

AI&IOT Based Intelligent Energy Monitoring and Optimization System

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ABSTRACT: Energy consumption is increasing rapidly due to the growth of industrialization, smart buildings, and digital technologies. Traditional energy monitoring systems lack real-time analysis and intelligent decision-making capabilities. This paper proposes an intelligent energy monitoring and optimization system using Artificial Intelligence (AI) and the Internet of Things (IoT). IoT sensors are used to collect real-time data such as voltage, current, temperature, and power consumption from electrical devices. The collected data is transmitted to a cloud platform where AI algorithms analyze energy usage patterns and provide optimization strategies. The system helps in reducing energy wastage, improving efficiency, and enabling predictive energy management. Experimental results show that the proposed system can significantly reduce energy consumption and operational cost in smart environments.

Keywords: Artificial Intelligence, Internet of Things, Energy Monitoring, Smart Grid, Energy Optimization, Smart Energy Management.

1.INTRODUCTION:

Energy management has become a critical challenge in modern society due to increasing energy demand and environmental concerns. Efficient monitoring and optimization of energy consumption are necessary for sustainable development. Traditional energy monitoring systems are mostly manual and do not provide intelligent insights.

The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies has created new opportunities for smart energy management. IoT devices such as sensors and smart meters can collect real-time data from electrical appliances and energy systems. AI techniques can analyze this data to identify patterns, predict energy demand, and optimize energy usage.

This research focuses on developing an AI and IoTbased intelligent system that monitors energy consumption in real time and provides automatic optimization recommendations.

2.LITERATURE REVIEW:

Several researchers have explored the use of IoT and AI technologies for smart energy monitoring and management.

Many smart energy systems use IoT sensors to monitor electricity consumption in real time. Smart meters collect data related to voltage, current, and power usage and transmit it to cloud platforms for analysis.

Machine learning algorithms have been widely used for predicting energy demand and optimizing energy usage. Techniques such as neural networks, regression models, and deep learning have shown promising results in forecasting energy consumption patterns.

However, many existing systems focus only on monitoring rather than intelligent optimization. There is a need for integrated systems that combine IoT with AI-based decision-making to provide real-time energy optimization

3.PROPOSED SYSTEM:

The proposed system integrates IoT devices and AI algorithms to create an intelligent energy monitoring and optimization platform.The system performs the following functions: sensing

- * Real-time energy consumption monitoring

- * Data collection from electrical devices

- *Data analysis using AI algorithms

- *Energy optimization recommendations

- *Visualization through a user interface

The system architecture includes sensors, microcontrollers, communication networks, cloud platforms, and AI-based data processing modules.

4.SYSTEM ARCHITECTURE:

The architecture of the proposed system consists of four layers.

4.1 Sensor Layer

This layer consists of sensors used to measure electrical parameters such as:

Current sensors

Voltage sensors

Temperature sensors (LM35)

Power sensors

These sensors collect real-time data from electrical appliances.

4.2 Data Acquisition Layer

A microcontroller such as Arduino, ESP8266, or ESP32 collects data from sensors. The microcontroller processes the sensor signals and prepares them for transmission.

4.3 Communication Layer

Data is transmitted to the cloud server through wireless communication technologies such as:

Wi-Fi

MQTT protocol

Internet gateway

This enables real-time data transfer.

4.4 Cloud and Application Layer The cloud platform stores and processes the collected data. AI algorithms analyze the data to detect abnormal energy consumption patterns. Users can monitor energy usage through a mobile or web-based dashboard.

5.DIAGRAM

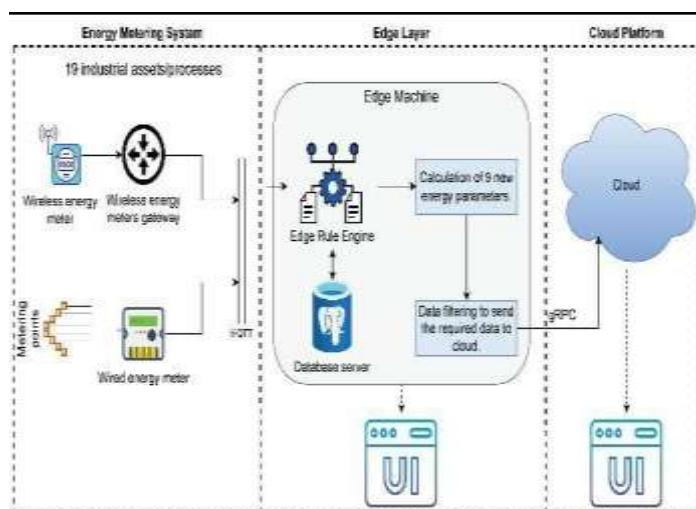


fig.1:IOT Based energy monitoring in industries

6 SENSORS:

This layer consists of sensors used to measure electrical parameters such as:

