EV Market Segmentation

- DURGA SHEKLE

GitHub Link - https://github.com/Durga1812/EV-Market-Segmentation-Analysis

1) Introduction:

The automotive sector in India is dominated by Non-Electric Vehicles since decades. Majority of public buying fossil fuel engine-based vehicles because of the its low prices, low maintenance cost and ease of availability of infrastructure for receiving facilities of petrol and diesel are another factor for popularity of these vehicles.

Electric Vehicles have become a new point of attraction in India. Many big automotive brands like TATA, Mahindra and other international companies are introducing their unique products in EV markets.

In this project, we have researched, analysed and came up with space and specific range of products which will help us to produce our unique Electric Vehicle to compete with these brands and help Indian public to cope up with technological advances in vehicles with economical prices and this will help our startup to grow EV business shoulder to shoulder with the bigger automotive companies.

2) Market Info:

a. General Usage Info:

- Electric Vehicles (EVs) currently account for less than 1% of total vehicle sales in India the market is growing rapidly and expected to be worth around at least INR 475 billion by 2025. Two-wheelers account for the largest share of this market at 62%, followed by three-wheelers at 37%.
- The Indian EV market varies significantly by state, depending on factors including demographics, income levels, regulatory landscape and urbanization. The state of Uttar Pradesh, for instance, with one of the lowest urbanisation rates, has seen significant uptake of electric two-wheelers.
- The four-wheeler segment currently has the lowest EV penetration of 0.12% (3,400 units of electric passenger cars sold in 2020) but may grow to 5% by 2025 in an optimistic scenario.

b. Battery Info:

- Lead-acid batteries currently dominate the market but demand for Lithium□ion battery models is expected to grow rapidly under government incentives and demand from bike and scooter.
- Current and desired driving range of different EV categories in India set by Government of India is presented in the following table.
- Table –

Vehicle Category	Battery Capacity (KwH)	Energy Consumption (kwh/km)
E-bike	1.2	0.016
2 WLS	2.2	0.025
2 WCS	3	0.03
2 WHP	4.6	0.035
Electric Cars	40	0.157
LPV	49	0.209

- The calendared lifetime of a battery used in an EV is dictated by the electrode materials. It is further determined by the number of charge and discharge cycles, charging speed, and temperature of operation.
- Batteries are generally retired from automotive application when they can retain only about 80% of their initial stated capacity, and proper treatment of retired EV batteries will both reduce their life-cycle greenhouse gas emissions and maximize their economic value.
- Before recycling, there are practical second-life applications of EV batteries. EV batteries that retain 80% of their original capacity might not be suitable for EVs but are appropriate for less demanding applications such as grid□scale renewable energy storage.
- This strategy aligns with Government of India's target of installing 175 GW of renewable energy capacity by 2022. It is estimated that these batteries can serve as energy banks until they deteriorate to 60% of their initial capacity35 and this extends their economic life by another 10 years.

3) Market Segmentation Analysis

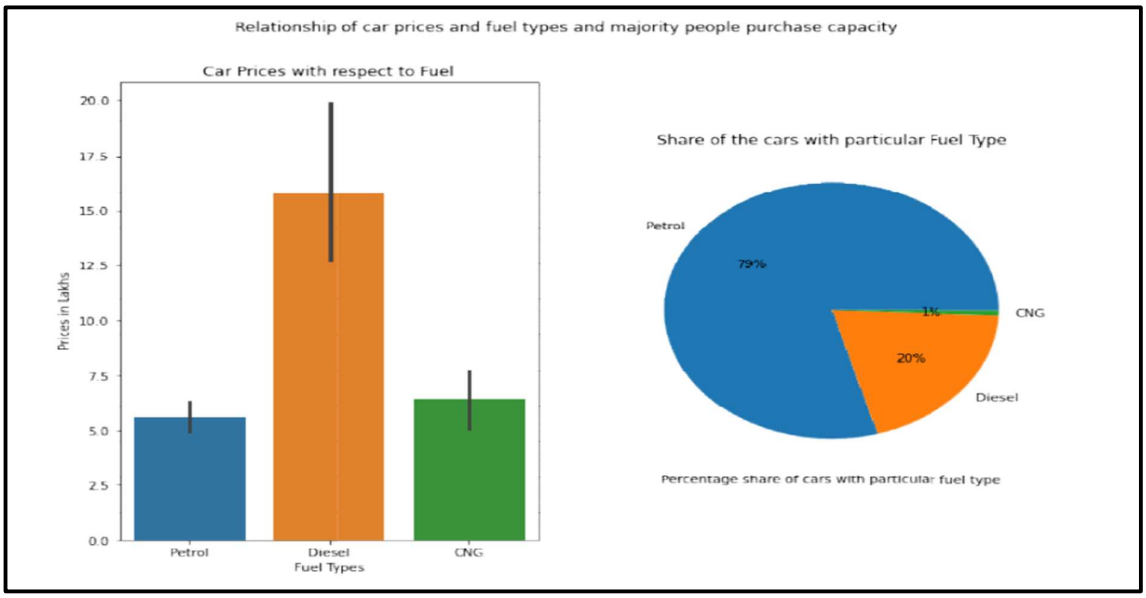
For this segmentation 5 types of datasets were used from different sources such as from government websites, car research platforms, and market research.

a. Visualization Analysis:

(a) Geographic and Demographic Research:

