# Web Based Real-Time Tracking of Home Appliance Energy Consumption

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***Abstract:-*** The accelerating interest in smart cities and infrastructure is coupled with an urgent need for energy-saving measures, addressing the global challenge of conserving energy in the face of predominantly non-renewable resources. This literature survey investigates the intricate landscape of energy conservation, emphasizing the critical role of a precise and comprehensive monitoring infrastructure in understanding consumption patterns at a granular level.

With a focus on overcoming the persistent challenge of electrical energy loss, the survey explores the potential of Automatic Meter Reading (AMR), particularly utilizing power line communication channels. The integration of AMR with power line carrier technology is highlighted, responding to evolving structural changes in the utility industry that demand heightened meter performance and utility.

Modern programming and communication platforms are identified as key enablers, incorporating cutting-edge techniques that significantly influence industrial control performance. The survey delves into a diverse array of studies, encompassing the development of IoT-based edge devices, the integration of IoT sensors and web servers. This holistic exploration extends to understanding the tangible benefits of these technologies, particularly in the context of electrical appliance monitoring and control, showcasing their potential to drive down energy consumption and costs.

The survey's results underscore the transformative impact of smart power line communication monitoring and management systems in both residential and commercial settings. While highlighting their significant contributions, the survey emphasizes the need for further research to fully realize the potential of these technologies. Ultimately, this literature survey serves as a valuable resource for researchers, practitioners, and policymakers, providing insights into the ongoing development and deployment of smart power line communication monitoring and management systems.

***Keywords****: Smart meters, Home automation; Energy efficiency, Renewable energy, Smart grid, Data analytics, Sustainability, Power consumption, Sensor networks.*

## 1. Introduction

In the ever-evolving tapestry of global energy dynamics, the responsible management of resources has become an imperative underscored by burgeoning demands and heightened environmental consciousness. At the heart of this complex interplay lies the realm of residential energy consumption, where domestic appliances silently shape the fabric of our daily lives. From the comforting hum of air conditioners to the glow of televisions and the rhythmic cycles of refrigerators and washing machines, these indispensable devices seamlessly integrate into our homes. However, their ubiquitous presence also marks a significant contributor to overall energy usage, propelling considerations of power costs and environmental impact to the forefront.

The modern landscape is characterized by an expanding array of domestic appliances, a testament to the confluence of changing lifestyles and relentless technological advancements. This surge in energy-consuming devices within households necessitates a profound understanding and vigilant monitoring of their energy consumption. Governments, utilities, environmental organizations, and individual homes are compelled to grapple with the escalating demand for energy comprehension and control. Beyond the immediate goal of empowering consumers to make informed decisions, efficient monitoring lays the foundation for initiatives seeking to curtail energy consumption, optimize utility costs, and mitigate environmental footprints.

This literature review embarks on an exploration, delving into a rich reservoir of research dedicated to the intricate task of monitoring the energy consumption of domestic appliances. With a focus on methodologies, technologies, and approaches employed in this dynamic field, the review aims to illuminate the challenges, unveil the advancements, and spotlight the opportunities that researchers and practitioners encounter. Through an in-depth analysis of existing literature, our objective is to extract and disseminate valuable insights, contributing to an enhanced comprehension of the current state of knowledge regarding energy monitoring in the intricate tapestry of residential environments.

## 2. Methodoligies

The primary methodologies for energy monitoring in domestic appliances involves:

### A. Block Diagram:

A hardware part and programming with the Blynk application. The block diagram illustrates the system's connection in a real situation, depicting the current sensor, ADS1115, Arduino Mega2560[9], ESP8266, LCD, and buzzer, along with their functions and interactions.

### B. Integration of Cloud Services:

Integrating the energy meter with the ESP32[12] microcontroller to view the data in the cloud. This integration includes converting RS485 to TTL using MAX 485 and connecting the energy meter and loads as per the wiring diagram.

### C. Software and Stimulation:

The simulation was initially run using PROTEUS[7], and the programming part was done in Arduino IDE. PROTEUS was used for circuit design and simulation, while Arduino IDE was used to write the program and upload it to the Arduino module.

