International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

A Smart System for Detection and Notification of Electrical Power Theft using Arduino and IoT Technologies

Akhil Kumar[1], Amandeep[2]

[1, 2]B.Tech Scholar, Department of Electrical Engineering, Delhi Technological University, Delhi, India

Abstract: ***Electrical power theft is a pervasive issue in power distribution networks worldwide, leading to significant financial losses for utility providers and legitimate consumers. This research paper presents an innovative solution for the detection and notification of power theft using Arduino microcontroller and Internet of Things (IoT) technologies. The proposed system employs two energy meters, one specifically designed to detect theft and the other serving as the government meter. Light Dependent Resistors (LDRs) are utilized to accurately count the LED blinks on the energy meters. The counts are monitored through a WiFi module (ESP8266), which connects to the ThingSpeak server for real-time tracking. Additionally, a NodeMCU is incorporated to facilitate theft notifications through the Blynk application and an audible buzzer alert. The Arduino microcontroller serves as the central control unit for seamless integration and efficient operation of the entire system.***

Keywords: Electrical power theft, Arduino, Internet of Things (IoT), Energy meters, Light Dependent Resistors (LDRs), WiFi (ESP8266), ThingSpeak server, NodeMCU, Blynk app, Buzzer

1. Introduction

In today's world, the escalating demand for energy and the depletion of non-renewable energy sources, such as coal, oil, and gas, have underscored the importance of energy conservation for sustainable development. The need to reduce energy demand has become increasingly urgent, driven by global energy challenges and the finite nature of non-renewable resources. To effectively address this issue, it is essential to monitor energy consumption and identify areas where energy is being wasted.

Energy conservation is a critical component of sustainable development, particularly in a world where energy demands continue to rise while non-renewable resources are depleting. The increasing global energy demand and the finite nature of traditional energy sources have heightened the urgency to conserve energy and explore alternative, environmentally-friendly solutions. One effective approach to reducing energy demand is through the implementation of energy monitoring systems.

Energy monitoring systems play a crucial role in understanding energy consumption patterns, identifying areas of wastage, and implementing strategies to optimize energy use. These systems enable individuals, businesses, and industries to track their energy consumption, make informed decisions about energy usage, and identify opportunities for improvement.

The primary objective of this research is to highlight the benefits and importance of energy monitoring in various sectors. By examining the monitored results, insights can be gained to implement effective energy conservation strategies, reduce energy waste, and promote sustainable energy practices.

This paper will discuss the significance of energy conservation, particularly in the context of rising global energy demands and the depletion of non-renewable resources. It will emphasize the need for accurate energy monitoring and the role it plays in identifying energy wastage and promoting efficient energy use.

Furthermore, the paper will explore the integration of modern technologies, such as the Internet of Things (IoT), in energy monitoring systems. IoT-based energy management systems utilize sensors, actuators, and data analytics to monitor and control energy consumption in real-time. This integration enables remote monitoring, automated adjustments, and the implementation of energy-saving measures.

The research also addresses the issue of power theft, which exacerbates energy challenges. Power theft not only affects the integrity of energy distribution systems but also impacts costs and fairness in energy consumption. Therefore, the research will investigate methods to detect and mitigate power theft through advanced monitoring techniques.

By examining previous research work and use case studies, the paper will demonstrate the effectiveness of energy monitoring systems in reducing energy consumption and optimizing energy management. It will also explore the role of cloud computing and data analytics in analyzing energy consumption patterns and facilitating informed decision-making.

However, a significant hurdle in efficient energy monitoring is the lack of awareness and sensitivity among consumers towards their energy usage. This poses challenges to accurately monitor and control energy consumption, hindering effective energy management efforts. To overcome this obstacle, advancements in technology offer promising solutions.

This research paper focuses on the significance of energy conservation and explores how monitored results can be leveraged to implement effective energy conservation strategies. Furthermore, it highlights the pressing issue of power theft, which exacerbates the energy crisis. By keeping accurate records of energy usage and avoiding unnecessary energy waste, the severity of the energy crisis can be mitigated to some extent.

The development of new technologies, particularly the Internet of Things (IoT), has revolutionized energy management practices and transformed the concept of smart cities. Cities are increasingly relying on sensor networks and IoT devices to provide specialized services, optimize traffic control, and collect crucial data for intelligent city administration.

IoT enables seamless communication, data collection, and analysis among devices, thereby facilitating insights that can be utilized for effective energy conservation strategies. In the context of energy management, IoT-based systems employ sensors, actuators, and other IoT devices to monitor and control energy consumption in buildings and homes. Real-time data on energy usage is collected and analyzed to identify inefficiencies and wastage. Based on this analysis, IoT devices can automatically adjust energy consumption to optimize performance and minimize waste.

