

PROJECT REPORT

Team ID: LTVIP2026TMIDS80003

1.INTRODUCTION:

1.1. Project overview

This project centre's on creating a visualization tool for analyzing **electric vehicle (EV)** performance-specifically focusing on battery charging time and driving range. These two factors are known hurdles in EV adoption, so the tool aims to deliver data-backed insights that help EV users optimize their experience.

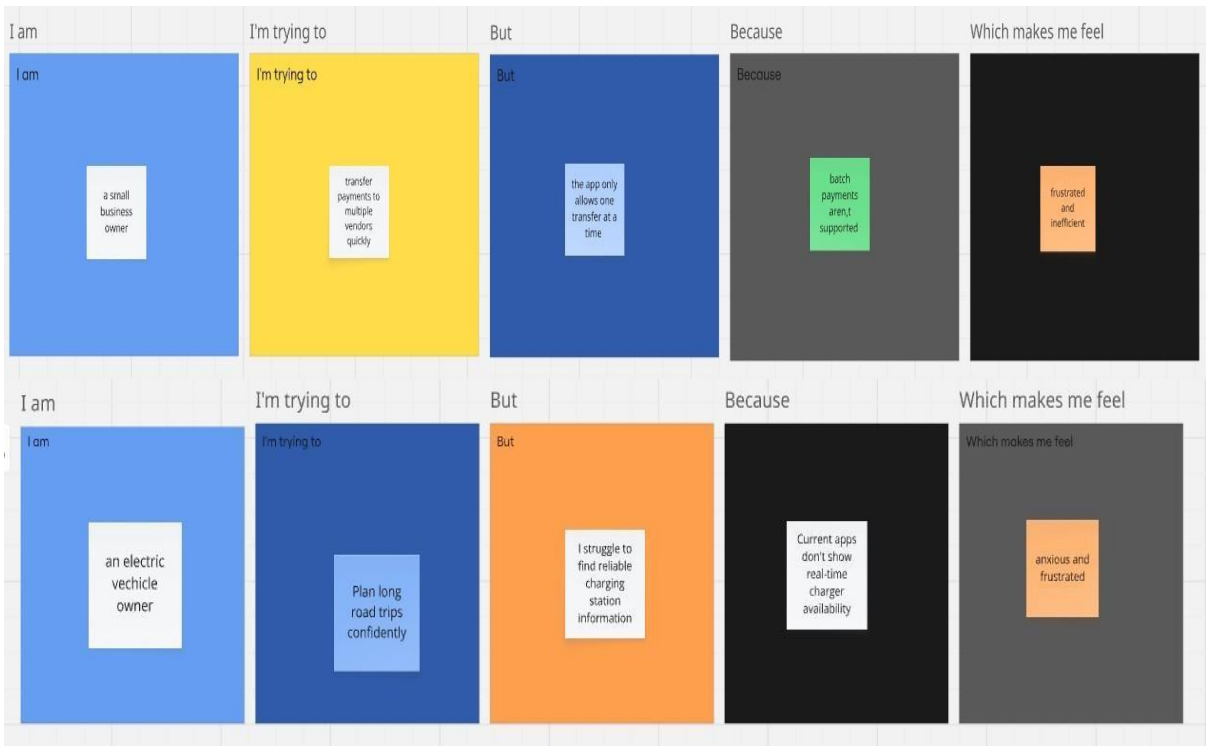
1.2. Purpose

The primary purpose of this project is to empower electric vehicle (EV) users with datadriven insights into their vehicle's performance—specifically charging efficiency and range prediction. By visualizing key metrics like battery capacity, charge time, and travel range, the tool helps users make smarter, more confident decisions about their EV usage. It also encourages energy-conscious driving habits through awareness and education.

