

Final Project Report

Visualization Tool for Electric Vehicle Charge & Range Analysis

Team ID: LTVIP2026TMIDS47701

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1. INTRODUCTION

1.1 Project Overview

The rapid adoption of Electric Vehicles (EVs) has increased the need for better understanding of battery performance, charging behavior, and driving range under different conditions. This project focuses on developing an interactive Visualization Tool for Electric Vehicle Charge and Range Analysis that helps users analyze and interpret EV charging patterns and range efficiency using data visualization techniques.

1.2 Purpose

The main purpose of this project is to analyze and visualize electric vehicle (EV) charge levels and driving range in an interactive and easy-to-understand manner. The tool helps users make data-driven decisions by presenting complex EV performance data through intuitive visual dashboards.

This project aims to:

- 1. Monitor battery charge levels and estimate the remaining driving range**
- 2. Visualize EV performance trends such as energy consumption, distance covered, efficiency using charts and graphs.**
- 3. Support EV users and manufacturers in understanding how factors like speed, terrain, and battery capacity impact vehicle range.**

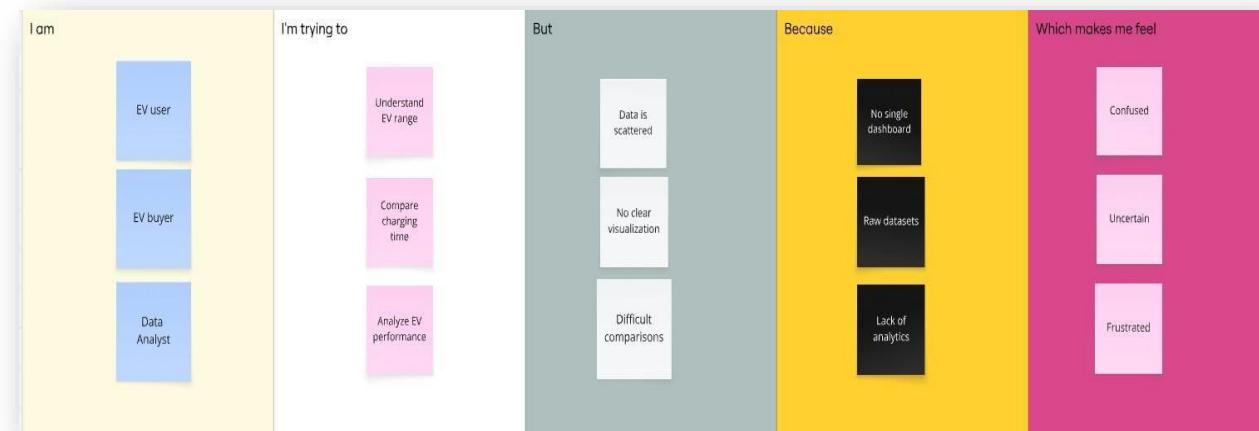
2.Ideation Phase

2.1 Problem Statements

Customer Problem Statement Template:

Create a problem statement to understand your customer's point of view. The Customer Problem Statement template helps you focus on what matters to create experiences people will love. A well-articulated customer problem statement allows you and your team to find the ideal solution for the challenges your customers face.

I am	Describe customer with 3-4 key characteristics - who are they?	Describe the customer and their attributes here
I'm trying to	List their outcome or "job" they care about - what are they trying to achieve?	List the thing they are trying to achieve here
but	Describe what problems or barriers stand in the way - what bothers them most?	Describe the problems or barriers that get in the way here
because	Enter the "root cause" of why the problem or barrier exists - what needs to be solved?	Describe the reason the problems or barriers exist
which makes me feel	Describe the emotions from the customer's point of view - how does it impact them emotionally?	Describe the emotions the result from experiencing the problems or barriers



Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
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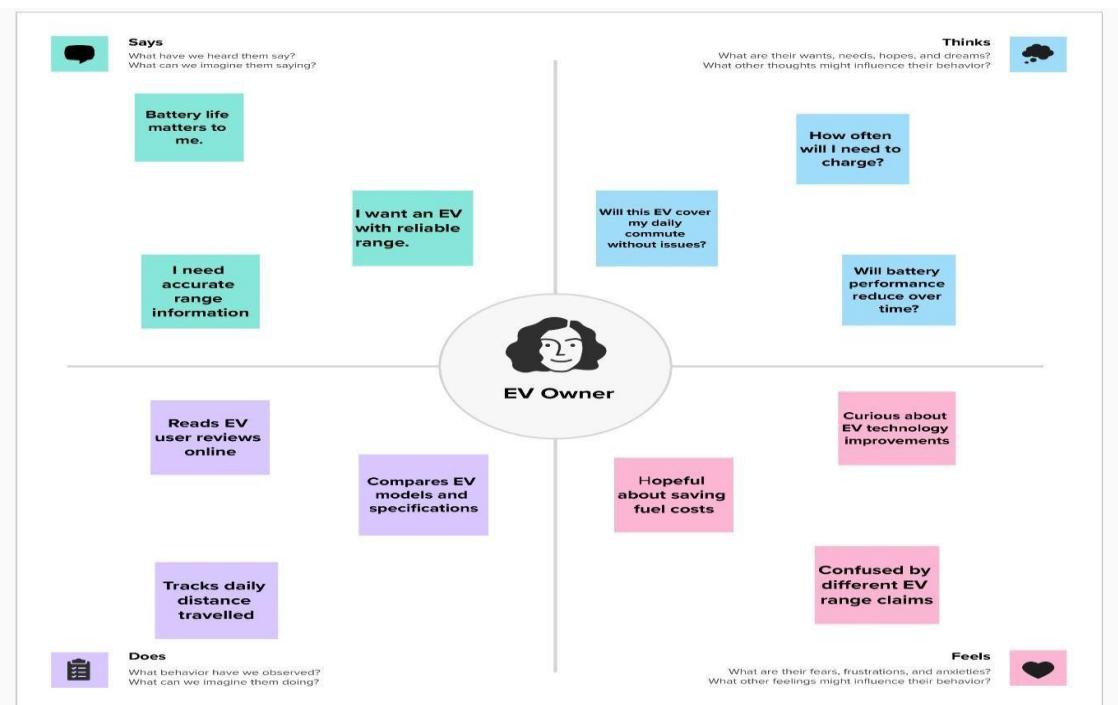
PS-1	An electric vehicle user.	understand the driving range and charging behavior of different electric vehicles.	understa nd the driving range and charging behavior of different electric vehicles.	there is no single interactive platform that visualizes EV range and charging data clearly.	confused and uncertain while making decisions.
PS-2	an EV analyst / policy maker.	analyze EV adoption trends, charging infrastructure, and performance metrics.	existing reports lack clear visual insights and comparisons.	raw data is not converted into meaningful dashboards.	inefficient and limited datadriven planning.

2.2 Empathy Map Canvas:

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes.

It is a useful tool to helps teams better understand their users.

Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user' perspective along with his or her goals and challenges.



2.3 Brainstorm

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative problem-solving process. Prioritization helps in selecting the most impactful and feasible ideas. This approach encourages collaboration, innovation, and structured decision-making to arrive at effective solutions.

This template is used to generate, analyze, and prioritize ideas for building a visualization tool that helps understand electric vehicle charging and range performance using data analytics and dashboards.

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

The screenshot shows a template for a Brainstorm & idea prioritization session. On the left, there's a sidebar labeled 'Template' with a lightbulb icon. The main area has three columns:

- Before you collaborate**: A section with a lightbulb icon, instructions about preparation, and a timer for 10 minutes.
- Define your problem statement**: A section with a lightbulb icon, instructions about framing the problem, and a timer for 5 minutes. It includes a box for writing the problem statement: "How might we use EV data visualization to understand charging behavior, range sufficiency, and performance trends?"
- Key rules of brainstorming**: A summary of five rules with icons:
 - Stay in topic.
 - Encourage wild ideas.
 - Defer judgment.
 - Listen to others.
 - Go for volume.
 - If possible, be visual.

Below these sections, there are three numbered steps (A, B, C) with descriptions and timers:

- A Team gathering**: "Define who should participate in the session and send an invite. Share relevant information or pre-work ahead." Timer: 10 minutes.
- B Set the goal**: "Think about the problem you'll be focusing on solving in the brainstorming session." Timer: 5 minutes.
- C Learn how to use the facilitation tools**: "Use the Facilitation Superpowers to run a happy and productive session." Timer: 10 minutes.

At the bottom, there's a link to "Open article" with a right-pointing arrow.

Step-2: Brainstorm, Idea Listing and Grouping

2 Brainstorm

Write down any ideas that come to mind that address your problem statement.

⌚ 10 minutes

AYASHA			SAGAR		
EV range comparison by model	Fast charging vs normal charging analysis	Charging time vs battery capacity	EV adoption trends (India & Global)	Cost efficiency comparison of EV models	EV range vs real-world usage analysis

AZMAL			MOUNIKA		
Battery efficiency analysis	Model-wise performance comparison	Charging station availability impact on range	Battery degradation effect on EV range	Interactive Tableau dashboard	Year-wise improvement in EV range and charging speed

3 Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

⌚ 20 minutes

```

graph TD
    A[Electric Vehicle Charge and Range Analysis] --> B[Vehicle Characteristics]
    A --> C[Charging Scenario]
    A --> D[Infrastructure Factors]
    A --> E[Cost & Market Factors]
    A --> F[Data Visualization & Analysis]
    
```

Step-3: Idea Prioritization

4 Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

⌚ 20 minutes

Importance
Feasibility
Impact
Risk

Feasibility
Importance
Impact
Risk

After you collaborate

You can export the mural as an image or pdf to share with members of your company who might find it helpful.

Share the mural
Share a view link to it or mail with shared orders to keep them in the loop about the outcomes of the session.

