Final Project Report Template

1. Introduction

1.1. Project overviews

Providing visual representations of the electric field (as vector fields or field lines) and electric potential (as equipotential lines/surfaces or colour gradients) generated by the defined charge distributions. This helps in understanding the strength and direction of the forces experienced by other charges in the vicinity. Allowing users to define and visualize intricate arrangements of point charges, line charges, surface charges, and potentially even volumetric charge distributions. This enables a clear understanding of the spatial relationships between charges. Enabling the visualization of the spatial extent over which the electric field or potential exceeds a certain threshold or has a significant impact. This "range analysis" can be crucial for understanding the effective reach of charged objects or devices.

1.2. Objectives

Exploration of Complex Systems: To provide a means to visualize and analyse the electromagnetic behaviour of systems with multiple charges or continuous charge distributions, which can be challenging to comprehend analytically.
Quantitative Analysis Support: To complement numerical analysis by providing a visual framework for interpreting quantitative data and identifying regions of interest for further investigation.
Consolidation of Diverse Data Sources: To integrate data from various sources (e.g., manual input, simulation outputs, experimental measurements) into a unified visualization environment.
Effective Presentation of Findings: To generate compelling and easily understandable visual representations of project results for presentations, reports, and publications.

2. Project Initialization and Planning Phase

2.1. Define Problem Statement

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	**Nissan Leaf**	Recurrent: This platform focuses on providing insights into EV battery health and range, often based on community data They offer reports and data points that can be visualized.	Battery State of Charge (SOC): The current percentage of battery capacity. Estimated Range: The predicted distance the car can travel based on current SOC and driving conditions.	Driving Conditions: Factors like speed, terrain, temperature, and use of climate control significantly impact range	Good
PS-2	**Maha Metro**	Focus on Mass Transit: Maha Metro is primarily a mass rapid transit system. While they may have some operational EVs for internal use or station related activities, their	Limited Public EV Data: Publicly available data on individual EV charging and range within the Maha Metro context is likely limited	Tableau Public: There are some publicly available dashboards on Tableau that analyse general EV charge and range data (search for "EV charge range analysis"). These are not specific to	Difficult

		primary focus isn't on public EV infrastructure and individual vehicle analysis.		Maha Metro but can give you insights into broader trends You can find an example here:	
PS-3	**Tesla**	Energy Consumption (Who/km or miles/kWh): How efficiently the car is using energy	Impact of Temperature: If you have data for different t temperatures, you can visualize how temperature affects range	Climate Control Usage: Heating and cooling consume battery power and affect range.	Frustrated
PS-4	**Tata Nexon EV**	Specific Car Brand Apps Sometimes, communities of EV owners develop apps that work with specific models. Search online forums and app stores for potential options for the Tata Nexon EV.	Tata Nexon EV Owner Forums and Groups: These online communities can be valuable resources for finding information about third-party tools or methods that other owners are using for analysis.	Charging Curves: If you monitor charging sessions you can plot the charging speed against the state of charge to understand how quickly the car charges at different levels.	Informed And Confident

2.2. Project Proposal (Proposed Solution)

<table>
<tr><td colspan="2">Project Overview</td></tr>
<tr><td>Objective</td><td>Enhance User Understanding: Provide clear and intuitive visualizations of EV charge and range data.

Facilitate Data-Driven Decisions: Offer comprehensive data analysis capabilities for performance evaluation and trend identification.</td></tr>
<tr><td>Scope</td><td>Data Acquisition and Integration: Real-time Data:
Integration with EV onboard diagnostics (OBD) systems or APIs (if available) to capture live data such as:
Battery state of charge (SOC).
Current power consumption.</td></tr>
<tr><td colspan="2">Problem Statement</td></tr>
<tr><td>Description</td><td>Aggregates and processes data: Collects real-time and historical data from EV onboard systems, charging networks, and other relevant sources.

