Project Documentation On Visualization Tool for Electric Vehicle Charge and Range Analysis

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Problem statement

The transition to electric vehicles (EVs) is rapidly expanding, necessitating advanced tools to analyze charging patterns and range capabilities effectively. Existing solutions lack comprehensive visualization capabilities, impeding users' ability to interpret EV charging data and optimize range management strategies. There's an urgent need for a user-friendly, interactive visualization tool that seamlessly integrates real-time charging data with predictive range analysis, enhancing EV owners' understanding of their vehicle's performance. Challenges arise from the diverse landscape of EV charging infrastructure, characterized by variations in availability, speed, and compatibility, hindering users' ability to plan efficient charging routes. Additionally, the absence of standardized data formats across charging networks complicates data aggregation and analysis. Users face difficulty interpreting complex charging metrics, leading to suboptimal charging behaviors and range management decisions. As EV adoption rises, there's a critical need for a scalable tool capable of accommodating large volumes of charging data while providing actionable insights to users. Addressing range anxiety, a significant barrier to EV adoption, requires accurate range prediction based on multiple variables including driving habits and environmental conditions. Furthermore, the integration of vehicle-to-grid (V2G) capabilities adds complexity to charging and range analysis, necessitating specialized visualization features. Inconsistent charging infrastructure deployment across regions poses challenges, necessitating adaptable tools. Privacy concerns, interoperability issues, and the proliferation of EV-sharing services further underscore the necessity for a comprehensive visualization tool. Government agencies and policymakers require such tools to monitor EV adoption rates and formulate sustainable transportation policies. In this context, the development of an intuitive visualization tool for EV charge and range analysis emerges as a crucial solution to empower users and stakeholders in navigating the electric vehicle ecosystem effective.

Business requirements

1. **User Interface:** The tool should feature an intuitive and user-friendly interface accessible to both novice and experienced users.It should offer customizable dashboards allowing users to personalize their display preferences and prioritize relevant metrics.The UI must support interactive visualization elements such as charts, graphs, and maps to facilitate data interpretation and analysis. Accessibility standards should be met to ensure usability for individuals with disabilities
2. **Analysis and Visualization Tools:** Implement advanced analytics and visualization tools capable of handling large-scale Electric cars data. The tools should enable thorough exploration of trends, patterns, and correlations in emissions data, facilitating insightful visual representations for stakeholders.

3. **Predictive Range Analysis:** The tool must incorporate advanced predictive algorithms to estimate EV range accurately based on factors such as battery state of charge, driving habits, terrain, weather conditions, and traffic patterns. Range predictions should be dynamic and adaptive, adjusting in real-time as new data becomes available and conditions change.Users should have the ability to customize range prediction models based on their specific driving preferences and environmental factors.

4. **Integration and Extensibility:** The tool should offer APIs and SDKs for easy integration with third-party applications and services, enabling developers to extend its functionality and integrate custom features. Compatibility with emerging EV technologies and standards should be prioritized to future-proof the tool and support ongoing innovation in the electric vehicle ecosystem.

5. **Charging Route Optimization:**The tool should offer route planning capabilities that optimize charging stops based on factors such as charging station availability, charging speed, and driving distance.Users should be able to set preferences for charging priorities (e.g., fastest route, most convenient stations, lowest cost) to tailor the optimization algorithm to their needs.Integration with mapping services (e.g., Google Maps, OpenStreetMap) for route visualization and navigation assistance should be provided.
6. **Scalability and Performance** :The tool should be designed to handle large volumes of data efficiently, with scalable architecture capable of supporting increasing user numbers and data throughput.Performance benchmarks should be established to ensure responsiveness and reliability under varying load conditions, with proactive monitoring and optimization of system performance.
7. **Cost and Licensing :** Transparent pricing models should be established, offering flexible licensing options tailored to different user needs (e.g., individual consumers, fleet operators, EV manufacturers). Clear terms of service and license agreements should be provided, outlining usage rights, limitations, and subscription terms to ensure transparency and fair pricing.

Literature Survey

Here's a concise breakdown of the reviewed articles for your literature review on Electric Vehicle Charge and Range Analysis:

1. **Power Grid Impact:** This study by [1] (reference citation style needed) examines how EVs interact with power grids. It highlights how charging behavior affects peak demand, suggesting your tool could encourage off-peak charging for grid stability.
2. **Charging Infrastructure:** The review by [2] explores various EV charging methods and optimization techniques. This emphasizes the importance of considering charging infrastructure limitations when predicting range within your visualization tool.
3. **User Charging Behavior:** This research by [3] analyzes how private EV owners charge their vehicles. Understanding user perspectives on charging decisions can help your tool provide features that support informed charging choices.
4. **Driving Style and Temperature Impact:** This study by [4] investigates how driving style and temperature affect EV range. This highlights the need for your tool to account for these factors in real-time to provide dynamic range predictions.
5. **Machine Learning for Range Prediction:** This review by [5] explores using machine learning to predict EV range. This suggests your tool could leverage machine learning to improve the accuracy of its range predictions.

Social or Business Impact.

A visualization tool for EV charge and range analysis can have a significant positive impact on both society and businesses:

Social Impact:

- **Reduced Range Anxiety:** By providing clear and accurate information on charging locations, remaining range, and factors affecting range, the tool can empower users to overcome range anxiety and confidently adopt EVs. This can lead to increased EV adoption and a subsequent reduction in greenhouse gas emissions.
- **More Informed Charging Decisions:** Users can optimize their charging habits based on factors like real-time electricity prices and charging station availability. This can promote efficient use of charging infrastructure and potentially reduce electricity bills.
- **Sustainable Transportation Choices:** The tool can encourage eco-friendly driving practices by showing users how their driving style impacts range. This can contribute to a more sustainable transportation ecosystem.

Business Impact:

- **Increased EV Sales:** Reduced range anxiety can lead to a significant increase in EV sales, benefiting car manufacturers and dealerships.
- **Optimized Charging Infrastructure Planning:** Businesses involved in EV charging infrastructure can leverage the data and insights from the tool to strategically place charging stations in areas with high demand.
- **Improved Grid Management:** By encouraging off-peak charging and providing insights into user behavior, the tool can contribute to a more stable and efficient electricity grid, benefiting utility companies.
- **Development of New Services:** The data generated by the tool can be used to develop new services, such as personalized charging recommendations or route optimization tools for long-distance travel, creating new revenue streams for businesses.

Overall, a well-designed visualization tool for EV charge and range analysis can play a crucial role in accelerating the adoption of EVs, promoting sustainable transportation practices, and creating new business opportunities in the EV ecosystem.