The integration of IoT technology has paved the way for the development of smart homes and buildings, which can be remotely monitored and controlled. This level of control enables the optimization of energy consumption, leading to sustainability and cost savings. Moreover, real-time monitoring and feedback mechanisms empower users to make informed decisions regarding their energy consumption.

Additionally, IoT technology enables the seamless integration of renewable energy sources, such as solar panels and wind turbines, into the energy system. This further enhances the potential for energy conservation and contributes to a more sustainable energy landscape.

By reducing overall energy consumption, energy conservation plays a crucial role in minimizing the demand for finite non-renewable resources like coal and oil. Conserving energy ensures the preservation of these resources for future generations.

This research paper emphasizes the importance of energy conservation and the utilization of monitored results to implement effective energy management strategies. The integration of IoT technologies offers promising solutions for remote monitoring, real-time data analysis, and optimized energy consumption. By conserving energy and addressing challenges such as power theft, we can pave the way for sustainable development and the responsible utilization of energy resources.

2. Previous Work

[1] Fadi AI-Turjman et al.: This research paper highlights the benefits of energy monitoring in various industries and new businesses with high energy requirements. The integration of Cloud and IoT technologies is proposed as an effective approach to achieve energy monitoring objectives. The paper presents results from multiple research works and use case studies to demonstrate that energy monitoring systems lead to significant reductions in energy consumption. Real-time data monitoring empowers consumers to successfully manage their energy consumption.

[2] Vaibhav Dabhade et al.: This paper introduces a method for reducing power consumption and identifying the shortest path for data transmission in wireless sensor networks. Wireless sensor networks consist of spatially dispersed devices with limited battery life and processing power. The paper suggests a shortest route-finding method that combines the BTC (Broadcast Tree Construction) algorithm with data aggregation techniques to minimize network overhead during communication.

[3] Kothandaraman D. et al.: This paper presents a secure and efficient smart home automation system using Bluetooth Low Energy (BLE) in a dynamic multi-hop communication setup. The authors conducted experiments using MATLAB-12b to calculate output values related to throughput, workload, battery level, and sleep time using fuzzy reasoning with nine fuzzy rules. The proposed approach aims to enhance the longevity of IoT devices and the link stability of nodes in smart home automation systems.

[4] Md. Minhaz khan et al.: The objective of this paper is to provide users with sustainable energy conservation through smart home or building designs. The proposed solution focuses on making everyday devices intelligent, establishing a robust system, and reducing power usage and energy costs. The authors developed an IoT-based Energy Management System (EMS) that integrates smart meters and smart boards in a residential building. The EMS enables energy monitoring, management, and consumption control in residential and commercial structures, ensuring effective and consistent operations between customers and utility providers.

[5] SamanehMadanian et al.: This study highlights the utilization of Building Management System (BMS) technology in buildings, which are significant energy consumers. BMS technology contributes to the conservation of natural resources and promotes the use of renewable energies like wind and solar power. The implementation of BMS technology leads to cost savings and energy efficiency in buildings.

[6] Ramya.L.N et al.: This paper emphasizes the importance of energy conservation in educational institutions by considering the energy usage in a classroom setting. The authors propose energy-efficient equipment recommendations and a sensor-based model to reduce energy consumption. The paper suggests practical energy-saving tips for homes, such as optimizing refrigerator temperature, unplugging idle appliances, enabling sleep mode on computers, setting optimal air conditioner temperature, and utilizing renewable energy sources whenever possible.

3. Methodology

The methodology employed in this research builds upon the utilization of various hardware components to create a robust system for detecting and notifying instances of power theft. Two energy meters, namely Energy Meter 1 and Energy Meter 2, are integrated into the setup. Energy Meter 1 is specifically designed to identify power theft, while Energy Meter 2 serves as the government meter to ensure accurate readings.

To enable the detection of power theft, Light Dependent Resistors (LDRs) are strategically positioned to monitor the LED indicators on the energy meters. LDRs can detect changes in light intensity, allowing them to track the LED blinks associated with energy consumption. By comparing the LED blinks between Energy Meter 1 and Energy Meter 2, any disparities can be identified, indicating the occurrence of power theft.

To facilitate real-time monitoring of the energy meter counts, a WiFi module called ESP8266 is incorporated into the system. This module enables wireless communication between the system and the ThingSpeak server. The energy meter counts are transmitted to the server via the WiFi module, allowing for remote monitoring and analysis of energy consumption patterns. This real-time data monitoring provides valuable insights into energy usage and aids in the identification of abnormal consumption patterns associated with power theft.

