

# Reducing Resource Energy Wastage for Smart Homes

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**Abstract-** Electricity is an essential requirement in modern life, and the increasing dependence on electrical systems demands efficient monitoring and maintenance. In many cases, irregularities in electrical machines and power usage remain undetected, which may affect system performance and safety. This project proposes an IoT-based smart monitoring system that continuously observes electrical parameters and machine operating conditions in real time. Whenever any irregularity is detected, the system automatically identifies it and sends alerts to the user through an online platform. The proposed system also supports timely corrective actions by providing necessary information to rectify the identified irregularities before they lead to major failures. By enabling continuous monitoring, early detection, and preventive maintenance, this project improves system reliability, enhances operational safety, and supports efficient utilization of electrical energy. The implementation of this IoT-based solution contributes to smarter electrical system management and reduced manual intervention.

**Keywords-** Internet of Things (IoT), Smart Monitoring System, Electrical Parameter Monitoring, Real-Time Monitoring, Fault Detection, Preventive Maintenance, Energy Management, Machine Condition Monitoring, Remote Alerts, Predictive Maintenance, Power System Safety, Automation.

## I. INTRODUCTION

Though electricity is very essential in day to day life, the proper utilization of it must be done. We can properly consume the electricity as well as calculate the electricity consumption by using the electric meter. The vulnerability about the supply of energy can tell the working of whole economy, especially in creating financial aspects. It is the necessity to manage consumption of electricity due to limited availability of resources. So the aim of this paper is to recognize and eliminate the misuse of electricity. Internet of things has helped many organizational systems to improve efficiency, increase the speed of processes, minimize error and prevent theft by coding and tracking the objects. Computing and communications has its future in the technological transformation brought by the IOT. Power consumption can be reduced to a great extent if we can monitor our daily power usage and switch off appliances which are unnecessary consuming electricity. This paper focuses on developing a monitoring system using the concept of Internet of

things. Conservation of energy is one of the most important need of the day. The concept of energy efficient devices has come up in various areas such as lighting, air conditioning and so on. Energy monitoring is an important tool for determining the energy efficiency of various devices. Energy bills are generated on monthly basis and the user has the option of analysing the consumption details every month. The energy meter installed in the residential buildings show the energy consumed by the household. Very often, devices which operate in standby mode consume a significant amount of power about which the end customer is unaware of. Many a times the domestic electricity bill shows excess amount which causes consumer dissatisfaction and complaints. Internet of things (IoT) has opened up a plethora of applications in numerous fields such as medical and healthcare systems, smart home automation and environmental monitoring. IoT is expected to bring about large amount of change in the field of ubiquitous computing. IoT based energy management system can contribute a lot into conservation of energy.

## II. LITERATURE SURVEY

### **The Electric Meter Reading System Based On Wireless Micro Computer**

**AUTHOR:** Lun Cuifen, Zhang Xiaoqin, Li Yanping, Liuce (2010).

This paper presents the design and implementation of an electric meter reading system based on a wireless micro-computer platform. The system aims to replace traditional manual meter-reading methods by integrating wireless communication, embedded control, and automated data acquisition. A low-power micro-controller is embedded into the electric meter to collect consumption data, which is then transmitted through a wireless module to a central monitoring station. The proposed system supports real-time data collection, remote monitoring, and multi-node networking, significantly improving accuracy and operational efficiency. Experimental results demonstrate stable wireless transmission, reduced human error, and effective performance over a wide range of household and industrial environments. The system provides a reliable and scalable solution for modernizing meter-reading processes in power distribution networks.

### **Design And Implementation Of Wireless Power Monitoring System For Public Buildings**

**AUTHOR:** Shu-ping Le, Hong Zeng, Jian Qiu, Song Zhang (2013).

This paper proposes a wireless power monitoring system designed specifically for public buildings to improve energy-use supervision and management efficiency. The system integrates embedded sensing nodes, wireless communication modules, and a centralized monitoring platform to collect and transmit real-time power consumption data. Each sensor node measures electrical parameters such as voltage, current, and energy usage, and communicates the data wirelessly to a control center for analysis and storage. The system enables remote monitoring, fault detection, and energy-usage optimization without the need for manual inspection. Experimental deployment results show that the system provides stable communication performance, high measurement accuracy, and scalability for various building environments.

