"PREPAID ENERGY METER USING GSM AND RASPBERRY PI"

1st Mangal Nehe,
Research Scholar
Ajeenkya D.Y Patil School Of
Engineering and technology,
Pune, India

2nd Omkar S. Gutal,
E&TC Dept.
Ajeenkya D.Y Patil School Of
Engineering and technology Pune,
India

3rd Balraj Singh,
E&TC Dept.
Ajeenkya D.Y Patil School Of
Engineering and technology Pune,
India

4th Bhavesh Patil,
E&TC Dept.
Ajeenkya D.Y Patil School of
Engineering and technology
Pune, India

Abstract-- Prepaid Energy Meter Using GSM and Raspberry Pi. This hardware and software hybrid solution is designed to revolutionize electricity distribution by eliminating overbilling, preventing meter tampering, and addressing electricity theft. With a prepaid model, users must pay for electricity in advance, enabling better energy management and reducing wastage. The system integrates a GSM module for instant communication, sending SMS alerts to users regarding energy consumption, balance updates, and potential theft incidents. If theft is detected, the system notifies both the consumer and utility authorities. This IoT-based smart energy metering solution modernizes traditional energy meters, making them more efficient, secure, and transparent.

Keywords-- Prepaid Energy Meter Using GSM & Raspberry pi, Prepaid Meter, Raspberry pi Pico w, Energy Optimization, GSM Module, IoT, Smart Metering, Energy Management, SMS Alerts, Energy Theft Detection, Prepaid Billing, Remote Monitoring, Load Disconnection, Digital Meter, Smart Grid, Consumer Awareness

INTRODUCTION--

In today's world, efficient energy management is essential due to the increasing demand and rising cost of electricity. Traditional energy metering systems often lack user engagement and fail to prevent theft effectively. This project, " Prepaid Energy Meter using GSM and Raspberry Pi " addresses these challenges by integrating a Raspberry Pi microcontroller with GSM technology to develop a more secure and efficient energy metering solution. The system enables prepaid energy consumption while ensuring accurate billing and minimizing energy theft. This innovative approach enhances user control, reduces operational costs, and promotes energy conservation, contributing to a more sustainable future.

Energy emergencies can be mitigated by effectively monitoring consumption and minimizing wastage. However, a major challenge lies in the lack of consumer awareness and responsiveness to their power usage. Smart meters with prepayment facilities have emerged as a rapidly growing technology, enabling utilities to manage cash flow more efficiently. Electricity theft not only reduces revenue but also forces higher charges on consumers, increasing the overall financial burden. Implementing prepaid smart metering systems ensures better energy management, enhances billing accuracy, and discourages theft, leading to a more sustainable and cost-effective power distribution system.

The Internet of Things (IoT) enables remote monitoring and control of devices through existing communication networks, allowing seamless integration between the physical world and computer-based systems. Effective energy monitoring and reduced wastage can help mitigate the energy crisis to some extent. However, many consumers are dissatisfied with electricity providers due to traditional meter reading methods, which require extensive manpower and long working hours for data collection and billing. Implementing smart, IoT-based prepaid energy meters enhances efficiency, improves accuracy, and streamline operations, ultimately leading to better consumer satisfaction and optimized energy management.
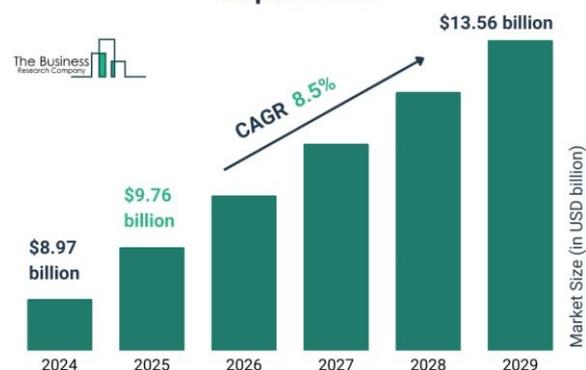

Fig. 1 Prepaid Electricity Metering Global Market Report 2025

The system can be categorized into two primary components: the consumer end and the service end.