*Current sensors

*Voltage sensors

*Temperature sensors (LM35)

*Light Dependent Resistor(LDR)

6.1 CURRENT SENSOR

Current sensors are devices that detect and measure the current flowing through a circuit or wire, playing a crucial

role in AI and IoT-based energy monitoring and optimization systems. These sensors convert the current into a measurable signal, allowing for realtime monitoring and analysis



Fig.2 Current sensor

Key Applications:

Energy Efficiency: Current sensors help optimize energy consumption by tracking energy usage patterns and detecting anomalies.

Predictive Maintenance: By monitoring current trends, AI algorithms can predict equipment failures, reducing downtime and maintenance costs.

Smart Buildings: Current sensors integrate with HVAC systems to optimize energy consumption based on occupancy and usage patterns.

Industrial Automation: Current sensors monitor machine health, enabling predictive maintenance and reducing energy waste.

6.2 VOLTAGE SENSOR

A voltage sensor is a device that measures the voltage level of an electrical circuit or system. It converts the voltage signal into a measurable output, allowing for monitoring and analysis.



Fig.3 Voltage sensor

Key Applications:

1. **Power Quality Monitoring:** Voltage sensors detect voltage fluctuations, sags, and swells, ensuring power quality and preventing equipment damage.

2. **Energy Efficiency:** Voltage sensors help optimize energy consumption by monitoring voltage levels and adjusting loads accordingly.
3. **Predictive Maintenance:** Voltage sensors detect voltage-related issues in equipment before they occur, reducing downtime and maintenance costs.
4. **Grid Management:** Voltage sensors monitor grid voltage levels, enabling predictive analytics and automated control for optimized energy distribution.

6.3 TEMPERATURE SENSOR

A Temperature sensor is a device that detects and measures temperature, converting it into a readable signal. Think of it like a thermometer, but often more advanced and accurate.

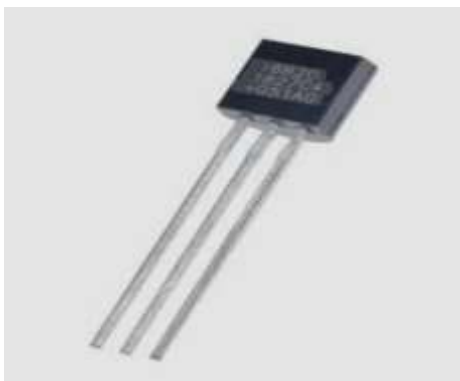


Fig.4 Temperature sensor

Key Applications:

1. **Equipment Monitoring:** Temperature sensors detect abnormal temperature changes in equipment, predicting maintenance needs and reducing downtime.
2. **HVAC Optimization:** Temperature sensors monitor and control HVAC systems, optimizing energy consumption and maintaining comfort levels.
3. **Energy Efficiency:** Temperature sensors help optimize energy consumption by monitoring temperature levels and adjusting loads accordingly.
4. **Predictive Maintenance:** Temperature sensors detect temperature-related issues in equipment before they occur, reducing maintenance costs.

