboards. SATHYABAMA (2022): A technical report for a project on an IoT-based prepaid smart energy meter, outlining components like Arduino Uno and various communication protocols. An IoT-Based Smart Real-time power monitoring, SMS/email alerts for consumption, automated billing, and remote load control (turning devices on/off).

Eliminates the need for manual meter readings, improving accuracy and reducing labor costs for utility companies.

Proposed methodology

The proposed methodology for an IoT-based energy meter using a Raspberry Pi involves. This system replaces manual, error-prone, and slow conventional reading methods with an automatic meter reading (AMR) system. Processing Unit (Raspberry Pi): The Pi acts as the central hub, receiving data, performing calculations (RMS values, power consumption), and acting as a local server. Data is transmitted via Wi-Fi/Ethernet to a cloud platform (e.g., Thingspeak, Adafruit IO) or a dashboard (e.g., Grafana, Blynk) for user monitoring. The current sensor (SCT-013) is clamped on the phase wire, and the potential divider measures voltage. Both are connected to the analog-to-digital converter (ADC), which communicates with the Raspberry Pi GPIO pins via I2C protocol.

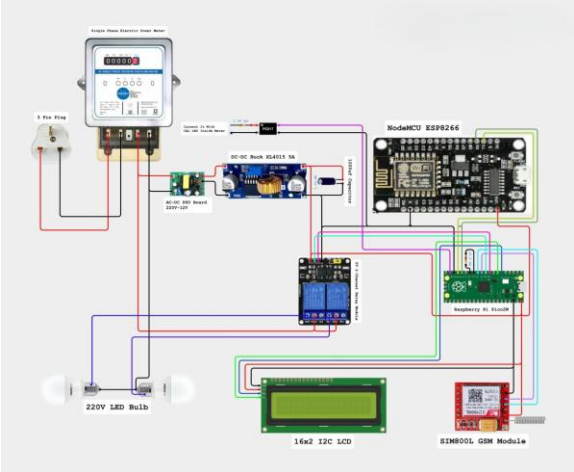

Fig.1*. Block Diagram*

An ESP8266-based smart energy meter block diagram includes an ESP8266 microcontroller, AC voltage and current sensors (like ZMPT101B and ACS712 or PZEM-004T), a power supply, an optional display (LCD or OLED), and an IoT plaɳorm (like Blynk or ThingSpeak) for data transmission and monitoring The diagram illustrates how AC power is measured, processed by the ESP32 to calculate energy consumption, and then sent wirelessly for remote viewing and analysis. Access live energy consumption data through mobile or web dashboards.Calculates monthly bills automatically and sends consumption alerts to consumers via SMS or internet.Helps detect high-load devices and provides analytics to minimize consumption. It replaces manual meter reading, provides insights into consumption patterns, and allows for remote monitoring of voltage, current, and power consumption.

Energy Meter

An energy meter (or electricity meter) is It acts as an integrating instrument, recording usage in kilowatt-hours (kWh) to enable accurate billing by utilities. Modern smart meters provide real-time data, while older electromechanical types use rotating discs, Traditional meters that use magnetic fields to rotate an aluminum disc, which drives a mechanical register. Utilize modern electronic circuits, microcontrollers, and digital displays, offering higher accuracy and advanced features

Fig.2 *Energy Meter*

Raspberry Pi

It supports MicroPython, C/C++, and features 264KB SRAM, 2MB+ onboard flash, and 26 GPIO pins. It is ideal for embedded systems, robotics, and IoT projects, including Wi-Fi-enabled models.Primarily programmed in MicroPython or C/C++.Drag-and-drop programming using mass storage over USB. Ideal for IoT, sensor data logging, robotics, and embedded electronics. Unlike standard Raspberry Pi computers, the Pico is a microcontroller board, meaning it does not run a full operating system (like Linux) and is designed for low-level hardware control, similar to an Arduino but faster.