- South India being a Tech Hub is a backbone of EV demands.
- In earlier part, we analysed those south Indian states has good number of charging stations available.
- Popular car brand's manufacturing plants and main head headquarters are in south India as well, which plays an important role for ease of survey and fulfil consumer's demands by these top companies.
- Delhi had highest number of charging stations (analysed earlier), but still EV popularity is relatively low.
- Northeast India is gaining popularity in EV despite less infrastructure.
- Other states and regions especially North, West, East and Central India has a balanced numbers and competitive demands.
- We did not get any survey information on Daman and Diu and Lakshadweep, so these 2 regions are not analysed properly.
- **On availability of charging stations, we observed**:
- First observation, only limited number of charging station is available in. India as of 2023.
- Delhi being capital has a greater number of charging station as compared to other metro cities.
- South Indian metro cities have balanced number, but still many cities are missing from south India.
- Mumbai being the economic capital of India have only 1 charging station in Navi Mumbai (private charging stations not counted or being missed).

(b) Psychographic and Behavioural Research:



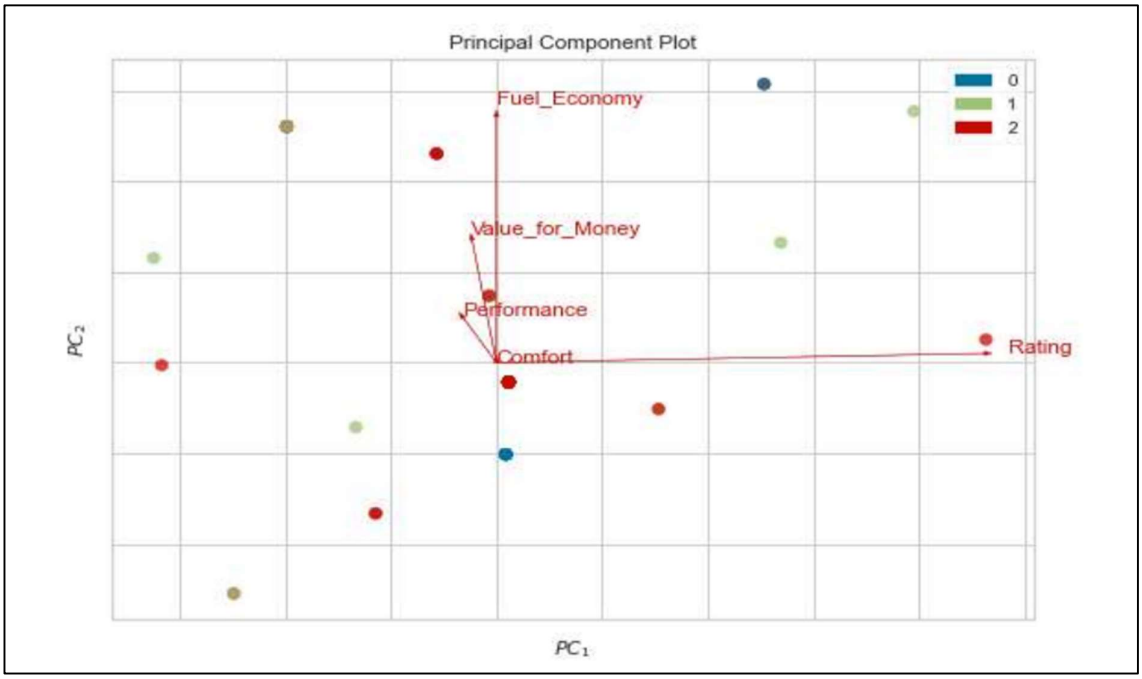
- Petrol cars are the most popular cars occupying 79% of its share in its competition. it is understandable because petrol cars are cheaper than Diesel cars and CNG cars.
- Diesel cars, despite being costly, it occupies a noteworthy share of 20% of the popularity.
- Diesel cars are more popular than CNG, this is because current diesel engines have greater performances than both petrol and CNG engines.
- Diesel cars are also very much long-lasting running cars as compared to both bot the other cars, that's why it has more popularity.
- CNG cars have lowest popularity, just because this car lacks competitive performance, and engine durability. CNG cars only have good fuel economy, because CNG is cheap.
- Vehicle Price is a big concern, First Majority of public buying petrol cars because of its cheap price.
- Second majority of public buying diesel cars, the public interested in high performance and long-lasting low maintenance car.

b. Segmentation Analysis:

In Segmentation analysis, we analysed segments on public reviews from car research platform (carwale.com). Below are the results:

