Smart Home Energy Management System

1.Project Statement

With increasing electricity costs and sustainability awareness, users need tools to monitor and optimize household energy usage.

This project helps users track device-level energy consumption, schedule appliance usage during off-peak hours, and receive personalized recommendations to save energy and reduce bills.

2.Outcomes

- User roles: **Homeowner**, **Technician**, **Admin**
- Real-time energy tracking per device
- Device scheduling and automation controls
- Energy cost forecasting based on usage
- Personalized energy-saving recommendations
- Visual dashboards and analytics

3.Modules to be Implemented

1. **Authentication & Role Management**
    a. JWT-based login & registration
    b. Roles: Admin, Homeowner, Technician
2. **Smart Device Management**
    a. CRUD for household devices (e.g., lights, AC, fridge)
    b. Device power ratings and usage logs
3. **Real-Time Energy Tracking**
    a. APIs to fetch or simulate device energy usage
    b. Display current and historical energy consumption
4. **Energy Analytics Dashboard**
    a. Visualize total consumption (daily, weekly, monthly)
    b. Identify high-usage appliances
    c. Cost estimation and comparison

5. **Scheduling & Automation**
    a. Allow users to schedule device ON/OFF times
    b. Notifications for unusual energy spikes
6. **Recommendation System**
    a. Suggest best usage times (off-peak hours)
    b. Recommend energy-efficient alternatives

4.Week-Wise Milestones

Milestone 1: Weeks 1–2

Authentication & Role Setup

- **Implement JWT authentication:**
  Secure login and registration system using JSON Web Tokens (JWT) for session validation and API protection.
  Users can sign up and log in with encrypted credentials ensuring privacy and security.

- **Role-based access (Admin, Homeowner, Technician):**
  Define role-based permissions for each user type to restrict access to certain APIs or dashboard features.
  Admins manage system settings, while homeowners manage devices, and technicians handle installations.

- **Profile setup: name, address, device preferences:**
  Create a detailed profile form where users input personal and household details. Store user data in the database for personalized energy recommendations and dashboard visualization.

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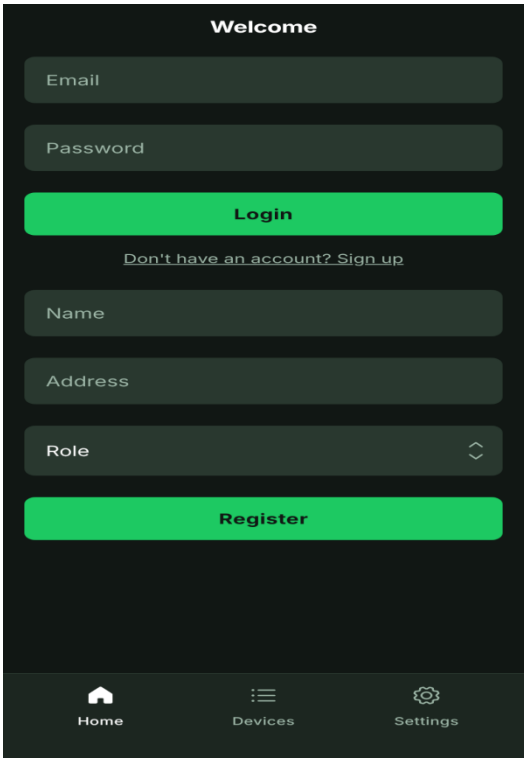


