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IoT-Based Renewable Energy and Asset Management

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ABSTRACT: With rising energy demands and environmental concerns, integrating Internet of Things (IoT) technologies into renewable energy systems has become increasingly important. This paper details the development of an IoT-enabled system for monitoring renewable energy resources and automating asset control. The approach integrates solar power with sensors (temperature, humidity, light, occupancy), a Raspberry Pi controller, and AWS IoT Core for remote monitoring and cloud-based data handling. Grafana dashboards provide live data visualization, facilitating data-driven decisions. The system supports predictive maintenance and remote supervision of assets, promoting sustainability and operational efficiency through smart infrastructure management.

KEYWORDS: IoT, Renewable Energy, Asset Automation, Solar Power, Raspberry Pi, AWS IoT, Energy Visualization, Predictive Maintenance.

I. INTRODUCTION

Growing environmental concerns and energy costs have created an urgent need for solutions that prioritize efficiency and sustainability. Solar energy continues to gain popularity due to its eco-friendliness and affordability. Concurrently, IoT technologies have transformed system control and optimization processes. This research addresses the combination of these trends by creating an IoT-driven renewable energy and asset management system tailored for industrial and smart-building environments. The design incorporates solar arrays, energy storage, sensors, and actuators to monitor and manage energy and environmental conditions. A Raspberry Pi centralizes data acquisition from sensors and updates AWS IoT Core. Users can remotely monitor and control assets via a cloud-connected Grafana dashboard, enabling smart infrastructure with minimal energy waste.

II. LITERATURE SURVEY

Abdullah A1, Mehedi Hussain, Towdhidul Islam, Dwin Islam (2024) – “IoT based solar energy monitoring system for environmental sustainability”[1].IoT enhances real-time monitoring and performance of solar energy systems. It enables efficient energy management, fault detection, and predictive maintenance[2].Chrysi K Metlab (2020) – “Energy Efficiency in Smart Buildings: IoT Approaches”,This research emphasizes the role of IoT in integrating HVAC, lighting, and occupancy systems for adaptive energy management[3].Dr. R Chiranasatyam, Shivanand S, C Prathap (2023) – “Raspberry Pi Based Smart Energy Meter Using IoT”,This work focuses on real-time energy monitoring, data logging, and remote access through cloud platforms[4].

L. Shamini (2023) – “Renewable Energy Based Greenhouse Environmental Monitoring System Using IoT” Integrates sensors and IoT devices to monitor temperature, humidity, and soil moisture. Solar energy supports off-grid operation[5].

Traditional monitoring systems often lack scalability, real-time analytics, and remote accessibility, leading to inefficient energy utilization and delayed fault detection.The proposed system addresses these challenges with,Real-time monitoring of energy generation and consumption,Cloud-based analytics for predictive maintenance,Secure and scalable infrastructure for remote asset management.

III. METHODOLOGY

The system leverages solar energy to power a Raspberry Pi 3B+, which acts as the control hub. A photovoltaic panel charges a 12 V battery via a charge controller, and a buck converter supplies regulated power to the Pi and connected sensors. The DHT11 sensor tracks temperature and humidity, the LDR monitors light levels, a PIR sensor detects occupancy, and the INA219 module measures voltage, current, and power. These devices are connected through GPIO and I²C interfaces to the Pi.