### **Communicating Power Supplies: Bringing The Internet to The Ubiquitous Energy Gateways Of Electronic Devices.**

**AUTHOR:** S. Lanzisera, D. Pajak(2014)

This paper explores the concept of communicating power supplies (CPS) as a means of integrating Internet connectivity directly into the power infrastructure of electronic devices. By embedding communication and sensing capabilities into power supplies, CPS technology enables devices to act as networked energy gateways without requiring major hardware redesign. The proposed architecture supports real-time monitoring of power consumption, device identification, and remote control through Internet-of-Things (IoT) protocols. The paper discusses system design considerations, communication mechanisms, and security aspects related to CPS deployment. Experimental evaluations demonstrate that CPS can provide accurate energy data, low communication overhead, and seamless integration into existing electronic ecosystems. This approach offers a scalable path to enabling widespread IoT functionality through already-ubiquitous power-supply components.

### **Internet of Things (IoT): A Literature Review**

**AUTHOR:** S.Madakam, S. Tripathi(2015)

This paper provides a comprehensive literature review of the Internet of Things (IoT), covering its foundational concepts, technological components, applications, and future research directions. The review analyzes how IoT integrates sensing devices, communication networks, data-processing platforms, and automation technologies to enable interconnected smart environments. Various IoT architectures, communication protocols, and enabling technologies such as RFID, wireless sensor networks, and cloud computing are examined. The study highlights applications across sectors including healthcare, transportation, energy management, and smart homes. Challenges related to security, privacy, interoperability, and standardization are also evaluated. The paper concludes by outlining emerging trends and identifying gaps that require further investigation to support large-scale IoT deployment.

### **Design and Implementation Of Smart Energy Meter**

**AUTHOR:** V. Preethi, G. Harish(2015)

This paper presents the design and development of a smart energy meter capable of accurately measuring electrical energy consumption while enabling advanced monitoring and communication features. The proposed system integrates a microcontroller, energy- measurement circuitry, and a communication module to support real-time data acquisition and remote access. The smart meter can transmit consumption data to a central server for billing, analysis, and load management purposes. Additional features such as tamper detection, automated meter reading, and user notification capabilities are incorporated to enhance system reliability and usability. Experimental results indicate that the meter provides precise measurement, low power consumption, and stable communication performance. The solution demonstrates the potential for modernizing conventional metering infrastructure and supporting smart-grid initiatives.

### **Smart Home Control and Monitor System Using Power of IoT's**

**AUTHOR:** Abhijeet Rajurkar, Onkar Shinde, Vinayak Shinde, Bhushan (2016)

This paper presents the design and implementation of a smart home control and monitoring system utilizing Internet of Things (IoT) technology to enhance automation, energy efficiency, and user convenience. The proposed system uses interconnected sensors, actuators, and communication modules to remotely monitor household parameters such as temperature, lighting, and appliance status. A centralized IoT platform enables real-time control, data logging, and notification services through mobile or web interfaces. The architecture focuses on low-cost hardware integration, wireless communication, and user- friendly operation. Experimental results demonstrate reliable connectivity.

### **Smart Home Monitoring Using Android And Wireless Sensors**

**AUTHOR:** Suresh Sankaranarayanan, Au Thien Wanb, Aida Harayani Pusac(2014)

This paper presents a smart home monitoring system that integrates wireless sensor technology with an Android-based mobile application to provide real-time surveillance and control of household environments. The system incorporates distributed wireless sensors to measure parameters such as temperature, motion, and light levels, transmitting data to a central processing unit for aggregation and analysis. An Android application serves as the user interface, enabling remote access, alerts, and device management through a simple and intuitive platform. The proposed architecture emphasizes low power consumption, ease of installation, and scalability. Experimental results confirm stable wireless communication, accurate sensor readings, and efficient remote monitoring capabilities. The system demonstrates a practical solution for enhancing home security, energy management, and user convenience.

### **Automatic Lighting and Control System For Classroom**

**AUTHOR:** Suresh S, Anusha H.N.S, Rajath T, Soundarya P, Prathyusha V(2016)

This paper presents an automatic lighting and control system designed to improve energy efficiency and comfort within classroom environments. The proposed system uses a combination of sensors—including motion detectors and ambient light sensors—to intelligently regulate lighting based on occupancy and illumination levels. A microcontroller-based control unit processes sensor data and adjusts lighting intensity to minimize energy wastage while maintaining optimal visibility for students and instructors. The system also supports manual override and status monitoring features for enhanced usability. Experimental results from a prototype implementation demonstrate reduced power consumption, reliable responsiveness, and improved lighting management. The solution provides a practical approach for integrating automation into educational infrastructure.