2. IDEATION PHASE:

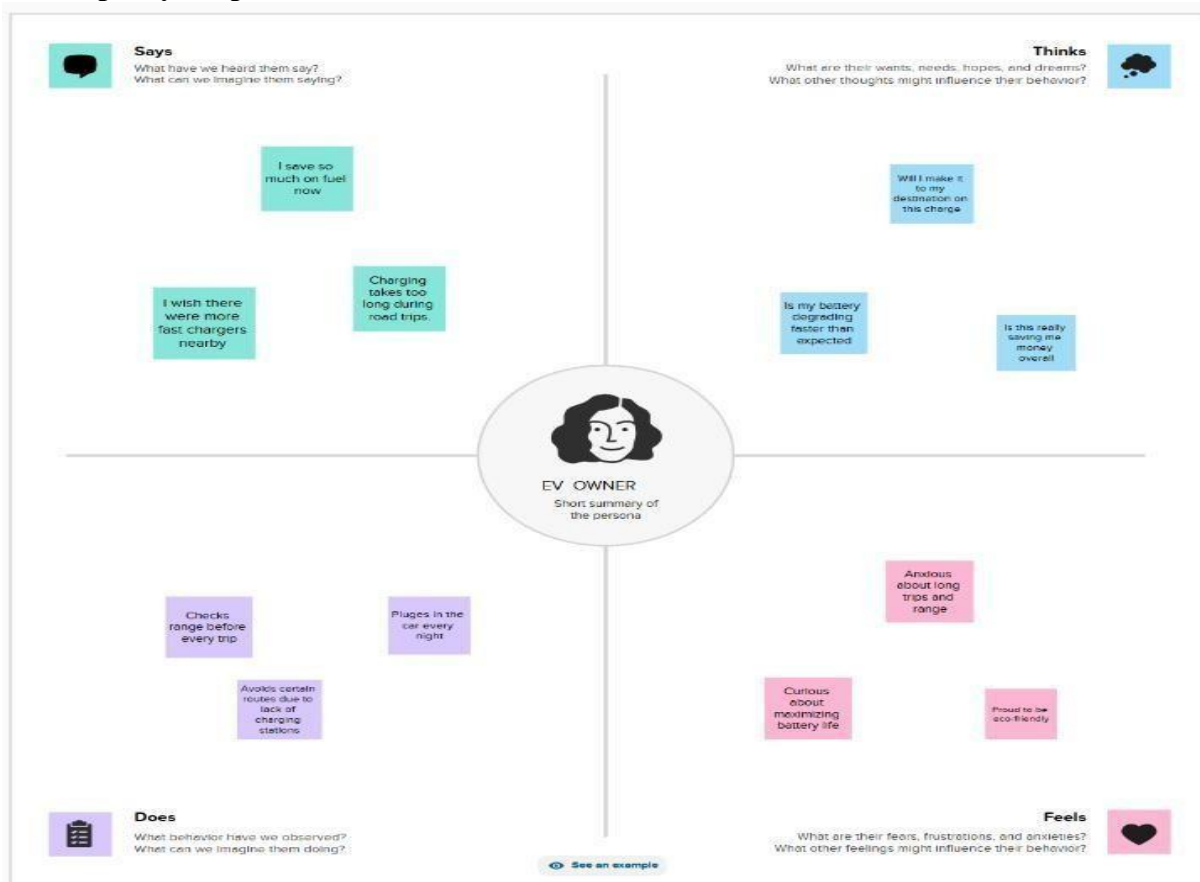
2.1 Problem Statement

Despite the growing adoption of electric vehicles (EVs), many users struggle with understanding how far they can travel on a charge and how long it will take to recharge their vehicle. Current EV dashboards often lack intuitive and detailed insights into battery health, charging efficiency, and real-time range predictions. This lack of transparency can lead to inefficient route planning, unexpected battery depletion, and user anxiety—commonly referred to as "range anxiety." There is a pressing need for a user-friendly tool that visually presents essential EV performance data, enabling users to make informed decisions about charging habits and travel plans.



Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	An electric vehicle owner	Plan long road trips confidently	I struggle to find reliable charging station information	Current apps don't show real time charger availability	Anxious and frustrated
PS-2	A small business owner	Transfer payments to multiple vendors quickly	The app only allows one transfer at a time	Batch payments are not supported	Frustrated and inefficient

