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Power Consumption Analytics Using Cloud Platforms

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Abstract- The increasing demand for electricity and environmental concerns have created a critical need for advanced energy management solutions. This study presents an IoT and cloud-based analytics system that provides real-time insights into power consumption, enabling efficient energy utilization. Leveraging ThingSpeak as the cloud platform, the system integrates smart meters to monitor voltage, power factor, and energy trends. Key contributions include real-time anomaly detection, dynamic visualization, and customizable alert systems. The proposed methodology enhances user engagement and supports scalability for diverse energy applications.

Index Terms- anomaly detection, energy efficiency, IoT devices, power consumption, ThingSpeak, voltage trends.

I. INTRODUCTION

Energy efficiency has become a critical concern in the modern era, driven by increasing energy demands and environmental challenges. Traditional energy management systems often lack the flexibility and precision required to address dynamic consumption patterns and optimize energy use. To bridge this gap, the Power Consumption Analytics system combines IoT-enabled devices, cloud computing, and advanced analytics to offer a comprehensive solution for real-time energy monitoring and optimization.

The proposed system is built around IoT-enabled smart meters that monitor electrical parameters, including voltage, power factor, and consumption trends. These devices transmit data to the ThingSpeak cloud platform using REST APIs, ensuring secure and reliable communication.

The cloud platform's analytical tools generate actionable insights, allowing users to make informed decisions regarding energy consumption and optimization. By integrating advanced visualization tools and predictive analytics, this system fosters energy efficiency and sustainability across diverse applications.

II. SYSTEM ARCHITECTURE

1. Input layer

The input layer consists of IoT-enabled smart meters that measure key electrical parameters, such as voltage levels across three phases, power consumption, and timestamps. These devices ensure high accuracy in data collection and support wireless communication protocols like Wi-Fi and Zigbee.

The processing layer involves cloud platforms, particularly

2. Processing Layer

ThingSpeak, where data is stored, structured, and processed. REST APIs facilitate real-time data transmission, while analytics tools calculate derived metrics, detect anomalies, and predict future trends. Integration with external platforms like Python further enhances data processing capabilities.

3. Output Layer

The output layer presents processed data through an intuitive user interface. Features include real-time dashboards, customizable alerts, and detailed consumption reports. Users can remotely manage devices, optimize energy consumption, and ensure timely responses to anomalies.

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III. MATERIALS AND METHODS

1. IoT Devices

Smart meters are employed as primary data collection devices. These devices are equipped with features to monitor voltage levels, power factor, and consumption trends while generating alerts for anomalies such as overvoltage or low power factor.

2. Cloud Integration

ThingSpeak serves as the central cloud platform for data storage and analytics. REST APIs enable seamless data transmission, and built-in visualization tools provide immediate insights into energy trends and anomalies.

3. Data Analytics
Advanced algorithms analyze collected data to calculate metrics such as apparent voltage and consumption trends. Predictive models forecast energy usage, enabling proactive energy management.

4. User Interface
The interface is designed using Flutter, ensuring compatibility across devices. Users can access real-time dashboards, receive alerts, and generate reports tailored to their energy management needs.

IV. FIGURES AND TABLES

1. System Architecture Diagram
The system architecture is represented in , which illustrates the three-tier structure: Input Layer, Processing Layer, and Output Layer. Smart meters transmit data to the ThingSpeak cloud platform, where it is processed and visualized via the user interface.

2. Voltage Trends Visualization
The visualization in showcases voltage trends across three phases, highlighting real-time monitoring capabilities. Users can observe phase-specific variations and identify potential anomalies.

3. Anomaly Detection Alerts
lists typical anomalies detected by the system, along with their descriptions and corresponding notifications.

4. Consumption Reports
The consumption report is illustrated in , displaying daily, weekly, and monthly trends to facilitate energy management.

1. Figure Captions
This figure presents the process flow for energy consumption analytics, highlighting the transformation of raw data into actionable insights. The process begins with the collection of hourly energy consumption data, followed by data preparation to ensure accuracy and reliability. The prepared data is categorized into hourly and daily energy consumption for detailed analysis, supporting diverse use cases such as trend identification and operational planning.

