Smart Solar Power Forecasting and Monitoring Platform

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Abstract: The Smart Solar Power Forecasting and Monitoring Platform is designed to provide real-time monitoring and predictive analysis of solar energy systems. With the increasing adoption of renewable energy, efficient monitoring and accurate forecasting have become essential to ensure optimal energy utilization and system performance.

This project integrates both monitoring and forecasting functionalities into a single platform. The monitoring system tracks key solar parameters such as voltage, current, and power in real time using a web-based dashboard. The backend is developed using Spring Boot, which generates and processes solar data through REST APIs, while the frontend visualizes the data using interactive charts.

This helps in better energy planning, load management, and improving overall system efficiency. The forecasting module can be extended using machine learning models for more accurate predictions.

The platform uses Chart.js for graphical visualization, enabling users to analyze trends and variations effectively. The system is designed to be scalable and can be integrated with IoT devices and cloud platforms such as AWS IoT Core for real-world deployment. The system includes a basic forecasting feature for future enhancement.

Keywords: Solar Power Monitoring, Solar Power Forecasting, Renewable Energy Systems, Real-Time Data Monitoring, Spring Boot, Machine Learning, Time Series Prediction, Smart Energy Management, IoT Integration, AWS IoT Core, Web Dashboard

I .INTRODUCTION

The growing demand for clean and sustainable energy has significantly increased the adoption of solar power systems across the world. Solar energy is one of the most abundant and environmentally friendly energy sources, making it a key component in modern energy solutions. However, efficient utilization of solar energy requires continuous monitoring and accurate prediction of power generation.

Traditional solar systems often lack advanced monitoring capabilities and rely on manual observation or basic measurement tools. These approaches are inefficient, time-consuming, and do not provide real-time insights into system performance. Additionally, the absence of forecasting mechanisms makes it difficult to predict future energy generation, leading to poor energy planning and management.

In addition to monitoring, the system incorporates forecasting techniques to predict future solar power output based on historical data trends. This helps in efficient energy planning, load balancing, and decision-making. The forecasting module can be enhanced using machine learning algorithms for improved accuracy.

The platform uses Chart.js for real-time data visualization, enabling users to analyze trends and detect anomalies easily. Furthermore, the system is designed to be scalable and can be integrated with IoT devices and cloud platforms such as AWS IoT Core for real-world deployment. The system can be extended with forecasting techniques in future to improve prediction accuracy.

Overall, the proposed system provides a cost-effective, scalable, and user-friendly solution for smart solar energy management, combining both monitoring and forecasting capabilities in a single platform.

A. Problem Statement

Smart solar energy systems currently face several limitations:

1. Lack of real-time monitoring of solar parameters such as voltage, current, and power
2. Inability to predict future solar power generation accurately
3. Poor visualization of data, making it difficult to analyze trends and performance
4. Dependence on manual monitoring and lack of automated insights

II .RELATED WORK

A. Existing Approaches

Early solar energy monitoring systems primarily focused on basic parameter measurement such as voltage and current using standalone devices. These systems lacked real-time data visualization and remote accessibility. Monitoring was often performed manually or through local display units, which limited the ability to analyze performance trends over time.

Previous research in solar monitoring systems emphasized the use of IoT-based sensors to improve data accessibility and system efficiency

Several studies highlighted the importance of integrating data visualization tools for better analysis of solar energy systems. However, many existing systems lacked forecasting capabilities and did not provide predictive insights for future energy generation.

The proposed system builds upon these concepts by integrating both real-time monitoring and forecasting into a single web-based platform. It provides efficient data visualization, easy accessibility, and scalable architecture for future enhancements.

III . PROPOSED SYSTEM

A. System Architecture

The proposed system follows a three-tier architecture consisting of presentation, application, and database layers.

1) **Presentation Layer:** Implemented using HTML, CSS, and JavaScript, this layer provides a user-friendly dashboard for displaying real-time solar parameters such as voltage, current, and power. It also includes graphical visualization using charts for better analysis.

2) **Application Layer:** Developed using Spring Boot, this layer handles business logic, data processing, and communication between frontend and backend through REST APIs. It generates solar data and supports forecasting functionality.

3) **Data Layer:** This layer manages data storage and retrieval. Currently, simulated data is used, but the system can be extended to integrate databases such as MySQL or cloud platforms for real-time data storage and forecasting models.

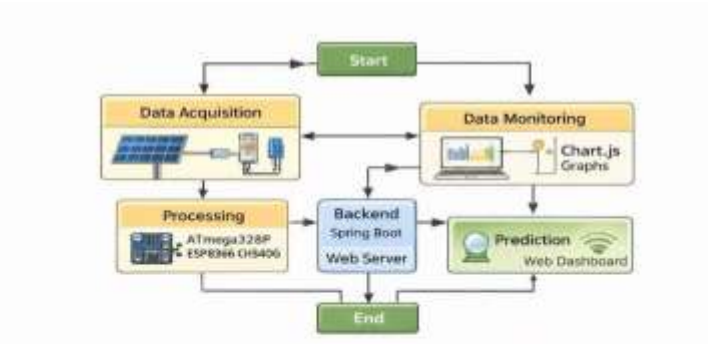

Fig 1: Shows the Workflow of the Proposed System Including Monitoring, and Forecasting Modules

B. Modules of the System

1) Data Generation Module

- Power in real time and simulates sensor data for monitoring purposes
- Generates solar parameters such as voltage, current
- Can be extended to integrate real-time IoT sensor input

2) Monitoring Module

- Displays real-time solar data on the dashboard
- Continuously updates voltage, current, and power values
- Provides instant visibility of system performance

3) Visualization Module

- Uses charts to represent solar data graphically
- Displays trends using line graphs and real-time updates Helps users analyze system behavior and detect anomalies

4) Forecasting Module

- Predicts future solar power generation based on historical data
- Provides basic estimation of future solar power
- Can be enhanced using machine learning in future
- Helps in energy planning and load management

5) API Integration Module

- Handles communication between frontend and backend using REST APIs
- Fetches data from backend server

Ensures smooth data transfer and system performance.

Fig 2 : Workflow of Smart Solar Power Monitoring System Architecture

C . System Implementation

The backend of the system is implemented using Java Spring Boot, which provides a robust framework for building RESTful web services. The backend handles data generation, processing, and API communication.

The frontend is developed using standard web technologies such as HTML, CSS, and JavaScript to ensure browser compatibility and responsive design. Real-time data is fetched using REST APIs and displayed on the dashboard.

Graphical visualization is implemented using Chart.js, which enables dynamic and real-time updates of solar parameters. The system continuously updates data at regular intervals, providing live monitoring functionality.

The integration between frontend and backend ensures efficient data flow, secure handling of requests, and smooth interaction between system components.

IV . RESULT AND DISCUSSION

The system was tested under multiple scenarios, including real-time solar data monitoring and forecasting analysis. The results demonstrate that the platform successfully tracks solar parameters such as voltage, current, and power with minimal delay.

The graphical visualization using charts provides clear insights into system performance and trends over time. The real-time updates ensure continuous monitoring, allowing users to detect variations and anomalies effectively. It reduces manual effort and improves accuracy in analyzing solar system performance

Fig.3. Result

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VI . CONCLUSION

The Smart Solar Power Forecasting and Monitoring Platform provides an efficient solution for real-time monitoring and prediction of solar energy systems. The system successfully displays solar parameters through an interactive dashboard and enables better analysis using graphical visualization. The system can be further enhanced by integrating advanced forecasting techniques and machine learning models. Overall, the platform is scalable, user-friendly, and suitable for future IoT-based solar applications.

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