### Data Monitoring Methodologies

**1. Smart Energy Meter Integration with Home Automation:** The smart energy meter is combined with home automation technology[12], allowing for the automation of various household appliances based on user preferences and energy consumption data. This integration enhances the monitoring and control capabilities of the system.

**2. THINGSPEAK-Analytics:** Energy use is analysed using THINGSPEAK [11], which also offers comprehensive information and visualisation of energy usage. It gives customers the flexibility to add more channels for data collecting and analysis and permits them to access information from anywhere in the world.

**3. ZigBee Wireless Sensor Network:** The Energy Management System uses a ZigBee wireless sensor network[8] which is designed for low-power, low-data-rate, and short-range wireless networking and an intelligent home gateway is used for real-time electricity consumption monitoring.

**4. Notification System:** The system is programmed to provide notifications[9] to the end-user based on specific conditions, such as reaching a cost limit value or exceeding the set limit for electricity usage. This keeps the end-user informed about their energy consumption

**5. Radio Frequency (RF) Communication:** RF communication[12] can be used to transmit data from the smart energy meter to a remote device, allowing for real-time monitoring and control of energy consumption.

## 3. Web Based Development

**1. PHP (Hypertext Preprocessor):** PHP[15] is a server-side scripting language which is used to integrate into an IoT system for smart energy monitoring and warning, particularly for handling the web-based aspects of the application like creating API files and for interacting with the database.

**2. Firebase Cloud Messaging:** Firebase Cloud Messaging[15] is a cloud solution for messages on iOS, Android, and web applications. It can be leveraged in an IoT-based Smart Energy Monitoring System to enable communication between the server, backend, and mobile devices. Also enables the generation of push notifications to the user's device.

**3. IFTTT (If This Then That):** IFTTT[6] is a web-based service that allows users to create conditional statements (applets) based on various triggers and actions. IFTTT can be utilized to enhance the automation and integration capabilities of the Energy Monitoring System.

**4. Flask (by Plotly):** Flask[10] is a flexible web framework for Python, and it can be used to develop the backend of a Smart Energy Meter. Flask allows you to create web applications and APIs efficiently using Python programming, making it a suitable choice for handling communication between the smart energy meter and the cloud.

## 4. Related Works

[6] *Boga Jyothi, Chandrika Gompa ,Chandana Vajrapu ,Rajyalakshmi Matchetti ,Appalaraju Yadla, Jai sai ganesh Kaki* "*A smart energy meter using IoT for monitoring and control energy via web application*" discusses the development of an IoT-based energy monitoring system that can help reduce energy waste by allowing users to turn off appliances and monitor energy usage and costs. The system features an ESP32 microcontroller board that communicates with a web server via its built-in Wi-Fi module, and a website that displays energy consumption and controls home appliances over the internet. The system is cost-effective, easy to install, and can be used in all types of residences and industries. The paper emphasizes the importance of IoT-enabled energy systems in promoting energy conservation and reducing electricity wastage and associated costs.

[7] *Saikat Saha, Swagata Mondal, Anindya Saha, P. Purkait* , "*Design and Implementation of IoT Based Smart Energy Meter",* describes the design and implementation of an IoT-based smart energy meter that integrates with communication networks and serves as an integral part of a smart grid system. The smart meter uses Arduino microcontroller with Wi-Fi modem to continuously monitor and record energy meter readings, which can be accessed remotely by electricity supply authorities and consumers.

[8] *Paul Stone Macheso, Doreen Thotho " ESP32 Based Electric Energy Consumption Meter* ", article on the ESP32 Based Electric Energy Consumption Meter, which is a low-cost IoT energy monitoring system that can be used for power billing, smart grid energy management, and home automation. The system is based on the ESP32 microcontroller and non-invasive Current Transformer (CT) sensors, and it can precisely record voltage, current, active power, and cumulative power consumption.

[9] *Hishamuddin Hashim, Mohd Ridzuan Ahmad "Electricity Usage Monitoring Based*

*on Internet of Things",* discusses an Electricity Usage Monitoring system based on Internet of Things (IoT) technology. It presents a detailed study on the design, methodology, hardware components, and data analysis of the system. The project utilizes an Arduino Mega2560, ESP8266, Split Core Current Transformer (SCT013), and ADS1115 to monitor and transmit electricity usage data to the end-user via the Blynk application. Experimental results demonstrate the system's real-time functionality and its ability to provide notifications to the end-user based on electricity consumption. The system aims to enable end-users to monitor and control their electricity usage efficiently.

