E-ISSN: 2583-9667
Indexed Journal
Peer Reviewed Journal
https://multiresearchjournal.theviews.in

Received: 09-01-2025
Accepted: 21-02-2025

INTERNATIONAL JOURNAL OF ADVANCE RESEARCH IN MULTIDISCIPLINARY

Volume 3; Issue 2; 2025; Page No. 307-311

Smart Energy Analyze

[1]Dr. AS Arunachalam and [2]L Sathiyaraman

[1]Professor, Department of Computer Science and Information Technology, Vels Institute of Science, Technology and Advanced Studies, Pallavaram, Chennai, Tamil Nadu, India
[2]PG Student, Department of Computer Science and Information Technology, Vels Institute of Science, Technology and Advanced Studies, Pallavaram, Chennai, Tamil Nadu, India

DOI: https://doi.org/10.5281/zenodo.15590981

Corresponding Author: Dr. AS Arunachalam

Abstract

Efficient energy utilization plays a very vital role for the development of smart grid in power system. So, proper monitoring and controlling of energy consumption is a chief priority of the smart grid. The existing energy meter system has many problems associated to it and one of the key problem is there is no full duplex communication. To solve this problem, a smart energy meter is proposed based on Internet of Things (IoT). The proposed smart energy meter controls and calculates the energy and uploads it to the cloud from where the consumer or producer can view the reading. Therefore, energy analyzing by the consumer becomes much easier and controllable. This system also helps in detecting power theft. Thus, this smart meter helps in home automation using IoT and enabling wireless communication which is a great step towards Digital India.

The effort of collecting electricity utility meter reading. Internet of Things (IoT) present an efficient and co-effective to transfer the information of energy consumer wireless as well as it provides to detect the usage of the electricity the main intention of this project is measure electricity consumption in home appliances and generate it's bill automatically using IoT. The energy grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. IoT can be utilized for various applications of the smart grid with distributed energy plant meter, energy generation and energy consumption meter smart meter, energy demand side management and various area of energy production.

Keywords: Smart energy analyzer, energy meter, current sensor, esp8266

1. Introduction

The energy consumption can be monitored by using an electric device called energy meter. The cost and the regular usage of Power consumption are informed to the user to overcome high bill usage. The Energy meter shows the amount of units consumed and transfers the data to both the customer and to the electrical board so this helps in reducing man-power. The user can check their Power usage from anywhere and at any time interval. The IoT is used to Turn on/off the household appliances using relay and Arduino interfacing. The objective of this system is to monitor the amount of electricity consumed. The distributor and the consumer both will be benefited by eventually reducing the total Power consumption.

A Smart Energy Analyzer records information such as consumption of voltage levels, current, and power factor. The cost and the regular usage of Power consumption are informed to the user to overcome high bill usage. The Energy meter shows the amount of units consumed and transfers the data to both the customer and to the electrical board so this helps in reducing man-power. The user can check their Power usage from anywhere and at any time interval. Recorded data's are collected in the Cloud Server and the user can view Energy Consumption analytic data through the Web APP.

2. Literature Survey

In (2021) [1] A significant advantage of implementing advanced metering infrastructure (AMI) in smart grid (SG) is the feature to allow utilities to monitor and curb power theft and proliferation. with help of sm communication becomes bidirectional. AMI test rig, consisting of three consumers, a distribution station (DS) and an operation center is designed to select the load 3 single-phase Phoenix 2 SMS are used to track the power consumption of each consumer.

In (2020) [2] They used Linear Regression method for detecting power theft by continuously monitoring the consumer and distribution end smart meters data. Android applications are developed for monitoring consumption & billing information of consumers and alerting the authorities in the event of theft. The presented system is capable of detecting power theft due to meter bypass, meter tampering and direct line hooking. As an additional feature, direct control of smart meters from distribution authorities is implemented for providing access/denial of power supply for an individual consumer. A prototype circuit is developed using ATmega328P micro-controller with NodeMCU as a WiFi module, for validating the presented system.

In (2019) [3] They had presented internet connected energy monitoring and controlling system that increases awareness of energy consumption amongst devices and users. Energy awareness enables the user to control the power state of the devices as per there needs which minimizes the energy use. In the coming future, each individual device will have their own identity that can share and communicate the information over the IP network.

In (2018) [4] The smart meter has a ZigBee transmitter which sends energy consumption data periodically to the Gateway over ZigBee network. The gateway receives the data and uploads it to the utility provider's cloud/database using internet connection. The utility provider monitors the data and manages the customer's billing information. The software called Digi XCTU is used to configure the ZigBee radios in different modes. An SD card module is also being used to store.