### **Energy Management System For Smart Home**

**AUTHOR:** Shamika Kshirsagar, Mr. D. E. Upasani(2016)

This paper presents an energy management system designed for smart homes to optimize power usage, reduce wastage, and provide real-time monitoring of household appliances. The proposed system integrates sensors, microcontrollers, and communication modules to track energy consumption and control connected devices based on user preferences or predefined rules. A user interface enables homeowners to view energy usage patterns, receive alerts, and manage appliances remotely. The architecture emphasizes low-cost implementation, ease of installation, and improved energy efficiency. Experimental testing shows that the system effectively reduces unnecessary power consumption.

### Home Automation Using Internet Of Things

**AUTHOR:** Vinay Sagar K, Kusuma S(2015)

This paper presents a home automation system based on Internet of Things (IoT) technology, enabling remote monitoring and control of household appliances through a unified digital interface. The system utilizes sensors, actuators, and wireless communication modules to automate tasks such as lighting, appliance control, and environmental monitoring. A microcontroller-based control unit processes input data and transmits information to a cloud platform, allowing users to interact with the system via smartphones or web applications. The proposed architecture emphasizes low-cost hardware, ease of deployment, and improved user convenience. Experimental results demonstrate reliable communication, efficient automation performance, and enhanced energy management. The solution highlights IoT's potential in advancing next-generation smart home systems.

### III. LITERATURE SURVEY

The existing systems used in modern homes for energy and resource management are still largely limited, fragmented, and far from being truly intelligent. Most households continue to rely on basic automation tools such as simple motion-based lighting, timer-controlled appliances, and manual on/off switching, which provide only minimal control and do not actively reduce wastage. Even though smart appliances like smart TVs, smart air

conditioners, and smart washing machines have become more common, they operate independently and are not connected through a unified intelligent platform. These devices perform specific tasks using fixed schedules or pre-programmed rules, but they lack the ability to learn from user behavior, adapt to changing conditions, or collaborate with other appliances to optimize overall resource consumption. Current IoT-based monitoring systems installed in some smart homes—such as electricity usage trackers, water-level sensors, or environmental sensors—mainly focus on giving notifications or real-time readings. However, these systems stop at monitoring and rarely take automated corrective action, leaving most decisions in the hands of the user. As a result, if the user forgets to turn off a device or respond to an alert, the wastage continues despite the presence of technology.

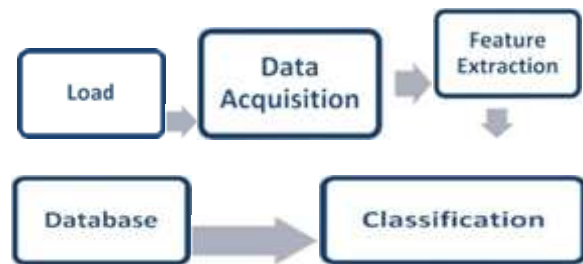


Fig 3.1 Basic Block Diagram Of NILM.

In many homes, mobile apps are used to control devices remotely, but this again relies heavily on manual interaction. Each device typically comes with its own mobile application, creating a fragmented ecosystem where the user must switch between multiple interfaces to monitor or operate various appliances. This lack of interoperability between different brands and platforms prevents smooth coordination and limits the potential for intelligent decision-making. For example, a smart AC might cool a room even when a window is open, because it does not communicate with the window sensor or consider occupancy data. Similarly, smart lighting systems may turn on based on motion detection without understanding whether natural sunlight is sufficient, leading to unnecessary electricity usage.

Management systems in existing homes also suffer similar drawbacks: conventional irrigation systems operate on fixed schedules rather than soil moisture or weather forecasts, while water pumps run manually without detecting tank levels or pipeline leakage. These outdated or semi-smart mechanisms contribute to significant water wastage, especially in regions where water scarcity is a growing concern.

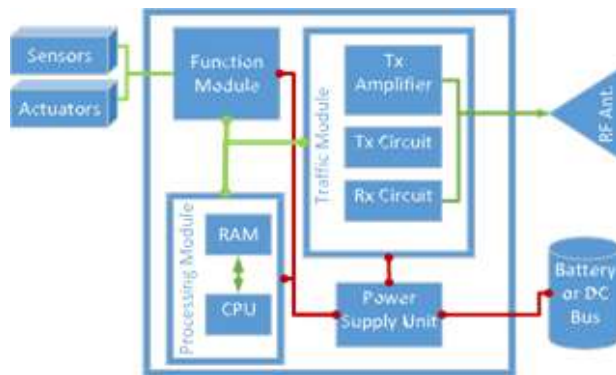


Fig 3.2 Block diagram of IOT node.