[10] *Malini V, Kumaresh R K, Kurinjimalar L , Dr. K Prathibanandhi , Venkateshwaran A , Harish Srivathsan J K ," Smart Energy Meter With Cloud Connectivity"*, discusses the Smart Energy Meter with Cloud Connectivity, which is a system designed to improve communication between customers and energy companies by providing more accurate and detailed information on energy usage and rates, also highlights the benefits of using smart

energy meters with cloud connectivity, such as improved transparency and efficiency, and provides a detailed overview of the system's hardware and software components.

[11] *Abhiraj Prashant Hiwale, Deepak Sudam Gaikwad, Akshay Ashok Dongare, Prathmesh Chandrakant Mhatre,"IOT BASED SMART ENERGY MONITORING"*, describes a project that aims to digitize load energy usage readings over the internet using IoT technology. The proposed system eliminates the need for human involvement in electricity maintenance and allows users to monitor energy consumption in watts from a webpage. The system utilizes THINGSPEAK analytics to provide detailed energy usage statistics. The key components used in the system include a current sensor, 16*2 LCD display, Arduino Nano Board, and ESP 8266 Wi-Fi Module.

[12] *M Senthamil Selvan, Dr R Ramesh, H Ragadeepa, T Sivabalan," IOT ENABLED SMART ENERGY METER FOR ENERGY MANAGEMENT",* discusses the importance of energy management and introduces the concept of smart energy meters as a solution. It explains the benefits of smart energy meters, such as real-time energy consumption data, remote access, and informed decision-making for users. The document also provides information on the hardware and software integration required for implementing a smart energy meter system, including the use of ESP32, MAX485, RF modules, and Arduino Nano.

[13] *Abdul Jaleel M M, Syed Suhail Aziz P , Hemavathy P R , Susai Mary J, Kanagaraj Venusamy, "IoT based Smart Energy Consumption and Monitoring System*”, presents a research work that focuses on the development of a smart energy monitoring system using IoT technology. The system utilizes components such as Elmeasure energy meter, RS485 converter, and LoRaWAN module to measure power consumption in real-time. It aims to provide high-resolution data for power consumption, enabling improved feedback to consumers and enhancing power conservation and management. The system integrates with the Things Network (TTN) using MQTT as a messaging protocol for data transfer. The graphical representation of data allows for quick analysis and informed decision-making.

[14] *Naziya Sulthana, Prakyathi N Y, Rashmi N, Bhavana S," Smart Energy Meter and Monitoring System using IoT",* discusses the benefits of using IoT technology to measure electricity consumption in home appliances and generate bills automatically, it also covers the hardware components of the system, including the energy meter, relay, and Wi-Fi module, as well as the proposed methodology for data communication and control.

[15] *Farhan Sadik Sium, Arnob Ghosh, Md. Junaed-Al-Hossain,* “*IoT Based Smart Energy Monitoring and Warning System",* provides a study on an Internet of Things-based gadget and application that can track and alert users to their energy usage. Users can receive alerts about impending load shedding due to overload by setting up the device in both homes and substations. Users of the app can also view their real-time electricity bill tracking. The study offers specifics on the system's hardware and software, as well as its possible advantages for encouraging energy conservation.

## 5. Existing System

Smart meters represent a significant leap forward in the energy industry's modernization, utilizing state-of-the-art technologies for more efficient electricity tracking and management. These devices employ digital measuring methods with specialized sensors, accurately converting analog electrical impulses into precise digital data. The integration of two-way communication modules, such as radio frequency or cellular technology, establishes seamless connectivity between utility providers and smart meters, enabling real-time data collection and remote communication for updates or commands.

Despite their technological prowess, the deployment of smart meters is not without challenges. Privacy concerns arise due to the granularity of the collected data, potentially revealing sensitive information about residents. The large-scale implementation of smart meters incurs significant upfront expenses, covering aspects like staff training, communication network deployments, and infrastructure modifications. Moreover, the two-way communication capability introduces cybersecurity challenges, such as unauthorized access and data breaches. Addressing these concerns is crucial to ensuring a secure and successful integration of smart meters into the energy infrastructure.

