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Raspberry Pi-Based Carbon Footprint Analyzer for Smart Homes

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Abstract - The Raspberry Pi-based Carbon Footprint Analyzer for Smart Homes is designed to monitor energy consumption, environmental pollution, and electrical safety in a smart home environment. The system uses a PZEM sensor to measure electrical parameters such as voltage, current, power, and energy consumption. MQ-7 and MQ-135 gas sensors are used to detect harmful gases and monitor indoor air quality. The collected data is processed using Raspberry Pi to calculate carbon footprint based on energy consumption and emission factors. The system also includes safety features such as relay protection, buzzer alerts, fingerprint authentication, and IR-based human detection. The system displays data on LCD and uploads data to IoT platform for monitoring.

Key Words: Raspberry Pi, Carbon Footprint, Smart Home, Energy Monitoring, Gas Sensor, IoT

1.INTRODUCTION

The rapid growth of smart home technologies and IoT-based systems has increased the demand for intelligent energy monitoring and environmental monitoring systems. Electricity consumption in residential buildings contributes significantly to carbon emissions and environmental pollution. Monitoring energy consumption alone is not sufficient; it is also important to calculate carbon footprint and monitor environmental conditions such as air quality and harmful gases. Smart home systems should not only automate appliances but also ensure energy efficiency, safety, and environmental sustainability.

The Raspberry Pi-based Carbon Footprint Analyzer for Smart Homes is designed to monitor electrical energy consumption, calculate carbon emissions, detect harmful gases, and provide safety features such as overload protection and authentication. The system integrates sensors, microcontrollers, and IoT technology to create a smart monitoring and control system. This system helps users understand their energy usage and environmental impact, thereby encouraging energy conservation and reducing carbon emissions.

2. LITERATURE SURVEY

In recent years, smart home automation systems have gained significant attention due to the rapid development of Internet of Things (IoT) technology. Many researchers have developed IoT-based smart home automation systems to control and monitor home appliances remotely using mobile applications and web interfaces. These systems improve convenience, energy efficiency, and remote accessibility for users. IoT-based smart home systems using sensors and wireless communication technologies have been widely implemented for home automation and monitoring applications [1], [3].

Several researchers have developed home automation systems using Raspberry Pi and voice recognition technologies to control appliances through voice commands and mobile applications. These systems provide user-friendly interfaces and automation features for smart homes. Voice-controlled home automation systems using natural language processing and IoT technology have also been developed to improve user interaction and automation efficiency [2], [5].

Mobile-based home automation systems using IoT allow users to monitor and control home appliances remotely through smartphones and internet connectivity. Wireless sensor networks and Wi-Fi-based automation systems are widely used for smart home monitoring and control applications. These systems provide flexibility, low power consumption, and easy installation in smart home environments [4], [9].

Researchers have also developed IoT-based automation systems focusing on energy management, appliance automation, and smart monitoring systems. These systems integrate sensors, microcontrollers, and cloud platforms to monitor environmental conditions and energy usage. IoT-based smart home automation systems help in reducing energy consumption and improving home safety and automation efficiency [7], [10].

Although many smart home automation systems have been developed, most of the existing systems focus only on appliance automation and remote monitoring. Very few systems focus on integrating energy monitoring, environmental monitoring, carbon footprint calculation, and safety features into a single system. Therefore, the proposed system aims to develop an integrated Raspberry Pi-based carbon footprint analyser for smart homes that monitors energy consumption, environmental pollution, and home safety in a single system [6], [8].

3. EXISTING METHODOLOGY

In existing systems, energy monitoring and smart home systems are implemented using smart meters and IoT-based monitoring devices. These systems are mainly used to monitor electricity consumption and control home appliances remotely. However, most existing systems only monitor electrical parameters and do not calculate carbon footprint or monitor environmental pollution. Some systems use gas sensors for gas leakage detection, but they do not integrate energy monitoring and environmental monitoring into a single system.

Existing systems also lack safety features such as overload protection, authentication systems, and real-time alert mechanisms. In many systems, data is monitored but not analysed to calculate environmental impact such as carbon emissions. Therefore, existing systems are limited to monitoring only and do not provide complete smart home environmental monitoring and carbon footprint analysis.

Limitations: Only energy monitoring is available, Carbon footprint is not calculated, and Environmental pollution monitoring is not included.

4. PROPOSED METHODOLOGY

The proposed system integrates energy monitoring, environmental monitoring, carbon footprint calculation, and smart home safety features into a single system as shown in figure 1. The system uses Raspberry Pi as the main processing unit and Arduino Uno for sensor interfacing. The PZEM energy meter measures electrical parameters such as voltage, current, power, and energy consumption. MQ-7 and MQ-135 sensors are used to detect harmful gases and air quality levels. The system also includes relay protection, buzzer alerts, fingerprint authentication, and IR-based automation. The data is displayed on LCD and uploaded to IoT platform for remote monitoring and analysis.