Although several products in the market claim to support energy savings, their impact is limited due to the absence of advanced analytics, AI-driven prediction, or automated optimization. The current systems do not incorporate occupancy-based control, meaning appliances may continue functioning even when rooms are unoccupied, a major contributor to energy waste. Traditional HVAC (heating, ventilation, and air-conditioning) systems function without real-time adaptation based on number of occupants, user comfort patterns, electricity tariffs, or outside weather conditions. This results in higher energy bills and inefficient resource utilization year-round. Moreover, current home setups do not feature a centralized intelligent controller that integrates all appliances, sensors, and environmental data into a single decision-making unit. Without this centralized intelligence, appliances fail to coordinate; for instance, washing machines do not schedule their cycle based on non-peak.

tariff hours, geysers continue heating water even when unnecessary, and refrigerators operate without energy load balancing.

Another key drawback of existing systems is the lack of predictive capabilities. They cannot forecast energy demand, detect abnormal consumption patterns, or anticipate situations that may lead to wastage. For instance, they cannot identify that electricity consumption is unusually high in a particular appliance, indicating malfunction or inefficient operation. They also lack learning capabilities that could adapt the home environment based on user lifestyle, daily routines, or seasonal behavioral changes. Most existing systems work reactively rather than proactively, taking action only when prompted by the user instead of preventing wastage on their own. Security and privacy issues also limit the use of advanced smart home solutions; many users avoid deeper automation due to fear of data leakage or lack of confidence in device interoperability.

#### IV. PROPOSED SYSTEM

##### Introduction to Proposed System

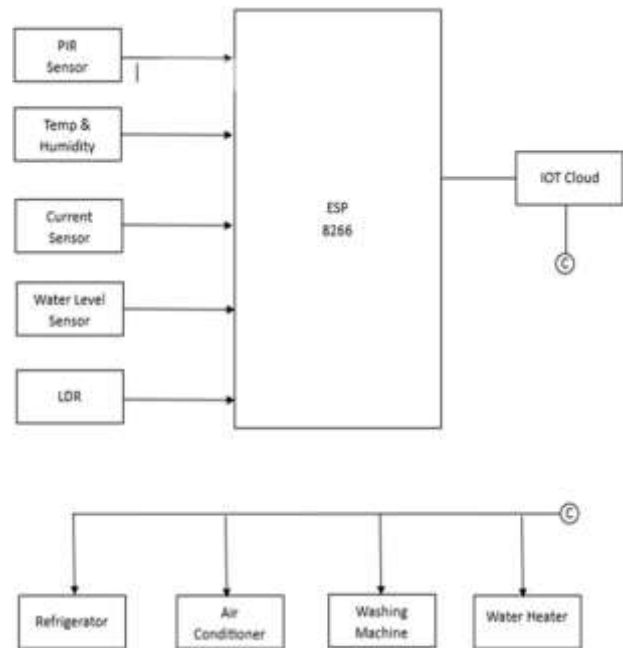


Fig 4.1 Block Diagram of Proposed System

### ESP 8266 Module

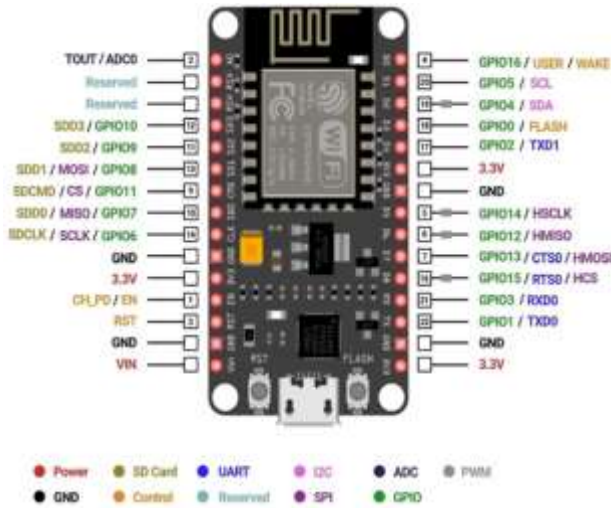


Fig 4.2 ESP 8266 Pin module

The ESP8266 module plays a central role in the sustainable smart home system by acting as the main controller that manages all intelligent appliances. It continuously collects data from various sensors such as PIR motion sensors, LDR light sensors, temperature and humidity sensors, and water or gas detectors. Using this real-time information, the ESP8266 processes and makes automated decisions, such as switching off lights when no motion is detected, adjusting appliances based on environmental conditions, or sending alerts when abnormal activity is sensed.