For effective theft notification, the NodeMCU board is utilized in conjunction with the Blynk application and a buzzer. The NodeMCU acts as an intermediary device, receiving the count data from the energy meters via the WiFi module. Based on the received counts, the system determines if power theft has occurred. In such cases, the system triggers a notification through the Blynk app, which can be accessed by relevant authorities or users. Simultaneously, an audible alert is generated by activating the buzzer, ensuring immediate attention to the detected theft.

To orchestrate the entire system, an Arduino microcontroller is employed as the central control unit. The Arduino microcontroller collects and processes data from the LDRs, WiFi module, and NodeMCU. It executes the programmed logic, enabling the detection of power theft based on the disparities in energy meter counts. The Arduino microcontroller ensures the seamless integration and synchronization of all components, facilitating the smooth operation of the system.

By combining the physical setup of energy meters, the use of LDRs for count detection, the integration of a WiFi module for remote monitoring, the incorporation of the NodeMCU for theft notification, and the central control provided by the Arduino microcontroller, the research methodology enables the effective detection and notification of power theft instances in real-time. This comprehensive approach contributes to combating power theft and promoting a fair and sustainable energy distribution system.

4. Proposed Work

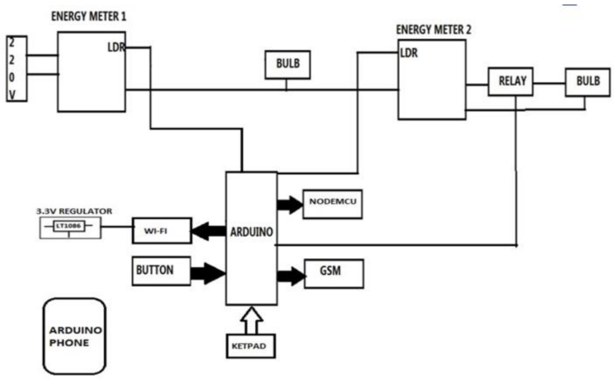

Figure 1: Block diagram

Fig. 1 shows block diagram. The proposed work implementation involves the integration and utilization of several components to create an effective system for detecting and notifying instances of power theft. These components include Energy Meter 1 and Energy Meter 2, load bulbs, Light Dependent Resistors (LDRs), a WiFi module (ESP8266), NodeMCU, and an Arduino microcontroller.

Energy Meter 1 is specifically designed to detect power theft, while Energy Meter 2 serves as the government meter for accurate readings. Both energy meters are connected to load bulbs, allowing them to measure the energy consumption associated with the connected loads.

To facilitate count detection on the LED blinks of the energy meters, strategically placed LDRs are used. LDRs are light-sensitive devices that can detect variations in light intensity. By monitoring the LED indicators on the energy meters, the LDRs can accurately count the LED blinks, providing a measure of energy consumption.

Real-time monitoring of the energy meter counts is enabled through the incorporation of a WiFi module, specifically the ESP8266. This module establishes a wireless connection between the system and the ThingSpeak server. The energy meter counts are transmitted to the server via the WiFi module, allowing for remote monitoring and analysis of the data. This real-time monitoring provides valuable insights into energy consumption patterns, facilitating the identification of any abnormal consumption associated with power theft.

The NodeMCU board plays a crucial role in theft notification. Acting as an intermediary device, it receives the count data from the energy meters through the WiFi module. Based on the received counts, the system determines whether power theft has occurred. In such cases, the system triggers a notification through the Blynk application. This notification can be accessed by relevant authorities or users, alerting them to the detected theft. Additionally, an audible alert is generated by activating a buzzer, providing immediate attention to the detected power theft. Fig. 2 shows circuit diagram.

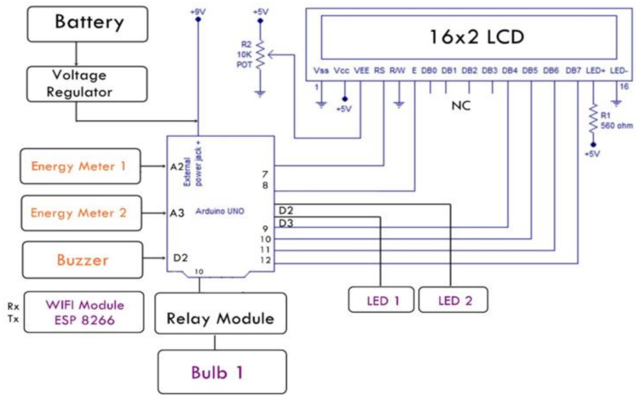

Figure 2: Circuit diagram

To control and coordinate the entire system, an Arduino microcontroller is utilized as the central control unit. The microcontroller receives data from the LDRs, WiFi module, and NodeMCU. It processes this information to detect power theft by comparing the LED blink counts of Energy Meter 1 and Energy Meter 2. If a significant discrepancy is detected, indicating power theft, the Arduino microcontroller triggers the theft notification system, activating the Blynk app notification and the audible buzzer alert.