Smart metres have problems with user involvement even if they provide detailed consumption data. It's possible that customers won't actively use or fully understand the detailed information supplied. The interoperability issues and worries about electromagnetic fields (EMFs) add to the complexity of the smart metre ecosystem. The further use of smart metre technology will be greatly aided by continued initiatives to build user confidence by openness and education, as well as by developments in resolving privacy and security concerns. Policies, consumers, and industry stakeholders working together will play a critical role in determining how energy monitoring and management develops in the future.

## 6. Proposed System

The primary objective of the proposed project is to develop an advanced system for monitoring electricity consumption, empowering customers with control over their energy use and real-time information. The project comprises several key modules, beginning with the Sensor Interface Module, which collects data from voltage and current sensors. Subsequently, the Analog Signal Processing Module refines the analog signals, and the Analog-to-Digital Conversion Module transforms them into a digital representation. The Arduino Processing Module manages digital data processing, while the Wireless Transmission Module, utilizing the ESP8266 module, ensures effective wireless connectivity for transmitting processed data.

One essential element is a strong web application with an easy-to-use interface that encourages user participation and offers insights into patterns of electricity consumption. Through the interface, users can customise the monitoring parameters, changing the transmission frequency and calibration. Customers may actively participate in managing their energy usage thanks to this user-centric approach, which improves the entire customer experience.

The project prioritises data security and user privacy, putting strong user authentication and permission processes in place. The system establishes a connection with a server or cloud platform to guarantee safe data storage and movement. By using a database to store historical data and real-time analytical algorithms, the backend data processing system efficiently handles incoming data. The implementation of strict security protocols demonstrates the dedication to protecting user data.

Going beyond basic data collection, the project incorporates advanced capabilities, including the integration of data visualization tools and libraries. This feature enables dynamic displays of electricity consumption data through real-time graphs and charts, fostering a deeper understanding for users and facilitating well-informed decision-making. With its comprehensive solution encompassing data collection, processing, user interaction, security protocols, and sophisticated visualization, this project not only addresses current needs but also establishes a foundation for an intelligent and adaptable monitoring system capable of accommodating future advancements in the energy management domain.