Export the mural
Export a copy of the mural as PNG or PDF to stick to prints, include it in docs, or send in your drive.

Quick add-ons

Strategy Blueprint
Define the components of a new idea or strategy.
[Open the template →](#)

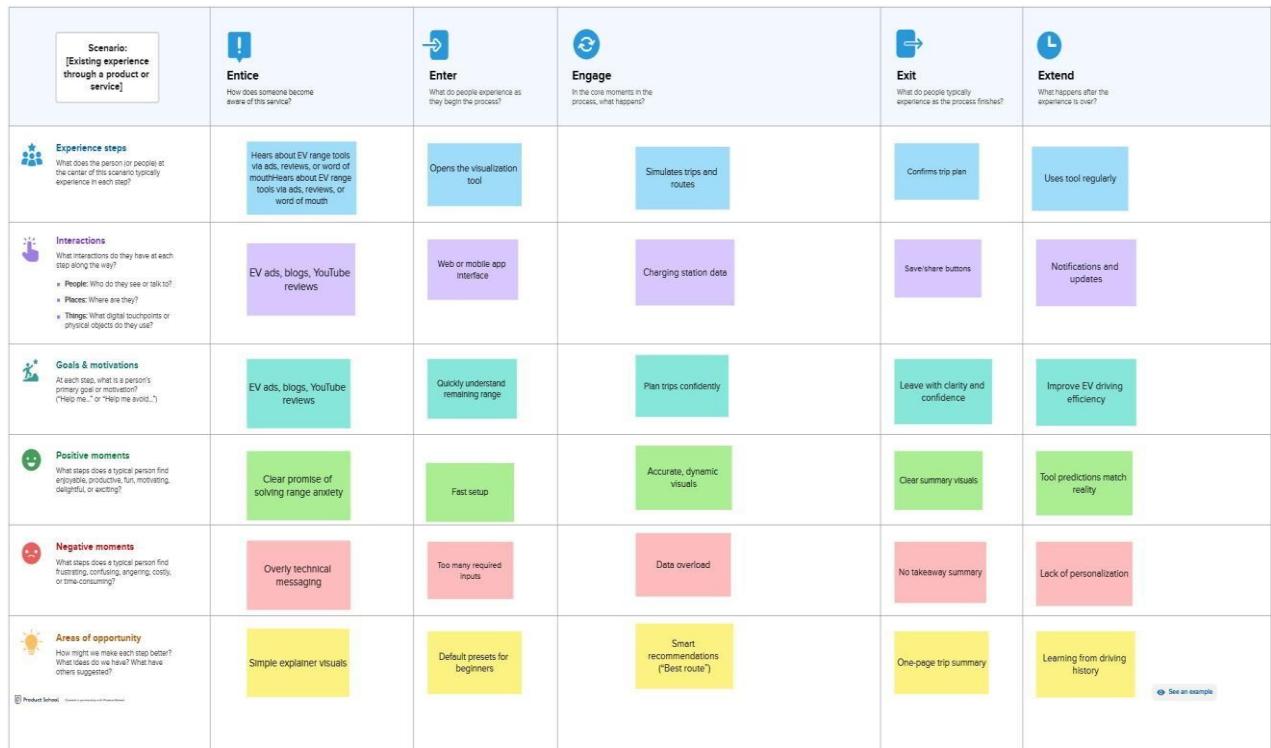
Customer experience journey map
Understand customer needs, motivations, and barriers to user experience.
[Open the template →](#)

Strengths, weaknesses, opportunities & threats
Identify strengths, weaknesses, opportunities, and threats (SWOT) to develop a plan.
[Open the template →](#)

Keep moving forward

3.REQUIREMENT ANALYSIS

3.1 Customer Journey Map



3.2 Solution Requirements (Functional & Non-functional)

Functional Requirements:

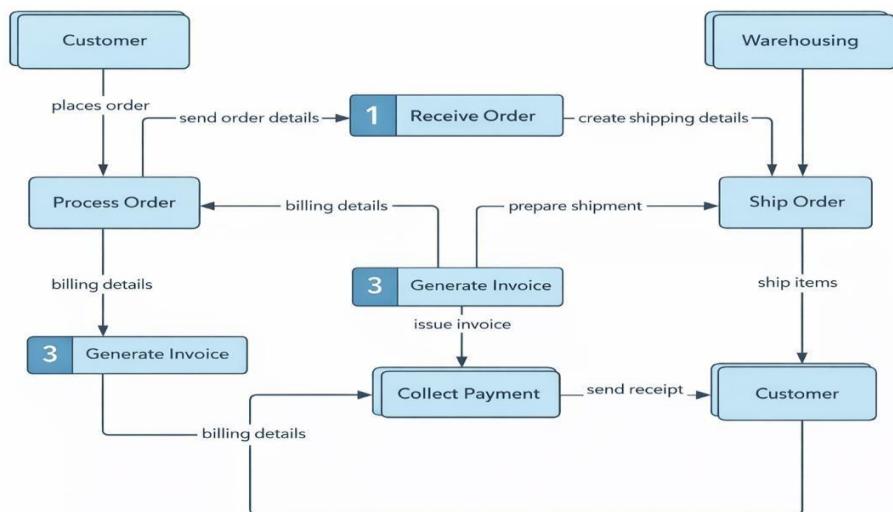
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User Login	Login using email & password Login using Gmail
FR-4	Dashboard Access	View EV range analysis View battery status & charging data
FR-5	Charging Station Information	View nearby charging stations Filter stations by availability
FR-6	Data Visualization	View charts and graphs for EV performance

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The system should be easy to use with a simple and intuitive user interface.
NFR-2	Security	User data should be protected using authentication and secure access.
NFR-3	Reliability	The system should provide accurate EV range and charging analysis without data loss.
NFR-4	Performance	The application should load dashboards and analytics within a few seconds.
NFR-5	Availability	The system should be accessible 24/7 with minimal downtime.
NFR-6	Scalability	The system should support an increasing number of users and EV datasets.

3.3 Data Flow Diagram & User Stories



User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I want to view electric vehicle data details.	EV data is displayed correctly	High	Sprint-1
Customer (Mobile user)	View EV Data	USN-2	As a user, I want to see charge and range data in charts so that it is easy to understand.	Charts load correctly	High	Sprint-1
Customer (Mobile user)	Data Visualization	USN-3	As a user, I want to compare EV models based on range and price.	Comparison chart is shown	Low	Sprint-2
Customer (Mobile user)	Model Comparison	USN-4	As a user, I want to filter EV data by brand model.	Filters work properly	Medium	Sprint-3
Customer (Mobile user)	Filter Data	USN-5	As a user, I want to view charging time	Charging time data is visible	High	Sprint-2
Customer (Mobile user)	Charging Time	USN-6	As a user, I want to analyze range.	Range updates correctly	High	Sprint-4
Customer (Mobile user)	Range Analysis	USN-7	As a user, I want to view charging station	Station data is displayed	Medium	Sprint-3
Customer (Mobile user)	Charging Stations	USN-8	As a user, I want to see EV performance	Dashboard is user-friendly	Low	Sprint-5
Customer (Mobile user)	Performance Analysis	USN-9	As a user, I want a simple and easy-to-use	Performance charts are shown	High	Sprint-4
Customer (Mobile user)	User Interface	USN-10	As a user, I want to download visual reports .	Report downloads successfully	Low	Sprint-5

3.4 Technology Stack (Architecture & Stack)

Technical Architecture:

The EV Charge & Range Analysis System follows a three-tier architecture consisting of User Interface, Application Logic, and Database layers. The system collects EV-related data, processes it using analytical logic, and displays insights such as battery status, range prediction, and charging station availability through an interactive dashboard.

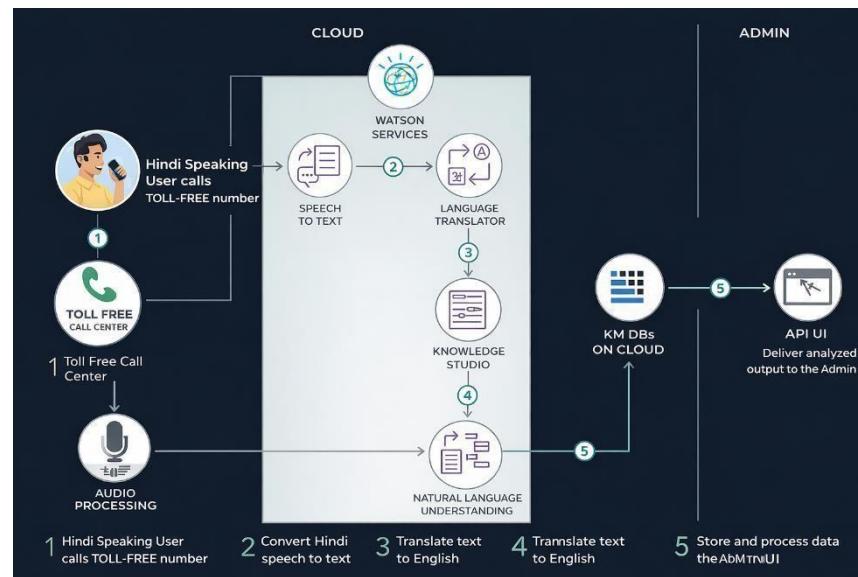


Table-1: Components & Technologies:

S.No	Component	Description	Technology

1.	User Interface	Allows users to interact with the application through dashboards and reports	HTML, CSS, JavaScript, React.js
2.	Application Logic-1	Handles user authentication and authorization	Python, Flask
3.	Application Logic-2	Processes EV range and charging data	Python, Pandas
4.	Application Logic-3	Performs data analysis and predictions	Python, NumPy
5.	Database	Stores EV data, user details, and charging station information.	MySQL
6.	Cloud Database	Stores backup and large datasets on cloud	AWS RDS / Firebase
7.	File Storage	Stores CSV files and datasets	Local File System / Cloud Storage
8.	External API-1	Fetches charging station location data	Google Maps API.
9.	External API-2	Fetches EV-related data if required	Open EV API.
10.	Machine Learning Model	Predicts EV range based on battery data	Linear Regression / Scikit-learn.
11.	Infrastructure (Server / Cloud)	Hosts the application and services	Local Server / AWS Cloud.