Collect the dataset

country	year	co2	co2_growth_prct	co2_per_capita	cumulative_co2	coal_co2	cement_co2	flaring_co2	gas_co2	oil_co2	other_industry_co2	cement_co2_per_ca	coal_co2_per_capit	flaring_co2_
Afghanistan	1975	2.121	10.88	0.167	21.287	0.399	0.069	0.304	0.476	0.874	0	0.006	0.031	
Afghanistan	1976	1.981	-6.62	0.153	23.267	0.425	0.079	0.293	0.3	0.883	0	0.006	0.033	
Afghanistan	1977	2.384	20.36	0.181	25.652	0.451	0.065	0.381	0.513	0.975	0	0.005	0.034	
Afghanistan	1978	2.153	-9.68	0.161	27.805	0.576	0.058	0.283	0.301	0.936	0	0.004	0.043	
Afghanistan	1979	2.233	3.69	0.166	30.038	0.352	0.064	0.267	0.385	1.165	0	0.005	0.026	
Afghanistan	1980	1.756	-21.34	0.132	31.794	0.316	0.023	0.305	0.187	0.925	0	0.002	0.024	
Afghanistan	1981	1.978	12.65	0.15	33.772	0.333	0.033	0.293	0.304	1.015	0	0.002	0.025	
Afghanistan	1982	2.095	5.87	0.163	35.867	0.385	0.039	0.282	0.396	0.993	0	0.003	0.03	
Afghanistan	1983	2.52	20.31	0.201	38.387	0.385	0.006	0.293	0.616	1.22	0	0	0.031	
Afghanistan	1984	2.822	11.97	0.231	41.209	0.393	0.048	0.316	0.932	1.134	0	0.004	0.032	
Afghanistan	1985	3.501	24.1	0.293	44.71	0.4	0.032	0.33	1.192	1.548	0	0.003	0.034	
Afghanistan	1986	3.134	-10.5	0.267	47.844	0.425	0.038	0.33	1.202	1.14	0	0.003	0.036	
Afghanistan	1987	3.114	-0.63	0.268	50.957	0.443	0.043	0.223	0.392	2.013	0	0.004	0.038	
Afghanistan	1988	2.857	-8.25	0.246	53.814	0.366	0.043	0.187	0.44	1.821	0	0.004	0.032	
Afghanistan	1989	2.765	-3.22	0.233	56.579	0.337	0.043	0.04	0.48	1.865	0	0.004	0.028	
Afghanistan	1990	2.603	-5.85	0.21	59.182	0.278	0.046	0.026	0.403	1.85	0	0.004	0.022	
Afghanistan	1991	2.427	-6.76	0.182	61.61	0.249	0.046	0.026	0.388	1.718	0	0.003	0.019	
Afghanistan	1992	1.379	-43.17	0.095	62.989	0.022	0.046	0.022	0.363	0.927	0	0.003	0.002	
Afghanistan	1993	1.333	-3.36	0.084	64.322	0.018	0.047	0.022	0.352	0.894	0	0.003	0.001	
Afghanistan	1994	1.282	-3.86	0.075	65.604	0.015	0.047	0.022	0.338	0.86	0	0.003	0.001	
Afghanistan	1995	1.23	-3.99	0.068	66.834	0.015	0.047	0.022	0.322	0.824	0	0.003	0.001	
Afghanistan	1996	1.165	-5.33	0.062	67.999	0.007	0.047	0.022	0.308	0.78	0	0.002	0	
Afghanistan	1997	1.084	-6.94	0.056	69.083	0.004	0.047	0.022	0.283	0.728	0	0.002	0	
Afghanistan	1998	1.029	-5.07	0.052	70.113	0.004	0.047	0.022	0.265	0.691	0	0.002	0	
Afghanistan	1999	0.81	-21.34	0.04	70.922	0.004	0.047	0.022	0.242	0.495	0	0.002	0	
Afghanistan	2000	0.758	-6.4	0.036	71.68	0.004	0.01	0.022	0.224	0.498	0	0	0	
Afghanistan	2001	0.798	5.32	0.037	72.478	0.07	0.007	0.022	0.209	0.491	0	0	0.003	
Afghanistan	2002	1.052	31.79	0.046	73.529	0.055	0.011	0	0.546	0.44	0	0	0.002	

A snapshot of the dataset

Understanding the dataset:

Data contains all the meta information regarding the columns described in the CSV files. we have provided 4 CSV files:
1. EVIndia
2. Electric_vehicle_charging_station_list
3. ElectricCarData_Clean
4. Cheapestm electriccars-EVDatabase

Column Description

EVIndia:

1. Car - Car Brand name and model
2. Style Range - Style range of car
3. Transmission- Transmission type
4. VehicleType – Type of vehicle
5. PriceRange(Lakhs) - Price Range in Lakhs
6. Capacity - Capacity of car 7. BootSpace – Bootspace of the car
8. BaseModel – Base model name
9. TopModel – Top model name Column Description for **Electric_vehicle_charging_station_list:**
1. region: This column represents the region of the charging station.
2. address: This column represents the address of the charging station.
3. aux address: This column represents the auxiliary address of the charging station.
4. latitude: This column represents the latitude of the charging station.
5. longitude: This column represents the longitude of the charging station
6. type: This column represents the type of the charging station.
7. power: This column represents the power of the charging station.
8. service: This column represents the type of service at the charging station. Column Description for ElectricCarData_Clean:

1. Brand
2. Model
3. AccelSec
4. TopSpeed_KmH
5. Range_Km 6. Efficiency_WhKm
7. FastCharge_KmH
8. RapidCharge
9. PowerTrain
10. PlugType
11. BodyStyle
12. Segment
13. Seats
14. PriceEuro Column

Description for Cheapest electriccars-EVDatabase:

1. Name
2. Subtitle
3. Acceleration
4. TopSpeed
5. Range
6. Efficiency
7. FastChargeSpeed
8. Drive
9. NumberofSeats
10. Price inGermany
11. PriceinUK

Data Preparation

1. **Data Cleaning:** Check for missing values, duplicates, and inconsistencies in the dataset. Handle missing values through imputation or removal, depending on the extent of missing data and its impact on the analysis. Eliminate duplicates and ensure data consistency across all columns.

2. **Feature Selection:** Identify relevant features for analysis based on the project objectives and research questions. Consider factors such as cars,longitube, latitude and Price of ev_cars for inclusion in the analysis. Exclude irrelevant or redundant features that do not contribute to the analysis.
3. **Data Transformation:** Convert categorical variables, such as country names, into numerical representations using techniques like one-hot encoding or label encoding. Normalize numerical variables to ensure uniform scales across different features, especially if using algorithms sensitive to feature scales, such as

4. **Feature Engineering:** Create new features or derived variables that capture additional insights from the data. For example, calculate the PowerTrain count for each Car Brand.Compute growth rates or trends in emissions to capture temporal patterns.

