University of South Wales
Prifysgol De Cymru

ENERGY METER WITH DATA COLLECTING AND MONITORING SYSTEM

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1. Abstract

This project presents the design and implementation of an IoT-based smart energy metering system that enables real-time monitoring, data logging, and visualisation of electrical consumption for residential or small commercial use. The proposed system utilises the ESP32 microcontroller in conjunction with ZMPT101B and SCT-013 sensors to accurately measure voltage and current, respectively. The collected data is displayed locally via an LCD and remotely through the Blynk IoT platform, offering real-time feedback to users.
A major innovation is the integration of cloud-based logging via Google Sheets using a custom HTTP request approach, eliminating reliance on premium services like IFTTT. The system visualises energy trends, estimates consumption costs, and provides insights that influence user behaviour toward energy-saving practices. Key features also include the ability to resume monitoring after power outages and the potential for billing calculations.
The system's affordability, modularity, and educational value position it as a viable solution in regions with limited access to smart metering infrastructure. Overall, this project demonstrates how low-cost components and open-source tools can support the development of scalable and sustainable energy monitoring systems.

2.Introduction

Main Points:

- Purpose: Provide real-time, affordable energy monitoring.
- Solves limitations of traditional meters (cost, real-time visibility, accessibility).
- Utilizes ESP32, ZMPT101B, SCT-013 sensors.
- Growing demand for smart meters in developing countries.
- Helps promote energy-saving habits and awareness.
- Key part of the move toward smart homes and sustainable living.

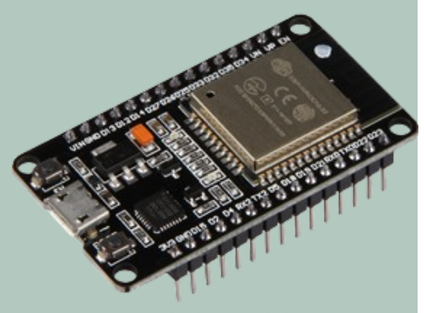


Fig1: ESP32 Module

3. Objectives

- Real-time monitoring.
- Affordable and user-friendly.
- Cloud-based data storage.
- Reduce energy wastage in households and small businesses.
- Provide visual data to support decision-making on appliance use.

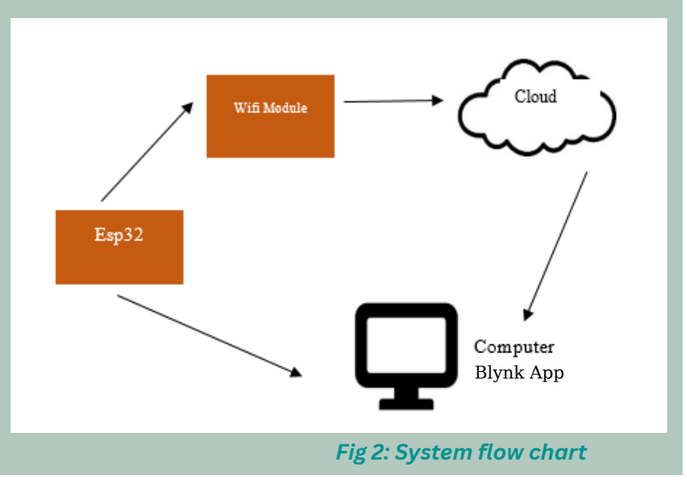
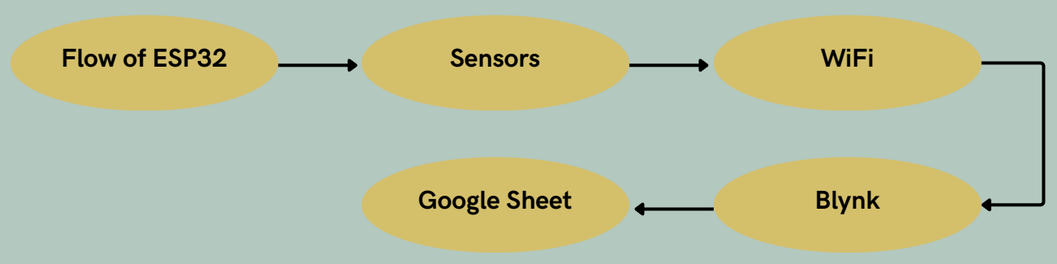


Fig 2: System flow chart

4. System Architecture & Components



- ESP32: Handles real-time sensing and cloud communication
- Blynk: dashboard view on mobile
- Google Sheets: data logging and graphs
- SCT-013 current sensor detects real-time current flow (non-invasive clamp).
- ZMPT101B provides high precision for AC voltage measurements.
- Google Apps Script bridges Arduino data with Google Sheets.