3. Methodology

The methodology for developing the Smart Energy Management System involves a structured, multi-phase approach to ensure accurate energy monitoring, seamless data communication, and user-friendly control. Initially, the hardware is designed by integrating the ZMPT101B voltage sensor and ACS712 current sensor with the Arduino Uno to measure real-time voltage, current, and power consumption. This data is processed and used to trigger safety mechanisms such as a relay-based power cutoff in cases of over-voltage or over-current. In the next phase, data is wirelessly transmitted using the NRF24L01 module or directly sent to the cloud via the ESP8266 Wi-Fi microcontroller. A responsive web application is developed using HTML, CSS, and JavaScript, which allows users to log in, monitor energy usage through interactive charts, and control appliances remotely. Alerts for high consumption or billing updates are sent via notifications, and automation ensures timely disconnection of power during critical scenarios. Finally, the system undergoes extensive testing for accuracy, usability, and reliability before being deployed in a real-time environment. It is also designed to be scalable, allowing integration across multiple households with individual user credentials and centralized monitoring.

4. Existing and proposed system

The existing electricity billing system in many regions is still dependent on manual processes, where field personnel from the electricity board physically visit each household or business every month to record meter readings. These readings are then used to generate electricity bills that are either delivered in person or sent via post. This traditional approach is not only time-consuming but also prone to human error, leading to incorrect billing and consumer dissatisfaction. Additionally, there is no provision for consumers to monitor their energy usage in real-time or receive alerts when their consumption exceeds a certain limit. This lack of transparency and automation often results in delayed bill payments, unnoticed power overuse, and overall inefficiency in the billing process.

To address these challenges, the proposed system introduces an advanced, IoT-based Smart Energy Analyzer built using NodeMCU, integrated with Wi-Fi modules. This system allows continuous, real-time monitoring of power consumption and automatically stores data in EEPROM for reliable, non-volatile memory retention. Users can view live energy readings on a dedicated web dashboard, providing greater transparency and control over electricity usage. Furthermore, the system is capable of sending SMS alerts when the consumption reaches a predefined limit, ensuring that users are always informed about their usage status. It also offers the ability to remotely control the power supply, such as disconnecting or reconnecting the load, which enhances consumer control and safety. By automating the entire process and reducing the need for manual intervention, this proposed smart energy solution significantly improves the accuracy, convenience, and efficiency of electricity billing and management.

5. Implementation

The energy monitoring system begins by converting the 230V AC power supply into a 5V DC supply using a DC adapter, which powers the core components of the system, including the Arduino Nano and NodeMCU microcontrollers. The system uses voltage and current sensors to monitor the energy consumption of connected appliances. The voltage sensor measures the input voltage, while the current sensor detects the current flowing through the appliances. These sensors provide real-time data on the power usage, which is then calibrated by the Arduino Nano.

After the calibration, the sensor data is transmitted to the NodeMCU via I2C communication. The NodeMCU handles the data processing and uploads it to a cloud database (e.g., Firebase) through its Wi-Fi module. This data can be accessed via a web application, where users can monitor their energy consumption history, view real-time voltage and current readings, and analyze their usage patterns.

In addition to data monitoring, the system includes a relay module that can be triggered to disconnect power from an appliance if the voltage or current exceeds a predefined threshold. This protective feature helps prevent damage to appliances caused by abnormal power conditions. The relay is controlled by commands sent from the NodeMCU based on the sensor data.

To enhance the user experience, the system integrates push notifications. The NodeMCU monitors the sensor data and, if an abnormal fluctuation in voltage or current is detected, sends a notification to the user's device. This feature allows users to stay informed of any issues in real time, ensuring timely responses to potential electrical hazards.

Furthermore, the system tracks energy consumption over time and generates billing information on a monthly basis, replacing traditional manual billing systems. By storing the

data in the cloud, users can access their energy usage history and receive notifications related to their consumption. The system is scalable and can be applied to monitor energy usage for multiple appliances within a home or a larger environment, such as a gated community, providing an efficient solution for energy management.

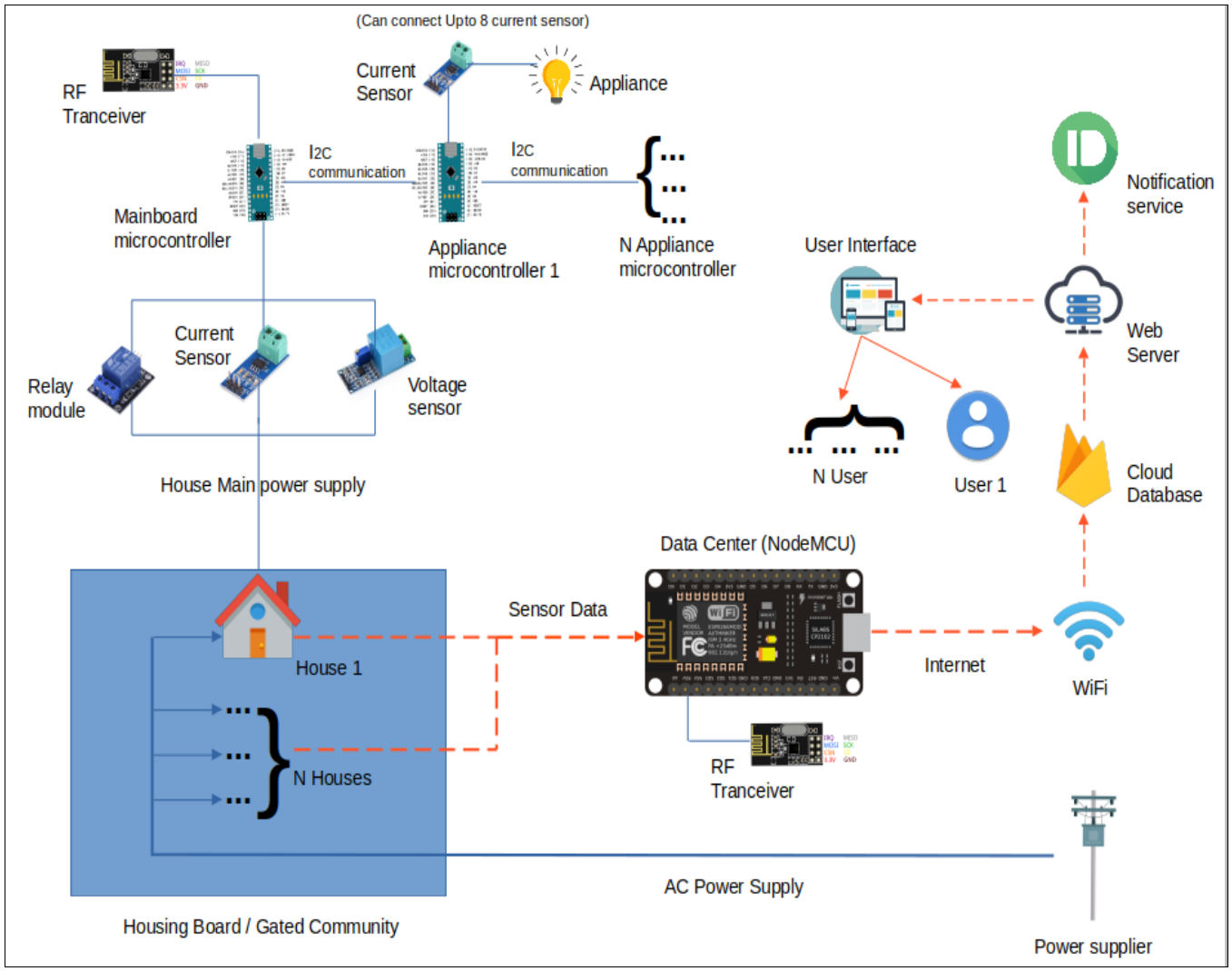

Fig 1: System Design

The energy monitoring system uses Arduino Nano and NodeMCU microcontrollers to measure and manage energy consumption. Voltage and current sensors monitor the appliances, sending data to the Arduino, which then transmits it to the NodeMCU. The NodeMCU uploads this data to a cloud database.

A relay module disconnects power if voltage or current exceeds safe limits. The system sends push notifications for abnormal conditions and tracks energy usage, providing monthly billing information. A web application allows users to view real-time data and historical consumption. The design is efficient, scalable, and user-friendly.

Result and discussion

In the proposed system we have used 230v 40w bulb as one load and 230v 1200w Dryer plus heater as secondary load, we have connected the both the load to the current sensor of the proposed system And the main power supply is connected to the relay module. When we switch ON the Data center module, it will get connected to WiFi and sync with the Firebase through the Internet and it will start fetching sensor data from houses through the RF Module.

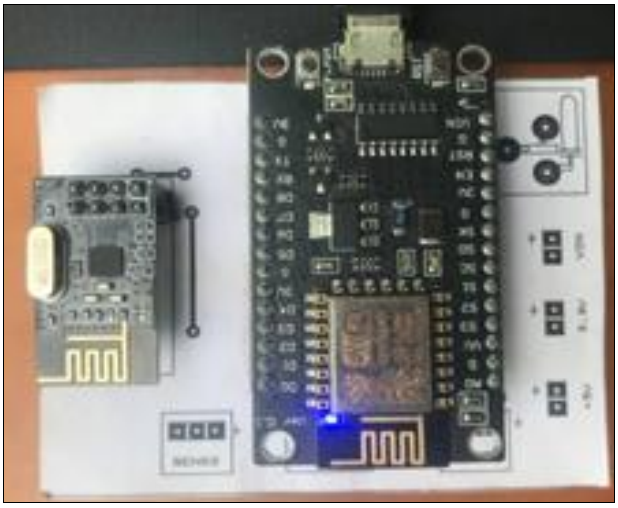

Fig 2: Data Center

When we switch ON the Energy Analyzer, it will get connected to the Data center through the RF Module and it

start fetching Main Phase 1 Current sensor data which the main power supply of the house is connected to this sensor. And it also fetch sensor data from its slave Energy analyzer. The first Load 40w bulb is connected to the Slave's First current sensor and the secondary load 1200w dryer and heater is connected to the Slave's second current sensor. In the initial state the Main Power supply sensor data and the Load's Sensor data will recorded as 0 as No load is in Active Currently. When we switch ON the Load one (40w bulb) the energy consumption of the load is start recording in Firebase by transferring sensor data to Data Center and Uploading in Firebase Database.

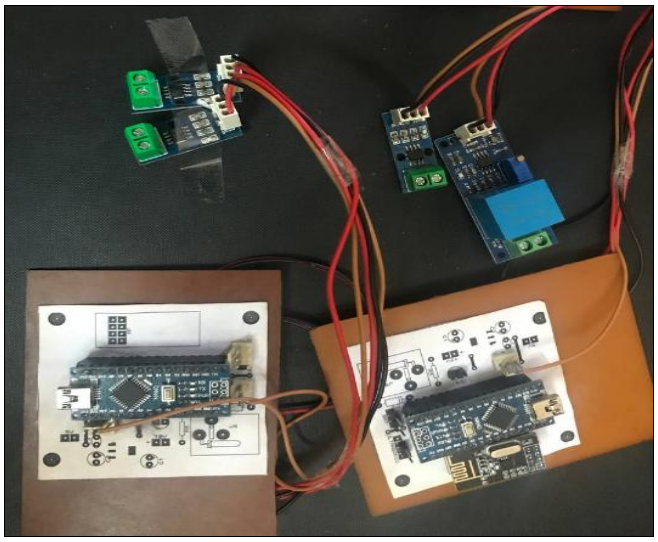

Fig 3: Main Board

As the load is in ON state the Overall energy consumption is get updated from Main current sensor by transferring to Data center and uploading to Firebase Database. The sensor data are got calibrate in the data-center and The Sensor data in Amp's is converted onto the Watt per hour (Wh). Where I is get from corresponding current sensor and Voltage is get from the Voltage sensor which is connect to the Main Power Supply. By this Power is Get calculated. This process will iterate in microseconds.