> ➢ **Consumer End:** Users interact with the system to access services, manage their accounts and preferences, provide feedback, and receive customer support.

> ➢ **Service End:** This represents the backend operations responsible for running the system, processing transactions, analyzing consumer data, ensuring service quality, and offering support.

This structured approach ensures that the needs of both consumers and service providers are met efficiently, optimizing user experience, performance, and overall functionality

Existing prepaid Energy Meters--

Smart Card-Based Prepaid Energy Meters

A smart card is a card made of plastic the size of a credit card with an embedded integrated circuit (IC), which usually contains ROM, EEPROM, and a CPU. It offers both storage capacity and processing ability. Access to data on the card is controlled by the operating system of the smart card.

In this process, the consumer needs to recharge the smart card with a desired amount and insert it into the energy meter's card reader. The meter then records the amount of recharged units and starts measuring energy consumption. When the bought units are depleted, the meter automatically cuts off the power supply until recharge is done again.

RFID (Radio-Frequency Identification) Based Prepaid Energy Meters

Radio-frequency identification (RFID) is an automatic identification technique based on storing and remotely retrieving data in RFID tags or transponders. RFID technology involves coordination between an RFID reader and an RFID tag.

An RFID tag is a small piece of hardware that can be attached to or implanted in a product, animal, or individual for identification and tracking by radio waves. Certain RFID tags can be read from several meters away, even without a line of sight to the reader.

Prepaid Energy Meters with GSM Technology

Under this system, consumers need to recharge their mobile account and send an SMS to the energy meter through the GSM network. The meter stores the purchased energy units corresponding to the recharge amount and allows electricity consumption up to depletion of the stored units.

Once the energy units in hand are depleted, the power supply is automatically disconnected. Upon recharging again by the consumer, the microcontroller extracts the SMS, interprets it, checks the mobile number, and restores the power supply. On a successful transaction, the controller sends a confirmation SMS to the person who owns the prepaid energy meter.
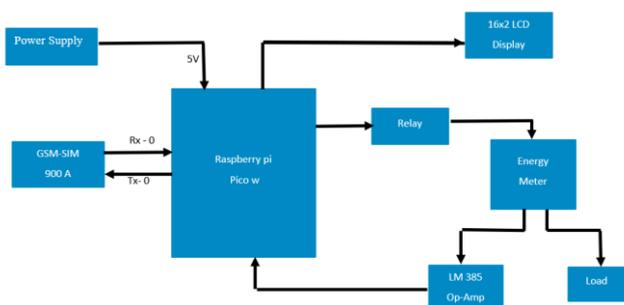
BLOCK DIAGRAM--

Figure: Block Diagram for Prepaid Energy Meter Using GSM & Raspberry Pi

A digital prepaid energy meter consists of an energy metering device and a prepaid module for billing and recharging. The proposed meter communicates with the utility server via GPRS technology. When the remaining energy drops below a threshold, the user is notified via SMS to recharge their account. If the balance reaches zero, the meter disconnects the power supply from the load. Once recharged above the reconnection threshold, the load is restored.

The user adds balance by sending an SMS command (e.g., #100* for 100 units). The Raspberry Pi stores this balance in memory and continuously tracks electricity usage. As power is consumed, the balance decreases. If it gets low, the system sends an SMS alert (e.g., "Recharge to continue using electricity"). If the balance reaches zero, the system automatically disconnects power. The user can recharge via SMS to restore power supply.