Table-2: Application Characteristics:

1.	Open-Source Frameworks	System supports increase in users and EV datasets.	Cloud Deployment, Modular Architecture.
2.	Security Implementations	Ensures accurate and consistent analysis results.	MySQL, Data Validation.
3.	Scalable Architecture	Application is accessible anytime.	Cloud Hosting
4.	Availability	Fast data processing and dashboard loading.	Optimized Queries, Caching
5.	Performance	Easy to update and modify system features.	Modular Code Structure

4. Project Design

4.1 Problem Solution fit Template

Define CS, fit into CC	1. CUSTOMER SEGMENT(S) <ul style="list-style-type: none">Electric Vehicle (EV) owners (2-wheelers, 3-wheelers, cars)Fleet operators (ride-hailing, delivery, logistics)EV buyers evaluating range performanceCharging infrastructure plannersAutomotive engineers & data analysts CS	6. CUSTOMER CONSTRAINTS <ul style="list-style-type: none">Limited technical knowledge of battery behaviorInaccurate or static range estimates.Lack of real-time data visualizationPoor integration with driving conditionsData overload without clear insights C	5. AVAILABLE SOLUTIONS <ul style="list-style-type: none">Basic dashboard range estimators in EVsMobile apps showing battery percentage onlyStatic manufacturer-claimed range valuesSimple navigation apps with charging points AS
Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS <ul style="list-style-type: none">Understand real-time battery charge and remaining rangePredict how driving behavior, terrain, and weather affect rangeReduce "range anxiety" during tripsPlan charging stops efficientlyCompare expected vs actual vehicle performance J&P	9. PROBLEM ROOT CAUSE <ul style="list-style-type: none">Range calculations based on ideal conditionsNo visualization of energy consumption patternsLack of predictive analyticsPoor user understanding of battery dynamicsFragmented data sources RC	7. BEHAVIOUR <ul style="list-style-type: none">Frequently checking battery percentageOver-charging due to fear of running outAvoiding long tripsDriving conservatively to save chargeRelying on external apps for reassurance BE

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

<p>3. TRIGGERS</p> <ul style="list-style-type: none"> • Low battery warning • Planning a long or unfamiliar trip • Unexpected drop in remaining range • Searching for nearby charging stations • Comparing EV efficiency across routes or vehicles <p>TR</p>	<p>10. YOUR SOLUTION</p> <p>SL Interactive visual dashboard showing:</p> <ul style="list-style-type: none"> • Battery charge vs distance • Energy consumption trends • Predicted remaining range <p>Real-time data integration (speed, terrain, weather)</p> <ul style="list-style-type: none"> • Route-based range forecasting • Charging station visualization and recommendations • User-friendly graphs, alerts, and insights 	<p>8. CHANNELS OF BEHAVIOUR</p> <p>CH</p> <ul style="list-style-type: none"> • In-vehicle infotainment system • Mobile application (Android / iOS) • Web dashboard for analytics • Alerts & notifications • Navigation and maps integration
<p>4. EMOTIONS: BEFORE / AFTER</p> <p>EM</p> <p>Before</p> <ul style="list-style-type: none"> • Anxiety about reaching destination • Uncertainty and lack of trust in range estimates • Frustration due to inaccurate predictions <p>After</p> <ul style="list-style-type: none"> • Confidence in trip planning • Reduced stress while driving • Trust in EV performance and data insights 		

4.2 Proposed Solution Template

Proposed Solution Template:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Electric Vehicle (EV) users face range anxiety due to inaccurate charge and range estimation and lack of proper visualization tools to analyze charging behavior and vehicle performance. This makes trip planning difficult and reduces confidence in EV usage.
2.	Idea / Solution description	The proposed solution is a virtualization tool that analyzes EV charging and range data and presents it through interactive dashboards and visualizations. The system helps users understand battery usage, predict driving range, and plan charging efficiently using data-driven insights.
3.	Novelty / Uniqueness	Unlike traditional static range indicators, this tool uses data analytics and visualization to provide deeper insights into EV performance. It combines charge patterns, range prediction, and visual dashboards in a single platform, making EV analysis simple and user-friendly.
4.	Social Impact / Customer Satisfaction	The solution reduces range anxiety, improves user confidence in electric vehicles, and supports ecofriendly transportation. It enhances customer satisfaction by enabling better trip planning and promoting sustainable mobility.
5.	Business Model (Revenue Model)	The platform can follow a freemium model where basic analytics are free, and advanced features are available through subscription. It can also generate revenue through partnerships with EV manufacturers, fleet operators, and charging service providers.
6.	Scalability of the Solution	The solution is highly scalable as it can be extended to support multiple EV models, large datasets, and real-time charging data. It can be deployed across cities and regions with increasing users and EV adoption

4.3 Solution Architecture

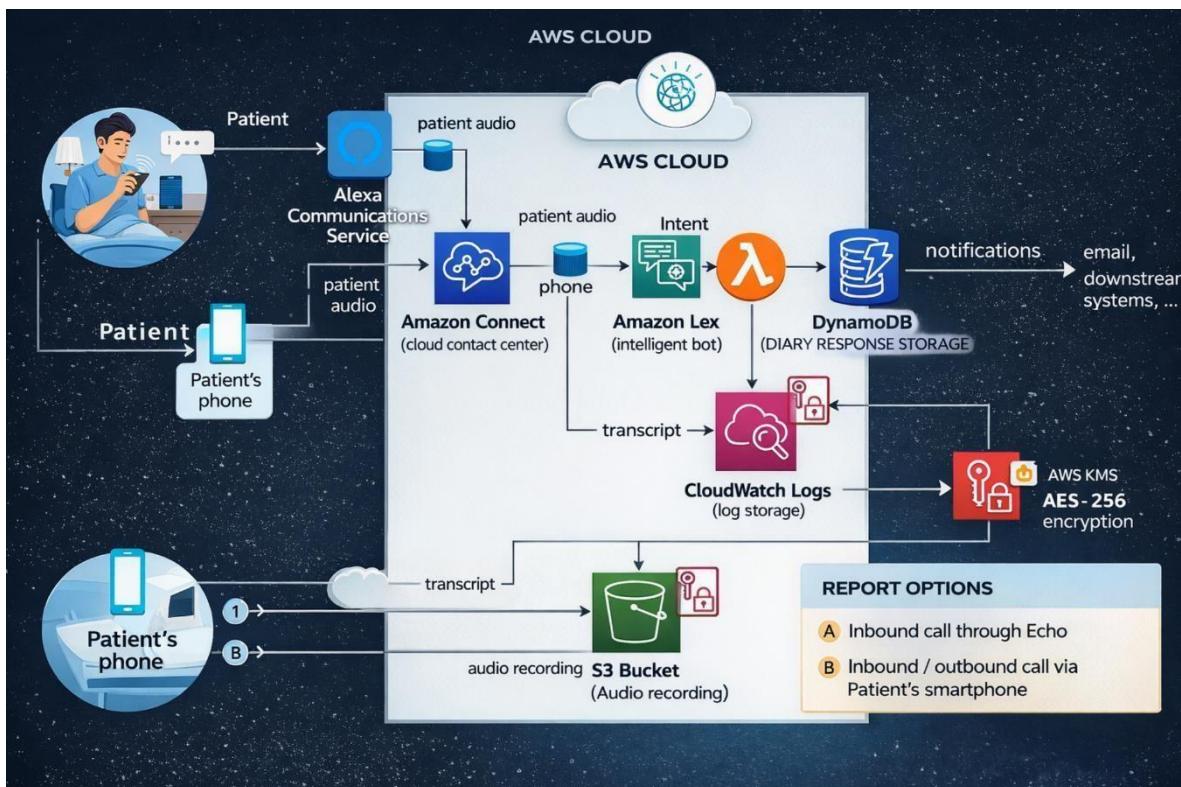
Solution Architecture:

The proposed solution uses a cloud-based, voice-enabled architecture on AWS to collect, process, store, and analyze patient voice responses securely and efficiently. The architecture integrates multiple AWS services to ensure scalability, security, and reliability.