2.2 Empathy Map Canvas

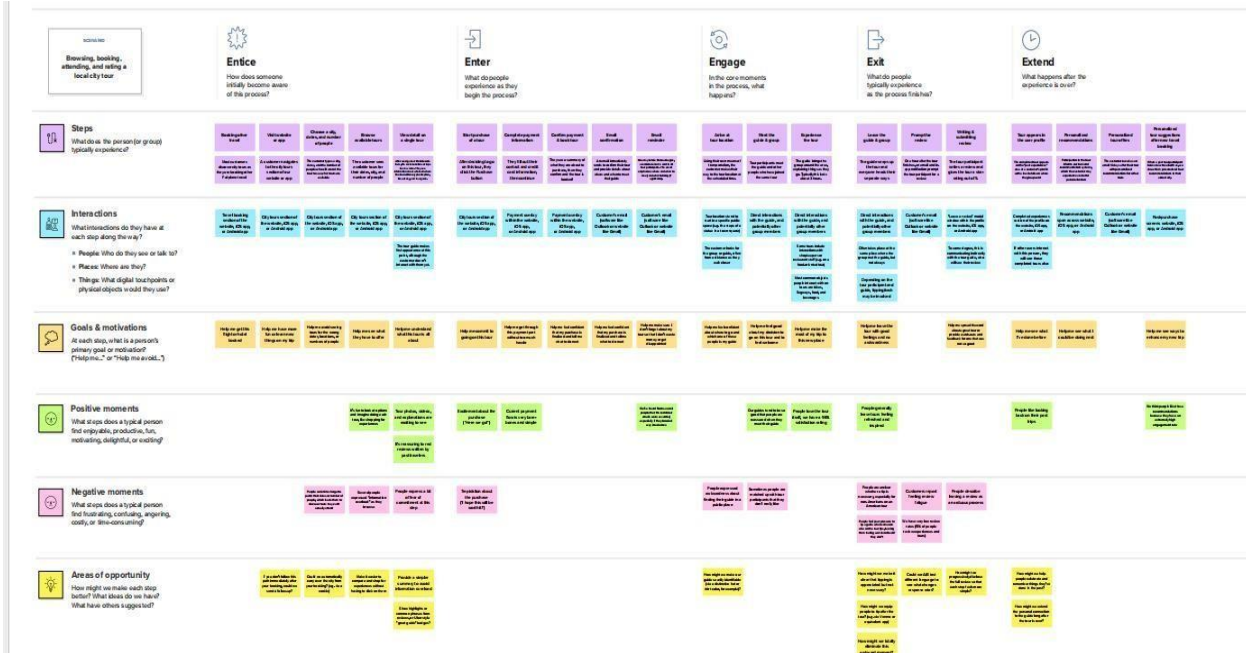


2.3 Brainstorming

Step-1: Team Gathering, Collaboration and Select the Problem Statement

3. REQUIREMENT ANALYSIS

3.1 Customer Journey map



3.2 Solution Requirement

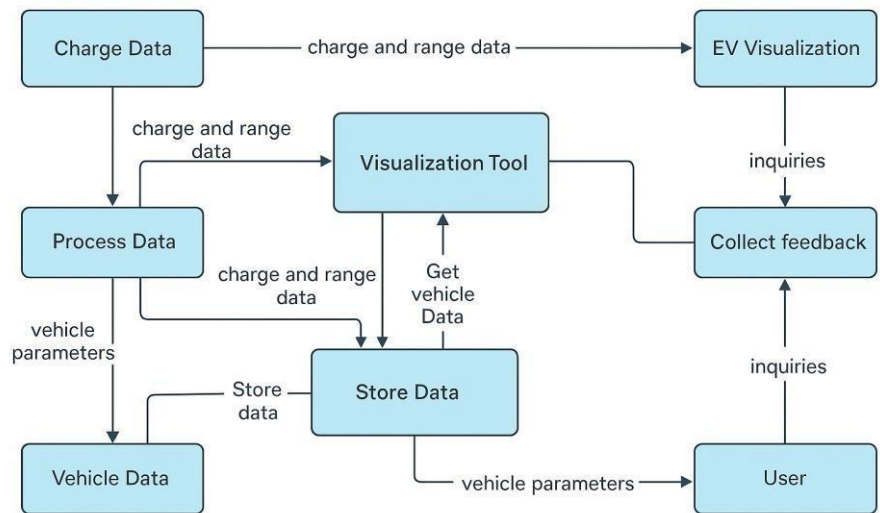
Functional Requirements: Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Account Management	Registration through Form Registration through Gmail Registration through Credentials.
FR-2	Vehicle Input Module	Enter battery percentage Input vehicle type/model
FR-3	Range and Charge Analysis	Display estimated range based on input Visualize charge level and consumption trend Suggest optimal charging stations
FR-4	Interactive Map View	Show nearby charging stations Filter stations based on power availability Highlight reachable area on current charge
FR-5	Session History and Reporting	Show previous charge sessions Export usage and performance data
FR-6	Admin Dashboard	Manage station database View user analytics

Non-functional Requirements: Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The interface must be intuitive for EV users, analysts, and admins, with smooth navigation across modules.
NFR-2	Security	Secure authentication and role-based access must be implemented to prevent unauthorized access.
NFR-3	Reliability	System must provide consistent performance and accurate range estimations during peak usage hours.
NFR-4	Performance	Real-time data updates and visualizations should render within 2 seconds of input for a smooth user experience.
NFR-5	Availability	The system should be operational 99.9% of the time, ensuring accessibility for daily EV planning.
NFR-6	Scalability	The tool should scale to accommodate more users, vehicles, and charging data without performance degradation.

