Swarajya : A Predictive Platform for Sustainable EV Battery Logistics and Retail-Based Charging Infrastructure

Batch/Group/Team No : 19

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Overview

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Motivation

- EV adoption is rising, but charging infrastructure remains uneven, causing range anxiety and delays.
- No real-time system exists to predict charging demand or guide users to nearby available stations.
- Urban spaces like hotels and shops are underutilized and not integrated into the charging network.
- SmartEVLink proposes an ML-powered platform to forecast demand and connect users with local hosts.
- IEA (2023): Over 14M EVs sold globally; 1 in 3 users cite limited charging access as a key concern.

Objective of the project

- To develop an intelligent platform that predicts EV battery swapping/charging demand using machine learning.

- To act as an intermediary between EV users, energy companies, and local hosts (e.g., hotels, stores).

- To optimize infrastructure placement and enhance EV charging accessibility in urban and semi-urban areas.

SDG Alignment & IKS Integration

SGD	Project Contribution	IKS
SDG 7 – Affordable and Clean Energy	Utilizes existing infrastructure (shops, hotels, MSMEs) for EV charging, reducing the need for new construction and promoting energy frugality.	Parigraha Parimita
SDG 9 – Industry, Innovation & Infrastructure	Fosters indigenous tech innovation through AI/ML-based energy logistics and decentralized infrastructure design.	Kaushalam
SDG 11 – Sustainable Cities and Communities	Enables community-powered EV infrastructure by turning small businesses into charging hubs, promoting urban inclusivity.	Vikendrīkaraṇam
SDG 13 – Climate Action	Supports predictive, low-emission mobility solutions that align technological growth with environmental responsibility.	Samriddhi saha Paryāvaraṇam
SDG 17 – Partnerships for the Goals	Builds synergy among EV users, local hosts, and energy providers—reflecting IKS ideals of collective welfare and cooperative ecosystems.	Samanvaya

Project Alignment with IKS :

SmartEVLink embodies Swarajya by empowering local businesses (MSMEs, shops, hotels) to independently host EV charging services, fostering self-reliance and decentralized energy access.

Literature Survey (Existing Technology)

Ref.No	Titlte, Author, Year	Methodology Used	Dataset	Advantages	Disadvantages
1	Sizing and Locating Planning of EV Centralized-Battery-Charging-Station, He et al., 2022	Double-level planning with time-space forecasting	Simulated regional SEV data	Considers logistics system, battery flow, and CBCS/BDS coordination	No real-time adaptability, lacks retail/consumer integration
2	A Deep Learning Approach for EV Load Forecasting, Zhang et al., 2021	Deep Neural Network (DNN) forecasting	Historical EV charging logs	Accurate EV load prediction, dynamic time series modeling	Focused only on charging (not swapping); lacks spatial granularity
3	Optimal Placement of Battery Swapping Stations, Ban et al., 2018	MILP optimization	City-level traffic and mobility data	Focus on swap station siting to minimize driver travel distance	Ignores dynamic demand changes and user participation

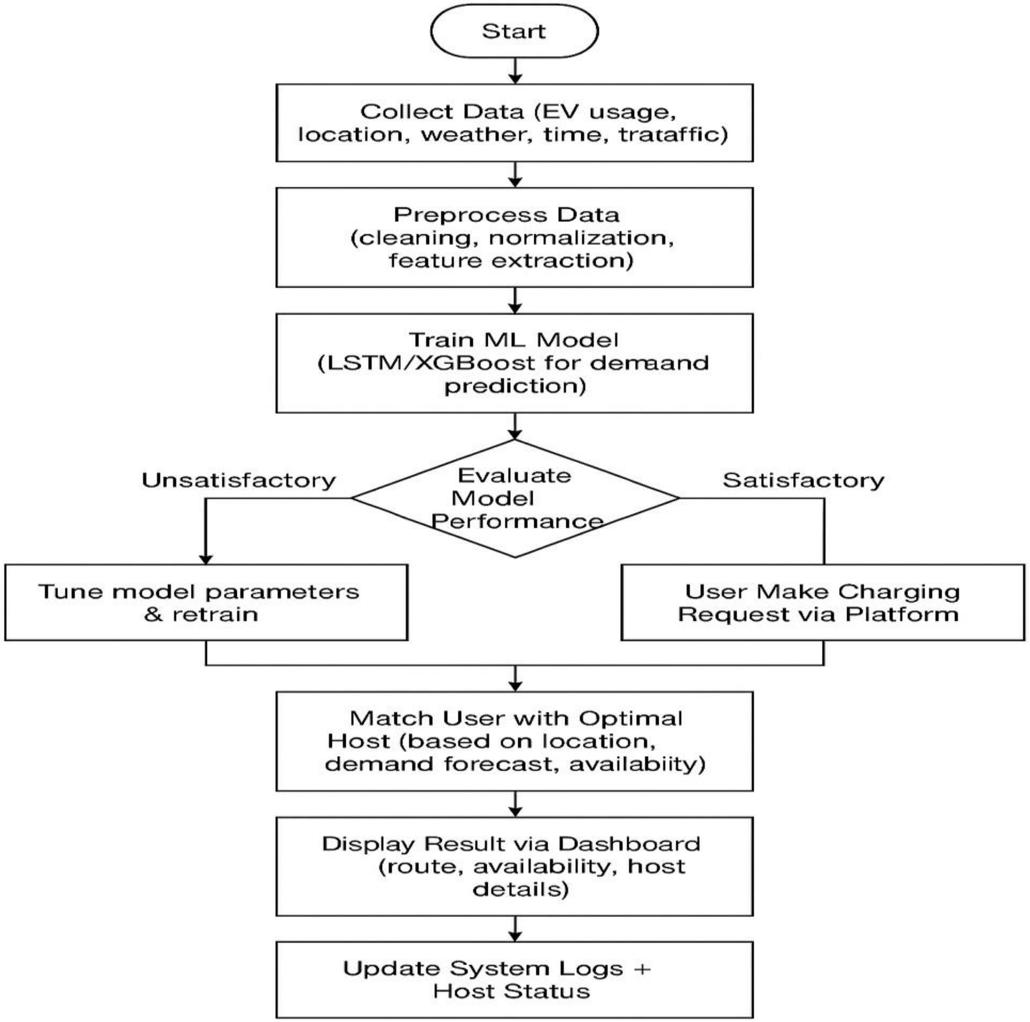
Objectives & Scope

- SMART Objectives
  - ML model to predict EV battery demand (≥85% accuracy)
  - Web platform to connect users, hosts & providers
  - Simulate demand across 10+ zones
  - Test energy efficiency in 3 urban cases
  - Align with SDG & IKS principles
- Project Scope
  - In-Scope:
    - ML forecasting, platform development, simulation, APIs
  - Out-of-Scope:
    - Physical deployment, utility integration, legal contracts

Proposed System / Methodology

- Key Technologies Used
  - ML: Python (LSTM/XGBoost)
  - Backend: FastAPI / Node.js
  - Frontend: React.js
  - DB: PostgreSQL / Firebase
  - APIs: Google Maps, Weather, Location
- Methodology
  - Agile development (2-week sprints)
  - CRISP-DM for ML lifecycle
  - AI-enabled simulation for real-world testing

FLOWCHART


Start
Collect Data (EV usage, location, weather, time, trataffic)
Preprocess Data (cleaning, normalization, feature extraction)
Train ML Model (LSTM/XGBoost for demaand prediction)
Evaluate Model Performance
Unsatisfactory
Satisfactory
Tune model parameters & retrain
User Make Charging Request via Platform
Match User with Optimal Host (based on location, demand forecast, availabiity)
Display Result via Dashboard (route, availability, host details)
Update System Logs + Host Status

Comparative Analysis

Feature	Existing Systems	SmartEVLink (Proposed System)
Charging Infrastructure	Fixed-location charging stations	Dynamic, host-integrated system (MSMEs, hotels, etc.)
Demand Forecasting	Static/manual	Real-time ML-based prediction (LSTM/XGBoost)
Stakeholder Model	Provider-centric	Inclusive: User ↔ Host ↔ Provider coordination
Accessibility	Urban-focused	Scalable to semi-urban and Tier 2/3 regions
Cost & Setup	High infra cost	Low-cost, software-driven with no hardware dependency

Project Plan & Team Roles

Project Plan

- Phase 1: Literature Review, Tool & Technology Selection, Market Study
- Phase 2: Dataset Collection (EV usage, traffic, weather, location)
- Phase 3: Data Cleaning, Feature Engineering, Model Selection (LSTM/XGBoost)
- Phase 4: Model Training, Evaluation & Demand Forecasting
- Phase 5: Web Platform Development (User ↔ Host ↔ Provider interface)
- Phase 6: Dashboard Visualization, Real-time APIs, SDG/IKS Alignment
- Phase 7: Testing, Documentation, Final Demo & Report Submission

Team Roles

- Shylendra Prabu R: Handles ML model development, training, and demand prediction
- Krithik SS : Develops frontend interface and dashboard with map/API integration
- Yaswanth Kumar S: Builds backend APIs, manages database, and supports SDG/IKS alignment

Expected Outcome

- A functional ML model (LSTM/XGBoost) to predict EV battery demand zone-wise
- A web-based platform connecting EV users with nearby host locations (e.g., shops, MSMEs, hotels)
- Real-time dashboard showing demand heatmaps, available hosts, and routing suggestions
- Simulation results validating system performance in at least 3 urban/semi-urban zones
- Integration of SDG/IKS principles to support inclusive and sustainable infrastructure

Resources

- Software: Python, TensorFlow/Keras, Node.js, React.js, Firebase/PostgreSQL
- APIs: Google Maps API, OpenWeather API
- Cloud Services: AWS / Heroku (for deployment & hosting)
- Tools: GitHub (version control), Figma (UI design – optional)
- Team collaboration tools: Google Docs, Trello/Notion for planning

References & Review Queries

1. C. He, J. Zhu, S. Li, Z. Chen, and W. Wu, "Sizing and Locating Planning of EV Centralized-Battery-Charging-Station Considering Battery Logistics System," IEEE Transactions on Industry Applications.
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4. G. R. Kamath and P. Kumar, "Electric Vehicle Demand Prediction Using Machine Learning Algorithms," in Proc. 2nd International Conference on Data Science, Machine Learning and Applications (ICDSMLA), 2020.
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Thank you