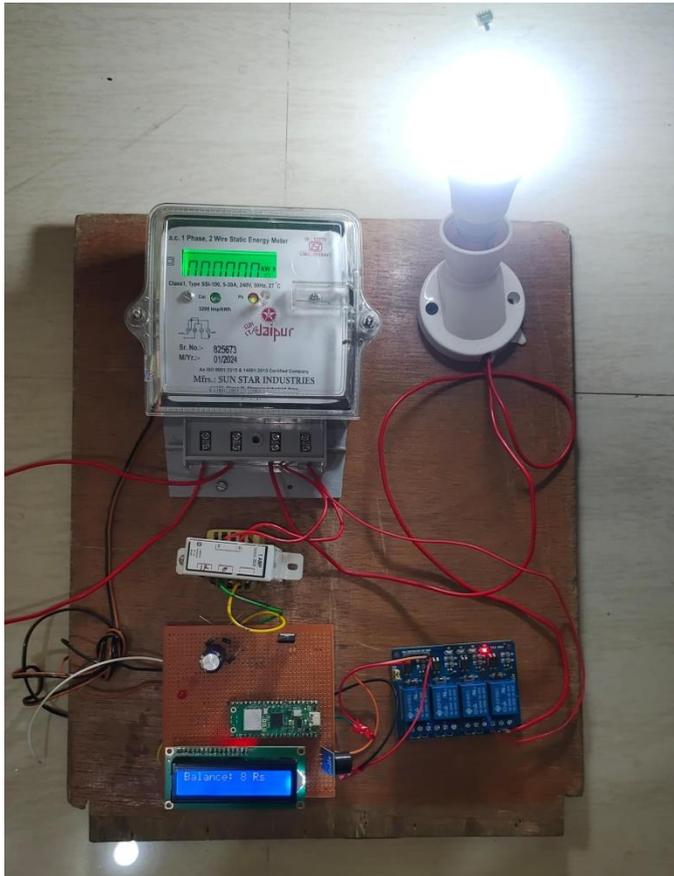*Flow Chart--*
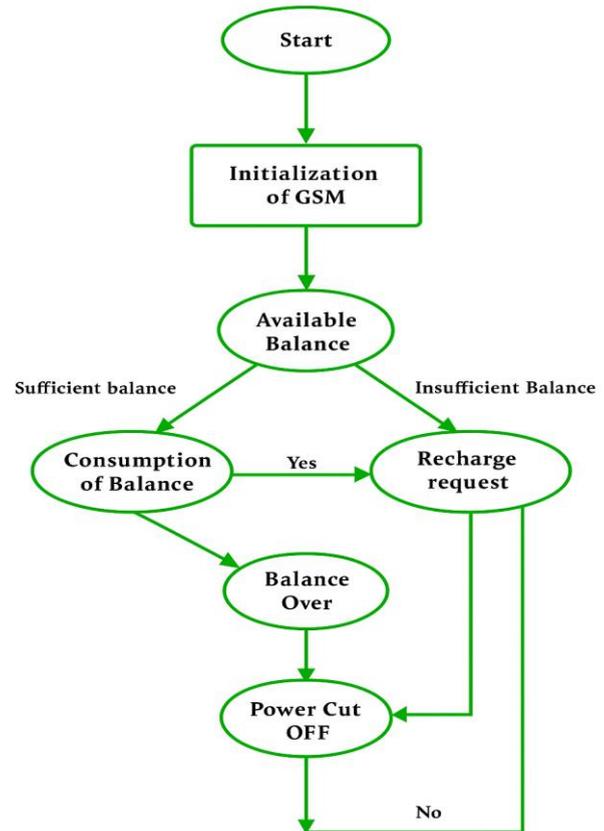
Circuit Diagram--
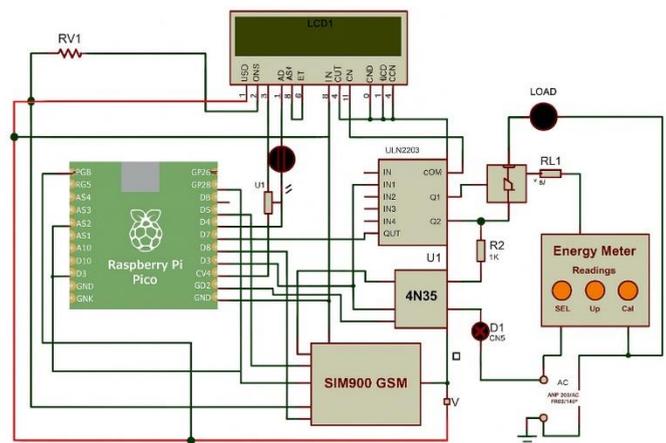
HARDWARE PROTOTYPE--

Figure 1:-led display

Figure 2:- led display after the recharge is made

A message is sent to the user when they successfully recharge

Figure 3:- Display when the recharge is finished

The device sends a message to the user when the recharge is about to run out.

