Smart Meter Peak Hour Electricity Analysis

Overview

Smart Meter Peak Hour Electricity Analysis is a data analytics and machine learning project that analyzes electricity consumption patterns from smart meter data and predicts evening peak hour demand. The system processes 15-minute interval electricity readings, converts them into hourly energy consumption, removes noise using moving average smoothing, and predicts upcoming peak hour usage using Linear Regression. The results are visualized through an interactive dashboard. This project demonstrates how data-driven techniques can support smart campus and smart grid energy management.

Problem Statement

Electricity demand in residential or dormitory environments increases during evening hours due to higher appliance usage. Sudden demand spikes can cause transformer overload, higher energy costs, and inefficient distribution. The objective of this project is to analyze historical smart meter electricity consumption, identify peak usage patterns, predict evening peak hour demand, and visualize trends for better energy planning.

Dataset

This project uses the Electricity Load Diagrams 2011–2014 dataset. Dataset characteristics: 370 smart meter clients, 15-minute interval readings, values in kW, no missing values, 96 readings per day, time recorded in Portuguese time zone. To convert kW readings to kWh, Energy (kWh) = Power (kW) × Time (0.25 hour), therefore values are divided by 4.

Project Workflow

Data Processing: Load smart meter dataset from .txt file, convert timestamp column to datetime, convert kW to kWh, resample 15-minute readings into hourly consumption, select last 7 days of data. Data Cleaning: Apply moving average smoothing to remove noise and handle minor fluctuations in consumption. Feature Engineering: Extract hour of day and day of week. Machine Learning: Train Linear Regression model using peak hour data and predict upcoming evening electricity usage. Visualization: Plot hourly consumption trend and predicted evening peak demand.

Technologies Used

Python, Pandas, Scikit-learn, Streamlit, Plotly or Matplotlib.

System Architecture

Smart Meter Data → Data Processing → Feature Extraction → Linear Regression Model → Peak Hour Prediction → Dashboard Visualization.

Installation

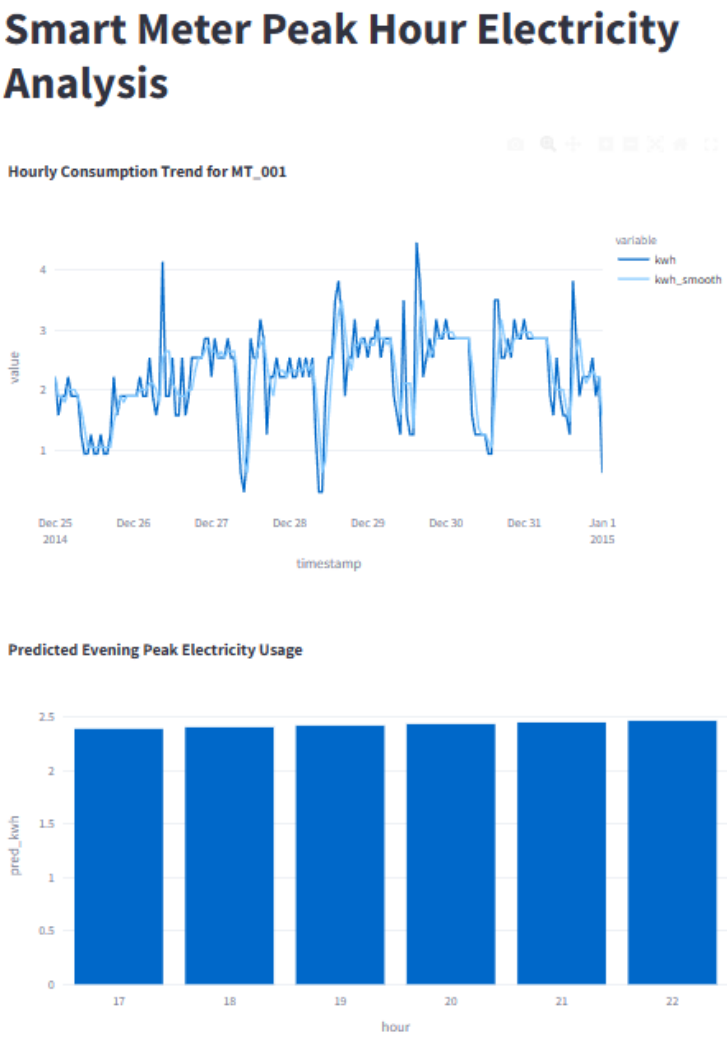
Install required libraries: pip install pandas scikit-learn streamlit plotly matplotlib

How to Run the Project

Place the dataset file LD2011_2014.txt in your system, update the dataset path in the code, then run the Streamlit app using streamlit run app.py and open the local browser link provided by Streamlit.

Output

The dashboard displays hourly electricity consumption trend, smoothed consumption curve, and predicted evening peak usage (5 PM–10 PM).



Key Features

Converts 15-minute smart meter data into hourly energy usage, removes noise using moving average smoothing, predicts peak electricity demand using machine learning, provides interactive visualization dashboard, and is suitable for smart campus and energy analytics applications.

Applications

Smart campus energy monitoring, load forecasting for smart grids, energy demand planning, infrastructure capacity management, and electricity cost optimization.

Limitations

Uses only time-based features, does not include weather or occupancy data, Linear Regression cannot capture complex nonlinear patterns, and predictions may be flat during stable consumption periods.

Future Enhancements

Use LSTM or ARIMA for time-series forecasting, add weather and temperature data, predict full-day load curve, detect abnormal energy spikes, and deploy as a real-time smart grid monitoring system.

Conclusion

This project demonstrates how smart meter data can be used to analyze electricity consumption behavior and predict peak hour demand, providing a simple and effective approach for short-term load forecasting and energy management using data analytics and machine learning techniques.