Objectives of the Solution Architecture

- To provide an efficient and scalable architecture for EV charge and range analysis
- To ensure smooth data flow from input to visualization
- To support accurate analysis and decision-making for EV users

Solution Architecture Diagram:



5.PROJECT PLANNING & SCHEDULING

5.2 Project Planning

Product Backlog, Sprint Schedule, and Estimation(4Marks)

Sprint	Functional Requirement(Epic)	User Story Number	User Story/Task	Story Points	Priority	Team Members
Sprint-1	Data Collection & Input	USN-1	As a user, I want to input EV battery capacity and current charges so I can see remaining range	5	High	TM1
Sprint-1	Data Collection & Input	USN-2	As a user, I want to select vehicle model so that range calculations are accurate	5	High	TM2
Sprint-2	Range Calculation Engine	USN-3	As a user, I want the system to calculate estimated driving range based on charge level	8	High	TM1
Sprint-2	Range Calculation Engine	USN-4	As a user, I want range to adjust based on driving conditions (city/highway)	7	Medium	TM3
Sprint-3	Visualization Dashboard	USN-5	As a user, I want to view charge and range using charts and graphs	10	High	TM2
Sprint-3	Visualization Dashboard	USN-6	As a user, I want color indicators (low/medium/high range) for easy understanding	10	Medium	TM3
Sprint-4	Reporting & Optimization	USN-7	As a user, I want to compare range across trips and time periods	10	Medium	TM1

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

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned EndDate)	Sprint Release Date (Actual)
Sprint-1	20	6Days	2February2026	7February2026	18	7February2026
Sprint-2	20	6Days	9February2026	14February2026	19	14February2026
Sprint-3	20	6Days	16February2026	21February2026	20	21February2026
Sprint-4	20	6Days	23February2026	28February2026	20	28February2026

Velocity Calculation:

Velocity = Total Story Points Completed ÷ Number of Sprints

Total completed story points

$18 + 19 + 20 + 20 = 77$ story points

Number of sprints

= 4

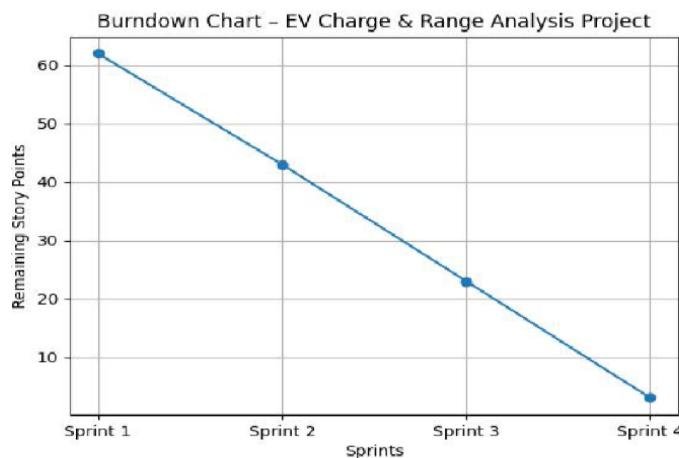
Average Team Velocity

Average Team Velocity Calculation

Velocity = $77 / 4 = 19.25$ story points per sprint

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

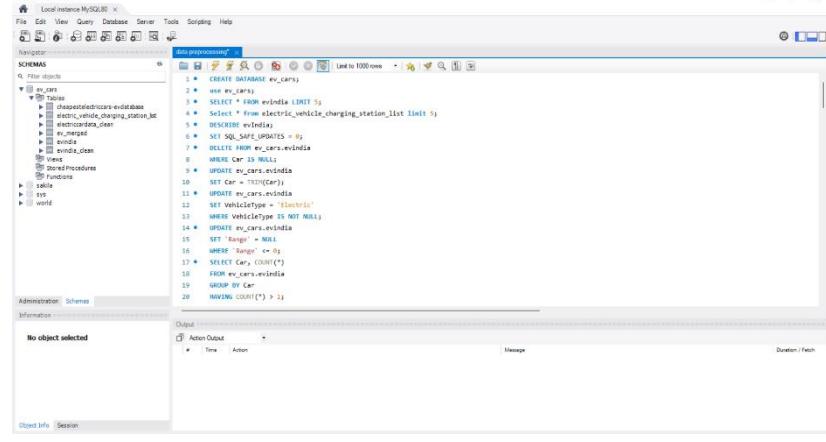


6. FUNCTIONAL AND PERFORMANCE TESTING

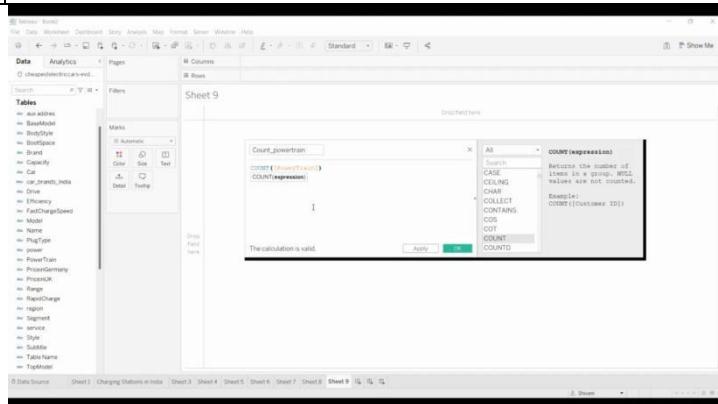
6.2 Performance Testing

Model Performance Testing:

S.No.	Parameter	Screenshot / Values
1.	Data Rendered	

2.	Data Preprocessing	 <pre> 1 • CREATE DATABASE ev_cars; 2 • USE ev_cars; 3 • SELECT * FROM evindia LIMIT 5; 4 • SELECT * FROM electric_vehicle_charging_station_list LIMIT 5; 5 • DESCRIBE evindia; 6 • SET SQL_SAFE_UPDATES = 0; 7 • DELETE FROM ev_cars.evindia; 8 • TRUNCATE TABLE evindia; 9 • UPDATE ev_cars.evindia 10 SET Car = TRIM(Car); 11 • UPDATE ev_cars.evindia 12 SET vehicleType = 'Electric'; 13 WHERE vehicleType IS NOT NULL; 14 • UPDATE ev_cars.evindia 15 SET "Range" = NULL; 16 WHERE Range < 0; 17 • SELECT Car, COUNT(*) 18 FROM ev_cars.evindia 19 GROUP BY Car 20 HAVING COUNT(*) > 1; </pre>
3.	Utilization of Filters	<p>Filters were used effectively to allow users to interact with the data. Filters such as EV brand, vehicle model, range, battery capacity, and price range were applied. These filters help users customize the dashboard view and analyze specific electric vehicle characteristics easily.</p>

4. Calculation fields Used



5. Dashboard design

The dashboard is designed to be simple, interactive, and user-friendly. Multiple visualizations are combined into a single dashboard to provide a complete overview.

No. of Visualizations / Graphs: 9

- ✓ Top Speed for Different Brands
- ✓ Different Electric Brands Of India
- ✓ Brands According to Body Style
- ✓ Top 10 Most Effective Brands in India
- ✓ Brands Filtered by PowerTrain Type

6. Story Design

A Tableau story was created to present insights in a structured and sequential manner. The story guides users from basic EV range understanding to advanced charge and station analysis, making the insights easy to follow.