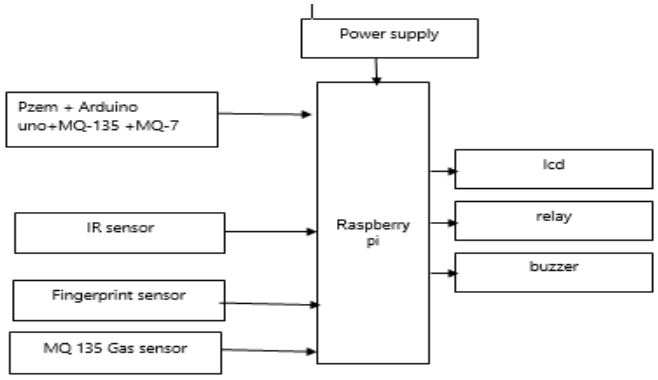

Figure 1: Block Diagram of Proposed System

5. WORKING PRINCIPLE

The system starts by initializing the Raspberry Pi, Arduino Uno, sensors, relay module, buzzer, and LCD display. First, the user authentication is performed using the fingerprint sensor, and only authorized users are allowed to access the system. After authentication, the IR sensor detects the presence of a person or object and automatically controls the appliances through the relay module to reduce unnecessary power consumption. At the same time, the PZEM energy meter measures voltage, current, power, and energy consumption, and the MQ gas sensors monitor air quality and harmful gases in the environment.

The Arduino Uno collects sensor data and sends it to the Raspberry Pi for processing. The Raspberry Pi calculates the carbon footprint based on energy consumption and emission factor, and all the values such as voltage, current, power, energy consumption, gas levels, and carbon emission are displayed on the LCD screen. If gas leakage or overload conditions are detected, the system activates the buzzer and turns OFF the load using the relay module for safety as shown in figure 2. The system continuously monitors and updates the data, providing smart home automation, energy monitoring, environmental monitoring, and safety control.

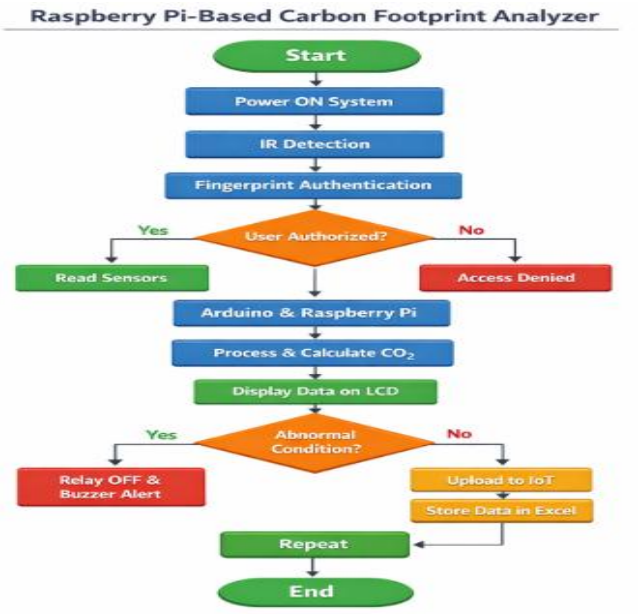

Figure 2: Flow Diagram of Raspberry Pi Carbon Footprint Analyzer

6. RESULTS AND DISCUSSION

The system successfully monitored voltage, current, power, gas levels, and carbon footprint. LCD displayed real-time values and IoT platform stored data as shown in below figures and tables. The system improved efficiency and safety.

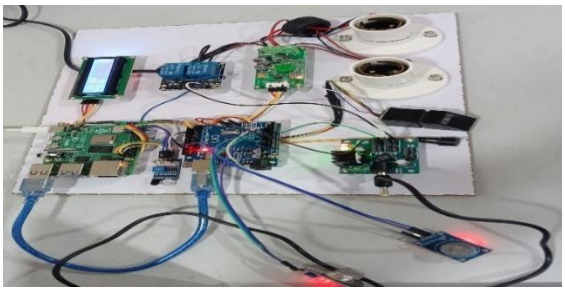

Figure 3: Hardware setup of proposed system

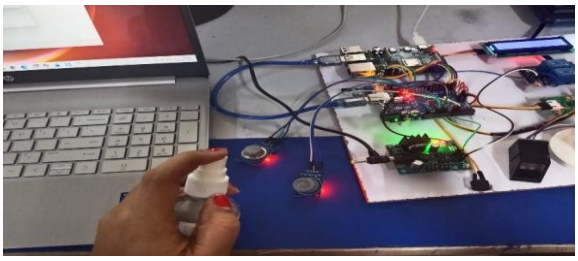

Figure 4: Gas Sensors Testing

Table 1: Excel Sheet Showing various parameters

Timestamp	Voltage	Current	Power	Energy	Frequency	PF	MQ135	MQ7
2026-02-2	230	0.26	60	0	50	1	544	629
2026-02-2	230	0.26	60	0	50	1	558	582
2026-02-2	230	0.26	60	0	50	1	475	543
2026-02-2	230	0.26	60	0	50	1	405	511
2026-02-2	230	0.26	60	0	50	1	385	488
2026-02-2	230	0.26	60	0	50	1	382	466

Figure 5: LCD Showing results

7. CONCLUSIONS

The Raspberry Pi-based Carbon Footprint Analyzer for Smart Homes was successfully designed and implemented to monitor energy consumption, environmental pollution, and electrical safety. The system measures electrical parameters, detects harmful gases, calculates carbon footprint, and uploads data to the IoT platform for monitoring. The system also provides safety features such as relay protection, buzzer alerts, fingerprint authentication, and IR detection.This system helps users understand their energy consumption and environmental impact, which helps in reducing electricity usage and carbon emissions.

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