

Empowering Energy Efficiency: A Smart Prepaid Electricity System for Sustainable Consumption

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Abstract

In response to the prevalent issue of excessive energy consumption leading to significant losses, this project proposes a smart and secure solution for a new prepaid electricity system. By introducing a rechargeable electricity smart grounded system, individuals can purchase specific amounts of energy tailored to their needs, thereby minimizing waste and optimizing energy usage. The system, designed for application in domestic households, hostel and hotel rooms, and various other settings, integrates components such as a microcontroller, digital energy meter, relay, LCD display, and IoT technology. The microcontroller effectively monitors and records electricity consumption, storing the data in its internal non-volatile memory. Similarly, the smartcard utilized in the system stores the prepaid amount for energy usage. The LCD display provides real-time updates on consumed units and remaining balance. Upon depletion of prepaid units, the microcontroller automatically disconnects connected loads, prompting users to recharge their smartcard for continued electricity access. This comprehensive system offers transparency and control, empowering users to manage their energy consumption efficiently.

Keywords: Prepaid electricity system, Smart system, Energy conservation, Rechargeable system, Microcontroller, Digital energy meter, IoT integration, Smartcard technology

1 Introduction

Electricity is an indispensable component for sustaining life's necessities. Its judicious utilization is imperative for optimal resource management. However, in our country, while certain regions enjoy surplus electricity supply, many areas remain devoid of access. Our distribution policies contribute partially to this imbalance, exacerbated by the persistent issue of power theft. Consumer dissatisfaction further compounds the problem, often stemming from perceived inaccuracies in monthly billing statements. Traditionally, electricity consumption has been monitored through mechanical meters, employing rotating metal strips to calculate usage. In contrast, our project utilizes pulse-based smart meters, equipped with an Android board to monitor consumption and generate bills accordingly. By implementing this technology, we aim to streamline the process of meter reading, eliminating the need for manual recordings at individual homes. A smart energy meter serves as an electronic device, offering precise measurements of electricity consumption for residences, businesses, and other electrically-powered entities. Its reliability ensures the provision of accurate data, minimizing the likelihood of errors within the existing billing framework. Moreover, our project endeavors to enhance efficiency by enabling the remote transmission of monthly energy consumption data to a centralized office. This innovative approach not only reduces the burden of manual meter reading but also facilitates real-time monitoring and management of electricity usage. Through the integration of smart metering technology, we strive to revolutionize the energy sector, promoting transparency, accuracy, and equitable distribution across diverse communities. The incorporation of smart home systems and Internet of Things (IoT) devices serves to elevate the functionality and versatility of the smart programmable energy meter. This synergistic integration enables users to effortlessly oversee and manage energy usage remotely, leveraging the power of connectivity to enhance control and convenience. With this interconnected ecosystem, individuals gain the ability to remotely monitor energy consumption levels, adjust settings, and even schedule appliance operations based on factors such as occupancy or time-of-day rates. Furthermore, the system is designed to alert users to any abnormal energy consumption patterns, empowering them to take

proactive measures to mitigate wastage and optimize efficiency. Beyond mere convenience, the implications of this technology extend to broader environmental considerations. In an era where sustainability is paramount, the smart programmable energy meter assumes a pivotal role in fostering eco-friendly practices. By furnishing users with actionable insights and tools for energy optimization, the project facilitates a reduction in unnecessary energy consumption, thereby contributing to a greener and more sustainable future. This initiative aligns seamlessly with the overarching vision of smart cities and communities, where intelligent technologies empower individuals to make informed decisions that not only benefit the environment but also enhance their overall quality of life. By bridging the gap between technological innovation and environmental stewardship, the integration of smart home systems and IoT devices represents a significant step towards creating more efficient, resilient, and environmentally conscious living spaces. By harnessing real-time data analytics and employing advanced machine learning algorithms, the smart meter system delivers precise insights into energy consumption patterns. These insights serve to identify areas where efficiency improvements can be made, allowing for targeted interventions to optimize energy management. Utilizing cutting-edge technology, the smart meter continuously collects and analyzes data on energy usage, taking into account various factors such as time of day, occupancy levels, and appliance usage patterns. Through sophisticated machine learning algorithms, the system can discern trends and anomalies in energy consumption, enabling it to provide actionable recommendations for enhancing efficiency. Moreover, the smart meter facilitates automated adjustments based on the insights gleaned from the data analysis. By dynamically regulating energy usage in response to changing conditions, the system ensures optimal performance while minimizing waste. The overarching goal of this smart meter is to empower homeowners with actionable information and automated control capabilities. By arming users with the knowledge needed to make informed decisions about their energy usage, the system enables them to take proactive steps towards reducing energy costs and promoting sustainability. Ultimately, the integration of real-time data analytics and machine learning algorithms fosters a more eco-friendly living environment. By leveraging technology to optimize energy management, the smart meter contributes to a more sustainable future, where individuals can enjoy the benefits of reduced energy consumption without sacrificing comfort or convenience.