5. **Handling Outliers:** Identify and handle outliers in the dataset that may skew the analysis results. Use statistical methods or domain knowledge to detect outliers and apply appropriate techniques such as trimming, winsorization, or transformation to mitigate their effects on the analysis.

6. **Temporal Alignment:** Ensure temporal alignment of data across different variables and datasets. Verify that the time intervals and granularity of the data are consistent to facilitate meaningful comparisons and analysis over time.

7. **Data Aggregation:** Aggregate the data at different levels of granularity, such as country-level, regional-level, or global-level, depending on the scope of the analysis. Compute summary statistics or aggregate measures such as averages, sums, or percentiles to condense the data for easier interpretation and analysis.

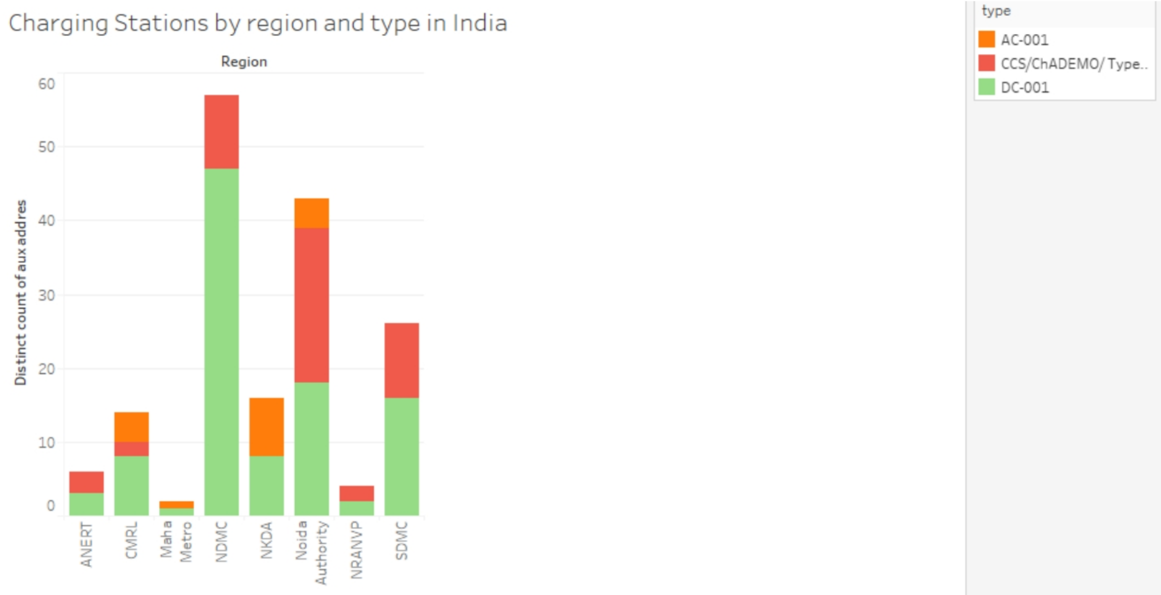
8. **Data Splitting:** Split the dataset into training, validation, and test sets if performing predictive modeling or machine learning tasks. Reserve a portion of the data for model evaluation and testing to assess the generalization performance of the models on unseen data.