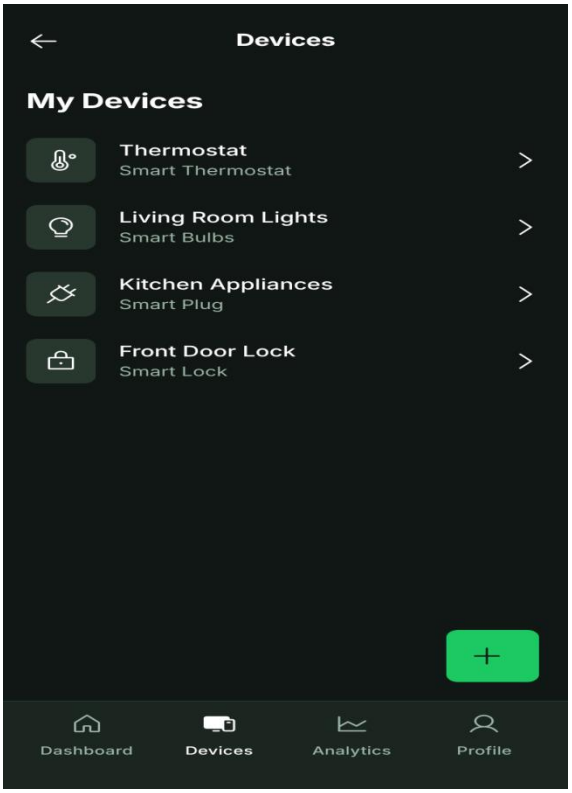
Milestone 2: Weeks 3–4

Device Management

- **CRUD for devices with fields (Name, Type, Power Rating):**
  Allow users to add, edit, and delete household devices with complete details like power consumption and type.
  Data persistence ensures easy retrieval and modification for accurate tracking.

- **Store energy usage logs per device:**
  Each device's daily or hourly energy usage is stored in logs for future analysis.
  Enables historical tracking and trend visualization on the analytics dashboard.

- **Homeowners can add/edit their own devices:**
  Implement ownership-based data control to ensure users manage only their own devices.
  Use authentication tokens to validate requests and secure device management operations.



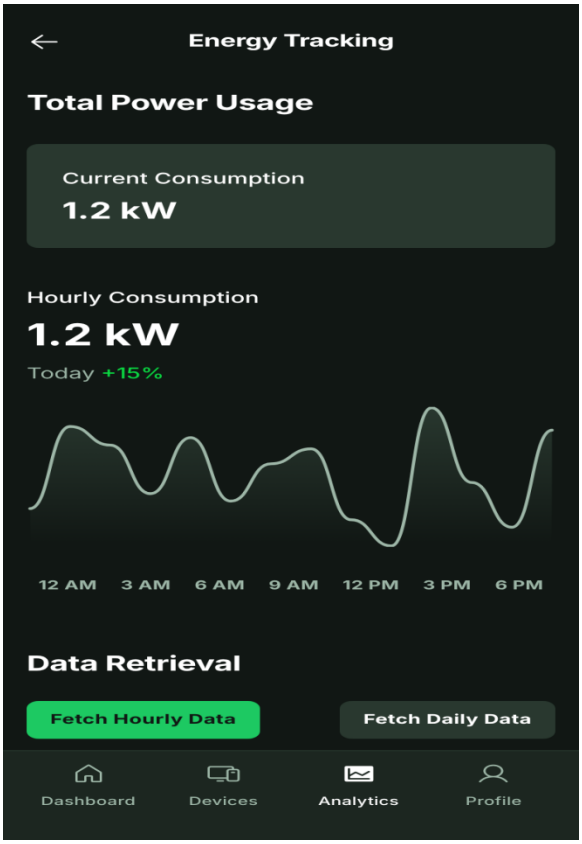
Milestone 3: Week 5

Energy Tracking & API Integration

- **Simulate or integrate an IoT API for live power usage:**
  Integrate dummy IoT data or third-party APIs to simulate real-time energy readings from connected devices.
  Ensure the system can scale for future real IoT integration with minimal modification.

- **Display total household energy usage:**
  Fetch all active device data to calculate total power consumption in real-time.
  Represent the total usage visually on the dashboard using dynamic charts or graphs.

- **Fetch hourly/daily consumption data:**
  Allow users to select a time period to view detailed energy usage statistics.
  Store data in a time-series format for efficient retrieval and analysis.