2 Literature Survey

When delving into the realm of biometric recognition systems, it's essential to understand the fundamental elements that underpin their functionality. Such systems rely on three core aspects: enrollment, storage, and comparison. Enrollment marks the initial interaction between an individual and the biometric system. During this phase, the system collects pertinent information about the individual, such as their name or identification number. Additionally, it captures a distinct biometric trait unique to that individual, such as a fingerprint, facial features, or voice pattern. This process essentially creates a digital representation or template of the individual's biometric data for future reference.

Subsequently, the collected biometric data is stored securely in a database. This database serves as a repository for the biometric templates of multiple individuals. The stored data undergoes various analyses and preprocessing techniques to ensure accuracy and reliability. These analyses may involve enhancing the quality of captured images or recordings, as well as performing normalization or standardization procedures to facilitate comparison. The comparison phase occurs when an individual seeks to authenticate themselves using the biometric system. During this process, the system retrieves the stored biometric template associated with the individual's identity from the database. It then compares this template with the real-time biometric data captured during the authentication attempt. This comparison typically involves complex algorithms designed to assess the similarity or match between the two sets of biometric data. The culmination of these operations determines the system's ability to accurately identify or verify the individual's claimed identity. Each biometric modality, whether it be fingerprint recognition, facial recognition, iris recognition, or voice recognition, follows a similar workflow encompassing registration, preprocessing, feature extraction, and matching stages. These stages collectively enable biometric systems to deliver reliable and robust authentication capabilities, enhancing security and efficiency across various applications and industries. During the comparison phase, the biometric system undergoes a critical process to ascertain the identity of an individual seeking authentication. This phase serves as the pivotal moment where the system evaluates the captured biometric data against the stored reference template associated with the individual's identity. Initially, the system accesses the database to retrieve the pre-enrolled biometric template linked to the individual's identity. This template serves as a digital representation of the unique biometric characteristics captured during the enrollment phase, such as fingerprint minutiae, facial features, or voice patterns. Next, the real-time biometric data obtained during the

authentication attempt is compared against this reference template. This comparison is executed through sophisticated algorithms specifically designed to analyze and quantify the similarities and differences between the two sets of biometric data. The comparison process involves intricate mathematical calculations and pattern recognition techniques. These algorithms assess various features and characteristics of the biometric data, seeking patterns or correlations that indicate a match or similarity between the captured sample and the stored template. The system evaluates factors such as the alignment, orientation, and quality of the biometric data to ensure accurate comparison results. Additionally, robust algorithms account for variations that may occur due to environmental factors, changes in lighting conditions, or natural fluctuations in the biometric traits themselves. Based on the outcome of the comparison analysis, the biometric system determines whether the real-time biometric data sufficiently matches the stored template to authenticate the individual's identity. If a significant degree of similarity is detected within predefined thresholds, the authentication is deemed successful, granting access or authorization as required. Ultimately, the comparison phase represents the culmination of the biometric authentication process, where complex algorithms and meticulous analysis enable the system to accurately verify an individual's identity based on their unique biometric characteristics. This phase plays a crucial role in ensuring the security, reliability, and efficiency of biometric authentication across a myriad of applications and industries. During the comparison phase, the biometric system meticulously evaluates a multitude of factors to ensure precise and reliable comparison results between the captured biometric data and the stored reference template. One crucial aspect that the system scrutinizes is the alignment and orientation of the biometric data. This entails analyzing the spatial relationship and positioning of key features within the biometric sample, ensuring that they correspond appropriately with those in the reference template. Correct alignment is essential for accurate comparison and recognition. Furthermore, the system assesses the overall quality of the biometric data. This includes factors such as resolution, clarity, and signal-to-noise ratio. High-quality data ensures that subtle nuances and distinguishing characteristics are adequately captured, facilitating more accurate matching during the comparison process. Robust algorithms are employed to account for variations that may arise due to environmental factors. Changes in lighting conditions, for instance, can impact the appearance of facial features or the clarity of fingerprint ridges. The system adapts to such fluctuations by employing adaptive techniques to normalize the biometric data and mitigate the effects of environmental variability. Additionally, natural fluctuations in biometric traits

themselves are considered during comparison. Biometric characteristics such as facial expressions, vocal variations, or physiological changes can introduce variability in biometric data over time. The system incorporates advanced algorithms capable of accommodating such variations while maintaining robustness and accuracy in the comparison process. Overall, the comparison phase of the biometric system represents a sophisticated interplay of algorithms and techniques aimed at ensuring accurate and reliable authentication. By meticulously evaluating factors such as alignment, quality, and environmental variations, the system enhances its ability to effectively match biometric data with stored templates, thereby enabling secure and efficient identity verification in diverse scenarios.