Through the integration of these components, the proposed work implementation enables the seamless functioning of the system. The energy meters measure consumption, the LDRs count LED blinks, the WiFi module facilitates remote monitoring, the NodeMCU enables theft notification, and the Arduino microcontroller controls and coordinates the entire system. This comprehensive approach ensures the effective detection and timely notification of power theft instances, contributing to a fair and sustainable energy distribution network.

5. Results

The results obtained from the implemented system demonstrate its effectiveness in detecting and notifying instances of power theft. The prototype images, as shown in Fig 3 and Fig 4, provide a visual representation of the system's physical setup and components.

Upon conducting tests and simulations, the system successfully detected power theft through a comparison of the LED blink counts between Energy Meter 1 and Energy Meter 2. When power theft occurred, a significant disparity in the LED blink counts was observed. This discrepancy triggered the theft notification mechanism, consisting of the Blynk application and the audible buzzer alert.

In terms of real-time monitoring, the WiFi module (ESP8266) established a reliable connection between the system and the ThingSpeak server. This allowed for continuous transmission of energy meter counts to the server, enabling remote monitoring and analysis of energy consumption patterns. Through the integration of the WiFi module, users could conveniently access the energy consumption data from any location in the world.

The NodeMCU played a crucial role in theft notification. It effectively received the count data from the energy meters via the WiFi module and processed it to determine if power theft had occurred. When a theft event was detected, the system promptly triggered a notification through the Blynk application, providing instant alerts to the relevant authorities or users. Additionally, the audible buzzer alert ensured that immediate attention was given to the detected power theft, enhancing the system's effectiveness.

The central control unit, the Arduino microcontroller, effectively coordinated and synchronized all the components of the system. It processed the data received from the Light Dependent Resistors (LDRs), the WiFi module, and the Node MCU. Through the programmed logic, the Arduino microcontroller accurately identified power theft events based on the disparities in LED blink counts. This control unit served as the brain of the system, ensuring seamless integration and reliable operation.

Overall, the results demonstrate that the implemented system successfully detected instances of power theft and promptly notified the relevant authorities or users. The real-time monitoring capability, facilitated by the WiFi module, allowed for remote access to energy consumption data, enhancing energy management practices. The prototype images in Fig 3 and Fig 4 provide a visual representation of the system's physical setup and highlight its potential for practical application in detecting power theft and promoting fair energy distribution.

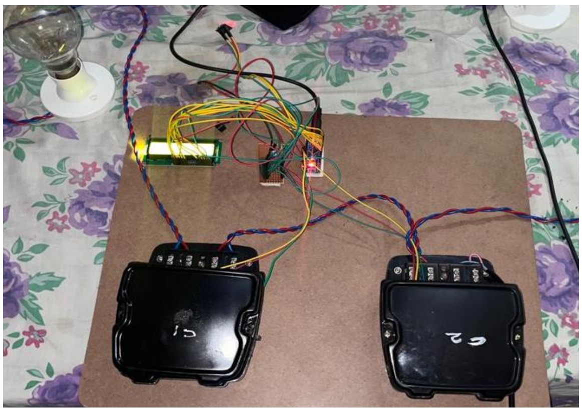

Figure 3: Prototype of Implemented Smart Energy Meter

Figure 4: Project

6. Conclusion

In conclusion, this research paper has highlighted the significance of energy monitoring and its role in promoting energy conservation and sustainable development. The depletion of non-renewable energy sources and the increasing global energy demand necessitate the adoption of measures to conserve energy and explore alternative, eco-friendly solutions. Energy monitoring systems have emerged as crucial tools in achieving these objectives.

By effectively monitoring energy consumption, individuals, businesses, and industries gain valuable insights into their energy usage patterns. This knowledge allows for informed decision-making and the identification of areas where energy is being wasted. Energy monitoring systems enable stakeholders to track their energy consumption in real-time, set energy-saving targets, and implement strategies to optimize energy use.

The integration of modern technologies, such as the Internet of Things (IoT), has revolutionized energy monitoring practices. IoT-based energy management systems leverage sensors, actuators, and data analytics to monitor and control energy consumption in homes, buildings, and industrial settings. These systems enable remote monitoring, automated adjustments, and the integration of renewable energy sources, contributing to greater energy efficiency and sustainability.