3.3 Data Flow Diagram



User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
EV Owner (Mobile user)	Account Management	USN-1	As an EV user, I want to register and log in to the app to securely access personalized features	User can create an account and sign in using valid credentials	High	Sprint-1
	Map Visualization	USN-2	As a user, I want to view a map showing nearby charging stations and range zones	Map loads with charging station icons and vehicle range overlay	High	Sprint-1
	Vehicle Charge Analysis	USN-3	As a user, I want to input my vehicle's battery level and get real-time range estimates	System provides accurate range estimates based on battery and driving data	Low	Sprint-2
	Charging History	USN-4	As a user, I want to view my previous charging sessions and performance reports	App displays historical charts and statistics about past charges	Medium	Sprint-2
Admin	Data Management	USN-5	As an admin, I want to upload and manage station data across different locations	Admin panel shows options to add/update station information	High	Sprint-1
	User Monitoring	USN-6	As an admin, I want to monitor system usage and user activity for improvement tracking	Dashboard reports include session logs and activity summaries	Medium	Sprint-3
Data Analyst	Reporting Module	USN-7	As an analyst, I want to generate customized reports based on station usage and range patterns	As an analyst, I want to generate customized reports based on station usage and range patterns	Medium	Sprint-3
Guest User	Demo Access	USN-8	As a guest, I want to explore the tool in demo mode without signing up	Demo mode provides limited but working sample visualizations	Low	Sprint-2