### Pir Motion Sensor



Fig 4.3 PIR motion sensor

The PIR (Passive Infrared) sensor detects human motion by sensing changes in infrared radiation. It is commonly used in automatic lighting systems. In this project, the PIR sensor is attached to the smart light so that the light only turns ON when movement is detected. When there is no movement for a set time, the light automatically switches OFF. This automation significantly reduces electricity wastage in rooms like hallways, bathrooms, and bedrooms.

### Dht11 / Dht22 Temperature & Humidity



Fig 4.4 DHT11 / DHT22 temperature and humidity sensor

It helps the smart fan to operate intelligently. When the temperature increases beyond the threshold, the fan switches ON automatically and turns OFF once the temperature drops. This ensures energy-efficient cooling and comfort. It is widely used in smart home automation due to its low cost, reliability, and easy integration with microcontrollers. Temperature and humidity sensors are essential tools for monitoring and controlling environmental conditions in a wide range of applications, from industrial processes to home automation. These sensors measure and report the temperature and moisture content of the surrounding air, providing valuable data for decision-making and optimization.

### Water Level Sensor / Float Sensor

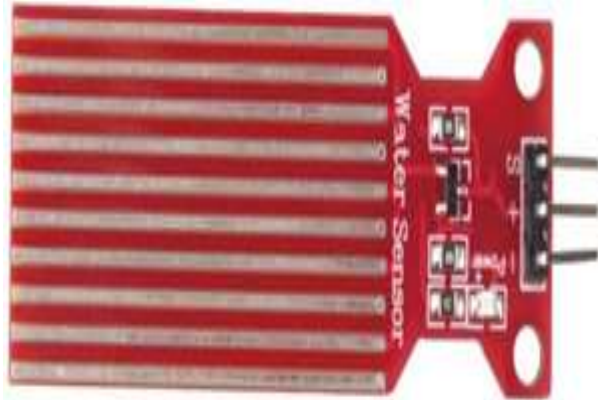


Fig 4.5 water level sensor

The water level sensor detects the height of water in a tank by measuring conductivity across its sensing traces. When the water reaches maximum level, the sensor signals the microcontroller to turn OFF the water pump. When the level drops, it signals the pump to turn ON. This prevents overflow, water wastage, and pump damage. It is an essential sensor for sustainable water management in smart homes. This leads to shorter cycle times, less energy required to heat water, and reduced strain on electrical components. A faulty water level sensor, however, can cause the appliance to use excess water, forcing the heating element and motor to work harder, thereby increasing power consumption.

### Current Sensor



Fig 4.6 current sensor

Current measurement is one of the most common parameters used to evaluate, control, and diagnose the operating efficiency of electronic systems. Although current is a very common measurement, problems can arise when designers underestimate the nuances of several variables when measuring current. Top engineers use SiC MOSFET modules to design highly efficient inverters that meet the following design criteria. Current sensors also need to be designed with low operating power consumption and compact size, as these are the most important design criteria.

### Embedded C Programming Environment

The primary software environment used in this project is Embedded C, which serves as the core programming language for driving the Arduino microcontroller and managing all connected sensors, IoT modules, and load-controlling components. Embedded C is widely used in embedded systems because it provides low-level hardware access, precise timing control, and efficient execution — all of which are crucial for real-time operations in an intelligent smart-home automation system.

In this project, Embedded C is responsible for executing sensor readings from the voltage sensor, current sensor, energy meter, and water-flow sensor, processing data values, and generating appropriate responses based on predefined logic.

For example, the LCD display, which shows live consumption statistics or status updates, is programmed through Embedded C routines that handle character printing, clearing, cursor movement, and refresh cycles. Similarly, the IoT module requires serial communication commands, often using UART, which are also implemented through Embedded C. Exception handling, safety cut-off routines, and threshold-based alerts are handled inside the code to ensure the system responds correctly to abnormal or excessively high consumption values. Because Embedded C allows direct manipulation of microcontroller registers, timers, ADC channels, and interrupt routines, it

ensures that the system behaves deterministically and efficiently.

### **Arduino Ide (Integrated Development Environment)**

Another major software utilized in this project is the Arduino IDE, which serves as the development, debugging, and uploading platform for writing and deploying the program onto the Arduino microcontroller. The Arduino IDE provides an easy-to-use interface where the code written in Embedded C is compiled, debugged, and uploaded to the board through USB.