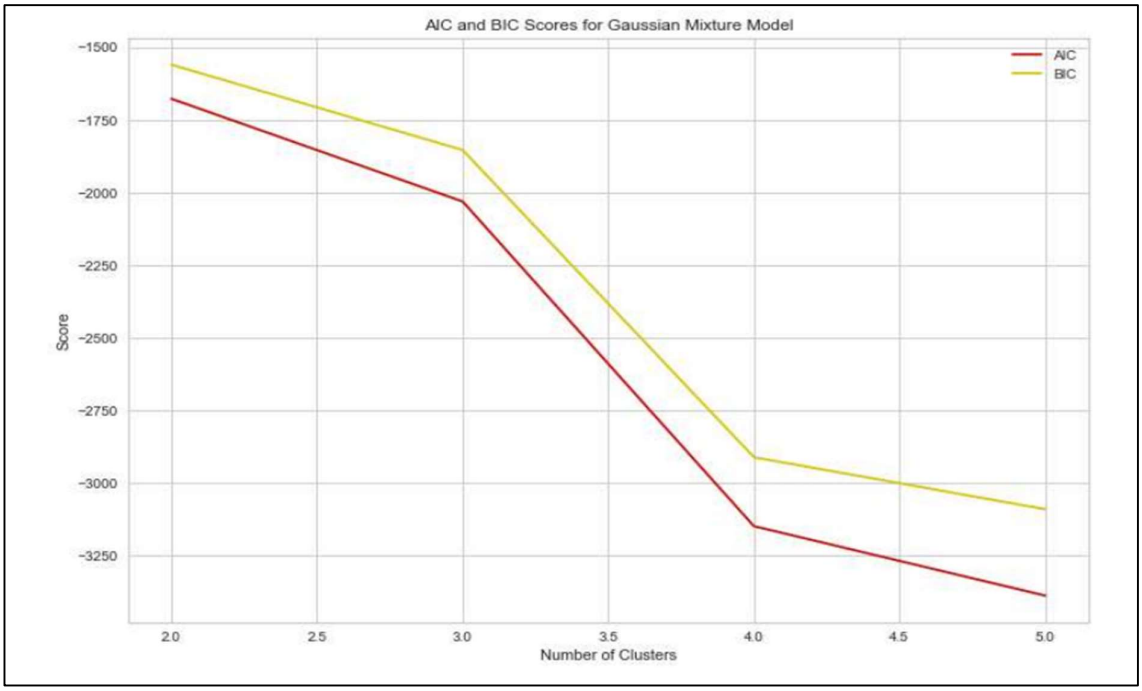
Psychographic and Behavioural Research:

❖ **Principal Component Analysis –**



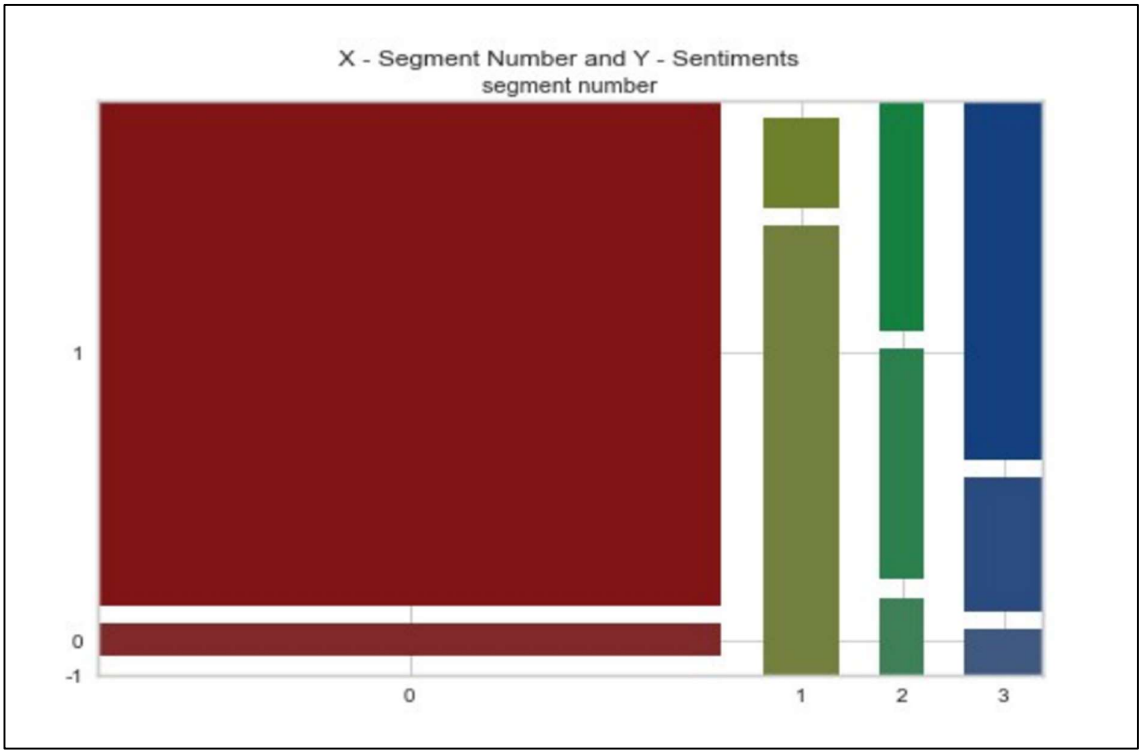
- PC1 and PC2 are the 2 components captured highest of information contained in segmentation variables.
- The above Principal Component Plot shows clearly:
  - According to first principal Component (PC1) we assess the fact that value for money, the performance and the Fuel economy feature of the EV has similar percentage and closest positive ratings.