3.4 Technology Stack

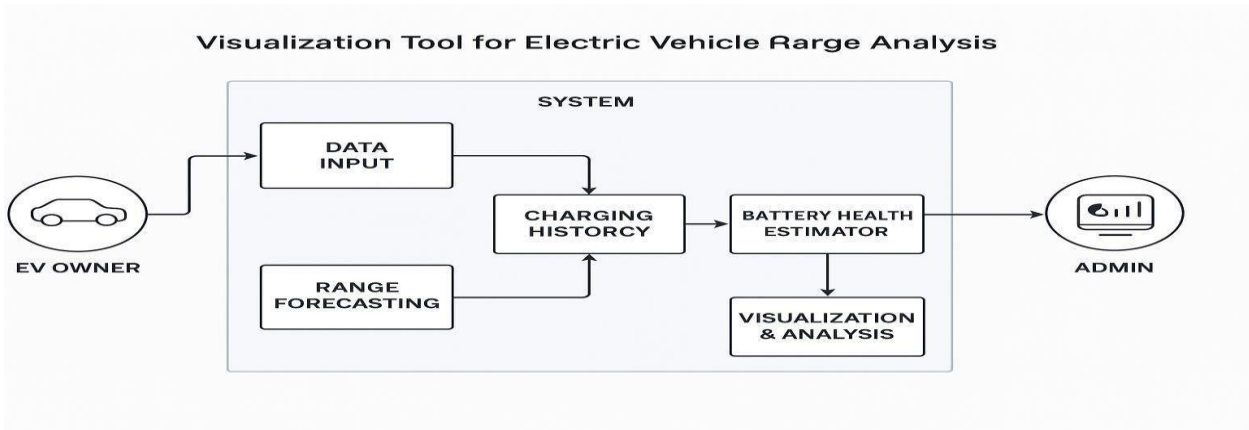


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	Provides interactive views for EV Owners, Admins, and Analysts	HTML, CSS, JavaScript, React or Vue.js
2.	Authentication Module	Handles secure login, signup, and role-based access	Firebase Auth, OAuth 2.0, JWT
3.	Vehicle Input System	Allows users to enter battery %, vehicle model, and trip preferences	JavaScript Form Logic, Python Flask AP
4.	Range Estimation Engine	Calculates real-time range based on input and terrain data	Python, Pandas, NumPy
5.	Charging Station Mapper	Displays nearby stations and highlights reachable zones.	Leaflet.js, Google Maps API
6.	Charging History Module	Visualizes past charging sessions with analytics	Chart.js, D3.js, MongoDB.
7.	Recommendation System	Suggests ideal routes and charging stops	Machine Learning Model, Scikit-learn
8.	Admin Dashboard	Admin access to station management and user analytics	React Admin, Node.js, MongoDB
9.	Database	Stores user data, station info, vehicle profiles	MongoDB, Firebase <u>Firestore</u>
10.	Hosting & Deployment	Runs backend and frontend on scalable infrastructure	<u>Vercel</u> , Netlify, AWS EC2 or Azure App Service.
11.	API Integration Layer	Connects external services like Maps and EV data APIs	REST APIs, <u>GraphQL</u> , <u>Axios</u> .

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Performance	Rapid data response for range calculations, map updates, and analytics	Redis Cache, CDN, Async Processing
2.	Maintainability	Easy to update components like maps, APIs, or authentication without affecting the entire system.	Modular Design, Git-based CI/CD.
3.	Scalable Architecture	Ensures the system handles increasing users, stations, and data; follows modular principles for flexibility	Microservices, Docker, Kubernetes
4.	Availability	Stable performance across user scenarios with accurate real-time outputs	Load Balancer (NGINX), Multi-region Hosting (Azure/AWS)
5.	Reliability	Design consideration for the performance of the application (number of requests per sec, use of Cache, use of CDN's) etc.	Automated Testing, Monitoring (Prometheus, Grafana)

4. PROJECT DESIGN

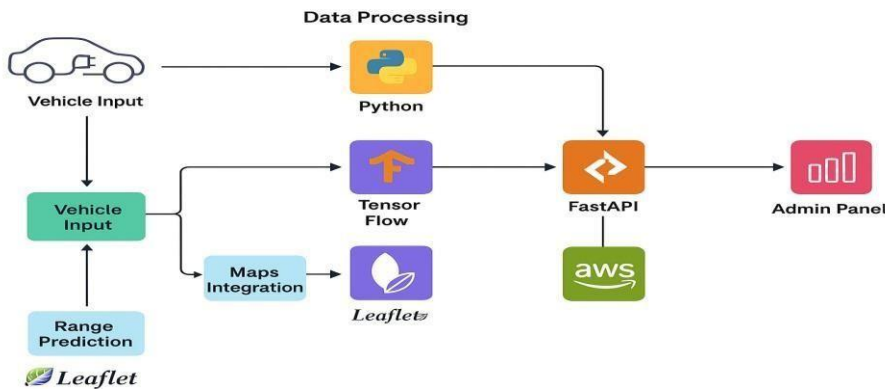
4.1 Problem Solution Fit

Define CS, fit into CC	1. CUSTOMER SEGMENT(S) Who is your customer? I.e. working parents of 0-5 y.o. kids As a working parent of a young child, I constantly feel torn between my job and giving my child the care and attention they need. I don't always have time to research the best activities or find trustworthy childcare options. I want something simple, reliable, and supportive that helps me manage parenting without feeling overwhelmed or guilty."	6. CUSTOMER CONSTRAINTS What constraints prevent your customers from taking action or limit their choices of solutions? I.e. spending power, budget, no cash, network connection, available devices. This section is meant to identify barriers or limitations that your target customers face, which can prevent them from adopting or benefiting from your proposed solution. Examples given include: Spending power Budget No cash Network connection Available device: Would you like help filling this out for a specific customer segment or use case?	5. AVAILABLE SOLUTIONS Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? I.e. pen and paper is an alternative to digital note-taking. Currently, working parents rely on a mix of informal and digital methods to manage childcare and daily responsibilities. Common solutions include paper-based planners, to-do lists, WhatsApp groups with caregivers, and digital calendars like Google Calendar. Some have used parenting apps that offer reminders or shared schedules. While these methods help with organization, they each have limitations. Paper tools are easy but not shareable in real-time. Messaging apps lack structure, and digital tools may be too complex or time-consuming to manage alongside a busy routine. Accessibility, device availability, and time constraints are major factors that affect solution choice.	Explore AS, differentiate
	2. JOBS-TO-BE-DONE / PROBLEMS Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one, explore different sides. Working parents of young children often struggle to manage time effectively while balancing job responsibilities and childcare duties. Key jobs-to-be-done include organizing daily routines, ensuring their child's safety and learning, coordinating with caregivers or family members, and finding trustworthy childcare solutions. They also need tools to help them communicate quickly, plan meals, track appointments, and get reminders for tasks. The lack of integrated, easy-to-use systems adds stress and results in missed tasks or inefficient time use.	9. PROBLEM ROOT CAUSE What is the real reason that this problem exists? What is the back story behind the need to do this job? I.e. customers have to do it because of the change in regulations. This is part of a problem-solving or design thinking framework. It encourages digging beyond surface-level symptoms to understand systemic or underlying causes—often related to external forces (e.g., regulations, trends, behaviors, or outdated systems). Would you like help applying this template to your own project? If yes, please tell me the problem you're working on.	7. BEHAVIOUR What does your customer do to address the problem and get the job done? I.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace) This section helps you identify customer actions—both practical and emotional/social—that reflect their attempts to solve the problem. It distinguishes: Direct behaviors: Actions directly related to solving the core problem or completing a task. Indirect behaviors: Lifestyle or value-based actions that may influence or reflect their attitude (e.g., environmental awareness).	Focus on J&P, tap into BE, understand RC
Focus on J&P, tap into BE, understand RC	3. TRIGGERS What triggers customers to act? I.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news. Seeing their neighbour installing solar panels Reading about a more efficient solution in the news. Identify external or internal events that prompt the customer to take action.	10. YOUR SOLUTION If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour. Identify the Problem The problem being worked on is not explicitly stated in the image, but it appears to be related to finding a solution to a business problem. Analyse the template The template provides guidance on how to approach the problem-solving process. It suggests writing down the current solution first and checking how much it fits the canvas. If working on a new business proposition, it advises keeping the canvas blank until filling it in and coming up with a solution that fits within customer limitations and matches customer behaviour. Determine the Solution	8. CHANNELS OF BEHAVIOUR 8.1 ONLINE What kind of actions do customers take online? Extract online channels from #7 social media, national or local, radio, magazines, and video; customer service; community groups; reputation; and get updates. social media: used for communication and exposure, and the marketing process, solution support - Company Website: The official website of a business where customers can find information, make purchases, and contact the company. - Online reviews: Websites or sections of websites designed to discuss and rate specific topics, where customers can share experiences and opinions. - News sites: Websites that report on current events and news, often featuring expert analysis and commentary. 8.2 OFFLINE What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development. - Visiting physical stores - Attending events or workshops - Engaging with sales representatives - Using customer service hotlines - Participating in focus groups or surveys	Extract online & offline CH of BE
	4. EMOTIONS: BEFORE / AFTER How do customers feel when they face a problem or a job and afterwards? I.e. less, insecure & confident, in control – use it in your communication strategy & design. This emotional journey can help tailor your communication strategy and product/service design.			

4.2 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Electric vehicle users and manufacturers face challenges in accurately predicting driving range under real-world conditions. Current tools often lack visual clarity and integration of variables such as terrain, temperature, driving habits, and battery health. This project aims to create a tool that visualizes these factors to improve decision-making.
2.	Idea / Solution description	The solution is a web-based visualization and analysis tool that models and predicts EV range based on various user-defined inputs like route elevation, temperature, speed, load, and driving behavior. The tool will integrate mapping APIs, real-time sensor data (optional), and machine learning models to provide personalized range estimations and visual outputs (e.g., range heatmaps, route optimizations).
3.	Novelty / Uniqueness	Unlike standard range calculators, this tool incorporates dynamic visualization with multi-parameter analysis. It also allows users to simulate future trips, compare different EV models, and see the impact of battery degradation over time — features that are often missing in current applications.
4.	Social Impact / Customer Satisfaction	The tool will enhance user confidence in EVs by reducing range anxiety and improving trip planning. It promotes sustainable transport by making EVs more predictable and accessible, indirectly supporting environmental goals and the broader adoption of green mobility.
5.	Business Model (Revenue Model)	Freemium model: basic features for free, advanced simulations and reports (e.g., for fleet owners or dealerships) under a paid subscription. Additional revenue via API licensing for OEMs, automotive portals, and map service providers.
6.	Scalability of the Solution	The tool can scale to accommodate different EV brands and geographies. With cloud-based infrastructure and modular design, it can be expanded to include more datasets (e.g., traffic, real-time weather), support international routes, and integrate with fleet management software.