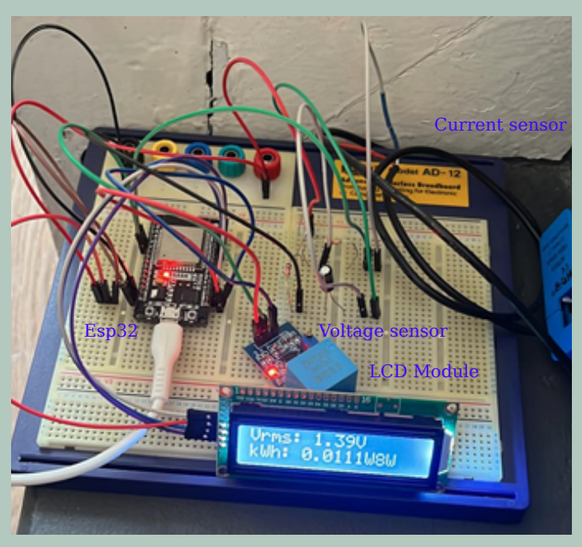


Fig 3: Full system

5. Comparison with Existing Systems

Feature	EMDCMS	OpenEnergyMonitor	Shelly EM
Cost	✅ Low	❌ High	⚠ Moderate
Open Source	✅ Yes	✅ Yes	❌ No
Mobile Friendly	✅	⚠ Limited	✅

Fig 4: OpenEnergyMonitor

Fig 5: Shelly EM

- EMDCMS is completely customizable and open to future expansion.
- OpenEnergyMonitor is effective but less affordable for local markets.
- Shelly EM is user-friendly but proprietary and cloud-dependent.

6. Real-Time Monitoring

- Users can track energy via the Blynk app.
- Get live data on voltage, current, and power.
- Visual feedback encourages users to modify usage patterns immediately.
- Data updates occur in intervals (e.g., every 1 second) for responsiveness.

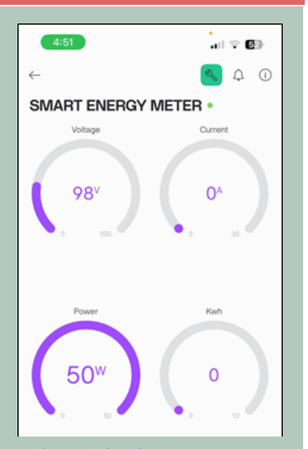
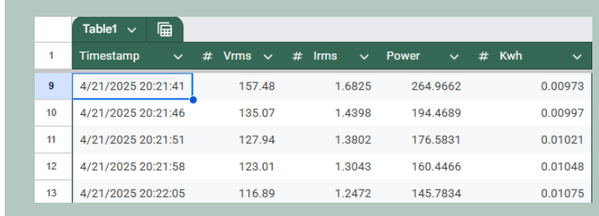


Fig 6: Blynk App output

7. Cloud Integration & Visualization

- Data logged to Google Sheets via Apps Script.
- Graphs and costs calculated.
- No paid services like IFTTT used.
- Data stored in the cloud allows for long-term tracking and reporting.
- Can be extended to mobile billing notifications or web dashboards.
- Google Sheets graphs auto-update with each new reading.



	Timestamp	Vrms	Irms	Power	Kwh
9	4/21/2025 20:21:41	157.48	1.6825	264.9662	0.00973
10	4/21/2025 20:21:46	135.07	1.4398	194.4689	0.00997
11	4/21/2025 20:21:51	127.94	1.3802	176.5831	0.01021
12	4/21/2025 20:21:58	123.01	1.3043	160.4466	0.01048
13	4/21/2025 20:22:05	116.89	1.2472	145.7834	0.01075

Fig 7: Google sheet data

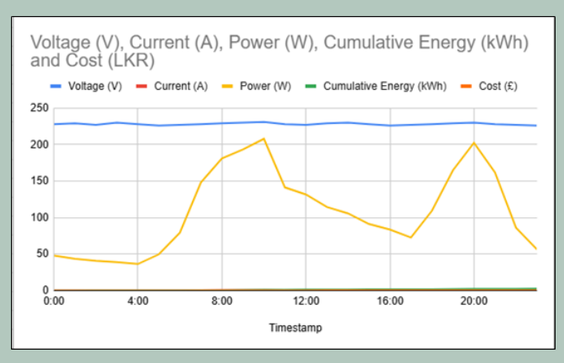


Fig 8: Graph visualization of energy trends

8. Limitations & Future Enhancements

The current system is limited to single-phase monitoring and depends entirely on a stable Wi-Fi connection for real-time data transmission. Manual sensor calibration is required, which may be difficult for non-technical users. The user interface, built with the Blynk platform, offers limited customization and lacks offline support. Additionally, the system is not legally certified for commercial billing and does not include built-in overload protection or automatic anomaly detection.
Future improvements include adding battery backup to maintain logging during power outages, expanding compatibility for three-phase systems, and integrating machine learning for predictive analytics and peak usage alerts. Other enhancements may involve developing a standalone mobile app, enabling SMS/email alerts, creating customizable dashboards via Node-RED, and adding voice assistant integration for easier interaction. These updates aim to improve the system's resilience, functionality, and adaptability for broader adoption.

9. Conclusion

This project successfully demonstrates the development of a cost-effective, real-time energy monitoring system using ESP32, ZMPT101B, and SCT-013 sensors. By integrating the Blynk app and Google Sheets, it offers users an intuitive platform to track, log, and analyze energy consumption from anywhere. The system encourages more conscious and responsible energy use while highlighting the potential of affordable IoT solutions in addressing everyday challenges. With future enhancements such as three-phase support, AI-driven analytics, and broader connectivity, the system can be scaled for smart homes and energy-conscious communities, particularly in developing countries li .

Contact: 30073395@students.southwales.ac.uk | Date: 07/05/025
Citations: (Source: Amazon, 2024), (Source: OpenEnergyMonitor, 2024), (Source: Shelly, 2024)
Note: Full references are included in the project report.

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