Milestone 4: Weeks 6–7

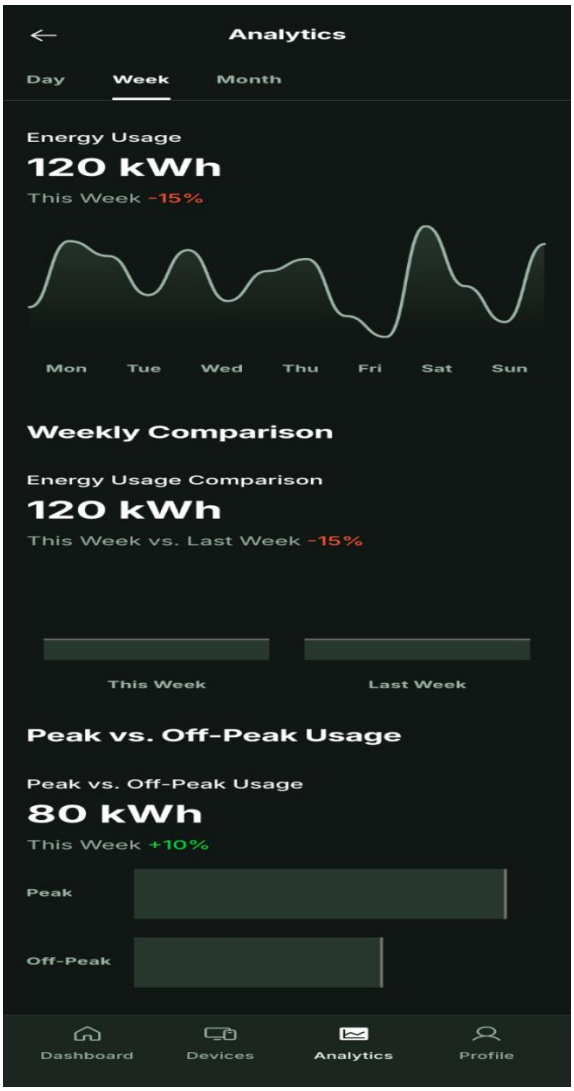
Analytics Dashboard

- **Charts for consumption patterns:**
  Visualize power usage through line and bar charts showing daily, weekly, and monthly energy trends.
  Use chart libraries (like Chart.js or Recharts) integrated via the frontend.

- **Compare total usage vs. previous weeks:**
  Generate comparison reports highlighting changes in consumption patterns over time.
  Provide insights into whether usage is improving or increasing week-over-week.

- **Energy cost prediction based on rate per unit:**
  Calculate estimated energy cost using local tariff rates and consumption logs.
  Display total and average expenses to help users plan and budget effectively.

- **Display peak vs. off-peak usage patterns:**
  Identify when energy usage is highest or lowest throughout the day.
  Highlight off-peak hours visually to encourage more efficient usage habits.



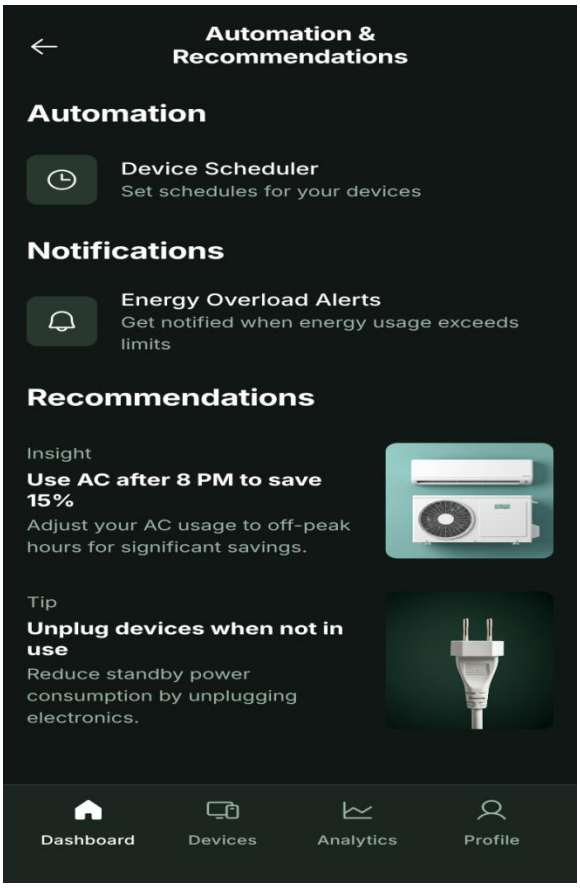
Milestone 5: Week 8

Automation & Recommendations

- **Scheduler for device ON/OFF:**
  Implement scheduling functionality that allows users to automate appliance operation.
  Use cron-like scheduling or backend timers to execute ON/OFF commands at user-defined times.

- **Send reminders for energy overloads:**
  Generate alerts when energy consumption crosses predefined limits.
  Notify users via email or in-app notifications to take action immediately.