Figure 4:- message for user when recharge is completed

This project is a smart prepaid energy metering system using Raspberry Pi and GSM technology, designed to allow users to recharge electricity credit in advance and monitor usage in real time. The system deducts balance based on energy consumption, displays the remaining amount on an LCD, and automatically disconnects the load via a relay when the balance reaches zero. Integrated with a GSM module, it sends SMS alerts for low balance, recharge confirmations, and power disconnection, while also enabling remote recharges via SMS commands. This eliminates the need for manual meter reading, promotes efficient energy usage, and offers a convenient, user-friendly solution for both rural and urban settings.

All relevant information is sent as message alerts to the consumer's mobile phone, ensuring transparency. Additionally, the system eliminates human intervention, improves meter reading accuracy, and prevents billing errors.

OBSERVATION--

The display shows the units consumed and the available balance

Time(sec)	Expected Energy Output(kW- sec)	Energy Output from Measurement (kW- sec)	Percentage of error
0	0	0	Not Applicable
20	24	22	3.17
40	48	46	2.08
60	72	68.6	1.94
80	96	95.5	-1.54
100	120	124	-1.67
200	264	217.7	-0.11

Figure 5: - Test result for Energy meter

Future Scope--

1. **IoT & Cloud Integration** – Enable remote monitoring and real-time data access via mobile apps or web dashboards.
2. **Online Recharge** – Add UPI or payment gateway support for seamless balance top-ups.
3. **Mobile App Control** – Develop an app to view balance, receive alerts, and recharge easily.
4. **AI-based Insights** – Use machine learning to predict usage patterns and optimize consumption.
5. **Multi-User Support** – Expand for housing societies or commercial spaces with centralized control.
6. **Renewable Integration** – Include solar/wind power sources for hybrid metering.
7. **Smart Load Management** – Prioritize essential loads during low balance for better energy control.
8. **Tamper Detection** – Add security features to detect unauthorized access or manipulation.
9. **Utility Integration** – Sync with electricity boards for automated billing and monitoring.
10. **Smart Grid Ready** – Make the system compatible with future smart grid infrastructure.

CONCLUSION—

In the era of smart cities and advanced smart grids, prototype smart energy meters represent a significant step forward, focusing on IoT-driven connectivity and networking.

This system calculates energy consumption by counting calibration pulses, implemented using a Raspberry Pi in the embedded systems domain. The proposed IoT-based meter reading system continuously monitors energy usage, detects theft, and allows the service provider to disconnect power if the consumer fails to pay the monthly bill.

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BIOGRAPHIES--

Mangal Nehe: Master's in Electronics and Communication with a specialization in Embedded Systems & VLSI With eight years of teaching experience, currently serving as an Assistant Professor in the Department of Electronics and Communication at DY Patil School.

Omkar Gutal: is pursuing a bachelor's degree in Electronics and Communication at DY Patil School of Engineering & Technology, Lohegaon. He is currently working as a Technical Writer at Philips HIC, with a strong interest in System Engineering and the creation and maintenance of technical documentation.

Bhavesh Patil: is pursuing a bachelor's degree in Electronics and Communication at DY Patil School of Engineering & Technology, Lohegaon. He is currently working as a Technical Intern at Omron Automation with strong foundation in robotics and automation sector.

Balraj Singh: is pursuing a bachelor's degree in Electronics and Communication at DY Patil School of Engineering & Technology, Lohegaon with strong foundation in programming and logical thinking.