4.3 Solution Architecture



5. PROJECT PLANNING & SCHEDULING

5.1 Project Planning

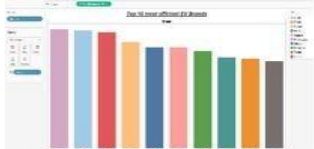

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration & Login	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	4
Sprint-1		USN-2	As a user, I receive confirmation email after registration	1	High	4
Sprint-1	Vehicle Input Module	USN-3	As a user, I can input battery %, vehicle model, and range preference	3	High	4
Sprint-2	Range Estimation	USN-4	As a user, I can view estimated range on a visual map	5	High	4
Sprint-1		USN-5	As a user, I can see alerts when range is critically low	2	Medium	4
Sprint-2	Charging Station Mapping	USN-6	As a user, I can view nearby stations filtered by charger type and availability	4	High	4
Sprint-3	History & Analytics	USN-7	As a user, I can view previous charge sessions with distance and cost data	3	Medium	4
		USN-8	As a user, I can export session summaries for analysis	2	Low	4

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	23 June 2022	23 June 2022	20	29 Oct 2022
Sprint-2	20	6 Days	23 June 2022	23 June 2022		
Sprint-3	20	6 Days	24 June 2022	24 June 2022		
Sprint-4	20	6 Days	24 June 2022	24 June 2022		