- **Generate energy-saving insights (e.g., "Use AC after 8 PM to save 15%"):**
  Analyze user activity patterns to create personalized energy recommendations.
  Display daily/weekly energy tips and suggestions to promote sustainability.



5.Evaluation Criteria

● **Week 1:** Project setup completed with database configuration and API skeleton initialized

● **Week 2:** Authentication and role-based access control (Admin / Homeowner / Technician) fully operational

● **Week 3:** Device management (Add / Edit / Delete) implemented with ownership restrictions

● **Week 4:** Energy usage logging per device stored and retrievable in time-series format

● **Week 5:** Real-time (or simulated) energy tracking API integrated and displaying live consumption

● **Week 6:** Historical analytics and comparison logic (daily / weekly / monthly trends) functional

● **Week 7:** Dashboard with visual charts, cost estimation, and peak vs off-peak insights displayed correctly

● **Week 8:** Automation (Scheduling + Alerts) and personalized energy recommendations tested successfully

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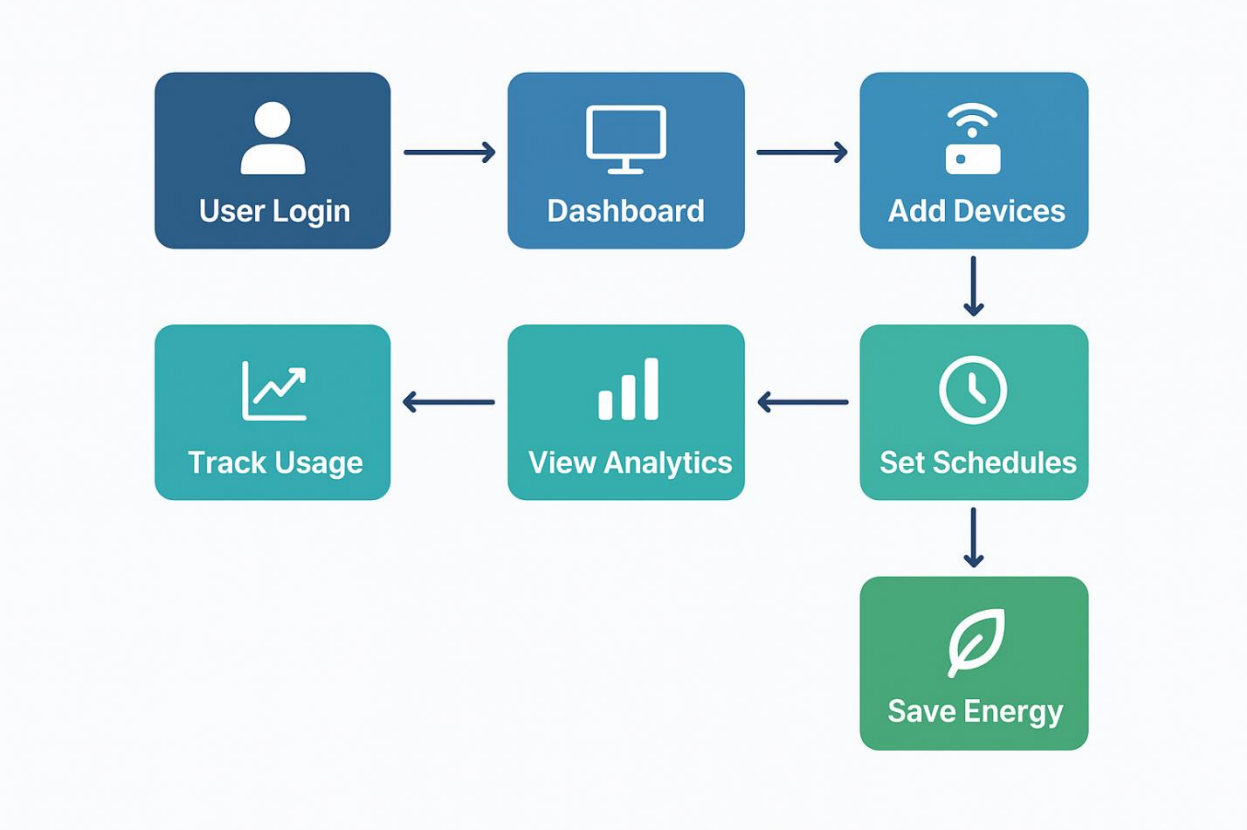
6. Workflow diagram:



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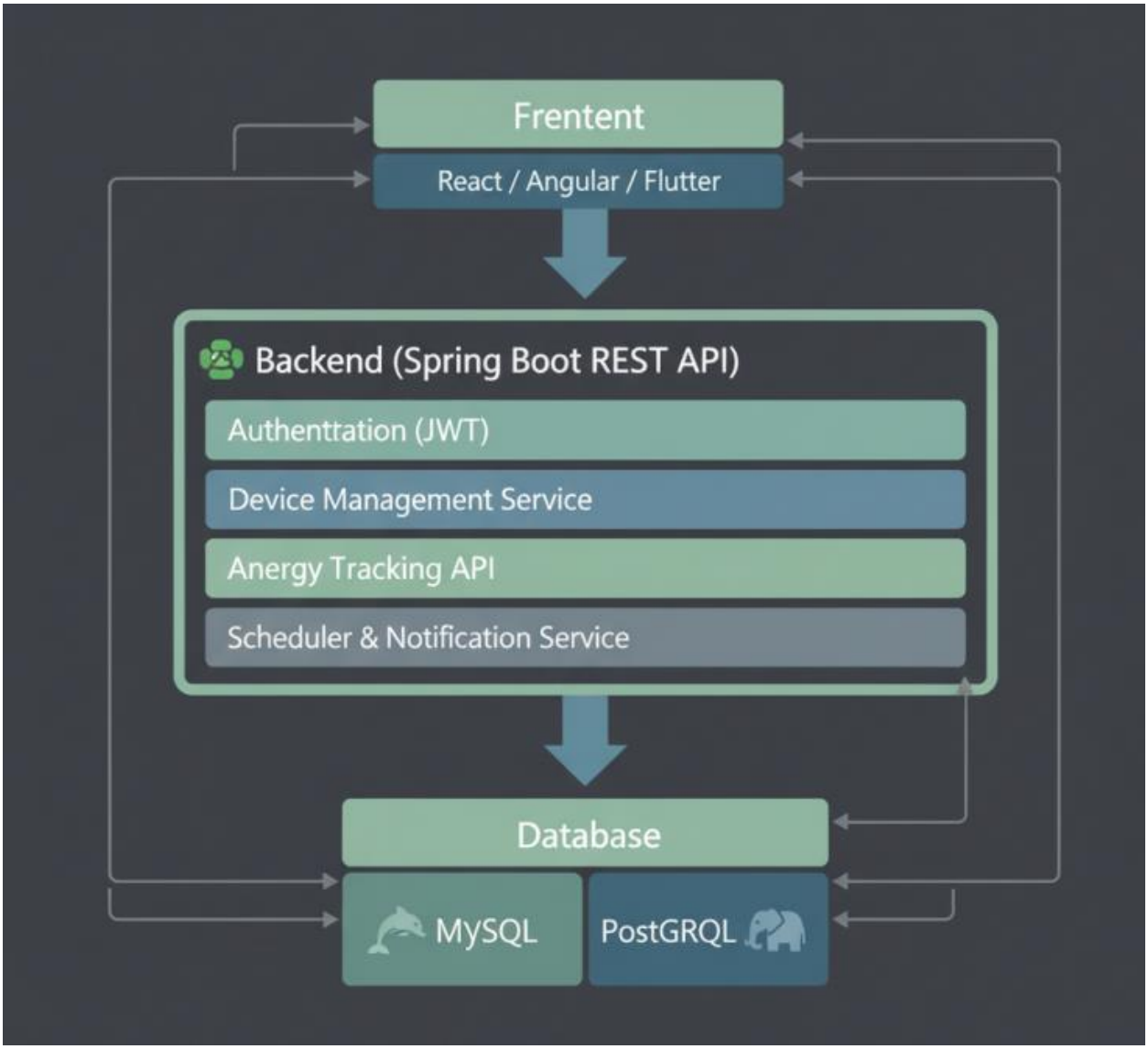
7. Architecture diagram:



8. Schema diagram: