End-to-End Smart Electricity Billing Analysis and Forecasting System

🔍 Problem Statement

In urban and semi-urban households, unpredictable spikes in electricity bills can cause confusion and budgeting issues. Consumers often have no tools to predict or verify their upcoming utility charges. There is a growing need for a smart, data-driven system that can forecast monthly electricity bills and flag unusual spikes in usage.

🎯 Research Objectives

1. **To develop a system** that stores electricity usage and billing data for users.
2. **To apply machine learning (Polynomial Regression)** to predict future electricity bills based on historical usage.
3. **To detect abnormal billing patterns or spikes**, enabling early alerts to users.
4. **To present results visually** through an interactive and user-friendly dashboard (Streamlit).
5. **To ensure the system works efficiently** even with minimal data (single user, limited months).

📌 Hypothesis

If sufficient historical billing data is available for a user, a machine learning model like Polynomial Regression can accurately predict the next month's electricity bill and detect anomalies based on past trends.

🗂️ Data Overview

- **Database Name**: UtilityBilling
- **Tables**:
    - users: Contains user ID, name, and address.
    - bills: Contains user ID, month, electricity usage (kWh), and bill amount (₹).
- **Data Volume**: 1 user with 30 months of billing data (including occasional spike).

📊 Analysis and Findings

- The model was trained using **Polynomial Regression (degree 2)**.
- **R^2 Score = 0.90**: Indicates a very good fit of the model with historical data.

- **MAE = ₹54.29** and **MSE = 4776.59**: Acceptable error levels for billing forecasts.
- The system correctly identified a spike when bill value exceeded **130%** of predicted value.
- The **Streamlit dashboard** displayed historical trends and the predicted value clearly, without requiring user interaction.

✅ **Recommendations**

1. **Deploy this system in housing societies or smart homes** to help consumers anticipate their bills.
2. **Extend the database** to support multiple users with monthly comparisons.
3. **Integrate alerts** via email or mobile app when an abnormal spike is detected.
4. Use additional features like **weather data** or **appliance usage** to improve prediction accuracy.
5. Provide **real-time billing insights** for energy optimization and budgeting.