It includes a built-in compiler (avr-gcc) that translates the source code into machine instructions that the Arduino can execute. The serial monitor feature of the IDE plays a crucial role in the development phase, allowing real-time observation of sensor outputs, debugging information, and IoT communication messages.

The IDE also simplifies library management. Many hardware components used in the project such as the LCD display, current/voltage sensor modules, and IoT modules require specific libraries for seamless operation. The Arduino IDE allows installing, linking, and referencing these libraries efficiently.

This reduces the complexity of writing low-level communication code and makes the development faster and more reliable. During the testing phase, the IDE helps verify correct sensor readings by printing values to the Serial Monitor, ensuring that all hardware components function before building the final prototype. Overall, the Arduino IDE acts as the bridge between the software logic and the actual hardware components used in the sustainable smart-home system.

### **Keysight Proteus Simulation And Testing Tool**

For circuit design, simulation, and pre-deployment testing, the project uses the Proteus Design Suite, a powerful tool for electronics simulation. Proteus allows the complete hardware circuit including Arduino, sensors, communication modules, power supply units, displays, and loads to be recreated in a

virtual environment before building the physical prototype.

This helps verify the correctness of wiring, evaluate expected sensor outputs, and test how the microcontroller responds to real-time inputs using the exact Embedded C code written for the project. One of the most important features used in this project is the Proteus VSM (Virtual System Modelling) simulation capability, which enables running the actual Arduino firmware inside the simulated environment.

With Proteus, potential hardware errors can be identified early in the design phase, such as incorrect voltage supply levels, wrong sensor polarity, incompatible communication pins, or unstable reading patterns. Additionally, the software allows simulating dynamic behavior for example, changing current levels, varying water flow rates, or modifying load conditions and checking how the system responds through the LCD display or IoT interface.

Using Proteus significantly reduces development costs and hardware damage risks during prototyping. It also ensures that the final system performs accurately and consistently, contributing to the overall goal of reducing resource wastage through intelligent automation.

Keysight Proteus is a powerful simulation and testing tool widely used for the design, analysis, and validation of electronic and embedded systems. It provides a comprehensive environment to simulate both hardware circuits and firmware execution simultaneously.

This capability allows developers to verify system functionality before physical hardware fabrication, thereby reducing development time and cost. In the proposed system, Keysight Proteus is used to simulate the microcontroller, sensors, actuators, and control circuitry. Real-time behavior of components such as temperature and humidity sensors, relays, motors, and display modules can be observed and analyzed under different operating conditions.

## Washing Machine

Table 4.1 Troubleshooting Guide for Washing Machine

S.NO	PROBLEMS	SOLUTIONS
1	clogged condenser coils	Regular Cleaning of Condenser Coils or Install a Dust Filter.
2	Low refrigerant level	Install a Refrigerant Pressure Sensor and Recharge/Refill the Refrigerant.
3	Blocked or dirty filters	Improve Refrigerator Airflow Management and Clean or Replace Filters Regularly.
4	Faulty thermostat	Install a Digital Temperature Sensor and Replace the Faulty Thermostat.
5	Faulty or weak door gasket	Add a Door Seal Tightness Sensor and Clean the Gasket Regularly
6	Poor ventilation	Install a Ventilation Booster Fan or Avoid Enclosing the Refrigerator

Regular maintenance is essential to ensure the proper functioning of household appliances. By identifying common problems early, users can prevent costly repairs and extend the life span of the machine. Routine inspection of internal components, cleaning of filters, and ensuring proper ventilation are important preventive measures. Timely replacement of damaged parts such as thermostats, gaskets, and coils helps maintain efficiency. Sensors and monitoring systems can also be installed to detect faults automatically improved appliance reliability and user satisfaction

### Refrigerator

Table 4.2 Troubleshooting Guide for Refrigerator

S.No	Problems	Solutions
1	Motor Running Longer Than Needed	Installing An "Intelligent Motor Control System" And Also Add An Automatic Load Detection System.
2	Heating Element Issue	Install A Smart Temperature Sensor
3	Blocked Or Dirty Filters	Install A Fine Mesh Filter Or Regular Filter Cleaning System
4	Overloading Clothes	Adding An Automatic Load Detection System
5	Worn Out Belt	Replace The Worn Belt With A High-Efficiency Belt Or Install A Belt Tension Sensor
6	Damaged Drum	Add A Drum Balance Sensor Or Repair Or Replace The Drum

Ensuring the refrigerator operates efficiently requires regular care and attention. Most performance issues

arise from neglect, improper usage, or delayed servicing. Users should frequently check for unusual noises, temperature fluctuations, and energy consumption changes, as these can indicate internal faults. Keeping the filters, coils, and vents clean allows for free airflow, which improves cooling capacity and lowers power usage. Faulty components like sensors, belts, or motors should be repaired or replaced immediately to avoid further damage.