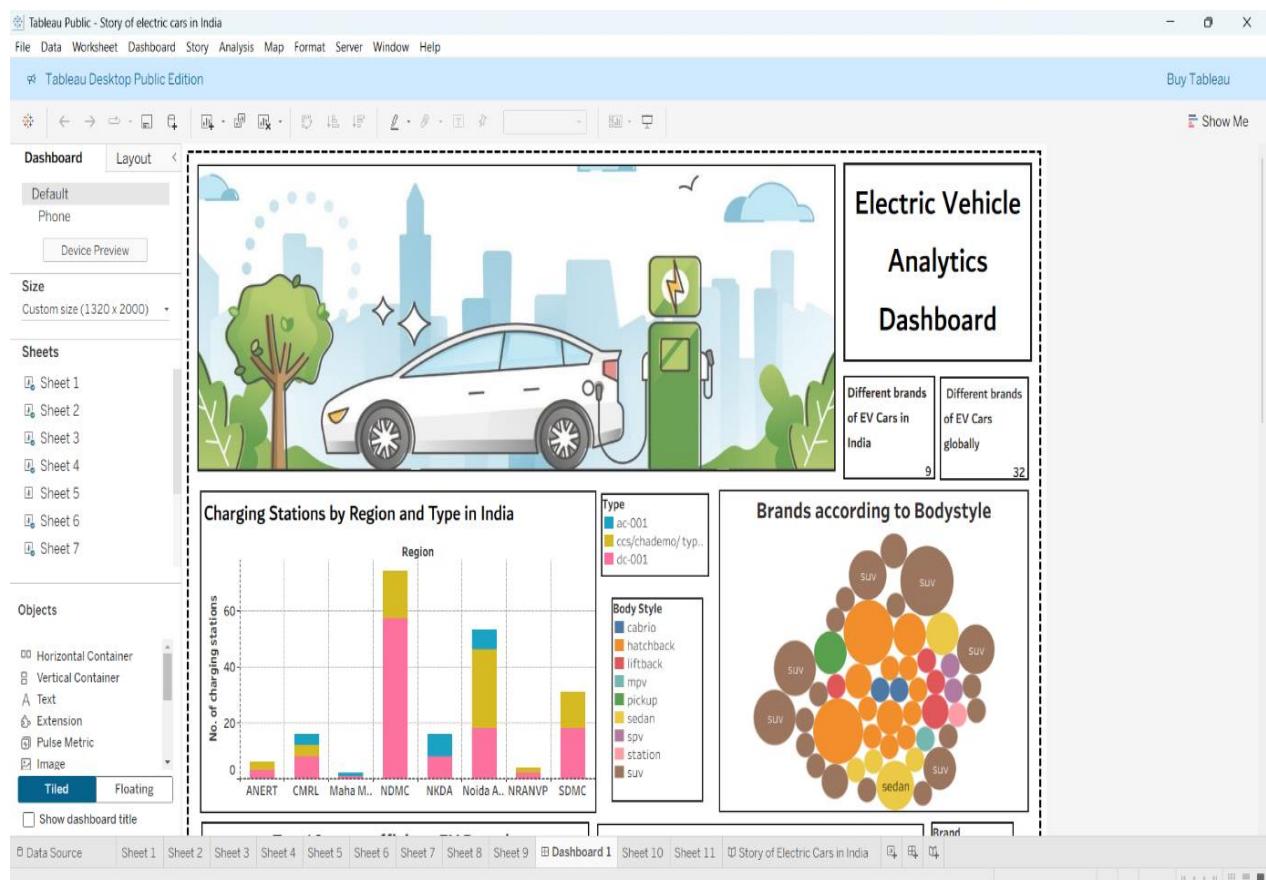
No. of Visualizations / Graphs: 5

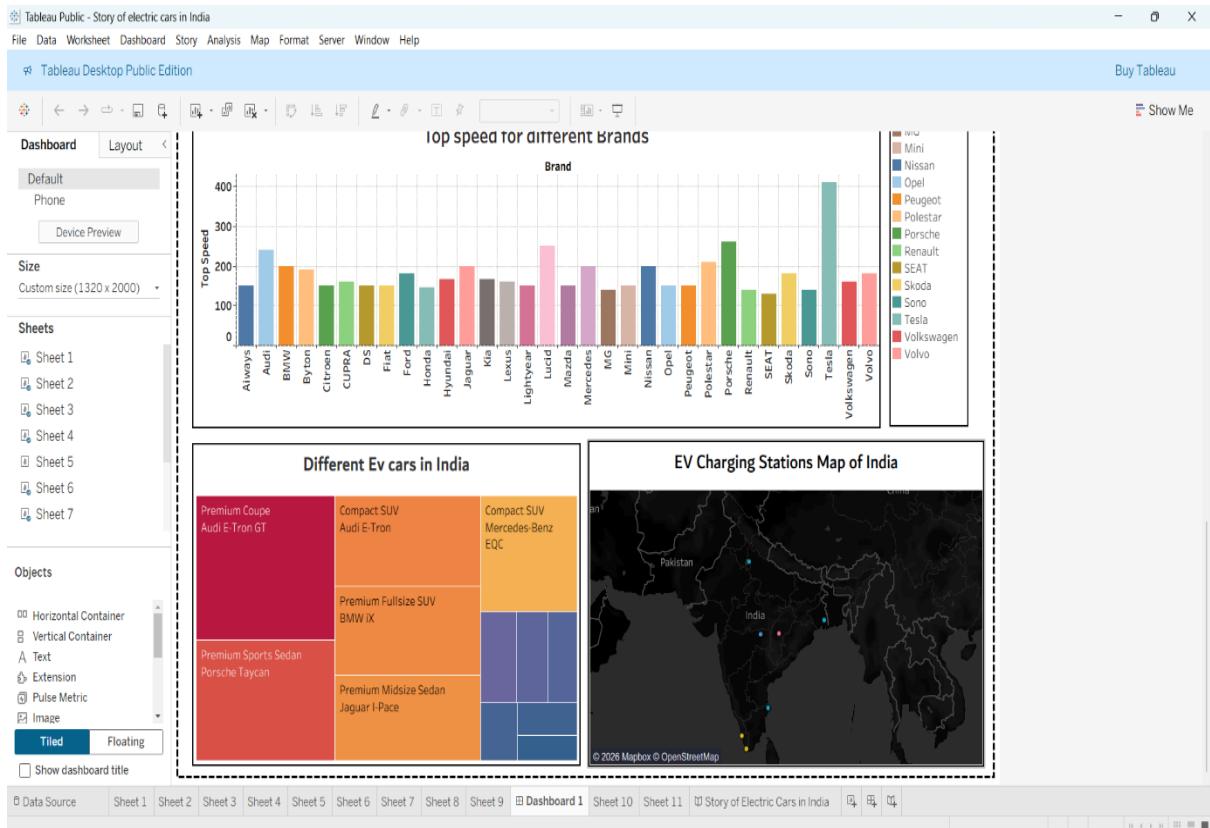
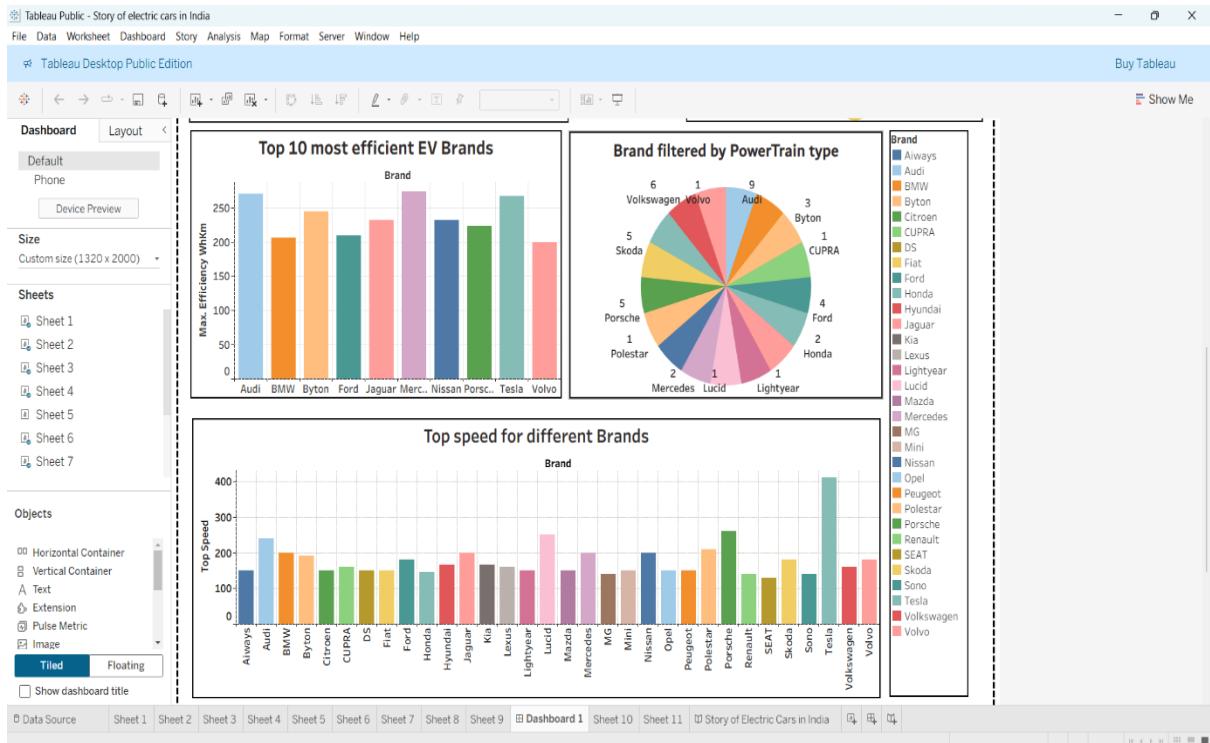
Story flow includes:

- EV range overview
- Charging performance comparison
- Charging station availability
- Final insights and observations
- Brands Filtered by Power Train Type

7. RESULTS

7.1 Dashboard





7.2 Story

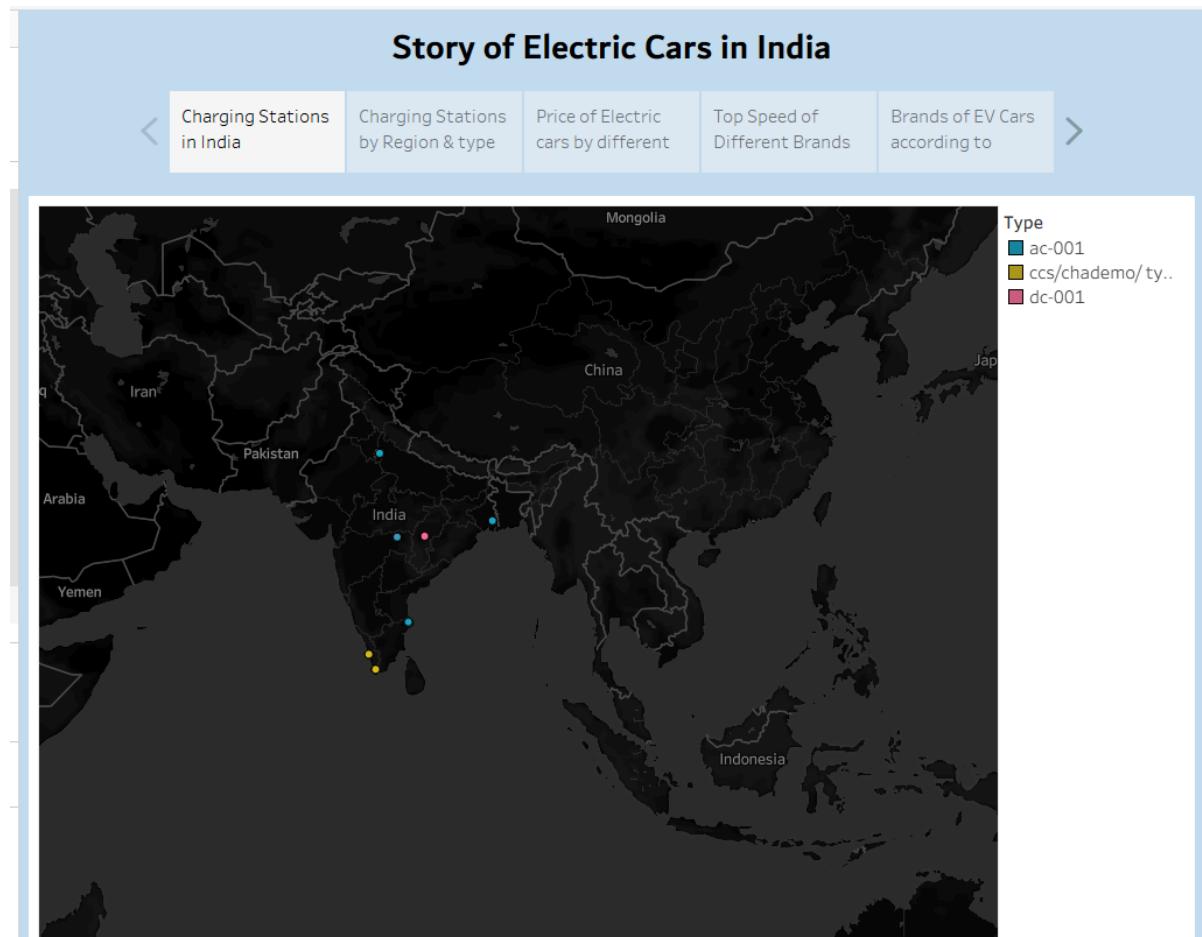


Tableau Public - Processing

File Data Worksheet Dashboard Story Analysis Format Server Window Help

Tableau Desktop Public Edition

Buy Tableau

Show Me

Story Layout < Charging Stations in India | Charging Stations by Region & type | Price of Electric cars by different | Top Speed of Different Brands | Brands of EV Cars according to >