Performs advanced analysis: Calculates range estimates, predicts charging times, analyses battery health, and generates performance metrics.</td></tr>
</table>

Impact	**EV Users:** **Reduced range anxiety:** Increased confidence in EV range and charging capabilities. **Improved trip planning:** Efficient route optimization and charging stop planning.
Proposed Solution	
Approach	The proposed solution is a web-based (or cross-platform mobile) application that integrates data from various sources to provide users with a comprehensive and intuitive visualization of their EV's charge and range performance. This tool will act as a central hub for EV data, transforming raw information into actionable insights.
Key Features	**Historical Data Analysis:** • Visualize past charging sessions, trip data, and performance metrics. • Generate reports on energy consumption, charging costs, and battery health. • Compare performance across different trips and time periods.

Resource Requirements

Resource Type	Description	Specification/Allocation
Hardware		
Computing Resources	Laptop (DELL)	Hp RYZEN 5
Memory	RAM specifications	8 GB
Storage	Disk space for data, models, and logs	476 GB
Software		
Frameworks	Python frameworks	Flask
Libraries	Additional libraries	scikit-learn, pandas, numpy
Development Environment	IDE, version control	Jupyter Notebook, Git
Data		
Data	Format	Ms Excel

2.3. <u>Initial Project Planning</u>

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members	Sprint Start Date	Sprint End Date (Planned)
Sprint-1	Data collection &	SCRUM-4	Downloading the Datasets	2	High	Vk Vishwanath	3-3-2025	4-3-2025
Sprint-1	Working with Dataset	SCRUM-7	Understand the Dataset Import Dataset Into Database Connect Tableau Desktop to Database Server	1	High	K.Sreelakshmi	4-3-2025	5-3-2025
Sprint-2	Data Visualization	SCRUM-11	Charging Stations By Region And Type In India EV charging Stations Map Of India Different EV cars In India Top Speed For Different Brands Price For Different Cars In India Top 10 Most Efficient EV Brands	2	High	K.Sreelakshmi	5-3-2025	9-3-2025
Sprint-2		SCRUM-11	Brands According To Body style Brand Filtered By Powertrain Type No Of Models By Each Brand Summary Card For Different Brands Of EV Cars Globally Summary Card For Different	2	High	K.Sreelakshmi	5-3-2025	9-3-2025

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members	Sprint Start Date	Sprint End Date (Planned)
			Brands Of EV Cars In India					
Sprint-3	Dashboard	SCRUM-23	Creating The Dashboard	1	High	K.Sreelakshmi	9-3-2025	14-3-2025
Sprint-4	Story	SCRUM-25	Creating The Story	2	High	K.Sreelakshmi	14-3-2025	20-3-2025
Sprint-5	Publishing And Web Integration	SCRUM-28	Embed Dashboard And Story With Web Bootstrap Publishing Dashboard And Reports To Tableau Public	2	High	Ulidra Usharani K,Narasimhulu	21-3-2025	22-3-2025

3.Data Collection and Preprocessing Phase

Section	Description
Data Overview	A comprehensive visualization tool for electric vehicle (EV) charge and range analysis depends on a multifaceted dataset. This data broadly falls into four categories: static vehicle specifications, dynamic charging infrastructure data, environmental and geographical information, and optional user usage data. Vehicle specifications, including battery capacity, rated range, and charging capabilities, provide the baseline for performance comparisons. Charging infrastructure data, such as station locations, charger types, and real-time availability, is crucial for route planning and charging optimization. Environmental and geographical data, encompassing temperature, terrain, and traffic, reveal the impact of external factors on EV performance.
Data Cleaning	Geocoding addresses to obtain precise latitude and longitude coordinates for charging stations is crucial for accurate mapping. Furthermore, data validation checks should be implemented to identify and correct outliers or errors, ensuring the dataset's integrity. Finally, consistent formatting of vehicle models, charging network names, and weather conditions will enhance the clarity and usability of the visualizations. By meticulously cleaning the data, the visualization tool can provide reliable and insightful analyses of EV charge and range performance.
Data Transformation	Data transformation is a vital phase in preparing data for an EV charge and range visualization tool, enabling it to deliver accurate and meaningful insights. This process involves converting raw data into a format suitable for analysis and visualization. Initially, data aggregation might be necessary, such as calculating average charging times or summarizing charging station usage patterns. Feature engineering plays a key role, creating new variables like "range per