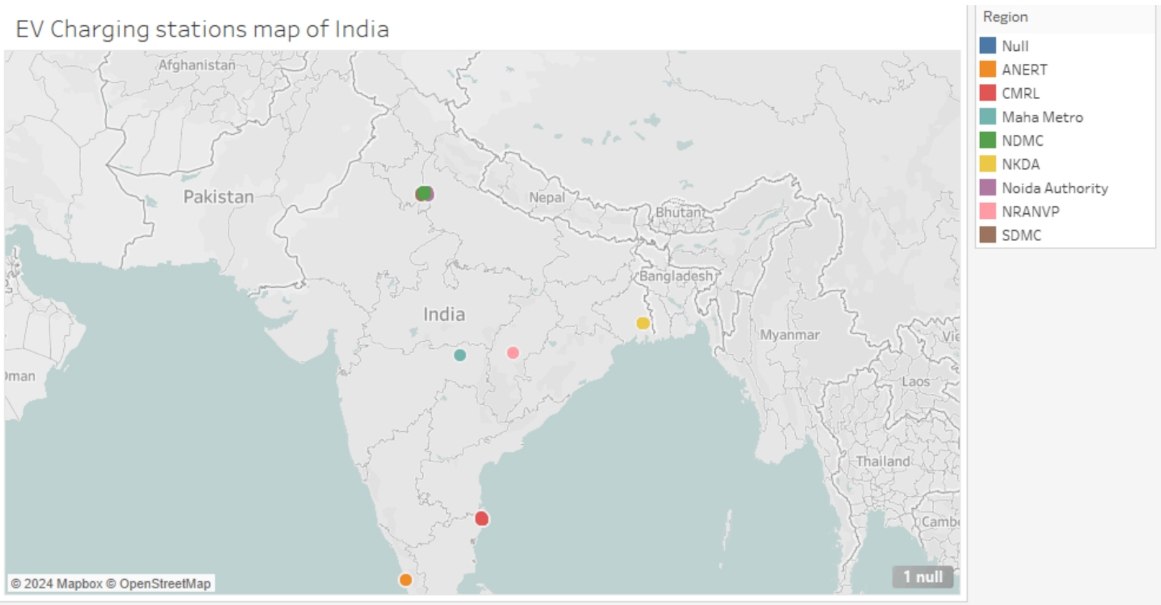
Data Visualization

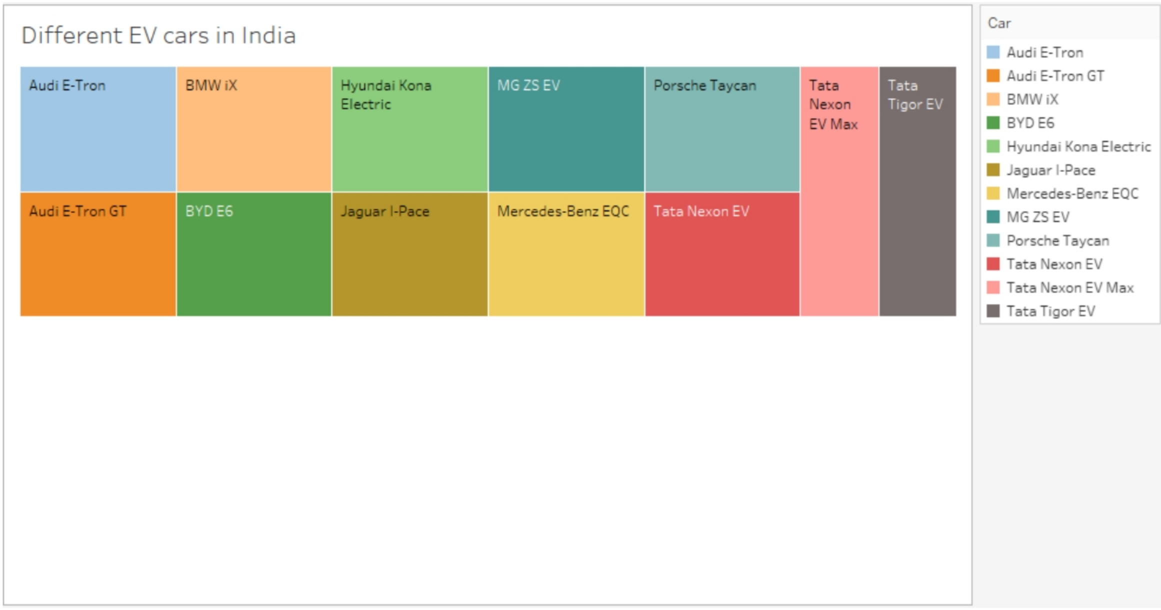
Data visualization is the process of creating graphical representations of data in order to help people understand and explore the information. The goal of data visualization is to make complex data sets more accessible, intuitive, and easier to interpret. By using visual elements such as charts, graphs, and maps, data visualizations can help people quickly identify patterns, trends, and outliers in the data.

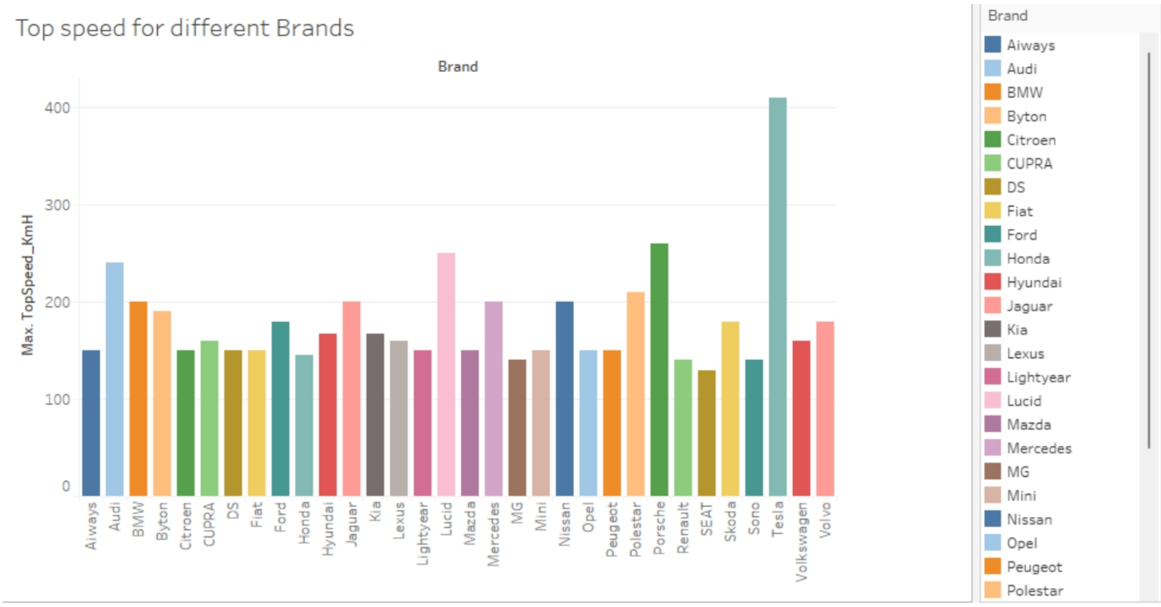
The number of unique visualizations that can be created with a given dataset. Some common types of visualizations that can be used to analyze the EV industry include bar charts, line charts, Tree Map, scatter plots, pie charts, Maps etc. These visualizations can be used to compare performance, track changes over time, show Growth, and relationships between variables.