New story point

Blank Duplicate

Sheet 1 Sheet 2 Sheet 3 Sheet 4 Sheet 5 Sheet 6 Sheet 7 Sheet 8 Sheet 9 Sheet 10 Dashboard 1 Sheet 11

Drag to add text

Show title

Size Story (1016 x 964)

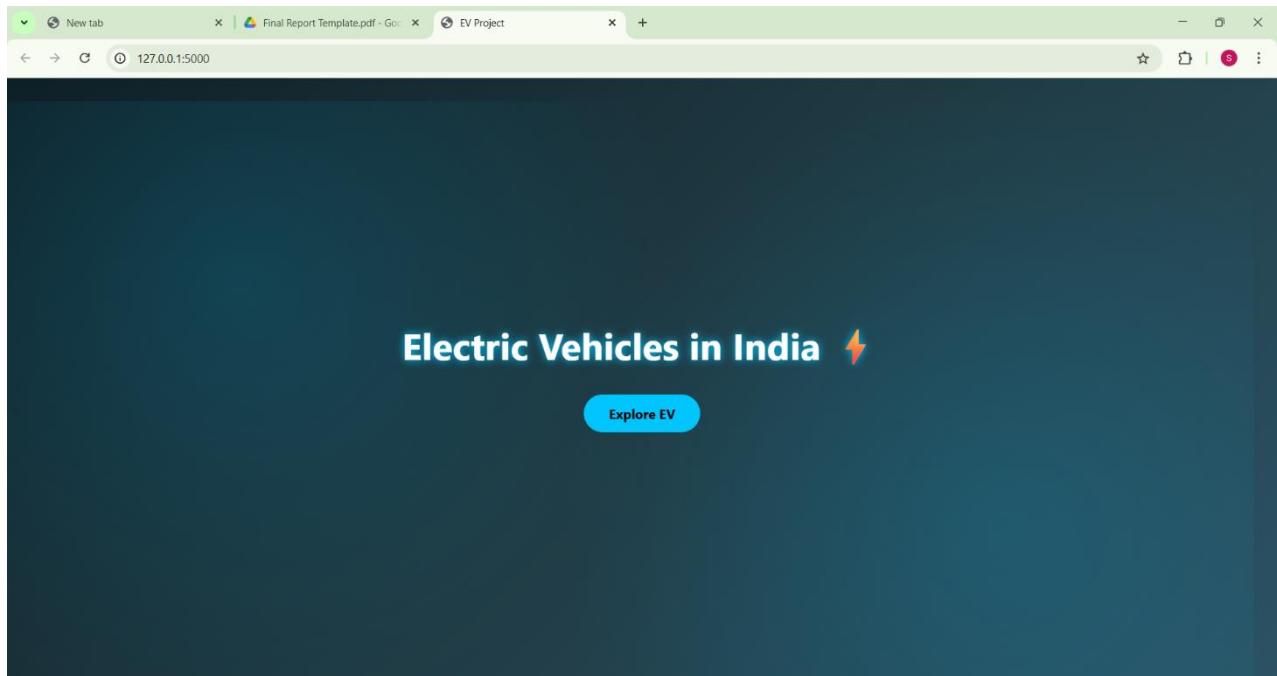
Brand

- Aiways
- Audi
- BMW
- Biton
- Citroen
- CUPRA
- Dacia
- Fiat
- Ford
- Honda
- Hyundai
- Jaguar
- Kia
- Lexus
- Lightyear
- Lucid
- Mazda
- Mercedes
- MG
- Mini
- Nissan
- Opel
- Peugeot
- Polestar
- Renault
- SEAT
- Skoda
- Sono

Top Speed

Story of Electric Cars in India

7.3 Web Integration



About Electric Vehicles

Electric Vehicles (EVs) are revolutionizing the global automotive industry by replacing traditional internal combustion engines with advanced electric powertrains. Instead of petrol or diesel, EVs operate using rechargeable lithium-ion battery packs that power electric motors. This transition significantly reduces greenhouse gas emissions, improves air quality, and promotes sustainable mobility. Modern EVs are equipped with regenerative braking systems, smart battery management technology, and connected dashboards that provide real-time performance insights. With lower operational costs and minimal maintenance requirements, electric vehicles are becoming a cost-effective alternative to conventional fuel-powered cars.

Why Electric Vehicles Matter

Reduction in Carbon Emissions and Air Pollution, Energy Independence & Reduced Oil Imports, Lower Running and Maintenance Costs, Technological Innovation in Battery & Charging Systems, Support for Sustainable Development Goals (SDGs).

Global EV Market Growth

Globally, electric vehicle adoption has accelerated rapidly over the past decade. Countries like China, the United States, and several European nations have led the transition through strong policy frameworks, charging infrastructure development, and financial incentives. Major automotive manufacturers are shifting toward fully electric production strategies, signaling a long-term transformation of the mobility ecosystem.

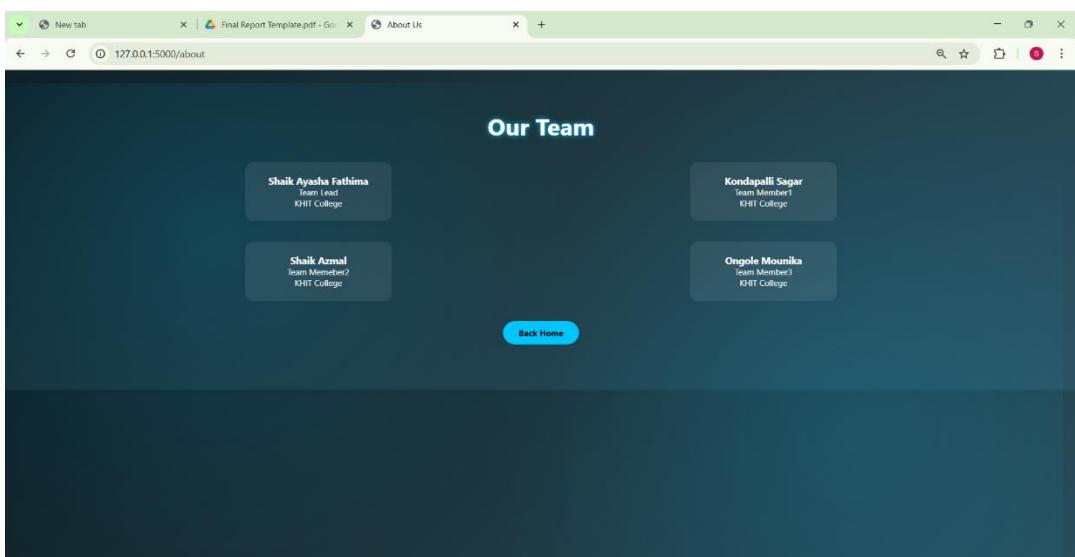
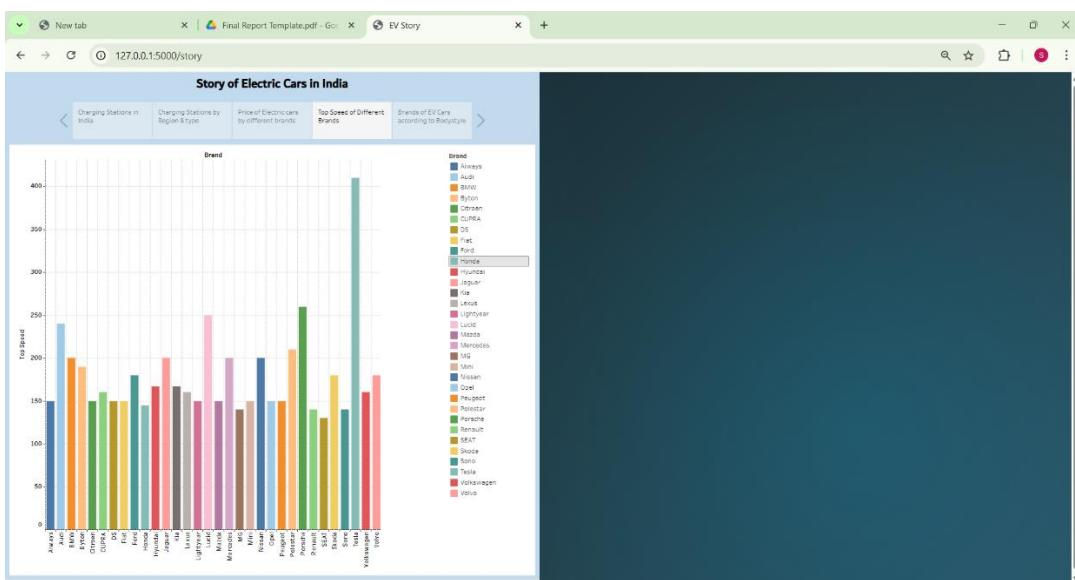
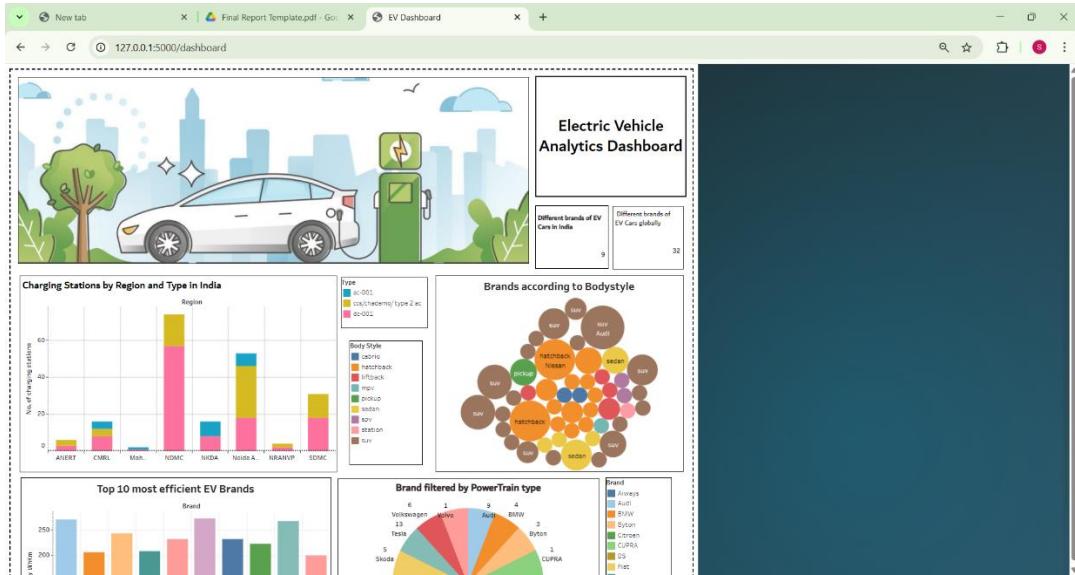
Growth of EVs in India