6.4 LIGHT DEPENDENT RESISTOR

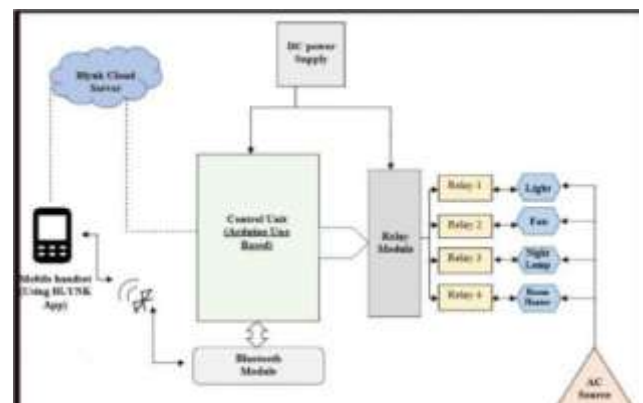


Fig.4 Light Dependent Resistor(LDR)

Key Applications:

1. **Smart Lighting:** LDRs monitor ambient light levels, adjusting artificial lighting to optimize energy consumption.
2. **Energy Efficiency:** LDRs help reduce energy waste by controlling lighting and HVAC systems based on occupancy and daylight availability.
3. **Predictive Maintenance:** LDRs detect changes in lighting patterns, predicting maintenance needs for lighting systems.

7.BLOCK DIAGRAM



8.METHODOLOGY

The methodology of the proposed system consists of the following steps:

Step 1: Data Collection

IoT sensors measure energy-related parameters such as voltage, current, and temperature from electrical appliances.

Step 2: Data Transmission

The collected data is transmitted to a cloud server using wireless communication technologies.

Step 3: Data Storage

Cloud databases store the energy consumption data for analysis and historical tracking. Step 4: Data Analysis

Artificial Intelligence algorithms analyze the collected data to identify energy usage patterns and detect inefficiencies.

Step 5: Energy Optimization

The system provides recommendations such as:

Switching off idle devices

Scheduling appliance usage

9.IMPLEMENTATION

The hardware components used in the system include:

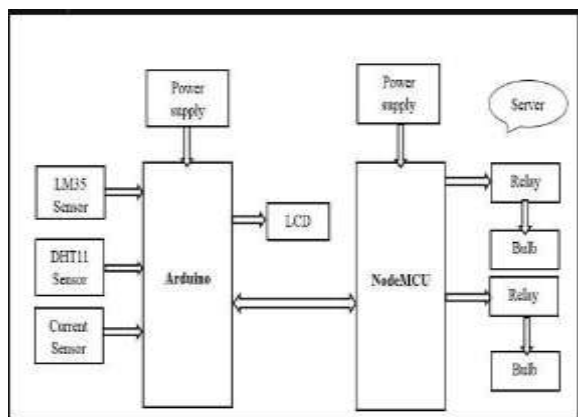
- * Microcontroller (Arduino / ESP32)
- * Current sensor (ACS712)
- * Voltage sensor
- * Temperature sensor (LM35)
- * Wi-Fi module
- * Power supply

The software components include:

- * Cloud platform for data storage
- * Machine learning algorithms for analysis
- * Mobile or web dashboard for visualization

Reducing peak power consumption.

10.BLOCK DIAGRAM



11.DATA ACQUISITION LAYER

A microcontroller such as Arduino, ESP8266, or ESP32 collects data from sensors. The microcontroller processes the sensor signals and prepares them for transmission.

12.COMMUNICATION LAYER

Data is transmitted to the cloud server through wireless communication technologies such as:

Wi-Fi

MQTT protocol

Internet gateway

This enables real-time data transfer.

12.BLYNK IOT PLATFORM

Blynk is a popular IoT platform that lets you control and monitor hardware remotely. It's super easy to use, even for non-techies.

Uses in Energy Monitoring and Optimization:

1. Remote Monitoring: Blynk lets you track energy consumption, voltage, current, and other parameters in real-time.
2. Control and Automation: Use Blynk to automate devices, set schedules, and optimize energy usage.
3. Alerts and Notifications: Get notifications when energy consumption exceeds thresholds or devices malfunction.
4. Data Analytics: Blynk's dashboard provides insights into energy usage patterns, helping you optimize consumption.

IoT Platform Features:

Cloud-based: Access data and control devices from anywhere.

Multi-device support: Manage multiple devices and locations.

Customizable dashboards: Create personalized interfaces for monitoring and control.



13.RESULT AND DISCUSSION:

The implemented system successfully monitors energy consumption in real time. The collected data helps identify energy usage patterns and inefficient appliances.

The AI-based analysis provides recommendations to reduce unnecessary power consumption.

Experimental results indicate that energy usage can be reduced by approximately 15–25% through intelligent optimization strategies.

The system also provides alerts when abnormal energy consumption is detected.

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