3 Methodology

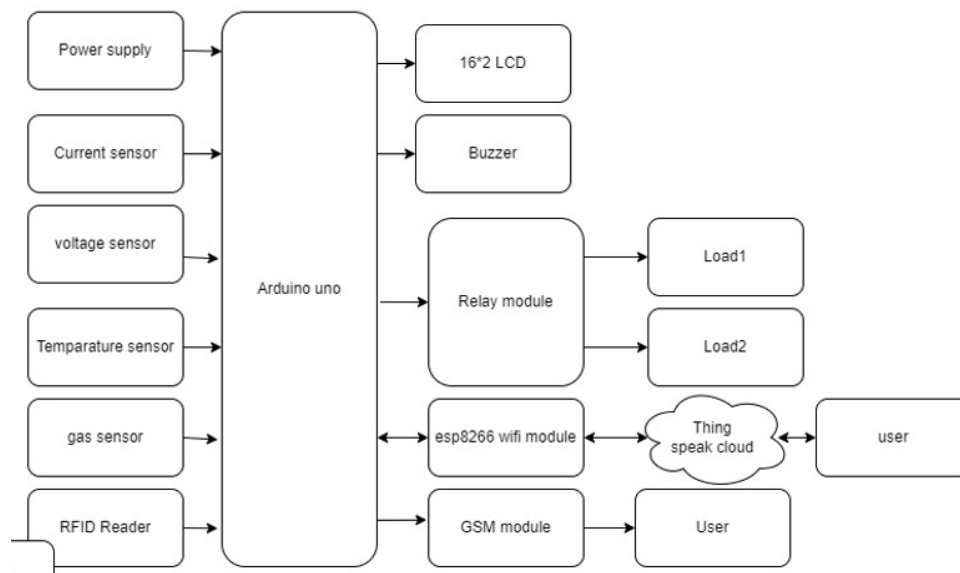


Fig 1 Block Diagram

Power Supply

- This block represents the source of power for the entire system. It likely utilizes solar panels that convert sunlight into electricity to run the system.

Water Reservoir

- This tank stores the water solution that will be used to nourish the plants.
- **Rain Drop Sensor:** This sensor detects rainfall and can be used to regulate the water supply in the reservoir. If rain is detected, the system might suspend pumping water from the external source to prevent overwatering the plants.

- **pH Sensor:** This sensor monitors the acidity or alkalinity of the water solution in the reservoir. Maintaining a proper pH level is crucial for optimal plant growth.
- **Web Server:** This component likely refers to a software application that allows remote monitoring and control of the hydroponics system. Users can access the web server through a web interface or a mobile app to view sensor data (e.g., pH, moisture levels) and adjust settings (e.g., pump schedules, nutrient levels).
- **Relay:** This electronic switch is controlled by the Node MCU and is likely used to turn the water pump on or off based on the system's needs.
- **Node MCU:** This microcontroller board is the central processing unit of the system. It collects data from sensors, controls the water pump and DC motor through the relay, and might communicate with the web server for remote control.
- **Moisture Sensor:** This sensor monitors the moisture content within the hydroponic tank where the plants reside. The Node MCU likely uses the sensor readings to determine when to pump water into the tank to maintain optimal moisture levels for the plants.
- **DHT11 Sensor:** This sensor measures the ambient temperature and humidity around the plants. This data can be helpful for monitoring the overall growing environment and potentially be used to control auxiliary systems like ventilation fans (not shown in the diagram).
- **Arduino (Uno):** While the functionality of the Arduino in this specific system is unclear, Arduinos are generally programmable microcontrollers that can be used for various purposes in conjunction with other components. In some hydroponics systems, Arduinos might be used to control lighting or other environmental factors.
- **LCD (Liquid Crystal Display):** This display panel provides a local interface for viewing sensor data (e.g., pH, temperature, humidity) and system status.
- **DC Motor 1:** This motor likely controls the water pump, drawing water from the reservoir and pumping it into the hydroponic tank based on signals from the Node MCU.
- **DC Motor 2:** The purpose of this DC motor is unclear based on a general block diagram. It might be used to adjust ventilation or other environmental controls within the hydroponics system, such as controlling the position of shades or opening/closing vents.