### Water Heater

Table 4.3 Troubleshooting Guide for Water Heater

S.No	Problems	Solutions
1	Heating Element Wear	Install An Overheat Protection Relay To Prevent Burnout Due To Dry Heating.
2	Sediment Scale Build-Up	Install A Pre-Filter To Stop Sediments Before Entering The Heater.
3	Thermostat Malfunction	Replace With A Digital Thermostat For Precise Temperature Control And Use A Dual-Thermostat Safety System
4	Leaking Hot Water Tank	Use Ultrasonic Leak Detection Or Pressure Testing To Identify Micro-Leaks.
5	Faulty Temperature	Install A Smart Insulation Monitoring Sensor That Detects

	Sensor	Heat Loss.
6	Poor Insulation	Add A Sensor Calibration Module In The Control System.

To maintain an efficient water heater system, it is important to regularly inspect and service the internal heating components. Mineral deposits and sediment build-up are common issues in hard-water areas, and routine filtering or descaling can prevent damage to the heater. Monitoring the thermostat performance ensures water is heated accurately without energy wastage or overheating. Modern heaters benefit from smart protection systems such as overheat relays, leak detection sensors, and insulation monitoring units to ensure safety.

### Air Conditioner (Ac)

Table 4.4 Troubleshooting Guide for Air Conditioner

S.NO	PROBLEMS	SOLUTIONS
1	Low Gas levels	Add a pressure sensor (manifold sensor) to detect refrigerant drop.
2	Blocked air filters	Install an airflow sensor that detects reduced airflow and alerts the user to clean the filter.
3	Faulty compressor	Add a temperature sensor on the compressor shell to detect overheating.
4	Dirty condenser coils	Install anti-dust mesh or coil guards to reduce dust accumulation.
5	Inefficient AC unit	Implement a smart thermostat with AI-based cooling control.
6	Faulty fan motor	Add a fan RPM sensor to detect speed drop due to motor fault.

For an air conditioner to operate at peak performance, consistent monitoring and upkeep of internal components is necessary. The cooling efficiency depends heavily on proper gas levels, smooth airflow, and clean condenser units. Any drop in refrigerant pressure can lead to reduced cooling, so regular pressure checks and early leak detection are essential. Dust accumulation on air filters and coils restricts airflow, forcing the system to work harder and consume more electricity.

## V. RESULTS AND DISCUSSIONS

The proposed sustainable smart home system was developed and tested using an Arduino microcontroller, IoT module, energy meter, current and voltage sensors, flow sensor, and LCD display. After implementing both the hardware and software components, the system demonstrated efficient real-time monitoring and intelligent control of home resources such as electricity and water. During testing, the energy meter and voltage-current sensor module were able to continuously measure load consumption with stable readings under varying conditions.

When low, medium, and high electrical loads were connected, the Arduino successfully processed the sensor values and displayed accurate consumption data on the LCD screen without delay. This real-time feedback allowed clear observation of how consumption changed based on the appliances used, proving that the system could capture even small variations in power demand. The integration of the flow sensor also provided consistent water usage readings, enabling the system to track how much water was consumed over a particular operation period. This was particularly effective during tests involving taps, pumps, and controlled water outlets, where the sensor detected flow changes instantly and transmitted the readings to the controller.

A major part of the system's evaluation involved assessing how effectively it could communicate with the IoT platform for remote monitoring. The IoT module transmitted the collected electrical and water usage data to the cloud dashboard with minimal latency. Users could access the data through a mobile or web interface, and the values matched the readings displayed locally on the LCD. The graphs generated in the cloud dashboard clearly showed consumption patterns both in real time and over extended periods. This seamless communication confirmed that the system was reliable for remote tracking, making it useful for households where monitoring is needed even when occupants are not present. The IoT integration also supported alerts and notifications.

Embedded C Programming is the soul of the processor functioning inside each and every embedded system we come across in our daily life, such as mobile phone, washing machine, and digital camera. Each processor is associated with an embedded software. The first and foremost thing is the embedded software that decides functioning of the embedded system. Embedded C language is most frequently used to program the microcontroller.

Earlier, many embedded applications were developed using assembly level programming. However, they did not provide portability. This disadvantage was overcome by the advent of various high level languages like C, Pascal, and COBOL. However, it was the C language that got extensive acceptance for embedded systems, and it continues to do so. The C code written is more reliable, scalable, and portable; and in fact, much easier to understand.