	kilowatt-hour" to analyses vehicle efficiency or "distance to nearest charging station" to assess infrastructure accessibility. Normalization or standardization of numerical data, such as battery capacity or charging speeds, ensures that variables are on a comparable scale.
Data Type Conversion	Data type conversion is a fundamental step in preparing data for an electric vehicle (EV) charge and range analysis visualization tool, ensuring that all data is in the correct format for accurate processing and visualization. This process involves changing the data type of various columns to match their intended use. For instance, numerical data, such as battery capacity or charging speeds, must be converted to numeric types like integers or floats to enable mathematical operations and charting. Date and time data, like charging session timestamps or weather observation times, must be converted to date/time formats to allow for time-series analysis and chronological visualizations. Geographical coordinates, typically stored as text, need to be converted to numeric types for accurate mapping and spatial calculations.
Column Splitting and Merging	column merging combines multiple columns into a single column, which can be useful for creating unique identifiers, such as merging manufacturer and model columns into a "vehicle identifier" column, or concatenating latitude and longitude into a "location" column. This streamlines data management and enables the creation of composite keys for relational data. Both techniques are crucial for restructuring data to better suit the visualization tool's requirements, improving data clarity, and enabling more effective analysis of EV charge and range parameters.
Data Modeling	A relational model is often preferred, organizing data into distinct tables such as "Vehicles," "Charging Stations," "Environmental Data," and potentially "Usage Data," with clearly defined relationships between them. The "Vehicles" table would contain static vehicle specifications, while the "Charging Stations" table would hold infrastructure details. The "Environmental Data" table would store weather and terrain information, and "Usage Data" (if available) would capture driving and charging habits. Primary and foreign keys are used to establish relationships, enabling joins and queries across tables.
Save Processed Data	The processed data, having undergone cleaning, transformation, and modelling, should be saved in a structured and accessible format. Common formats include CSV files for portability, Parquet files for efficient storage and retrieval of large datasets, or relational database tables for structured querying. Cloud-based storage solutions, like AWS S3 or Google Cloud Storage, provide scalability and accessibility for large datasets. Regular backups should be implemented to prevent data loss and ensure data integrity.

3.1. Data Collection Plan and Raw Data Sources Identified

Section	**Description**
Project Overview	To develop an Interactive visualization demonstrating the impact of temperature and driving style on range. Visualizations analyzing charging infrastructure utilization and explore how factors like temperature, driving style, and terrain impact range.

Data Collection Plan	A robust data collection plan is crucial for a successful Tableau visualization tool focused on electric vehicle.
Raw Data Sources Identified	Data collected from onboard vehicle systems offering real-time data on station locations, availability, and charging speeds.

Raw Data Sources Template

Source Name	**Description**	**Location/URL**	**Format**	**Size**	**Access Permissions**
Cheapest Electronic Cars	Leading the charge is the MG Comet EV, a highly compact city car designed for easy manoeuvrability and efficient urban commuting. Tata Motors has also made significant strides with models like the Tata Tiago EV and the Tata Punch EV, offering more traditional vehicle designs with varying battery options to suit different needs	Cheapestelectriccars-EVDatabase.csv	CSV	26 KB	Public
Electronic Vehicle Charging Station	These stations provide the necessary power to replenish the batteries of electric vehicles, offering varying levels of charging speed and convenience. Level 1 charging, the slowest, typically uses a standard household outlet, while Level 2 charging significantly reduces charging time through higher voltage connections. DC fast charging, the quickest option, delivers high-power direct current, allowing for rapid battery replenishment, often suitable for long-distance travel.	electric_vehicle_charging_station_list.csv	CSV	44 KB	Public
Electric Car Data	Electric car data encompasses a wide range of specifications and performance metrics crucial for understanding and comparing these vehicles. Key data points include battery capacity, measured in kilowatt-hours (kWh), which directly impacts the vehicle's range. Range itself, typically expressed in miles or kilometres, varies based on testing standards like EPA or WLTP and is influenced by factors like driving conditions and temperature. Energy consumption, often represented as watt-hours per mile (mile) or kilometre (km), indicates the vehicle's efficiency. Charging capabilities are also vital, detailing AC and DC charging speeds, connector types (CCS, CHAdeMO, Tesla), and charging times.	ElectricCarData_Clean.csv	CSV	8 KB	Public