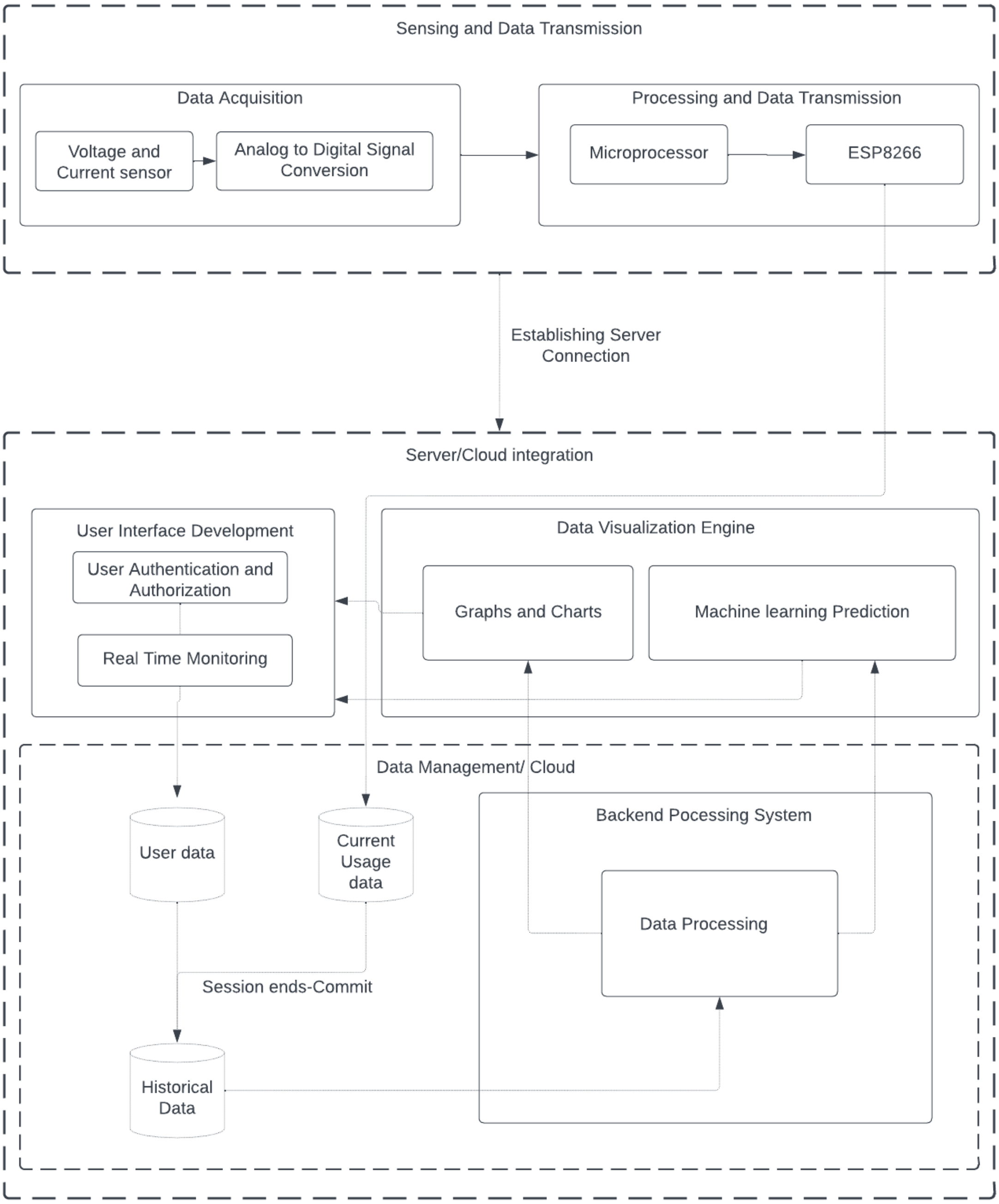


**Fig 1 : Architecture diagram of the proposed system**

## 7. Conclusion

The energy consumption monitoring system is a groundbreaking initiative that redefines how end users engage with and manage their energy usage. Through real-time insights and an intuitive user interface, individuals gain the ability to make informed decisions, optimizing electricity consumption and reducing expenses. The system places a strong emphasis on security, ensuring the safeguarding of user data and fostering trust among users. With the added convenience of remote accessibility, users can manage and monitor their energy usage from any location, adapting to the demands of contemporary lifestyles. This project actively encourages users to participate in reducing their carbon footprint, aligning with global sustainability goals and fostering environmental consciousness. The integration of real-time analysis and dynamic visuals enhances users' comprehension of energy patterns, while historical insights provide strategic planning opportunities. Beyond individual benefits, the project contributes to a more mindful and sustainable approach to energy consumption, benefitting both end users and the broader community. In essence, it marks a significant step towards an efficient, economical, and environmentally responsible future in energy management.

## 8. Future Works

The future trajectory of the electricity consumption monitoring project holds exciting prospects for heightened impact and innovation. Machine learning algorithms are poised to revolutionize the system, elevating its capacity to predict and adapt to individual consumption patterns. This opens the door to personalized suggestions for energy efficiency, providing users with tailored strategies for optimal electricity management. The integration of smart appliances and IoT devices emerges as a pivotal avenue, expanding the system's reach for precise regulation and automation of energy-intensive devices. Collaborations with utility providers to incorporate real-time price data empower users to make more economical choices and engage in dynamic energy management practices.

The project's evolution may extend to supporting advanced grid interactions, demand response initiatives, and bolstering overall grid stability. Additionally, exploration of cutting-edge technologies like blockchain for secure energy trading or sharing scenarios adds an innovative layer to the project's potential. Lastly, fostering community engagement through gamification and social elements could instigate a more cooperative attitude toward energy conservation, positioning the initiative as a catalyst for broader social change. Overall, the future developments hold the promise of enhancing system functionality, integrating cutting-edge technology, and contributing to the establishment of a more interconnected and sustainable energy landscape.

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