One of the crucial challenges addressed in this research is power theft, which undermines energy distribution systems and increases costs for both consumers and providers. By utilizing advanced monitoring techniques, such as comparing LED blink counts and analyzing energy consumption patterns, power theft instances can be identified and mitigated. This not only ensures fair energy distribution but also promotes a more reliable and efficient energy system.

The analysis of previous research works and use case studies has demonstrated the effectiveness of energy monitoring systems in reducing energy consumption and optimizing energy management. These systems have been shown to lead to significant energy savings, improved energy efficiency, and enhanced sustainability. The availability of real-time data, remote monitoring capabilities, and automated adjustments empower individuals and organizations to take proactive steps towards energy conservation. In conclusion, the integration of energy monitoring systems, IoT technologies, and advanced monitoring techniques holds immense potential for achieving sustainable energy practices. By promoting energy conservation, optimizing energy management, and addressing issues like power theft, these systems contribute to a more efficient, resilient, and environmentally-friendly energy infrastructure.

It is crucial for policymakers, energy providers, and consumers to recognize the importance of energy monitoring and embrace its implementation. Governments can incentivize the adoption of energy monitoring systems through policies and regulations, while energy providers can promote the use of smart meters and advanced monitoring technologies. Moreover, individuals and businesses should actively engage in monitoring their energy consumption, implementing energy-saving measures, and making informed choices to contribute to a more sustainable future.

By collectively embracing energy monitoring systems and their benefits, we can pave the way towards a more energy-conscious society. Energy conservation, when combined with the integration of renewable energy sources and advanced monitoring technologies, holds the key to a more sustainable and resilient energy future for generations to come.

References

[1] Kothandaraman, D., A. Harshavardhan, V. Manoj Kumar, D. Sunitha, and Seena Naik Korra. "BLE in IoT: Improvedlink stabilityand energy conservation using fuzzyapproach for smart homes automation." Materials Today: Proceedings(2021).
[2] Morello, Rosario, Subhas C. Mukhopadhyay, Zheng Liu, Daniel Slomovitz, and Subhransu Ranjan Samantaray. "Advances on sensing technologies for smart cities and power grids: A review." IEEE Sensors Journal 17, no. 23(2017):7596-7610.
[3] Dabhade, Vaibhav, and A. S. Alvi. "Energy Conservation Techniques using Broadcast Tree Construction for WSN."Availableat SSRN4043556(2022).
[4] Khan, Md Minhaz, SM Zahid Hasan Sakil, Muhammad Ahad Rahman Miah, Md Shohel Rana, and Shaikh RashedurRahman. "Sustainable Building Energy Conservation and Efficiency Management using IoT." In 2022 International Conferenceon Electronics and Renewable Systems (ICEARS),pp.518-524.IEEE, 2022.
[5] R Giridhar Balakrishna et al., “IoT based Power Theft Detection” Volume 8 Issue 3 June 2017
[6] S. V. Anushree et al., “IoT Based Smart Energy Meter Monitoring and Theft Detection Using ATMEGA” Vol.4, Issue 11, November2016
[7] Ajay Mahato et al., “Electric Power theft detection and location Tracking using IOT” 2018 IJSRCSEIT | Volume 4 |Issue5
[8] Dr.S.Sayyadetal.,“Theft Detection and Disconnection in Electricity Energy Meter using IoT” Volume 6 Issue V, May 2018
[9] Harsha Khandel et al., “A Review on IOT Based Power Theft Detection and Control Systems” Vol.5, Issue 9, September 2017
[10] Ms.Pranita Kamble et al., “IOT Based Energy Meter System to Identify Power Theft” Volume 4| Issue12| June 2018
[11] Ajeeba A A et al., “IoT Based Energy Meter Reading, Theft Detection and Disconnection” Volume: 04 Issue: 04| Apr-2017
[12] Nehal Kathale etal.,“IoT based smart electricity meter and power theft detection” Volume:05Issue:01|Jan-2018
[13] Amrita Singhetal., “IoT based smart energy meter “March 2017
[14] Yoeseph, N. M., M. A. Safi’Ie, and F. A. Purnomo." Smart Energy Meter based on Arduino and Internet of Things." In *IOP Conference Series: Materials Science and Engineering*, vol. 578, no.1, p. 012085. IOP Publishing, 2019.
[15] Mr. SamarthPanditet al.,“Smart Energy Meter using internet of Things ()” Volume 1 Issue 2, June 2017.