Fig.3 *Raspberry Pi*

NodeMCU ESP8266

It features built-in USB-to-serial support (often CP2102 or CH340), 17 GPIO pins, and operates at 3.3V, making it ideal for Wi-Fi projects, IoT automation, and smart homesystems programmed via Arduino IDE, MicroPython, or Lua.17 pins (with 11 usable) supporting PWM, I2C, SPI, and UART.ADC One 10-bit analog-to-digital converter. 3.3V operating voltage, typically powered via Micro USB (5V).

Fig.4 *NodeMCU ESP8266*

Internet of Things

The Internet of Things (IoT) links anything from anywhere in the universe. It communicates with almost everything around the world. The communication can be a control signal or identified data from this world. It is a common internet data communication and is communicated in different ways. The Internet of Things (IoT) collects the data of automated objects and helps the machine learn where it needs to. The data is stored in the cloud and sent to the energy meter to switch on/off objects.

Final Hardware

It replaces manual meter reading, provides insights into consumption patterns, and can prevent power theft. Raspberry Pi (3, 4, or Zero W) with built-in Wi-Fi. Non-invasive Current Sensor (clips onto the AC live wire) or PZEM-004T. A transformer-based sensor or a voltage divider network to step down AC voltage to a safe level. ADS1115 (16-bit I2C ADC) is required because the Raspberry Pi does not have built-in analog pins.View energy usage anytime, anywhere. Calculates electricity bills based on current tariffs.

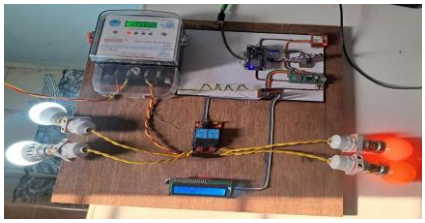

Fig.5 *Project Model*

Results and discussions

A 16x2 LCD (Liquid Crystal Display) is a standard alphanumeric display commonly used in energy monitoring systems to show real-time power consumption data. It can display 16 characters per line across two lines.

Fig.6 *Energy Used*

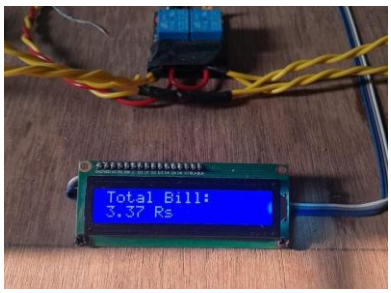

Fig.7 *Total Bill*

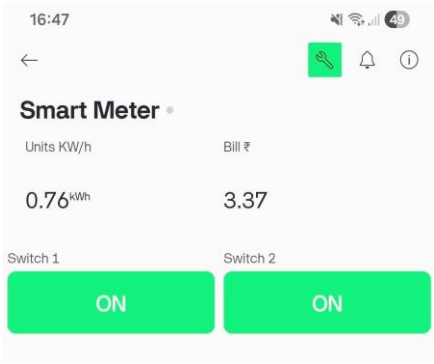

Fig. 8 *On Blynk App*

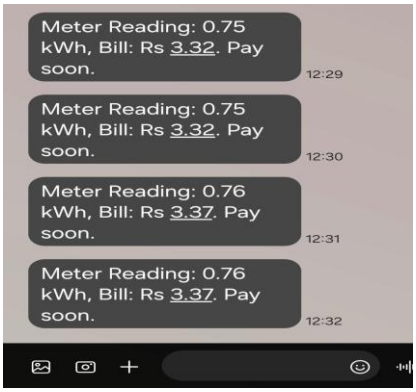

Fig.9. *Messages on Mobile*

Conclusions

An IoT-based energy meter using a Raspberry Pi offers real-one remote monitoring of energy consumption, enabling automated billing, power management, and then prevention. Key benefits include increased accuracy, reduced human error, cost savings through energy conserva on, and enhanced customer awareness. The system achieves this by collecting meter data, sending it to a cloud plaɳorm via a Raspberry Pi, and presenting it through user-friendly mobile or web applications for data analysis and control. The development of an IoT-based energy meter using Raspberry Pi involves integrating electrical sensing hardware with cloud-based monitoring, requiring the support of various individuals and institutions. Below is a sample acknowledgement template, followed by key components to include based on typical research and project implementations

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