- **Rain Protection System:** This component is likely some form of shelter or covering to protect the hydroponics system from rain.

Overall, this block diagram depicts a solar-powered automated system that leverages sensors and microcontrollers to monitor and regulate the growth environment for fodder within a hydroponics system. By using solar panels and automating tasks like watering, this system can be a sustainable and relatively hands-off way to grow fodder.

Results

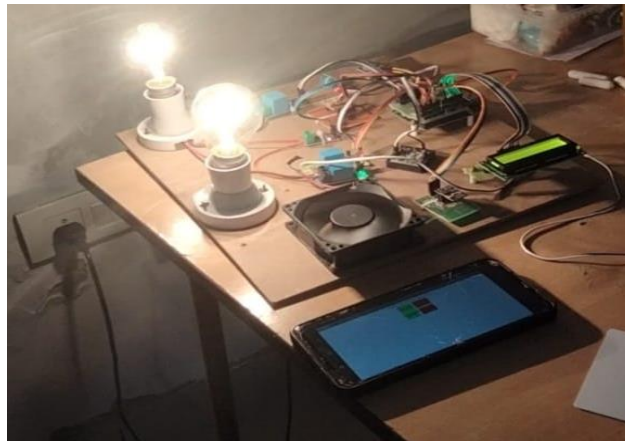


Fig 2 Output



Fig 3 Registration Successful Message on LCD

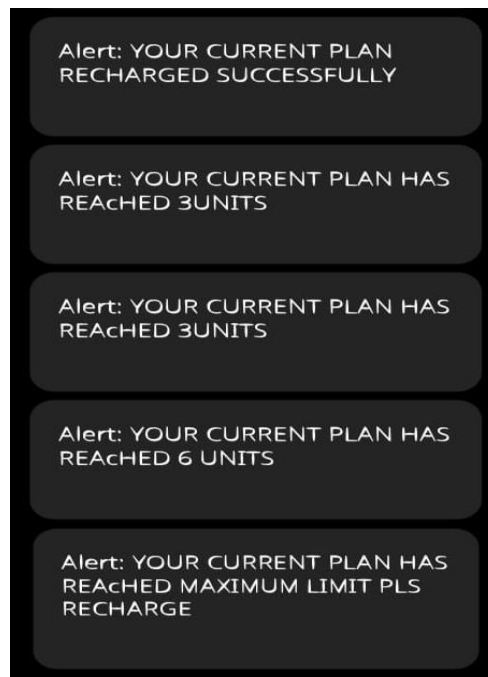


Fig 4 Messages

Conclusion

In conclusion, the proposed smart prepaid electricity system offers a compelling solution to address the pressing issue of excessive energy consumption and associated losses. By leveraging innovative technology, including microcontrollers, digital energy meters, smartcards, and IoT integration, the system provides a secure and efficient method for managing electricity usage. Designed for deployment in various settings, from domestic households to hostel and hotel rooms, the system offers tailored energy purchasing options, allowing users to optimize their consumption and minimize waste. The microcontroller plays a central role in monitoring and recording electricity usage, while the smartcard enables convenient prepaid transactions, storing users' available energy credits. Real-time updates provided through the LCD display enhance transparency and empower users to make informed decisions about their energy usage. Moreover, the automatic disconnection of loads upon depletion of prepaid units encourages responsible energy management practices and prompts users to recharge their smartcards promptly. Overall, this comprehensive system not only addresses the challenges associated with energy consumption but also provides users with greater control and transparency over their electricity usage. By promoting efficiency and accountability, the smart prepaid electricity system represents a significant step towards a more sustainable and environmentally conscious approach to energy management.

Feature Scope

The feature scope of the proposed smart prepaid electricity system includes the integration of a microcontroller, digital energy meter, smartcard technology, LCD display, and IoT connectivity to enable users to purchase prepaid energy credits tailored to their needs. This system offers real-time monitoring of electricity consumption, transparent display of remaining balances, and automatic load disconnection upon credit depletion. Additionally, it provides users with remote access via mobile or web platforms for recharging smartcards and accessing energy usage insights, all while ensuring robust security measures to protect user data and transactions. Overall, the feature scope encompasses comprehensive functionalities aimed at promoting efficient energy management, convenience, and sustainability across various user environments.

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