❖ Segment Extraction –



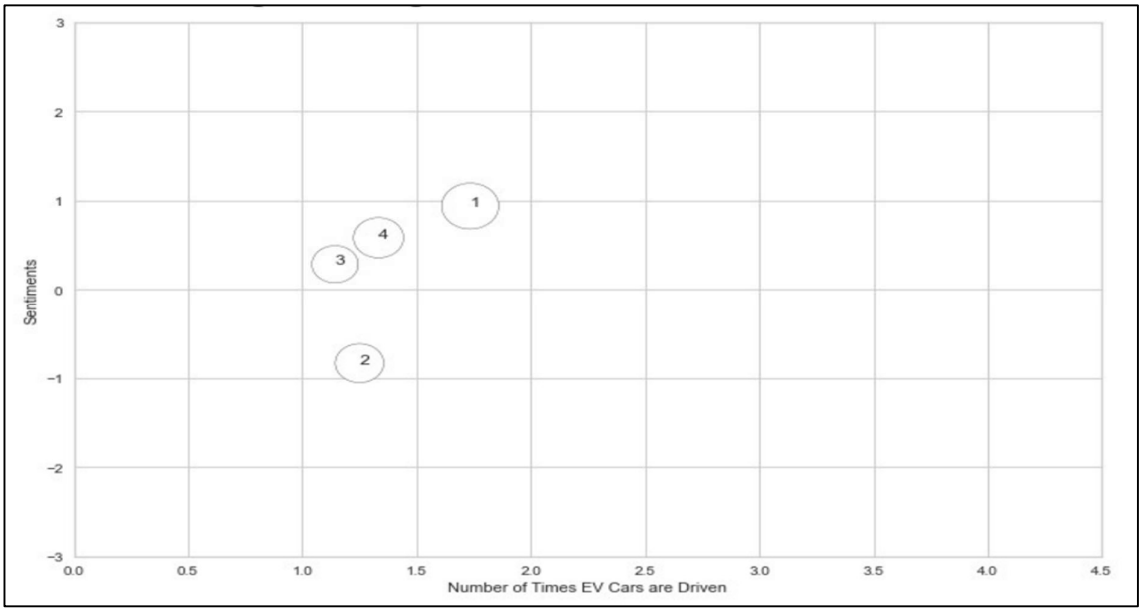
- From the plot above, we can clearly see that the 4 and 5 market segment solution have some stability here 4 market segment solution makes some stability, and the curves flatten for a while.

❖ **Describing Segments –**



- Members of segment 1 (depicted in the first column) expresses most positive responses of EVs the top left boxes being coloured in red.
- In stark contrast, members of segment 2 expresses Negative Thoughts (as indicated by the pale green bar boxes).
- Segment 3 provides info about people expressing balanced responses (as indicated by dark green colour).
- Segment 4 have majority of positive responses (as indicated by dark blue).

❖ **Selecting The Segments:**



- Market segments 1 are located in the attractive quadrant of the segment evaluation plot. Members of these two segments like EVs and recommend others to buy it. These segments need to be retained, and their feedback must be considered seriously.
- Market segment 3 and 4 also provides positive sentiments towards EVs but there driving frequency is less. Therefore, There feedback are also important and need special attention as well for the betterment in the Electric Vehicle.
- Market segment 2 is located at least attractive position, members in this segment not having positive attitude towards EV, thus making them unattractive as a potential market segment.

(a) **Economic Research**:

- Another dataset was considered for economic analysis to check for best technical specification and we come up with the best range for price, battery capacity, driving range, power, and the total charging time require.
- Below is the excel spreadsheet table of ranges:
  1. Price range
  2. Battery Capacity
  3. Driving Range
  4. Power (Performance)
  5. Charging time

  946000 Lakhs - 3950000 Lakhs
  26.0 KwH - 107.8 KwH
  315.0 KMs - 857.0 KMs
  73.75 BHP - 516.29 BHP
  1.5 Hours - 9.0 Hours
- We come up with a competitive range of price. Our product price range should be within range or more economical if possible.
- We defined a range of Kilo-Watt Hour battery capacity.

- The defined batteries should produce significant range of power as defined.
- We have to see if we can improve more on driving range provided, but our driving range should be at maximum of given range. Time taken to charge a battery should be within the range.

4) Conclusion:

a) Geographic and Demographic analysis:

- We analysed that south India region is more technologically advanced with good availability of charging infrastructure and Electric vehicles becoming more popular. Big Brands who already launched their products and have their manufacturing plants in south India. It is possible that we can create space for our EVs but it will be very difficult.
- Northeastern states have growing popularity specially Sikkim, this is a good place for us to create space for our EVs.
- Once our EV popularity grows up, we can target to East Indian states and central Indian states.

b) **Psychographic and Behavioural analysis**:

- From Reviews Dataset from carwale.com, I did market segmentation on people's reviews on EVs whether they have positive approach towards it. we found that 3 out 4 have positive approach and are likely to buy new EV. Those who have done small test drive are likely to buy. Those who already driving regularly are recommending others to buy it.
- Competitive prices, more features and good performance in EVs are key points to be considered, as in the analysis i come up with the observation of the people more tended to buy low priced and low maintenance cost vehicles.

c) Economic Analysis:

- From the information in the dataset about current details on electric cars. I came up with a dictionary of different specifications and its ranges.
- I concluded that, if we want to successfully come to the competition with other products, we need to follow this ranges.
- For the price range our product price should be within the maximum range of price and will keep on optimizing so we can keep our vehicle price low.
- Keeping an eye on price, we should deliver with maximum battery capacity and good quality battery following the guidelines of Government of India, so that the power sustain capability will improve and we will be capable of producing environment friendly vehicles.
- We must balance our battery capacity with the performance power and driving range as well.
- Fast-charging mechanism should be implemented for better and faster charging ability and to keep the charging time within the range.

Final Thoughts on Startup Strategy

1) In case of E-Bikes we can target some East Indian states like Uttar Pradesh, Bihar and West Bengal as the economic condition of majority of people is low so a good competitive E-bike with good number of features and reasonable price range will be a good choice. Central Indian States like Madhya Pradesh will also a good choice to introduce E-Bikes
2) In case of E-Cars North-East India and Central India should be the first-choice region as they have good popularity of EVs. East Indian states would be the second choice after the popularity of the startup improves and we are safe to grow our business.