The next stage involves model identification and building, where analytical frameworks are developed to interpret the data. The prediction and performance analysis stage evaluates the model's accuracy and efficiency, ensuring reliable energy forecasts. The process concludes with model output, offering actionable insights for optimizing energy usage and enhancing sustainability.

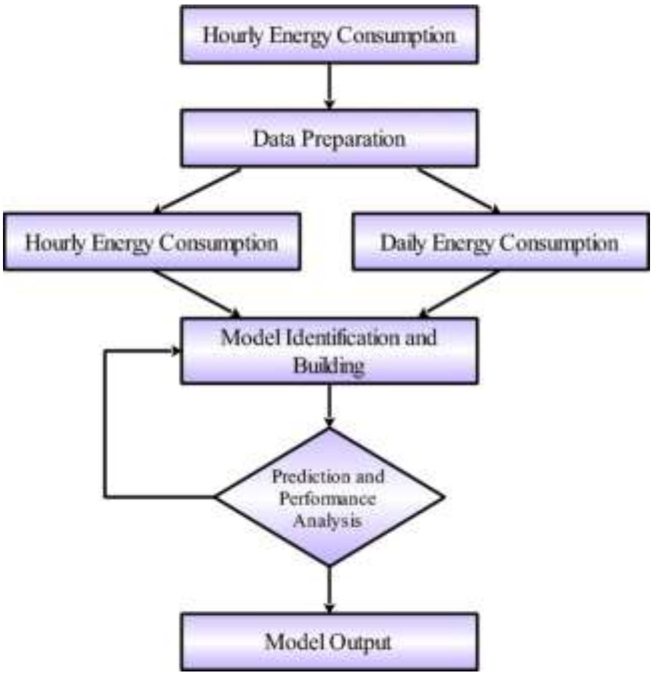

Fig 1: Process Flow Diagram for Energy Consumption Analytics

Fig 2: Data flow from IoT device to analysis via ThingSpeak and Flutter-based power consumption analytics

This figure illustrates the data flow in a power consumption analytics system. The process begins with an IoT device that captures raw data related to power consumption.

This data is transmitted to **ThingSpeak**, a cloud-based IoT analytics platform, where it is processed and stored for further use. ThingSpeak acts as a bridge between the IoT device and the analytics layer by enabling seamless data integration and retrieval.

The processed data is then accessed by a **Flutter** application that provides real-time analytics and insights into power consumption patterns.

The Flutter-based application transforms the raw data into meaningful visualizations and metrics, enabling users to make informed decisions.

2. Table Captions
Table 1 lists typical anomalies detected by the system, along with their descriptions and corresponding notifications.

Table 1: PARAMETERS MONITORED AND ASSOCIATED ALERTS

Parameter	Description	Notification Trigger	Threshold
Voltage	Monitors voltage across three phases	"Overvoltage detected"	> 240V
Power Factor	Evaluates efficiency of power consumption	"Low power factor alert"	< 0.8
Current	Tracks current flow in the system	"High current anomaly"	> 20A
Total Power Usage	Measures cumulative power consumption	"Excessive consumption"	> 50 kWh per day
Apparent Voltage	Computes and checks for significant discrepancies	"Apparent voltage anomaly"	> 260V or < 200V

V. RESULTS AND DISCUSSION

The developed system successfully demonstrated its capability to monitor and analyze energy consumption in real-time. Key outcomes include:

- **Anomaly Detection:** Real-time alerts for overvoltage and low power factor deviations minimized risks and optimized energy usage.
- **User Engagement:** Intuitive dashboards and dynamic visualizations improved user interaction and understanding of energy trends.
- **Scalability:** The cloud-based architecture ensured seamless performance with increasing numbers of devices and users.
- **Energy Optimization:** Insights derived from data analytics empowered users to implement energy-saving measures, reducing overall consumption.

VI. CONCLUSION

The proposed Power Consumption Analytics system integrates IoT devices and cloud platforms to offer a robust solution for real-time energy monitoring and optimization. By detecting anomalies and providing actionable insights, the system promotes energy efficiency and sustainability of the work or suggest applications and extensions.

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