EV India	The electric vehicle (EV) market in India is experiencing rapid growth, driven by increasing environmental awareness, government initiatives, and technological advancements. The Indian government has actively promoted EV adoption through policies like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, offering subsidies and incentives to both manufacturers and consumers. This push has led to a surge in the availability of electric two-wheelers, three-wheelers, and passenger cars, with both domestic and international manufacturers investing in the Indian market. Urban areas, particularly, are witnessing a rising number of charging stations, although infrastructure development remains a crucial area for further expansion.	EVIndia.csv	CSV	1 KB	Public

3.2. Data Quality Report

Data Source	**Data Quality Issue**	**Severity**	**Resolution Plan**
Cheapest Electric Cars-EV Database	The data is not properly organised, and the quality of the data depends on the reliability of the sources used. Databases that aggregate information from various sources may inherit inaccuracies.	High	Generate reports to monitor data quality trends and identify areas for improvement. Implement data validation rules at the database level to prevent invalid data from being entered
Electric Vehicle Charging Station	Incorrect or incomplete information about charger type (AC, DC), charging speed, and connector type can cause compatibility issues.	High	Promote and enforce the use of open communication protocols like OCPP (Open Charge Point Protocol) to ensure seamless data exchange between different charging networks and platforms.
Electric Car Data Clean	Data from charging stations may come from diverse networks with inconsistent reporting standards. • This can lead to discrepancies in location, availability, and pricing information.	High	Establish clear data schemas and formats for all data sources, including sensor data, charging station data, and user-generated data. • This ensures consistency across different data sources.

EV India	A lack of standardized charging protocols and data formats across different charging network providers can hinder interoperability and data sharing • This makes it difficult to create comprehensive and reliable charging station maps and apps.	High	Create a national platform to aggregate and standardize EV data from various sources, including vehicle manufacturers, charging network operators, and government agencies. • Define clear data standards for charging infrastructure, vehicle performance, and battery health.

3.3. Data Exploration and Preprocessing

Section	Description
Data Overview	A comprehensive visualization tool for electric vehicle (EV) charge and range analysis depends on a multifaceted dataset. This data broadly falls into four categories: static vehicle specifications, dynamic charging infrastructure data, environmental and geographical information, and optional user usage data. Vehicle specifications, including battery capacity, rated range, and charging capabilities, provide the baseline for performance comparisons. Charging infrastructure data, such as station locations, charger types, and real-time availability, is crucial for route planning and charging optimization. Environmental and geographical data, encompassing temperature, terrain, and traffic, reveal the impact of external factors on EV performance.
Data Cleaning	Geocoding addresses to obtain precise latitude and longitude coordinates for charging stations is crucial for accurate mapping. Furthermore, data validation checks should be implemented to identify and correct outliers or errors, ensuring the dataset's integrity. Finally, consistent formatting of vehicle models, charging network names, and weather conditions will enhance the clarity and usability of the visualizations. By meticulously cleaning the data, the visualization tool can provide reliable and insightful analyses of EV charge and range performance.
Data Transformation	Data transformation is a vital phase in preparing data for an EV charge and range visualization tool, enabling it to deliver accurate and meaningful insights. This process involves converting raw data into a format suitable for analysis and visualization. Initially, data aggregation might be necessary, such as calculating average charging times or summarizing charging station usage patterns. Feature engineering plays a key role, creating new variables like "range per kilowatt-hour" to analyses vehicle efficiency or "distance to nearest charging station" to assess infrastructure accessibility. Normalization or standardization of numerical data, such as battery capacity or charging speeds, ensures that variables are on a comparable scale.
Data Type Conversion	Data type conversion is a fundamental step in preparing data for an electric vehicle (EV) charge and range analysis visualization tool, ensuring that all data is in the correct format for accurate processing and visualization. This process involves changing the data type of various columns to match their intended use. For instance, numerical data, such as battery capacity or charging speeds, must be converted to numeric types like integers or floats to enable