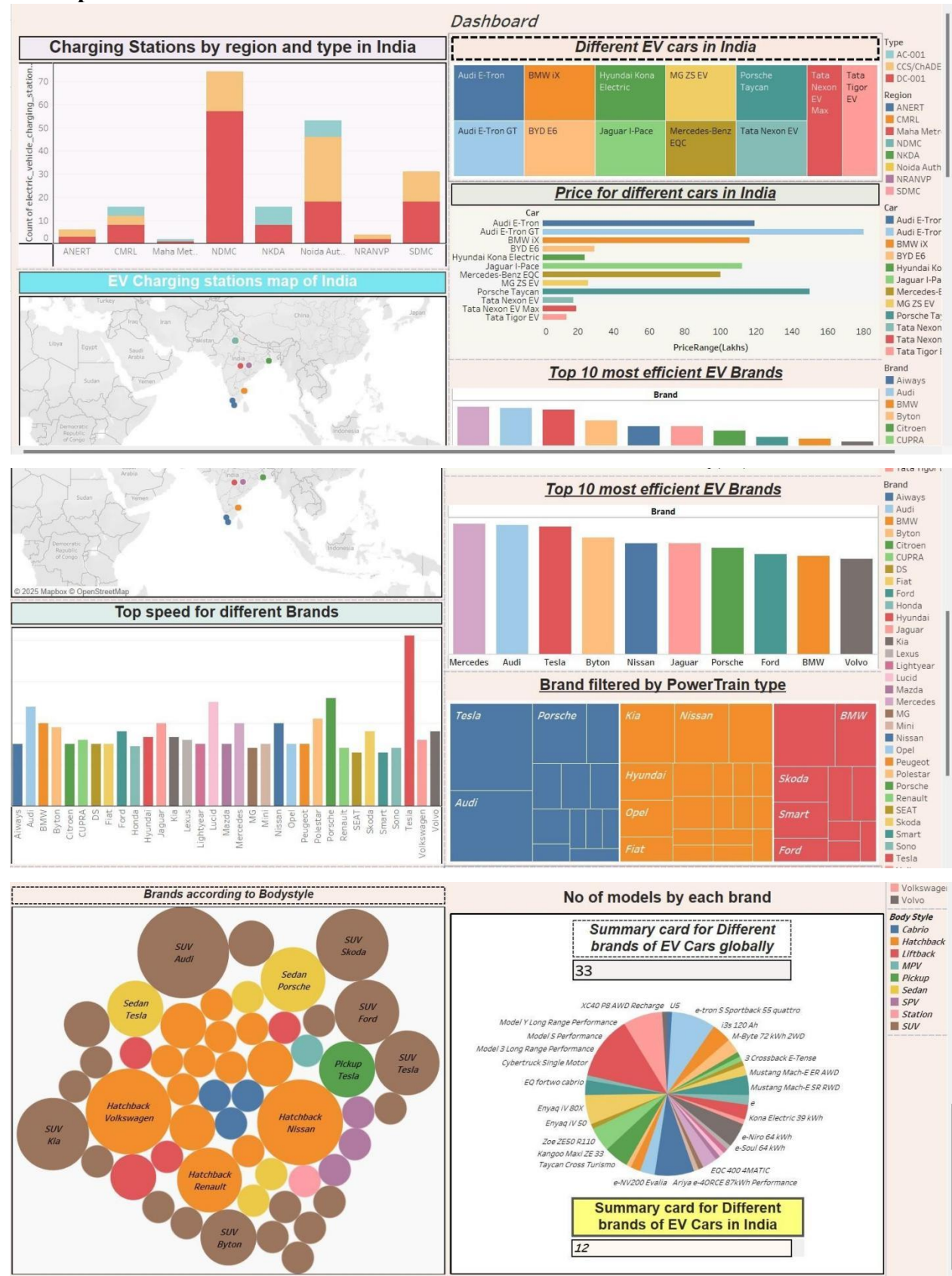
6. FUNCTIONAL AND PERFORMANCE TESTING

6.1 Performance Testing

S.No.	Parameter	Screenshot / Values
1.	Data Rendered	Cheapestelectriccars-EVDatabase : contains total eleven fields electric_vehicle_charging_station_list : contains total eight fields ElectricCarData_Clean : contains total fourteen fields EVIndia : contains total ten fields
2.	Data Preprocessing	The dataset is already clean and preprocessed. Only combining of all four datasets are done in the data preprocessing phase.
3.	Utilization of Filters	 <p>Brand filter is used for- Top 10 most efficient EV Brands</p>  <p>Power train filter is used for- Brand filtered by PowerTrain type</p>
4.	Calculation fields Used	Body style, Car brands in India, Efficiency.
5.	Dashboard design	No of Visualizations / Graphs – A dashboard containing total eleven visualizations.
6.	Story Design	No of Visualizations / Graphs -Story design of all eleven visualizations created using the dataset.

7. RESULTS

7.1 Output Screenshots



8. ADVANTAGES & DISADVANTAGES Advantages

- **Enhanced User Awareness:** Helps users understand charging behavior, energy consumption, and travel planning.
- **Customizable Analysis:** Allows EV owners to input specific vehicle data for tailored insights.
- **Educational Utility:** Promotes informed decision-making and environmental consciousness, especially if gamified.
- **Accessible Visualization:** Transforms complex battery and performance data into intuitive, visual formats.
- **Potential for Expansion:** Can be integrated with map APIs, real-time charging station data, and IoT inputs.

Disadvantages

- **Data Dependency:** Accuracy relies heavily on the availability and quality of EV-specific data.
- **Device Compatibility:** May require optimization for different screen sizes or browser support.
- **Scalability Limitations:** Handling real-time data for numerous users simultaneously could strain server resources.
- **Learning Curve:** Users unfamiliar with data dashboards or EV tech may find the interface initially complex.

9. CONCLUSION

The EV Charge and Range Visualization Tool offers a practical solution to one of the most pressing concerns in electric vehicle adoption: understanding and managing battery performance. By transforming complex EV data into accessible visuals, this project empowers users to make confident, informed decisions about their charging habits and travel planning. With customization options, educational potential, and opportunities for future expansion, the tool represents a meaningful step toward enhancing the EV user experience and promoting sustainable mobility.

10. FUTURE SCOPE

The EV Charge and Range Visualization Tool has strong potential for further development and innovation. Here are some directions to expand its scope:

- **Real-time Data Integration:** Connect with live data sources from EVs or IoT charging stations to offer dynamic, up-to-date insights.
- **Route Planning with Charging Stops:** Incorporate map APIs to suggest optimal travel routes based on battery range and nearest charging stations.
- **AI-Powered Predictions:** Use machine learning to forecast battery degradation, energy consumption patterns, and charging time under varying conditions.

- Mobile App Version: Expand accessibility by developing a lightweight, responsive mobile version for on-the-go users.
- Community-Driven Insights: Allow users to share charging experiences, station reviews, and efficiency tips, building a knowledge-sharing ecosystem.
- Gamification Elements: Introduce interactive missions, eco-badges, or progress tracking to boost user engagement and learning, especially in educational contexts.

11. APPENDIX

Dataset Link -

<https://drive.google.com/drive/folders/1Rkzdks6Us1Uq2SRB4nxMAb83jN5bpHl>

GitHub-

<https://github.com/Muni-kumar1/visualization-tool-for-electric-vehicle-charge-and-range--analysis.git>

Video link-

https://drive.google.com/file/d/1zUVnW_rzrc8BcRcqKPxjCg4G2c6BrWlf/view?usp=drivesdk