3) North Indian states are not recommended right now because of the analysis results. People are not buying EVs despite having lots of charging infrastructure.
4) South Indian states should be kept for future as there are already many international brands launched their EVs at competitive prices and tones of features. So South India will not be a safe option right now.

Electric Vehicle Market Segmentation

Jerusha Naomi M J

Introduction

In the realm of electric vehicles (EVs), India emerges as a vibrant and evolving market, shaped by its expansive geography and diverse cultural tapestry. As businesses navigate the intricacies of this burgeoning industry, recognizing the significance of geographic segmentation becomes crucial. This report probes into the geographic dimensions of the Indian electric vehicle market, investigating how regional disparities influence consumer preferences, market potential, and strategic business decisions.

Diversity Across Regions: India's geographical spectrum, spanning diverse terrains, languages, and cultural traditions, contributes to a varied landscape for the electric vehicle sector. From the bustling urban centers to the serene rural expanses, each region showcases unique characteristics that mold consumer inclinations and drive market dynamics in the electric mobility space.

Significance of Geographic Segmentation: Geographic segmentation acts as a strategic lens, allowing us to unravel the nuances of consumer behavior and adapt business strategies accordingly. In the context of India's expansive and heterogeneous electric vehicle market, comprehending the distinct requirements, preferences, and challenges across different regions is essential for businesses aiming at sustainable growth and market penetration in the evolving landscape of electric mobility.

Market Segmentation on EV_India.csv dataset

Data Analysis

```
print(df.head())
```

	Sr. No.	State Name	Total Electric Vehicle	Total Non-Electric Vehicle	Total
0	1	Andaman & Nicobar Island	162	1,46,945	1,47,107
1	2	Andra Pradesh	NaN	NaN	NaN
2	3	Arunachal Pradesh	20	2,52,965	2,52,985
3	4	Assam	64766	46,77,053	47,41,819
4	5	Bihar	83335	1,04,07,078	1,04,90,413

```
print(df.describe())
```

	Sr. No.
count	36.000000
mean	18.500000
std	10.535654
min	1.000000
25%	9.750000
50%	18.500000
75%	27.250000
max	36.000000

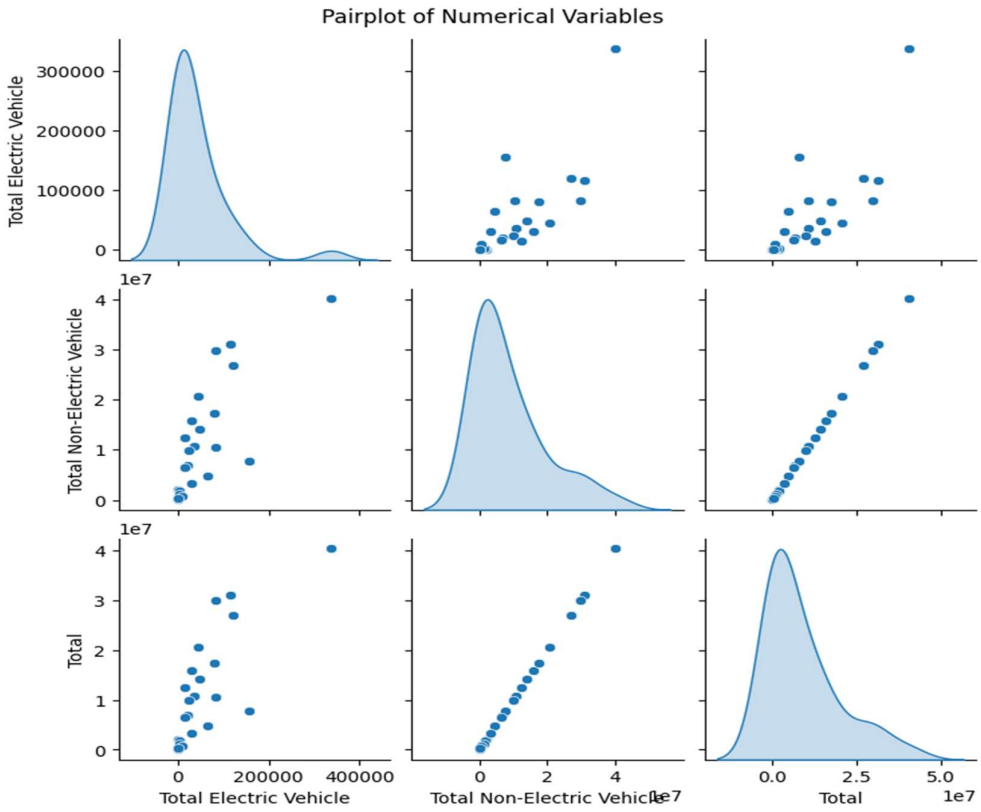
Data analysis is the cornerstone of informed decision-making in today's dynamic business environment. In the context of market segmentation, it involves scrutinizing and interpreting the gathered data to extract meaningful insights. By employing statistical techniques, pattern recognition, and visualization tools, data analysis unveils trends, identifies correlations, and helps businesses understand the intricacies of consumer behavior within different geographic segments. The process enables companies to make evidence-based decisions, refine marketing strategies, and uncover untapped opportunities, fostering a more targeted and effective approach

to engaging diverse markets. In essence, data analysis transforms raw information into actionable intelligence, empowering businesses to navigate the complexities of the market with precision and agility.