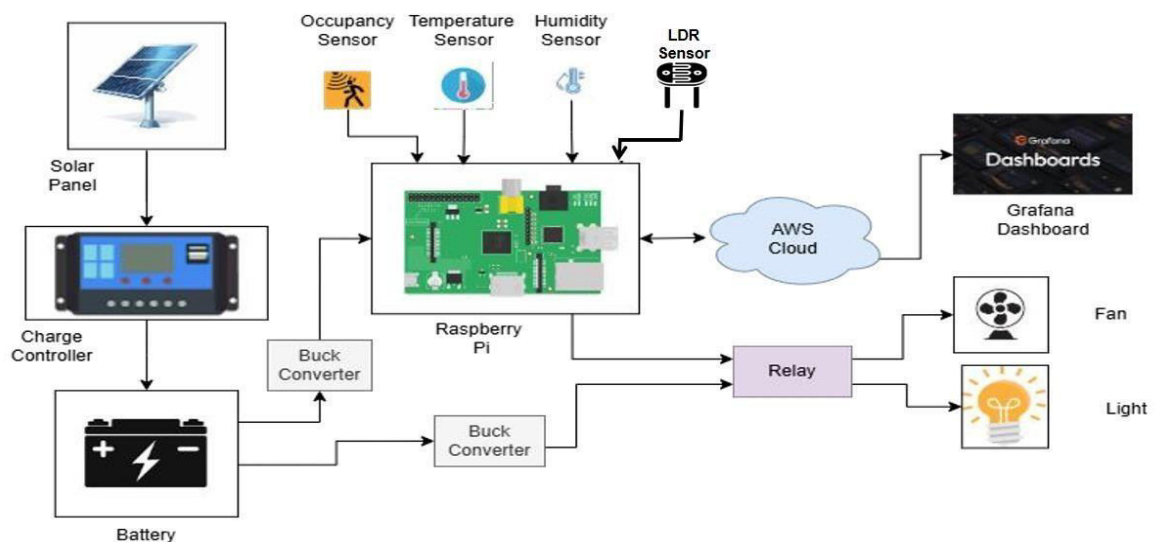


Fig : Block Diagram

Collected data is sent via MQTT to AWS IoT Core over Wi-Fi. AWS stores the information in Timestream and evaluates predefined conditions (such as high temperature or low light) to issue control commands back to the Pi, which toggles relays managing fans and lights. Grafana dashboards, connected to the AWS time-series database, visualize system performance metrics including temperature trends, energy usage, and asset activity.

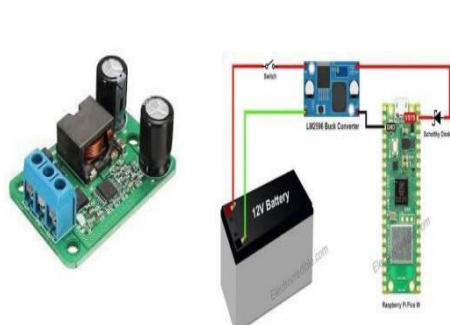


Fig : Buck converter

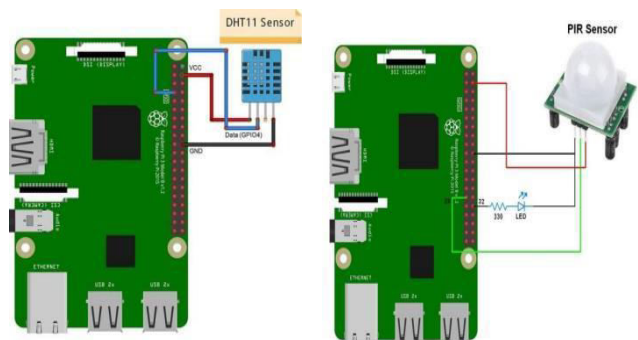


Fig : DHT11 and PIR Sensors



This closed-loop design—data → cloud logic → actuation → visualization—enables automated responses, energy optimization, and predictive maintenance in a cloud–edge integrated framework.

IV. EXPERIMENTAL RESULTS

The system was tested under controlled conditions to assess its performance. The sensors consistently transmitted accurate environmental data to AWS IoT Core. Cloud-based automation responded effectively—fans switched on when temperatures surpassed 30 °C in occupied rooms, and lights were activated when ambient illumination fell below set thresholds with detected movement. This resulted in significant energy savings by preventing unnecessary usage. Grafana dashboards offered clear visualization of sensor readings and device status, enhancing transparency. The seamless integration among sensor input, cloud processing, and asset response validates the practicality and dependability of the solution for industrial and smart-building applications.

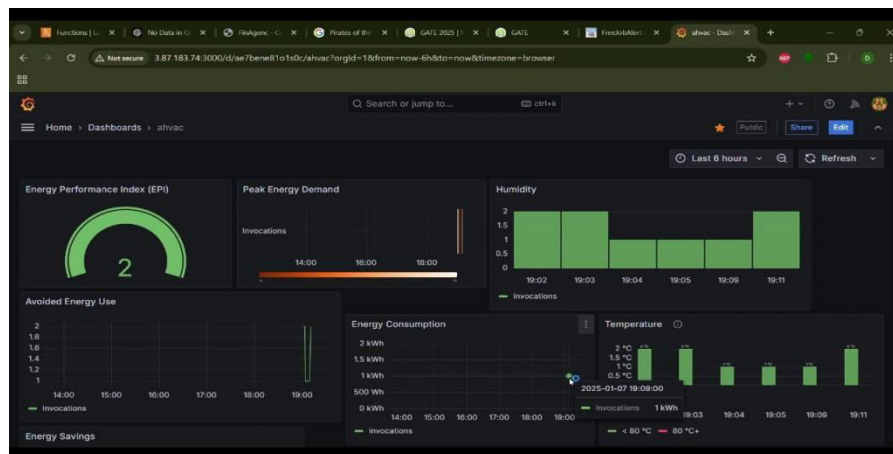


Fig : Grafana dashboard

V. CONCLUSION

This study presents a scalable IoT-based system that enhances renewable energy utilization and asset control for smart environments. Utilizing solar power, IoT sensing, AWS cloud services, and Grafana analytics, the solution provides real-time monitoring and automation. Experimental verification confirms its capability to manage energy, support predictive maintenance, and streamline operations through intelligent asset control. This work demonstrates a viable path toward sustainable, automated energy infrastructures.

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