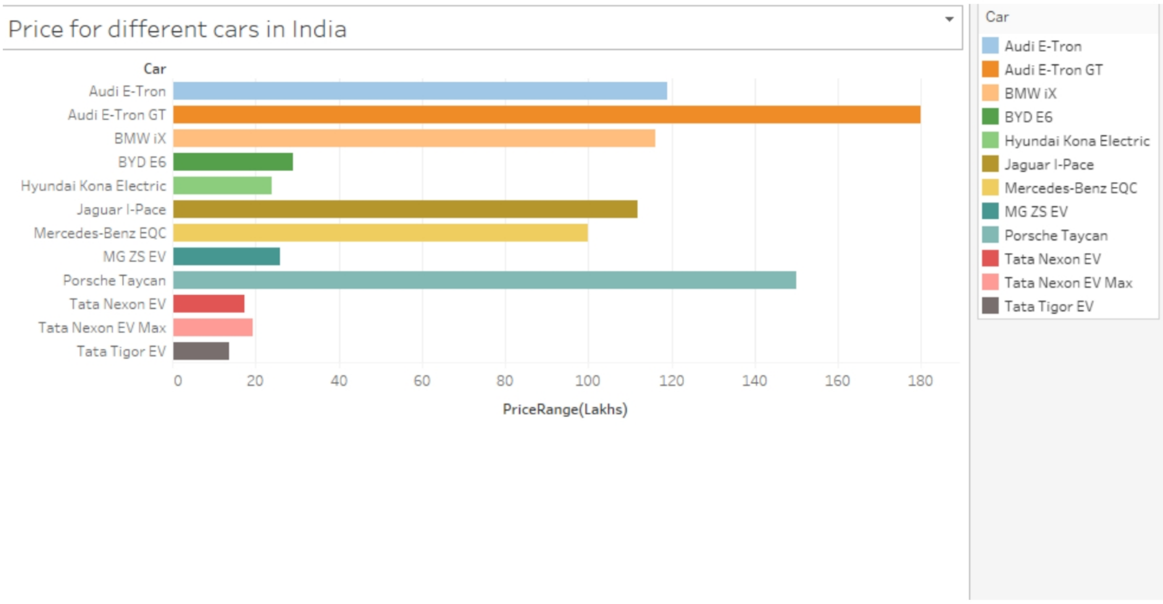
My Tableau Data Visualizations

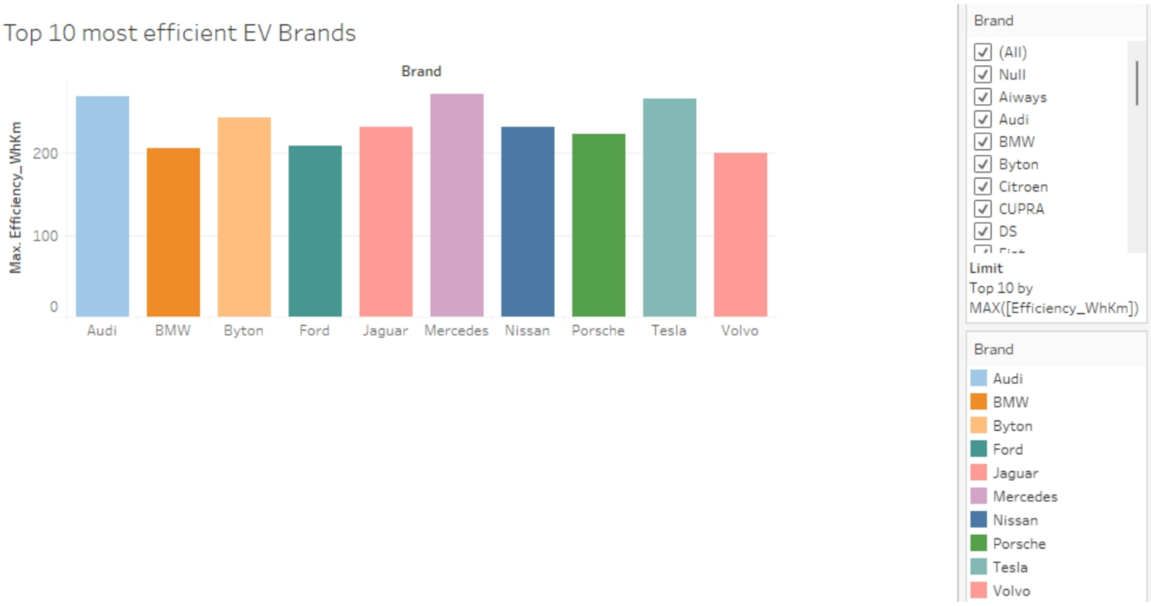


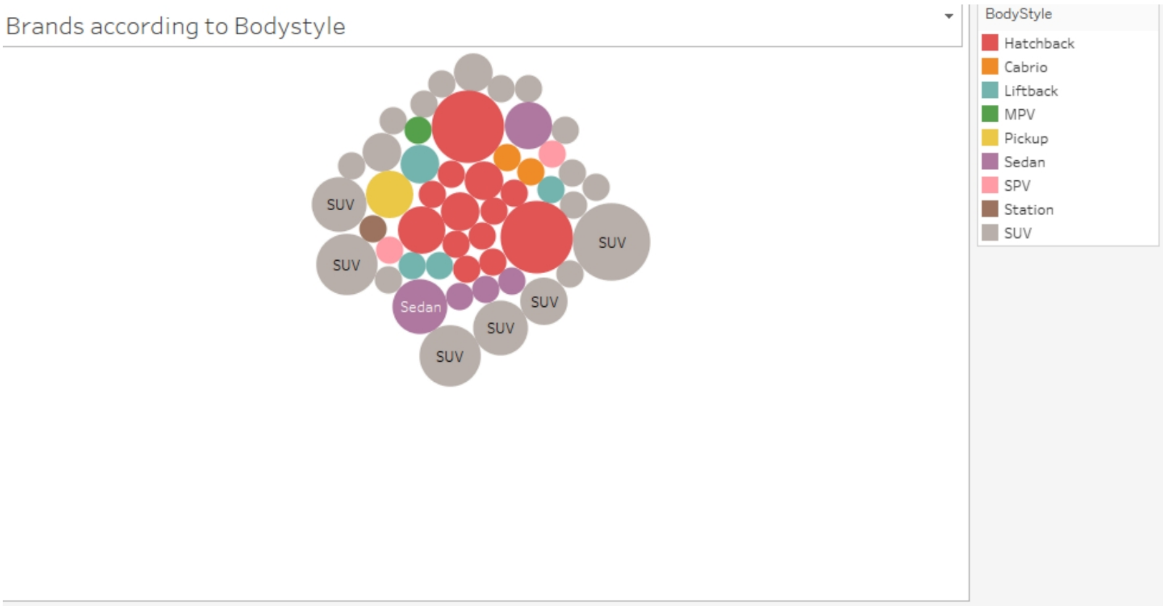


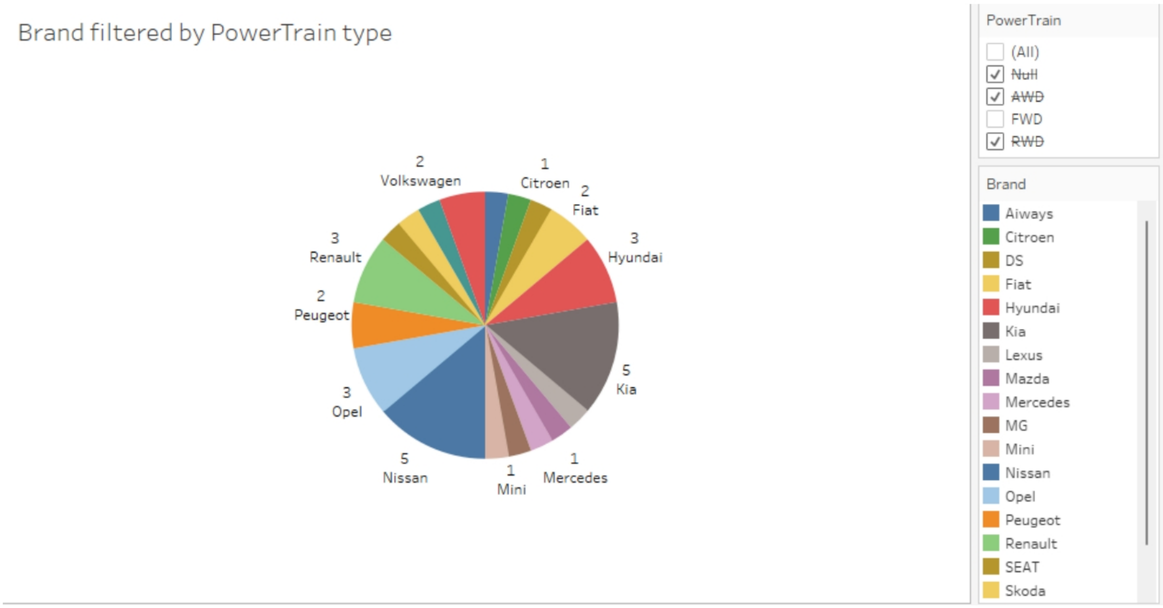

Different EV cars in India
Audi E-Tron
BMW iX
Hyundai Kona Electric
MG ZS EV
Porsche Taycan
Tata Nexon EV Max
Tata Tigor EV
Audi E-Tron GT
BYD E6
Jaguar I-Pace
Mercedes-Benz EQC
Tata Nexon EV
Car
Audi E-Tron
Audi E-Tron GT
BMW iX
BYD E6
Hyundai Kona Electric
Jaguar I-Pace
Mercedes-Benz EQC
MG ZS EV
Porsche Taycan
Tata Nexon EV
Tata Nexon EV Max
Tata Tigor EV