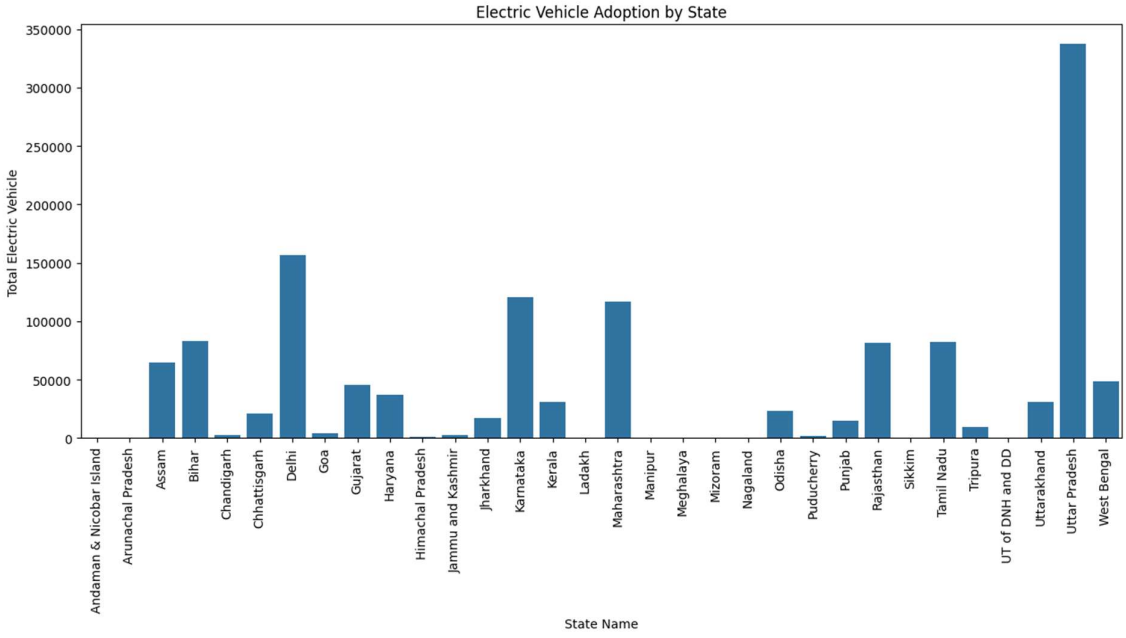
Data after Cleaning

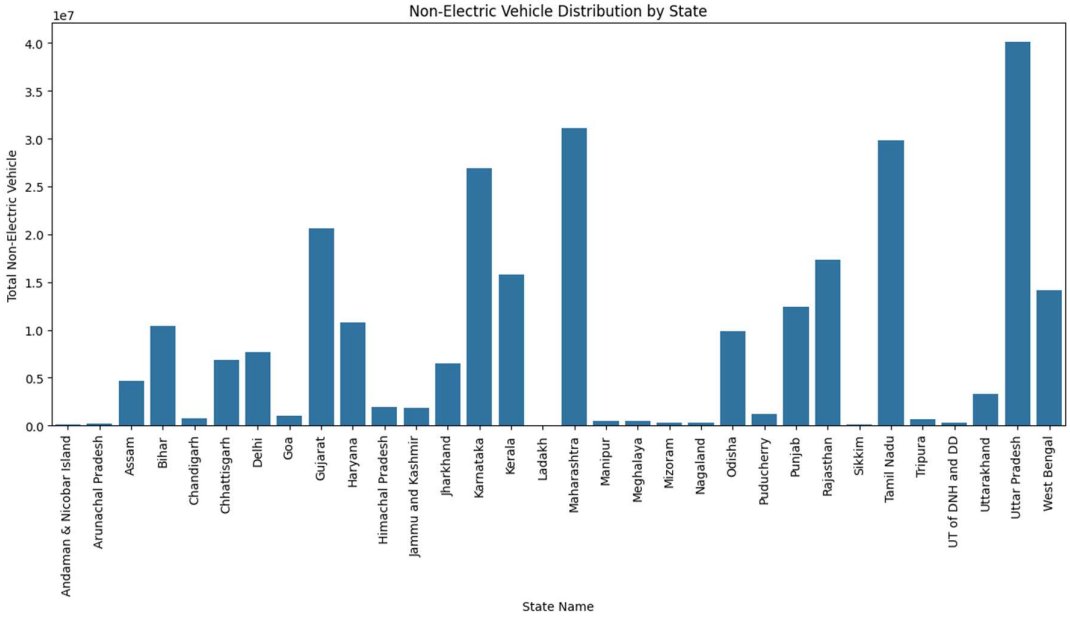
```
display(df)
```

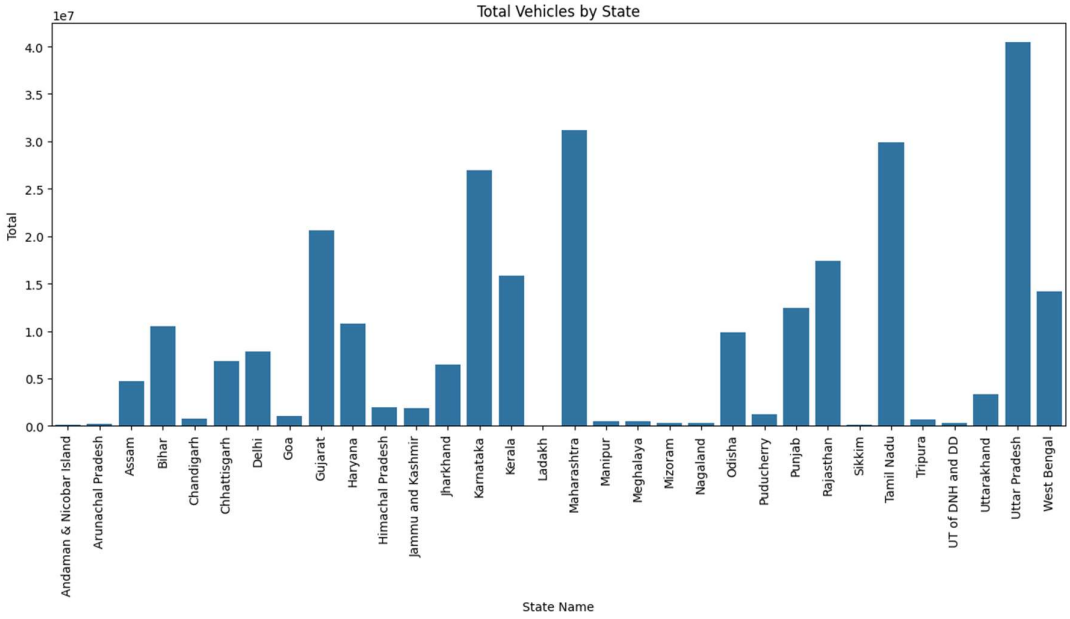
	State Name	Total Electric Vehicle	Total Non-Electric Vehicle	Total
0	Andaman & Nicobar Island	162.0	146945.0	147107.0
2	Arunachal Pradesh	20.0	252965.0	252985.0
3	Assam	64766.0	4677053.0	4741819.0
4	Bihar	83335.0	10407078.0	10490413.0
5	Chandigarh	2812.0	746881.0	749693.0
6	Chhattisgarh	20966.0	6836200.0	6857166.0
7	Delhi	156393.0	7685600.0	7841993.0
8	Goa	3870.0	1071570.0	1075440.0
9	Gujarat	45272.0	20605484.0	20650756.0
10	Haryana	37035.0	10778270.0	10815305.0
11	Himachal Pradesh	1175.0	1964754.0	1965929.0
12	Jammu and Kashmir	2941.0	1869962.0	1872903.0
13	Jharkhand	16811.0	6486937.0	6503748.0
14	Karnataka	120532.0	26870303.0	26990835.0
15	Kerala	30775.0	15774078.0	15804853.0
16	Ladakh	26.0	38302.0	38328.0
19	Maharashtra	116646.0	31058990.0	31175636.0
20	Manipur	586.0	499324.0	499910.0