	mathematical operations and charting. Date and time data, like charging session timestamps or weather observation times, must be converted to date/time formats to allow for time-series analysis and chronological visualizations. Geographical coordinates, typically stored as text, need to be converted to numeric types for accurate mapping and spatial calculations.
Column Splitting and Merging	column merging combines multiple columns into a single column, which can be useful for creating unique identifiers, such as merging manufacturer and model columns into a "vehicle identifier" column, or concatenating latitude and longitude into a "location" column. This streamlines data management and enables the creation of composite keys for relational data. Both techniques are crucial for restructuring data to better suit the visualization tool's requirements, improving data clarity, and enabling more effective analysis of EV charge and range parameters.
Data Modelling	A relational model is often preferred, organizing data into distinct tables such as "Vehicles," "Charging Stations," "Environmental Data," and potentially "Usage Data," with clearly defined relationships between them. The "Vehicles" table would contain static vehicle specifications, while the "Charging Stations" table would hold infrastructure details. The "Environmental Data" table would store weather and terrain information, and "Usage Data" (if available) would capture driving and charging habits. Primary and foreign keys are used to establish relationships, enabling joins and queries across tables.
Save Processed Data	The processed data, having undergone cleaning, transformation, and modelling, should be saved in a structured and accessible format. Common formats include CSV files for portability, Parquet files for efficient storage and retrieval of large datasets, or relational database tables for structured querying. Cloud-based storage solutions, like AWS S3 or Google Cloud Storage, provide scalability and accessibility for large datasets. Regular backups should be implemented to prevent data loss and ensure data integrity.