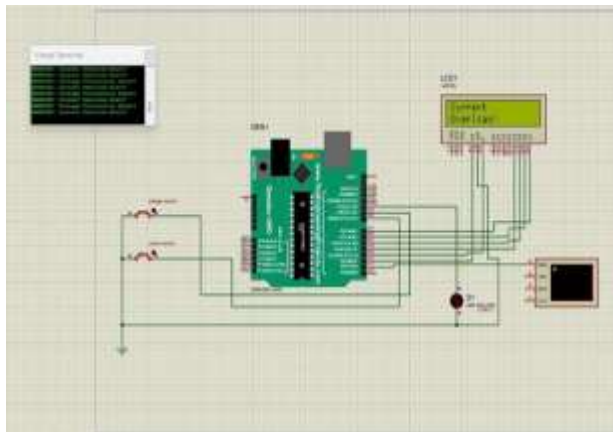


Fig 5.1 Result Simulation for Smart Homes

The discussion also reveals that the combined effect of hardware and software significantly enhanced system reliability. The use of Embedded C for coding ensured precise timing and predictable response, especially while handling sensor signals that required frequent sampling. Arduino IDE's debugging tools made the development smoother by allowing calibration of sensor values until stable outputs were achieved. Proteus simulations played a crucial role before hardware implementation,

helping verify circuit correctness and eliminating wiring errors early in the development cycle.

In this section, the IHEH method readily handles the operational power range of various sensors and IoT devices, which is between 0.1  $\mu$ W and 1 W. Because ambient resources are stochastic and energy supply and demand may not be synchronized in time, effective power management circuits are required to ensure that power is transmitted from the harvester to IoT devices on time. A range of communication protocols, including Wi-Fi, Bluetooth, ZigBee, and LoRa, have been used by IoT devices to interface with networks. Table 1 shows the power and distance covered in the communication protocol used in IoT devices. EH will play a major role in the future trends of smart housing and home automation. The EH technique will result in batteries for mobile devices that are smaller. Rechargeable power supplies with cheap installation and maintenance costs are made possible by energy harvesting, which facilitates the Internet of Things' significant growth.

The harvested waste energy from the home appliances and it shows the converted power value. From depending on the temperature, the heat energy is transformed into electrical energy. Three input cases are laptop heat, oven heat, and air conditioner heat. Regarding these inputs, the temperature range can be set as in the range from 20 to 40 degrees Celsius. The heat radiation can be measured and it will be given to solar panels to make electrical energy Comparison of accuracy with the existing method. The proposed IHEH method maintains an excellent accuracy level of 90%. The IHEH method improves the overall accuracy by 3%, 7.7%, and 20% better than IPLEH, EEM, and REEH respectively.

We consider thermal waste heat from alternating current for energy reuse. An air conditioner runs for 7 hours and produces 63,000 BTUs of waste energy. This wasted AC energy is converted to electrical energy. Initially, the 63,000 BTU heat flow from the air conditioner represents a very high load, so this heat is fed directly to the AC-DC converter.

## VI. CONCLUSION

The development of sustainable smart homes using intelligent appliances demonstrates a powerful and practical approach to reducing resource wastage in modern living environments. By integrating IoT-enabled devices, sensor-based monitoring, automated control systems, and data-driven decision-making, the system successfully enhances energy efficiency, conserves water, and minimizes unnecessary consumption. Throughout the project, it became clear that households can significantly lower their environmental footprint when appliances are designed to respond intelligently to real-time conditions such as occupancy, temperature variations, and usage patterns. The proposed smart home framework not only optimizes resource usage but also improves user convenience, safety, and overall quality of life. Features like automated lighting, smart energy meters, intelligent HVAC control, and water-usage analytics collectively contribute to a more sustainable lifestyle without compromising comfort. The implementation process further highlighted the importance of interoperability, low-power communication protocols, and cloud-based data handling for reliable system performance.

The 21st century has brought great discoveries and advancements in the field of technology. These advancements also brought many challenges and require approaches to handle these challenges. Smart metering system is one such approach. This paper has presented a comprehensive survey of smart metering and electricity smart meter data analytics. The model satisfactorily worked with a Bulb. Automatic meter reading can be explained well using this system. Financial losses of electricity board can be minimized. Labour charges and effort can be reduced. The error, time delay that occurs due to manual metering can be avoided to a great extent. Electrical line fault detection has been made easy for the electricity board. Finally but not the least this type of meter supports remote metering which is the future of energy meters.

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