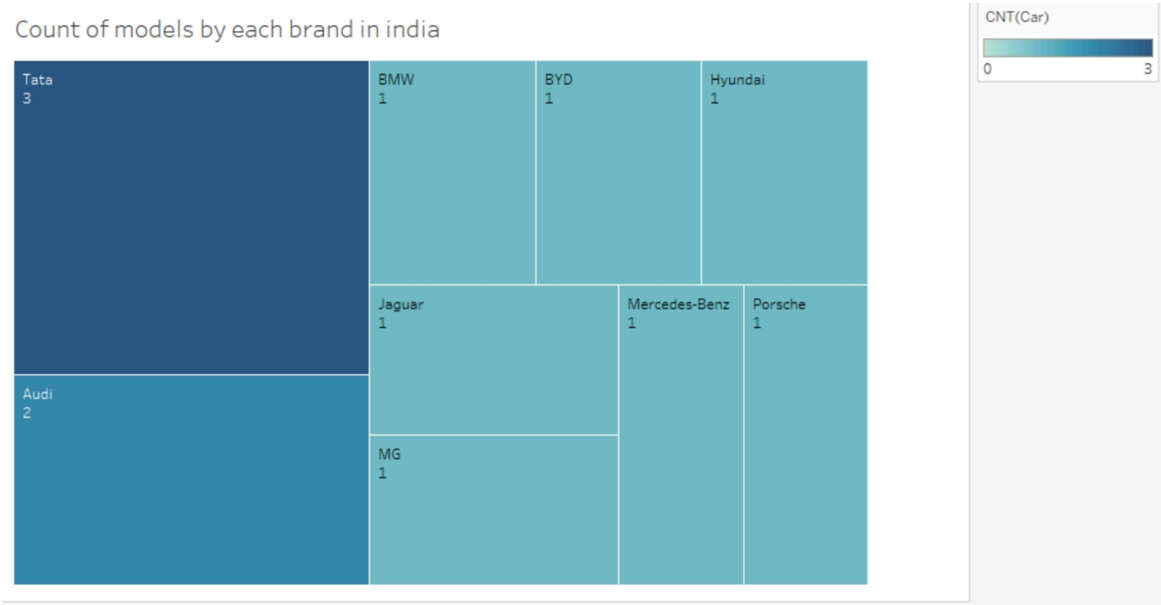

Top speed for different Brands
Brand
Max. TopSpeed_KmH
400
300
200
100
0
Aiways
Audi
BMW
Byton
Citroen
CUPRA
DS
Fiat
Ford
Honda
Hyundai
Jaguar
Kia
Lexus
Lightyear
Lucid
Mazda
Mercedes
MG
Mini
Nissan
Opel
Peugeot
Polestar
Porsche
Renault
SEAT
Skoda
Sono
Tesla
Volkswagen
Volvo
Brand
Aiways
Audi
BMW
Byton
Citroen
CUPRA
DS
Fiat
Ford
Honda
Hyundai
Jaguar
Kia
Lexus
Lightyear
Lucid
Mazda
Mercedes
MG
Mini
Nissan
Opel
Peugeot
Polestar


Price for different cars in India
Car
Audi E-Tron
Audi E-Tron GT
BMW iX
BYD E6
Hyundai Kona Electric
Jaguar I-Pace
Mercedes-Benz EQC
MG ZS EV
Porsche Taycan
Tata Nexon EV
Tata Nexon EV Max
Tata Tigor EV
0
20
40
60
80
100
120
140
160
180
PriceRange(Lakhs)
Car
Audi E-Tron
Audi E-Tron GT
BMW iX
BYD E6
Hyundai Kona Electric
Jaguar I-Pace
Mercedes-Benz EQC
MG ZS EV
Porsche Taycan
Tata Nexon EV
Tata Nexon EV Max
Tata Tigor EV


Top 10 most efficient EV Brands
Brand
Max. Efficiency_WhKm
200
100
0
Audi
BMW
Byton
Ford
Jaguar
Mercedes
Nissan
Porsche
Tesla
Volvo
Brand
(All)
Null
Aiways
Audi
BMW
Byton
Citroen
CUPRA
DS
Limit
Top 10 by
MAX([Efficiency_WhKm])
Brand
Audi
BMW
Byton
Ford
Jaguar
Mercedes
Nissan
Porsche
Tesla
Volvo


Brands according to Bodystyle
SUV
SUV
Sedan
SUV
SUV
SUV
SUV
BodyStyle
Hatchback
Cabrio
Liftback
MPV
Pickup
Sedan
SPV
Station
SUV


Brand filtered by PowerTrain type
2
Volkswagen
1
Citroen
2
Fiat
3
Hyundai
3
Renault
2
Peugeot
5
Kia
3
Opel
5
Nissan
1
Mini
1
Mercedes
PowerTrain
(All)
~~Null~~
~~AWD~~
FWD
~~RWD~~
Brand
Aiways
Citroen
DS
Fiat
Hyundai
Kia
Lexus
Mazda
Mercedes
MG
Mini
Nissan
Opel
Peugeot
Renault
SEAT
Skoda



