EnergySense – Intelligent Load Forecasting and Anomaly Detection for Smart Buildings

Abstract

Accurate short-term load forecasting is critical for decarbonizing buildings, which contribute to roughly one-third of global energy consumption and greenhouse gas emissions. Inefficient energy usage leads to unnecessary costs, higher carbon footprints, and challenges in integrating renewable energy sources. **EnergySense** addresses this problem by leveraging advanced **time-series forecasting models** and **anomaly detection techniques** to predict energy consumption patterns in both residential and commercial buildings.

The proposed solution utilizes **pre-trained Time Series Foundation Models (TSFMs)** to learn generalizable temporal patterns, enabling high-accuracy load predictions across multiple building types and datasets. By analyzing historical energy consumption data, EnergySense can detect anomalies, such as abnormal spikes or drops, which may indicate equipment malfunctions or unusual operational behavior. This allows building managers to take timely corrective actions, optimize energy usage, and reduce operational costs.

The system is designed for **scalability** and **adaptability**, capable of handling diverse datasets and incorporating renewable energy inputs. EnergySense provides actionable visualizations and reports for decision-makers, supporting efficient energy management and sustainability goals.

Project Objectives

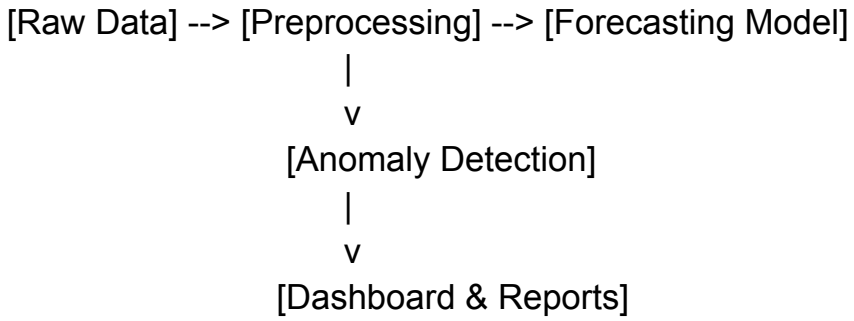
1. Forecast short-term energy consumption accurately for buildings.
2. Detects anomalies in energy usage for proactive maintenance.
3. Enable integration of renewable energy sources with predictive insights.

4. Provide intuitive visualizations and actionable recommendations for building managers.

Proposed Methodology

Stage	Details
Data Collection	ASHRAE Energy Prediction Dataset, UCI Building Energy Dataset, Open Power System Data
Data Preprocessing	Handle missing values, normalize features, engineer temporal & weather-related features
Modeling	Time Series Foundation Models (TSFMs), compare with other forecasting models
Anomaly Detection	Statistical approaches (Z-score, moving averages), ML-based detection
Deployment & Visualization	Real-time prediction dashboards, reports with actionable insights

Workflow Diagram



Expected Outcomes

- Reduced energy waste and operational costs.
- Early detection of equipment faults or abnormal usage.
- Improved integration of renewable energy sources.
- Scalable, reusable solution for different types of buildings.

Conclusion

EnergySense provides a **data-driven solution** to optimize energy consumption in buildings while enabling the integration of renewable energy sources. By combining **short-term load forecasting** with **anomaly detection**, the project empowers building managers to make informed decisions, reduce energy waste, and lower operational costs. The system's **scalable and adaptable design** ensures that it can handle diverse datasets and building types, making it a versatile tool for sustainable energy management.

In essence, EnergySense bridges the gap between **smart energy analytics** and **actionable insights**, contributing to **efficient, sustainable, and cost-effective building operations**, while supporting global decarbonization goals.