India has emerged as one of the fastest-growing EV markets. Government initiatives such as the FAME scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) have played a key role in boosting EV adoption. The expansion of charging infrastructure, increasing consumer awareness, and the launch of affordable EV models have significantly improved market penetration. The growth is especially strong in electric two-wheelers and three-wheelers, while electric passenger cars are steadily gaining traction in metropolitan and Tier-2 cities. With rising fuel prices and environmental concerns, India is steadily progressing toward a cleaner transportation ecosystem.

Project Objective

This project analyzes and visualizes electric vehicle trends across India and global markets. Through interactive dashboards and data-driven storytelling, the objective is to understand adoption patterns, brand performance, regional penetration, and overall EV ecosystem growth. By exploring the dashboard and story sections, users can gain insights into real-world EV data, helping them understand the transformation of the automotive industry toward electrification.

[Explore Dashboard](#) [Explore Story](#)



8. ADVANTAGES & DISADVANTAGES

Advantages

1. **Improves Decision-Making**
 - Visual dashboards make battery charge and range data easy to understand.
 - Helps users plan trips and charging schedules efficiently.
2. **Reduces Range Anxiety**
 - Clear visualization of remaining range builds driver confidence.
 - Avoids unexpected battery drain during long trips.
3. **User-Friendly Interpretation of Complex Data**
 - Converts raw EV data into graphs, charts, and maps.
 - Non-technical users can understand insights quickly.
4. **Supports Data-Driven Analysis**
 - Identifies usage patterns, efficiency trends, and charging behavior.
 - Useful for performance evaluation and optimization

Disadvantages

1. Depends on Data Accuracy
 - Incorrect or incomplete data leads to misleading visualizations.
 - Quality of insights fully depends on input data reliability.
2. Limited Real-Time Capability (Initial Version)
 - Without live vehicle data, analysis is mostly historical or simulated.
 - Real-time integration increases complexity.
3. Range Prediction Variability
 - Factors like driving style, weather, and terrain may not be fully captured.
 - Predictions may differ from actual vehicle performance.
4. Technical Complexity
 - Requires knowledge of data analytics tools and visualization platforms.
 - Maintenance and upgrades may need skilled professionals.

9. CONCLUSION

The Visualization Tool for Electric Vehicle Charge and Range Analysis successfully demonstrates how data visualization can play a crucial role in understanding and optimizing electric vehicle performance. By transforming raw battery and range data into interactive charts and dashboards, the project provides clear insights into charging patterns, energy consumption, and range behavior of electric vehicles.

This tool helps reduce range anxiety by enabling users to monitor battery status and predict driving range more effectively. It supports data-driven decision-making for users, fleet managers, and planners by identifying efficiency trends and potential charging requirements. The project also highlights the importance of analytical tools in promoting efficient EV usage and sustainable transportation.

10. FUTURE SCOPE

1. Real-Time Data Integration

- Connect the tool with live EV sensor data (battery SOC, temperature, energy consumption).
- Integrate IoT devices and vehicle APIs to show real-time charge and range updates.
- Useful for fleet operators and smart city dashboards.

2. AI-Based Range Prediction

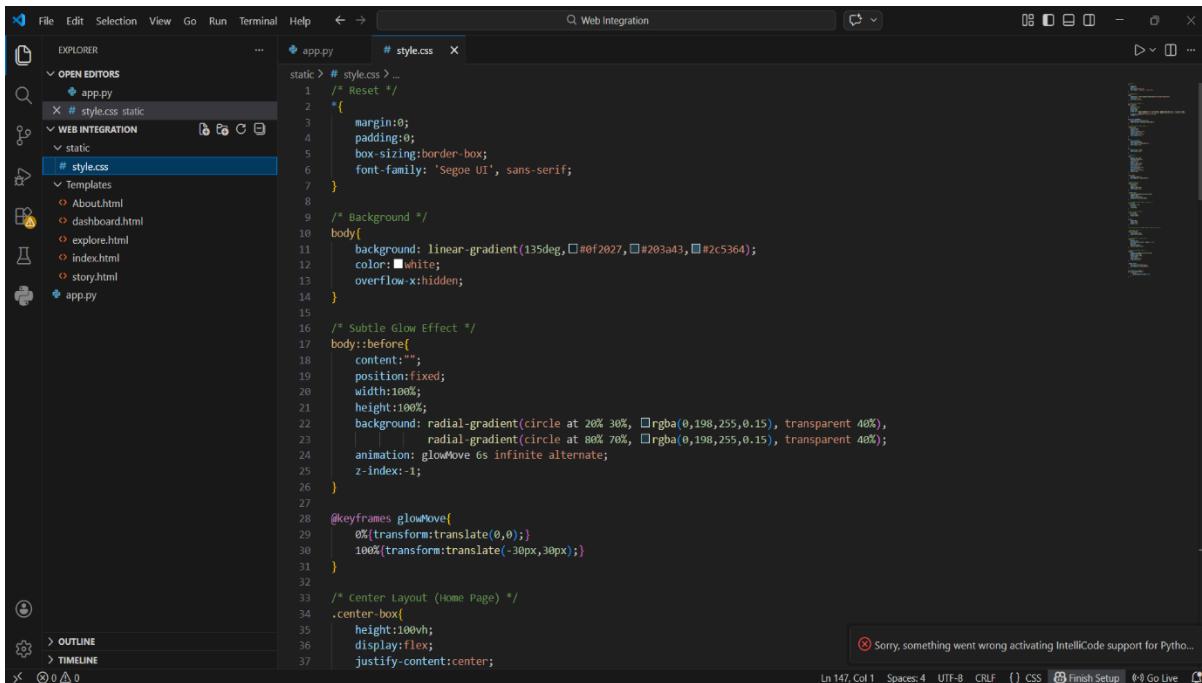
- Use machine learning models to predict range more accurately based on:
 - Driving behavior
 - Road conditions
 - Weather and traffic
- Improves decision-making for drivers and reduces range anxiety.

3. Charging Station Optimization

- Integrate charging station availability data.
- Visualize:
 - Nearest stations
 - Wait times
 - Fast vs slow chargers
- Helps users plan trips efficiently.