Different brands of EV Cars globally

32

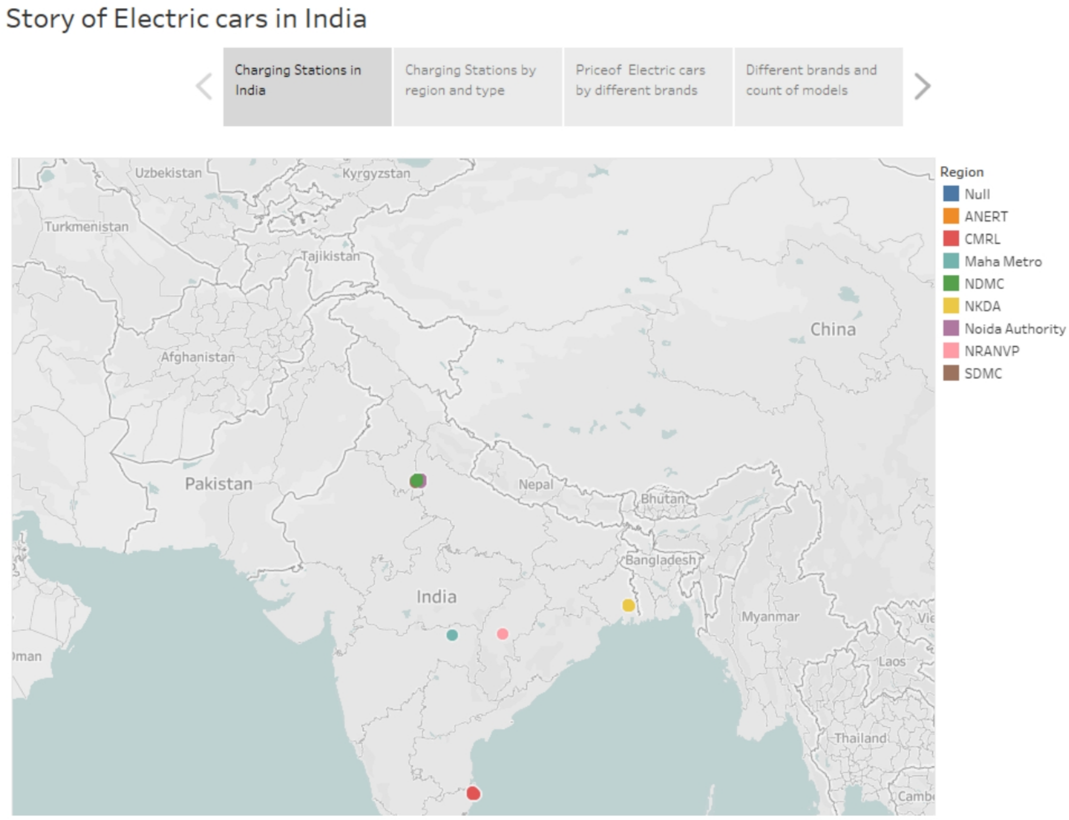
Different brands of EV Cars in India

9

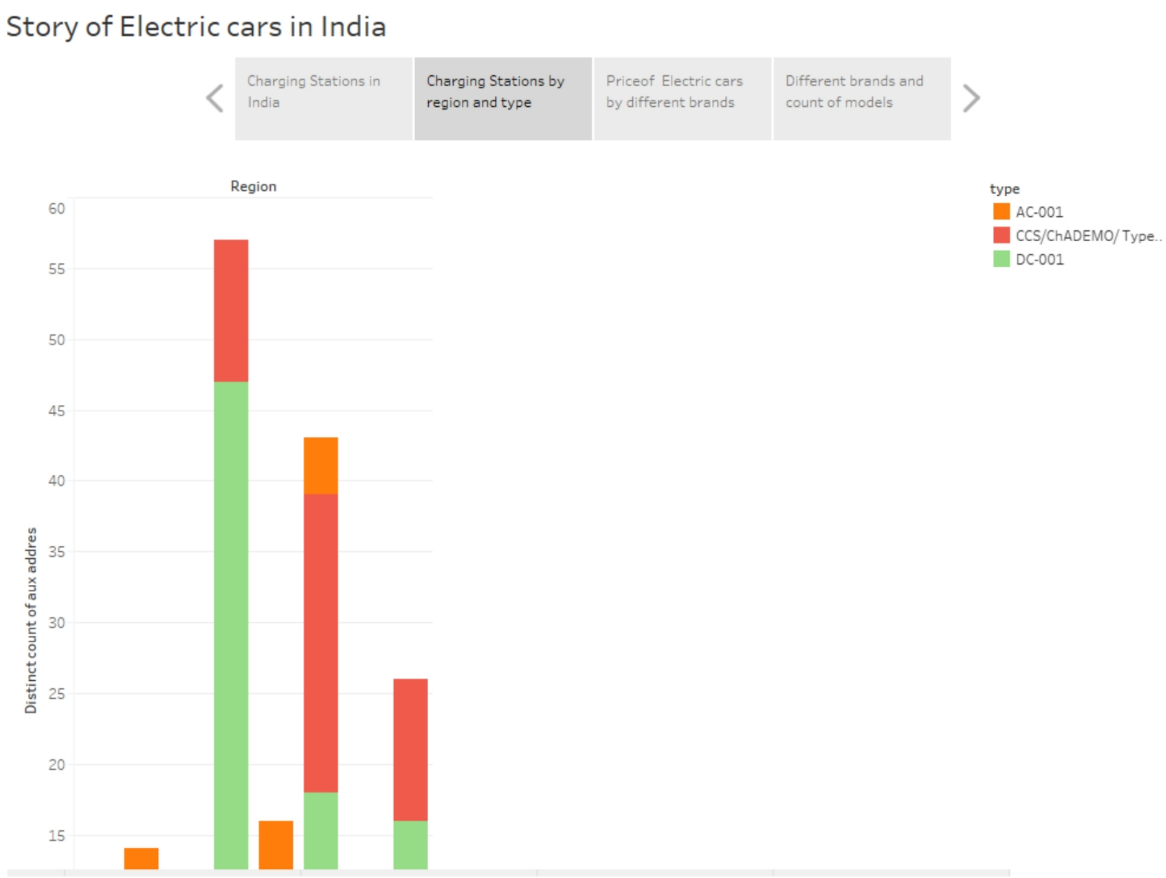
Dashboard


Electric cars Analytics DashBoard
Different brands of EV Cars globally
32
Different brands of EV Cars in India
9
MPV
Pickup
Sedan
SPV
Station
SUV
PowerTrain
(All)
Null
AWD
FWD
RWD
Car
Audi E-Tron
Audi E-Tro..
BMW iX
BYD E6
Hyundai K..
Jaguar I-P..
Mercedes-..
MG ZS EV
Porsche T..
Tata Nexo..
Tata Nexo..
Tata Tigor..
Brand
(All)
Null
Aiways
Audi
BMW
Byton
Citroen
CUPRA
DS
Fiat
Porsche
Renault
SEAT
Skoda
Sono
Tesla
Volkswa..
Volvo
Brands according to Bodystyle
SUV
Sedan
Top 10 most efficient EV Brands
Brand
Max. Efficiency_WhKm
200
100
0
Audi
BMW
Byton
Ford
Jaguar
Mercedes
Nissan
Porsche
Tesla
Volvo
Limit
Top 10 by MAX([Efficiency_WhKm])
Brand
Audi
BMW
Byton
Ford
Jaguar
Mercedes
Nissan
Porsche
Tesla
Volvo
Brand filtered by PowerTrain type
2 Volkswagen
1 Aiways
3 Hyundai
2 Peugeot
5 Kia
5 Nissan
1 Mercedes
Different EV cars in India
Audi E-Tron
BYD E6
MG ZS EV
Tata Nexon EV
Tata Nexon EV Max
Audi E-Tron GT
Hyundai Kona Electric
Mercedes-Benz EQC
BMW iX
Jaguar I-Pace
Porsche Taycan
Tata Tigor EV
Top speed for different Brands
Brand
Max. TopSpeed_KmH
400
300
200
100
0
Audi
BMW
Byton
DS
Fiat
Ford
Kia
Lexus
Lucid
MG
Mini
Opel
SEAT
Skoda
Sono
Tesla