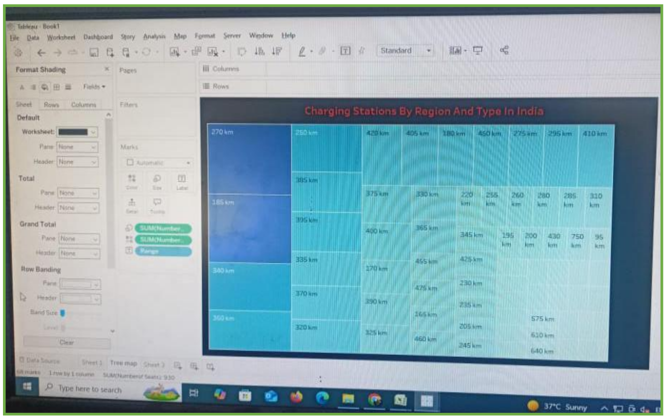
4. Data Visualization

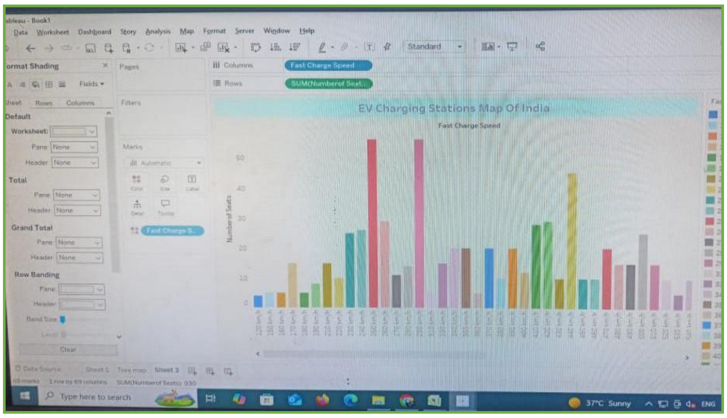
4.1. Framing Business Questions

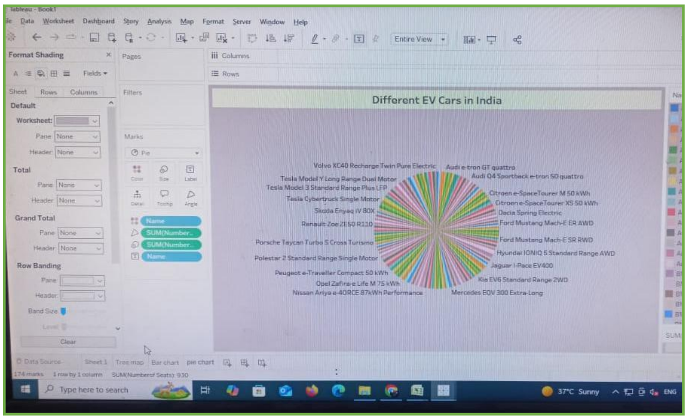
1. **What is the average range or coverage (in kilometres)provided by charging stations in different regions?**
2. **Which fast charge speeds are most common in India’s EV charging stations in different regions?**
3. **What are the most popular electric vehicle (EV) models in India based on the number of seats offered?**
4. **What is the distribution of top speeds for different car brands, categorized by their power transmission type?**
5. **What is the relationship between the price of a car(in euros) and the number of seats it offers across different brands?**
6. **Which EV brands are leading in efficiency and by what margin?**
7. **Which car body styles tend to offer the most seating capacity?**
8. **Which power train type is associated with the highest top speeds?**
9. **Which brand offers the greatest number of electric vehicle models?**
10. **What is price range for different top models of electric vehicles globally?**

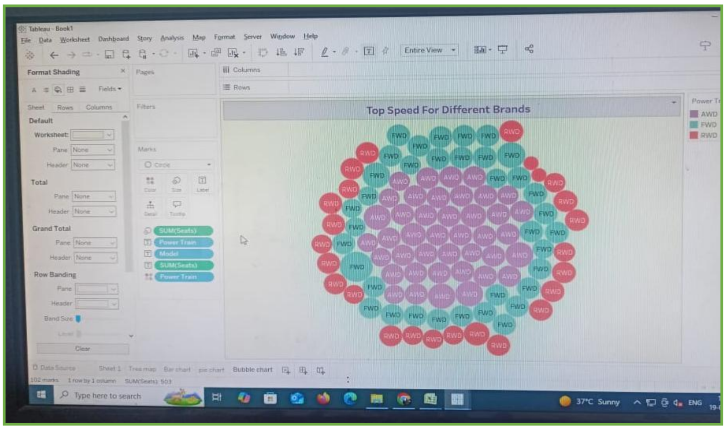
11. What is average price range for different styles of electric vehicles (EVS)?