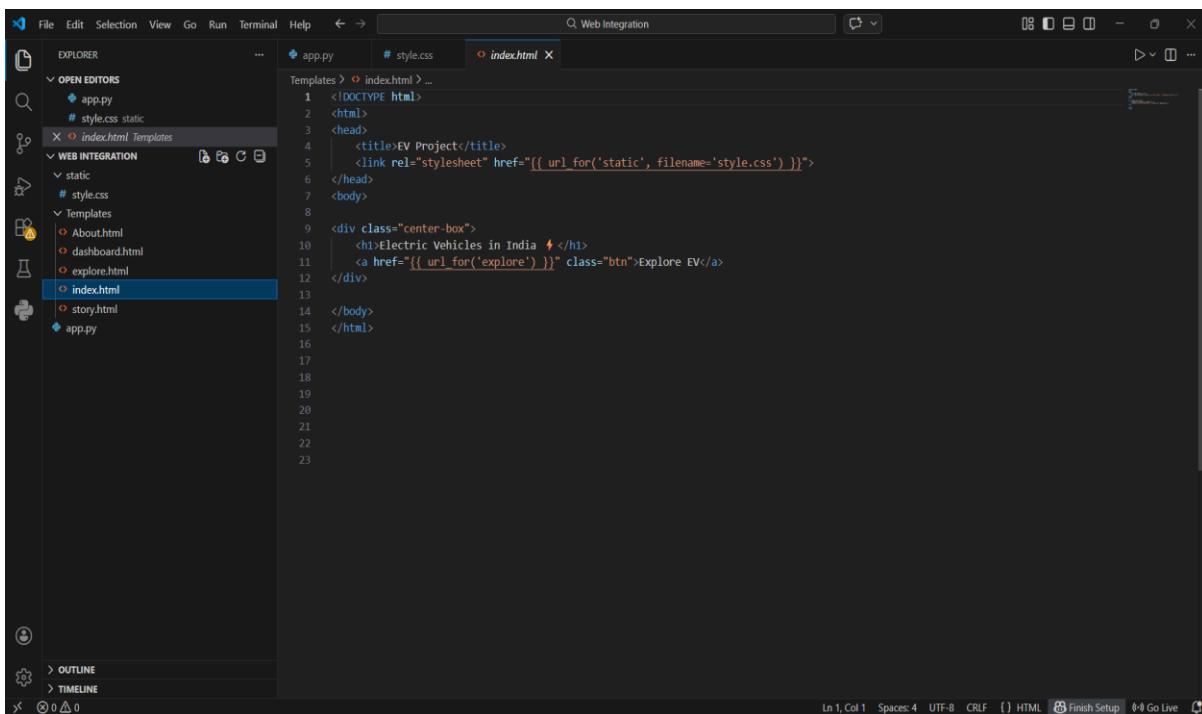
11.APPENDIX

Source code



The screenshot shows the Visual Studio Code interface with the 'style.css' file open in the editor. The file contains CSS code for a web application, including a gradient background, a subtle glow effect using before/after pseudo-elements, and a center layout class for the home page.

```
static > # style.css > ...
1 /* Reset */
2 *{
3     margin:0;
4     padding:0;
5     box-sizing:border-box;
6     font-family: 'Segoe UI', sans-serif;
7 }
8
9 /* Background */
10 body{
11     background: linear-gradient(135deg, #0f2027, #203a43, #2c5364);
12     color:#white;
13     overflow-x:hidden;
14 }
15
16 /* Subtle Glow Effect */
17 body::before{
18     content:"";
19     position:fixed;
20     width:100%;
21     height:100%;
22     background: radial-gradient(circle at 20% 30%, rgba(0,198,255,0.15), transparent 40%);
23     |   radial-gradient(circle at 80% 70%, rgba(0,198,255,0.15), transparent 40%);
24     animation: glowMove 6s infinite alternate;
25     z-index:-1;
26 }
27
28 @keyframes glowMove{
29     0%{transform:translate(0,0);}
30     100%{transform:translate(-30px,30px);}
31 }
32
33 /* Center Layout (Home Page) */
34 .center-box{
35     height:100vh;
36     display:flex;
37     justify-content:center;
}
Sorry, something went wrong activating IntelliCode support for Python...
Ln 147, Col 1  Spaces:4  UTF-8  CRLF  {} CSS  Finish Setup  Go Live  
```



The screenshot shows the Visual Studio Code interface with the 'index.html' file open in the editor. The file contains the HTML structure for the home page, including a title, a link to the style sheet, and a central box containing a heading and a button.

```
<!DOCTYPE html>
<html>
<head>
    <title>EV Project</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='style.css') }}"/>
</head>
<body>
    <div class="center-box">
        <h1>Electric Vehicles in India </h1>
        <a href="{{ url_for('explore') }}" class="btn">Explore EV</a>
    </div>
</body>
</html>
```

The screenshot shows a code editor interface with a dark theme. The left sidebar has sections for 'OPEN EDITORS' (app.py, style.css) and 'WEB INTEGRATION' (static, Templates: About.html, dashboard.html, explore.html, index.html, story.html). The main editor area displays the 'explore.html' template file:

```
<!DOCTYPE html>
<html>
<head>
<title>Explore EV</title>
<link rel="stylesheet" href="{{ url_for('static', filename='style.css') }}"/>
</head>
<body>
<a href="{{ url_for('about') }}" class="btn top-right">About Us</a>
<div class="page-container">
    <h1>Electric Vehicles in India </h1>
    <div class="content-box">
        <h2>About Electric Vehicles</h2>
        <p>Electric Vehicles (EVs) are revolutionizing the global automotive industry by replacing traditional internal combustion engines with electric motors. Modern EVs are equipped with regenerative braking systems, smart battery management technology, and connected dashboards that provide real-time data on performance and energy usage.</p>
        <h2>Why Electric Vehicles Matter</h2>
        <ul>
            <li>Reduction in Carbon Emissions and Air Pollution,</li>
            <li>Energy Independence & Reduced oil imports,</li>
            <li>Lower Running and Maintenance Costs,</li>
            <li>Technological Innovation in Battery & Charging Systems,</li>
            <li>Support for Sustainable Development Goals (SDGs).</li>
        </ul>
        <h2>Global EV Market Growth</h2>
        <p>Globally, electric vehicle adoption has accelerated rapidly over the past decade. Countries like China, the United States, and several European nations have implemented policies to encourage EV production and use, driving down costs and improving infrastructure. As a result, the global market for EVs is projected to continue growing at a rapid pace in the coming years, with significant implications for the automotive industry and the environment.</p>
    </div>
</div>

```

At the bottom, status bar items include: Ln 1, Col 1 | Spaces: 4 | UTF-8 | CRLF | () HTML | Finish Setup | Go Live |

The screenshot shows a code editor interface with a dark theme. The left sidebar has sections for 'OPEN EDITORS' (app.py, style.css) and 'WEB INTEGRATION' (static, Templates: About.html, dashboard.html, explore.html, index.html, story.html). The main editor area displays the 'dashboard.html' template file:

```
<!DOCTYPE html>
<html>
<head>
<title>EV Dashboard</title>
<link rel="stylesheet" href="{{ url_for('static', filename='style.css') }}"/>
</head>
<body>
<div class="full-screen">
    <iframe
        src="https://public.tableau.com/views/ElectricvehicleanalyticsDashboard/Dashboard1?:embed=y&:display_count=yes&:showVizHome=false"
        allowfullscreen
    </iframe>
</div>
</body>
</html>

```

At the bottom, status bar items include: Ln 1, Col 1 | Spaces: 4 | UTF-8 | CRLF | () HTML | Finish Setup | Go Live |

The screenshot shows a code editor interface with a dark theme. The top menu bar includes File, Edit, Selection, View, Go, Run, Terminal, Help, and a search bar for 'Web Integration'. The left sidebar has sections for EXPLORER, OPEN EDITORS, and WEB INTEGRATION. Under WEB INTEGRATION, there are static files (style.css) and templates (About.html, dashboard.html, explore.html, index.html, story.html). The 'story.html' file is currently selected and open in the main editor area. The code in 'story.html' is as follows:

```
<!DOCTYPE html>
<html>
<head>
<title>EV Story</title>
<link rel="stylesheet" href="{{ url_for('static', filename='style.css') }}"/>
</head>
<body>
<div class="full-screen">
<iframe
src="https://public.tableau.com/views/StoryofEvCarsinIndia/StoryofElectricCarsinIndia?:embed=y&display_count=yes&showVizHome=no"
allowfullscreen>
</iframe>
</div>
</body>
</html>
```

The bottom status bar shows 'Ln 1, Col 1' and other settings like 'Spaces: 4', 'UTF-8', 'CRLF', 'HTML', 'Finish Setup', 'Go Live', and a refresh icon.

The screenshot shows a code editor interface with a dark theme, similar to the first one. The top menu bar includes File, Edit, Selection, View, Go, Run, Terminal, Help, and a search bar for 'Web Integration'. The left sidebar has sections for EXPLORER, OPEN EDITORS, and WEB INTEGRATION. Under WEB INTEGRATION, there are static files (style.css) and templates (About.html, dashboard.html, explore.html, index.html, story.html). The 'About.html' file is currently selected and open in the main editor area. The code in 'About.html' is as follows:

```
<!DOCTYPE html>
<html>
<head>
<title>About Us</title>
<link rel="stylesheet" href="{{ url_for('static', filename='style.css') }}"/>
</head>
<body>
<div class="page-container">
<h1>Our Team</h1>
<div class="team-box">
<div class="member">
<h3>Shaik Aysaha Rathima</h3>
<p>Team Lead</p>
<p>KHIT College</p>
</div>
<div class="member">
<h3>Kondapalli Sagar</h3>
<p>Team Member1</p>
<p>KHIT College</p>
</div>
<div class="member">
<h3>Shaik Azmal</h3>
<p>Team Member2</p>
<p>KHIT College</p>
</div>
<div class="member">
<h3>Ongole Monika</h3>
<p>Team Member3</p>
<p>KHIT College</p>
</div>
</div>
</div>
</body>
</html>
```

The bottom status bar shows 'Ln 1, Col 1' and other settings like 'Spaces: 4', 'UTF-8', 'CRLF', 'HTML', 'Finish Setup', 'Go Live', and a refresh icon.

The screenshot shows the Visual Studio Code interface with the following details:

- File Explorer (Left):** Shows the project structure with files like `app.py`, `style.css`, and various HTML templates (`About.html`, `dashboard.html`, `explore.html`, `index.html`, `story.html`).
- Editor (Center):** Displays the `app.py` file content, which imports `Flask` and defines routes for different pages.
- Terminal (Bottom):** Shows the command `python app.py` being run, indicating the application is running locally.
- Status Bar (Bottom):** Provides information about the current file (Line 4, Col 1), code style settings (Spaces: 4, CRLF), and the Python environment (Python 3.12 (64-bit)).

Project Links

Public link of Dashboard:

https://public.tableau.com/views/ElectricVehicleAnalyticsDashboard/Dashboard1?:language=en-US&:sid=&:redirect=auth&:display_count=n&:origin=viz_share_link

Public link of Story :

https://public.tableau.com/views/StoryofEvCarsinIndia/StoryofElectricCarsinIndia?:language=en-US&:sid=&:redirect=auth&:display_count=n&:origin=viz_share_link

Demo Video link:

https://drive.google.com/file/d/15aGHRBHkj3RjXQIgyfV_scqYwvfIRp84/view?usp=sharing

Datasets Link:

https://drive.google.com/drive/folders/1Hy6NcdbugtID3SNQA5aavnAisCJ_1j6?usp=drive_link

GitHub Link:

<https://github.com/Ayasha-72/Visualization-Tool-for-Electric-Vehicle-Charge-and-Range-Analysis.git>