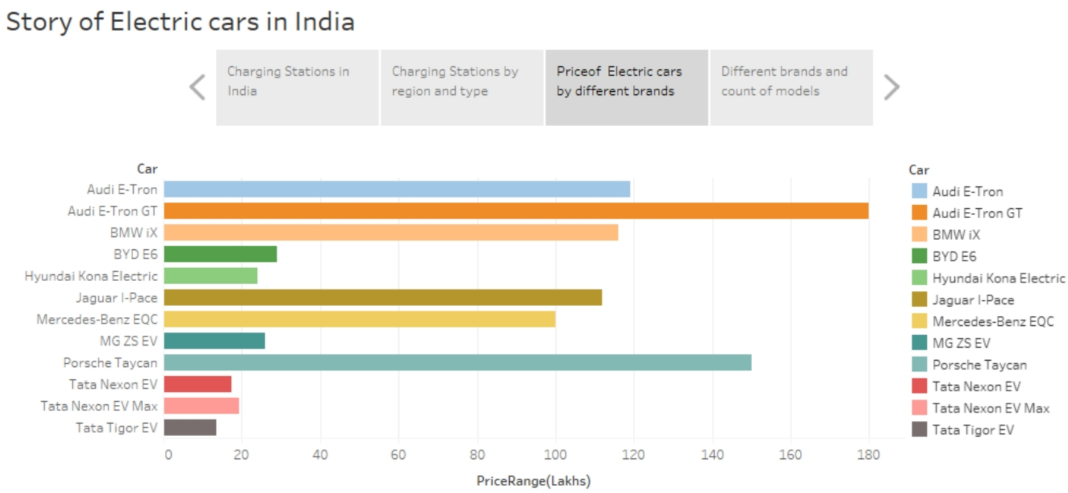
Story



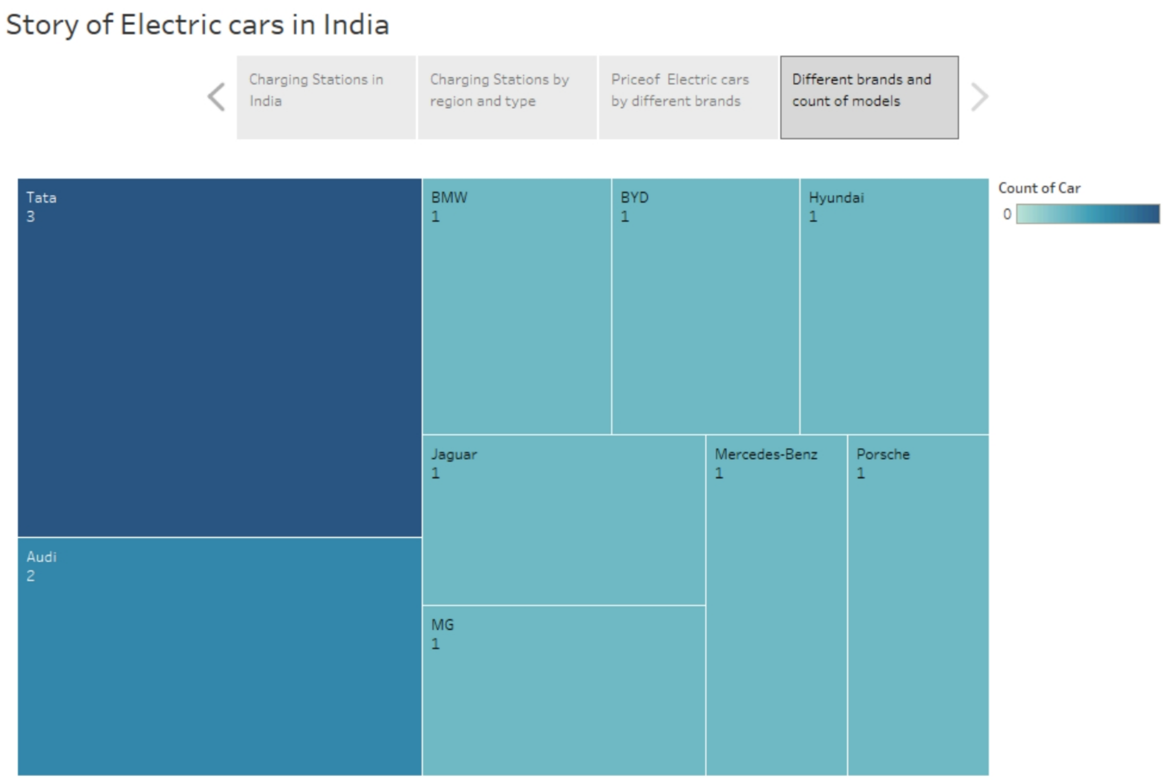
Story of Electric cars in India
Charging Stations in India
Charging Stations by region and type
Priceof Electric cars by different brands
Different brands and count of models
Uzbekistan
Kyrgyzstan
Turkmenistan
Tajikistan
Afghanistan
China
Pakistan
Nepal
Bhutan
Bangladesh
India
Myanmar
Laos
Thailand
Region
Null
ANERT
CMRL
Maha Metro
NDMC
NKDA
Noida Authority
NRANVP
SDMC



Story of Electric cars in India
Charging Stations in India
Charging Stations by region and type
Priceof Electric cars by different brands
Different brands and count of models
Region
Distinct count of aux addres
60
55
50
45
40
35
30
25
20
15
type
AC-001
CCS/ChADEMO/ Type..
DC-001



Story of Electric cars in India
Charging Stations in India
Charging Stations by region and type
Priceof Electric cars by different brands
Different brands and count of models
Car
Audi E-Tron
Audi E-Tron GT
BMW iX
BYD E6
Hyundai Kona Electric
Jaguar I-Pace
Mercedes-Benz EQC
MG ZS EV
Porsche Taycan
Tata Nexon EV
Tata Nexon EV Max
Tata Tigor EV
0
20
40
60
80
100
120
140
160
180
PriceRange(Lakhs)


Story of Electric cars in India
Charging Stations in India
Charging Stations by region and type
Priceof Electric cars by different brands
Different brands and count of models
Count of Car
0
Tata
3
Audi
2
BMW
1
BYD
1
Hyundai
1
Jaguar
1
MG
1
Mercedes-Benz
1
Porsche
1

Project Demonstration & Documentation

References:

The tableau workbooks are hosted in the following github link.

Github link :

https://github.com/VenkataSuryaN/Visualization-Tool-for-Electric-Ve

hicle-Charge-and-Range-Analysis