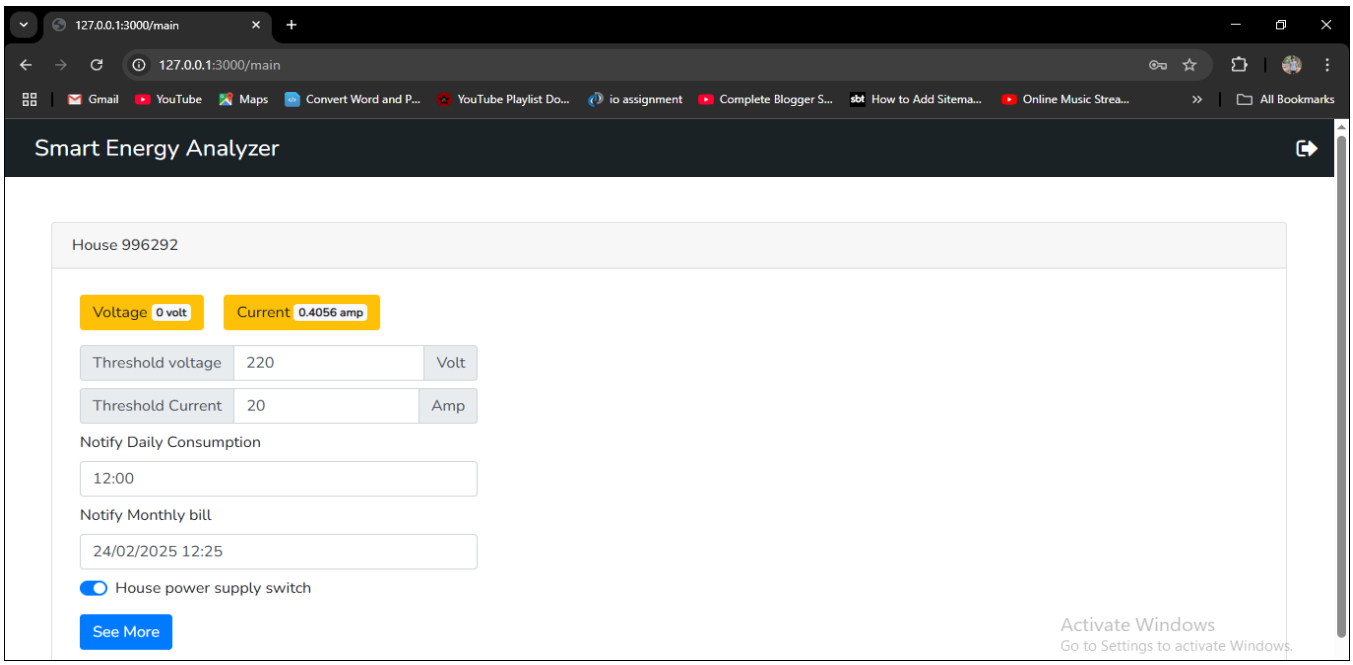

Fig 4: Web App

By using the Web Application we can View the Real-time Input AC Voltage of the House and Overall Current Consumption which will be updated per second. The History of the Over consumption of house and energy Consumption of the individual Load can be viewed by using the Chart View the Web Application.

6. Conclusion

The Smart Energy Analyzer is a trending IoT-based system designed to monitor and control household appliances to manage energy consumption. The prototype currently tracks the power usage of two appliances (fan and light) and uploads the data to a cloud server, providing real-time

energy consumption information.
In the future, the system will be expanded to control more appliances like refrigerators, air coolers, and televisions. Human presence will trigger appliance usage, and manual control will be available to save energy. Planned improvements include enhancing sensor accuracy, extending the RF transceiver's range, speeding up data transfer, adding WhatsApp notifications, and enabling dynamic user creation in the web app.
The system aims to be scalable, moving from single-house applications to larger community or apartment settings, with plans for broader smart home integration.

7. References

1. Jithin Jose K, Mohan L, Nijeesh UK, Benny TC. Smart energy meter. International Journal of Engineering Trends and Technology (IJETT). 2015;22(4):183–186.
2. Paul DE, Vijayan A. Smart energy meter using Android application and GSM network. International Journal of Engineering and Computer Science. 2016;5(3):16058–16063.
3. Sahani B, Ravi T, Tamboli A, Pisal R. IoT based smart energy meter. International Research Journal of Engineering and Technology (IRJET). 2017;4(4):1519–1522.
4. Singh A, Gupta R. IoT based smart energy meter. International Journal of Advance Research and Development (IJARND). 2018;3(3):25–28.
5. Islam MR, Sarker S, Mazumder MS, Ranim MR. An IoT based real-time low-cost smart energy meter monitoring system using Android application. International Journal of Engineering and Techniques. 2019;5(3):89–93.
6. Nanoti A, Patil V, Shetty S, Nath D. IoT based smart energy meter. International Journal of Creative Research Thoughts (IJCRT). 2020;8(2):403–407.
7. Pimple M, Thopate S, Nikam A, Gadekar S. IoT based smart energy meter using ESP 32. In: International Conference on Communication and Information Processing (ICCIP); c2021 Sep 5. Abstract 3917892.
8. Bacchad V, Doye V, Buddhe Y, Udapure S, Ther K, Pardhi J, Admane A. Smart energy meter with load control using IoT. International Research Journal of Modernization in Engineering Technology and Science (IRJMETS). 2023;5(2):201–205.