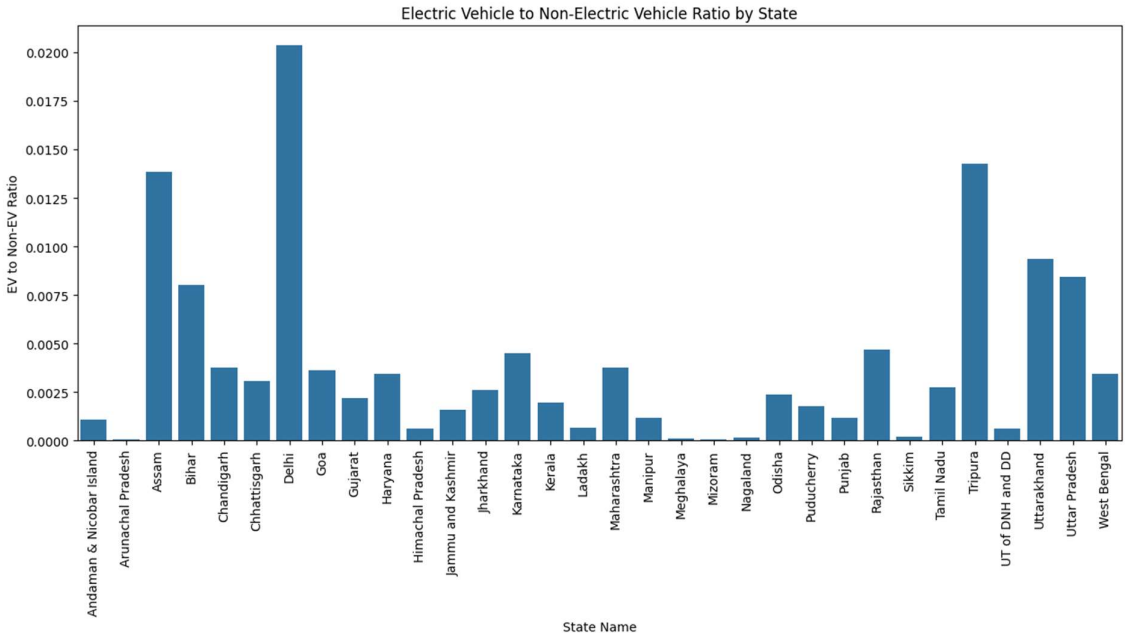


Statistics of each state



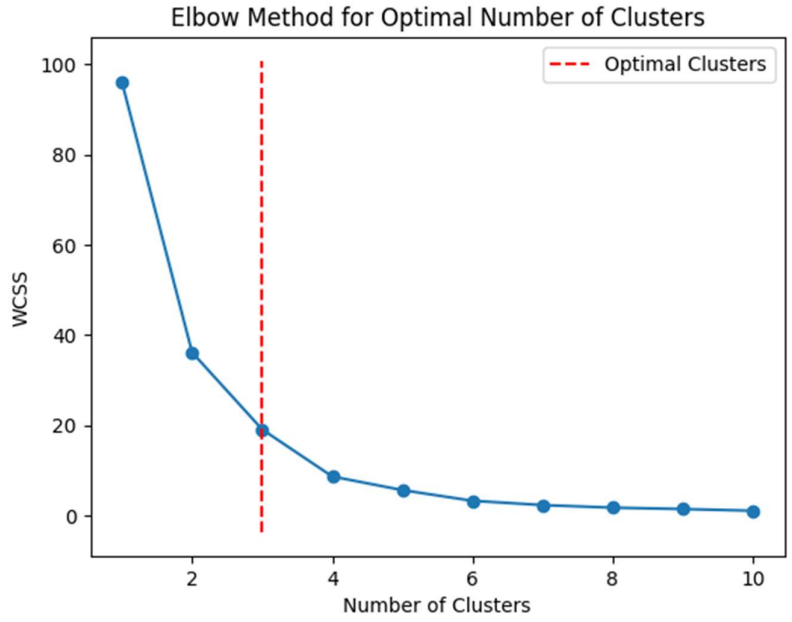

Non-Electric Vehicle Distribution by State
1e7
Total Non-Electric Vehicle
State Name
Andaman & Nicobar Island
Arunachal Pradesh
Assam
Bihar
Chandigarh
Chhattisgarh
Delhi
Goa
Gujarat
Haryana
Himachal Pradesh
Jammu and Kashmir
Jharkhand
Karnataka
Kerala
Ladakh
Maharashtra
Manipur
Meghalaya
Mizoram
Nagaland
Odisha
Puducherry
Punjab
Rajasthan
Sikkim
Tamil Nadu
Tripura
UT of DNH and DD
Uttarakhand
Uttar Pradesh
West Bengal


Total Vehicles by State
1e7
Total
State Name
Andaman & Nicobar Island
Arunachal Pradesh
Assam
Bihar
Chandigarh
Chhattisgarh
Delhi
Goa
Gujarat
Haryana
Himachal Pradesh
Jammu and Kashmir
Jharkhand
Karnataka
Kerala
Ladakh
Maharashtra
Manipur
Meghalaya
Mizoram
Nagaland
Odisha
Puducherry
Punjab
Rajasthan
Sikkim
Tamil Nadu
Tripura
UT of DNH and DD
Uttarakhand
Uttar Pradesh
West Bengal



Principal Component Analysis

Principal Component Analysis (PCA) is a powerful dimensionality reduction technique widely used in data analysis and machine learning. Its primary objective is to transform high-dimensional data into a lower-dimensional space while