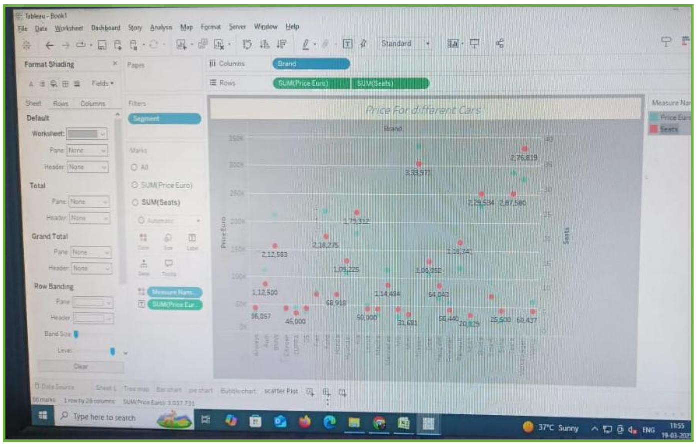
4.2. Developing Visualizatio

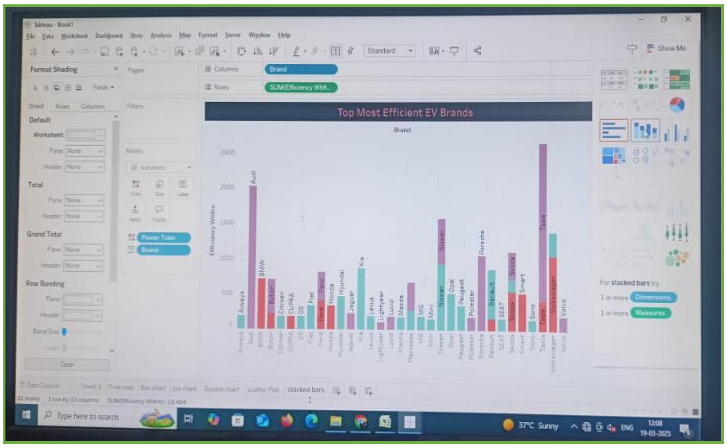


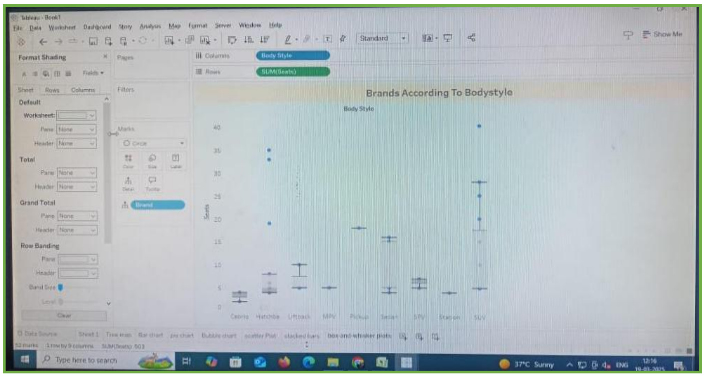


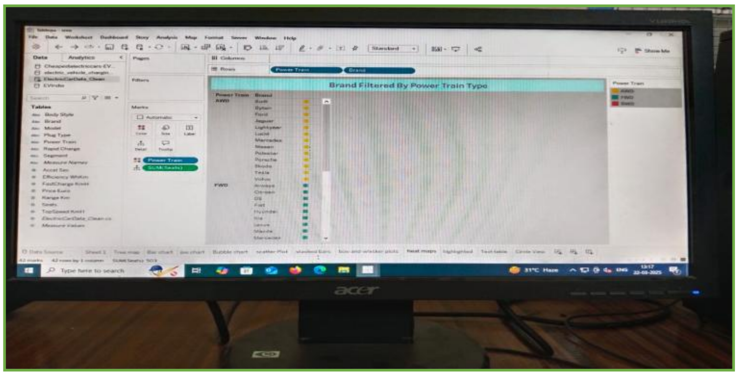


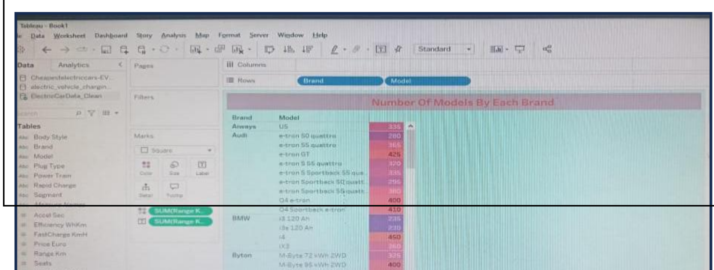


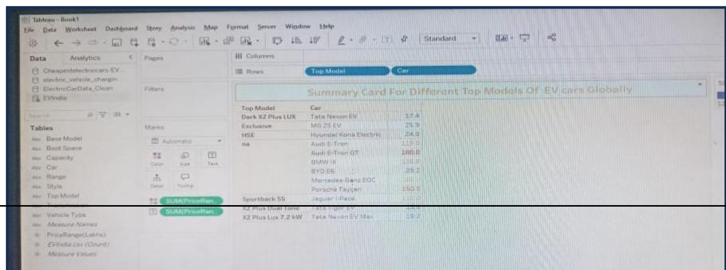


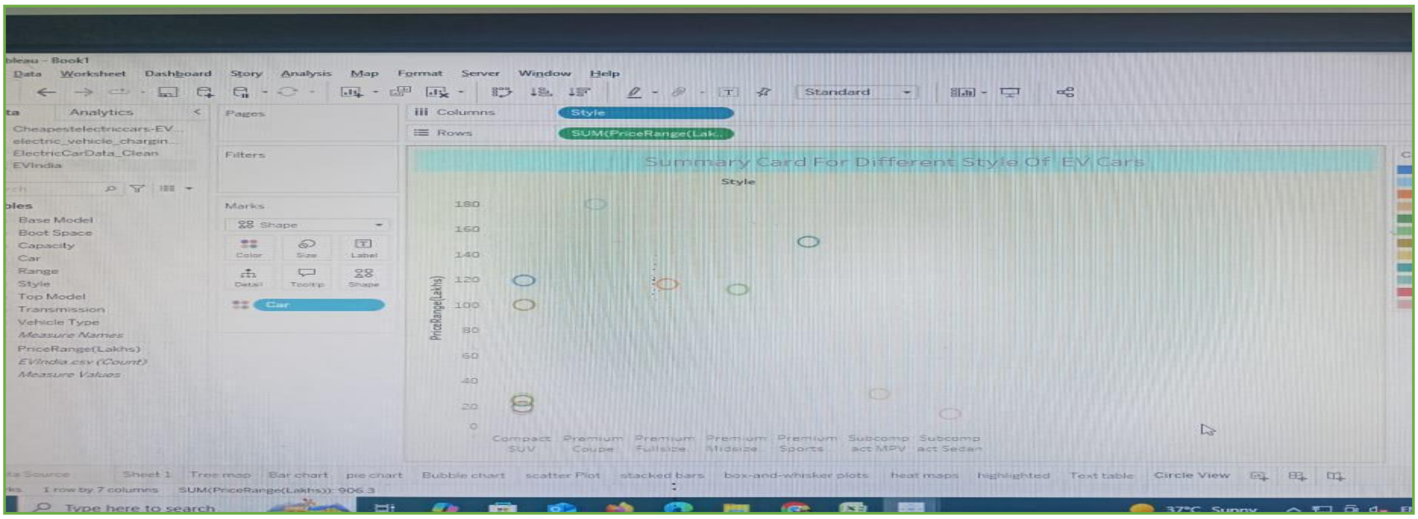












7.3 No of Visualization

8. Conclusion/Observation

The development and utilization of a dedicated visualization tool for an electric charge and range analysis project offer significant advantages in understanding, analysing, and communicating complex electromagnetic phenomena. By translating abstract data into intuitive visual representations, the tool empowers users to gain deeper insights into charge distributions, electric fields, potentials, and teir effective ranges. This capability enhances the overall research process, facilitates problem-solving, and strengthens the impact of project findings.

9.Future Scope

The future scope of a visualization tool for electric charge and range analysis is vast and holds the potential to significantly enhance research, education, and practical applications in electromagnetics. Here's a breakdown of very important potential future developments:

- Enhanced Physics and Modelling Capabilities:
  - ❖ Integration of Time-Varying Fields and Electrodynamics
  - ❖ Advanced Material Properties
  - ❖ Quantum Effects (Conceptual Visualization)
- Advanced Visualization Techniques:
  - ❖ Immersive and Interactive 3D Visualizations
  - ❖ Flow Visualization for Fields
  - ❖ Animated Visualizations
- Enhanced Analysis and Quantification Features:
  - ❖ Automated Range Analysis
  - ❖ Data Export and Reporting Enhancements
  - ❖ Machine Learning Integration
- User Experience and Accessibility Improvements:

- Intuitive and Customizable User Interface
- Accessibility Features
- Wireless Power Transfer Analysis

10. Appendix

10.1. Source Code(if any)

10.2. GitHub & Project Demo Link

https://github.com/sreelakshmiBai/visualization-tool-for-electric-vehicle-charge-and-range-analysis