retaining as much of the original variance as possible. By identifying the principal components, which are linear combinations of the original variables, PCA simplifies complex datasets and aids in visualizing underlying patterns and relationships. This reduction not only enhances computational efficiency but also helps in identifying the most significant features, streamlining data interpretation and facilitating more efficient modeling. PCA is a valuable tool for extracting essential information from large datasets and plays a crucial role in various fields, including image processing, finance, and pattern recognition.

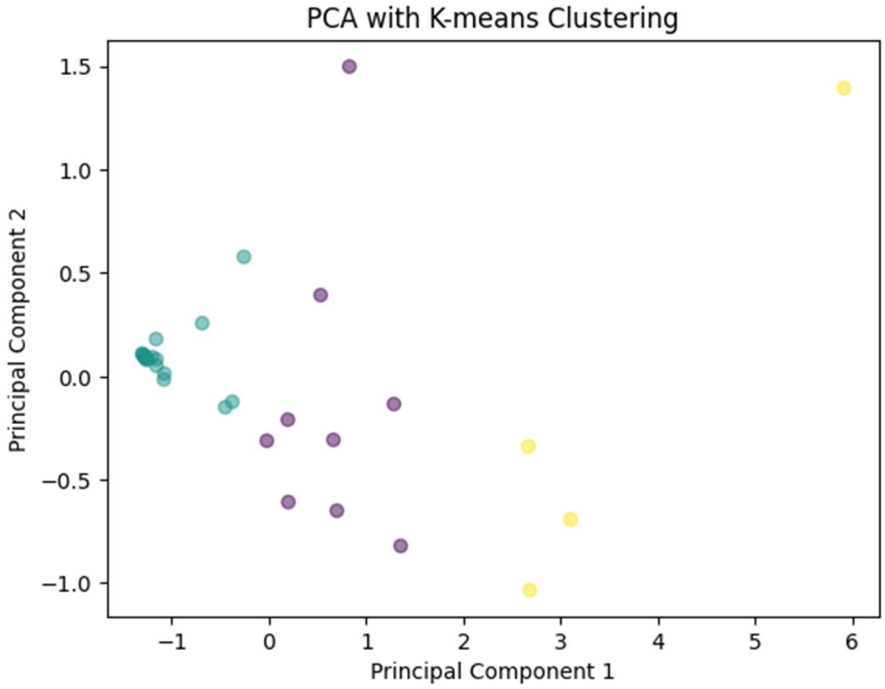


Segmentation using K – Means Clustering Algorithm

K-Means clustering is a widely-used unsupervised machine learning algorithm for data segmentation. The challenge often lies in determining the optimal number of clusters ('k') to effectively group data points. The "kneed" package in Python offers a valuable tool for addressing this challenge.

Process:

1. **Data Preparation:** Input the dataset to be clustered.
2. **Choosing k Values:** Use the "kneed" package to identify the elbow point in the within-cluster sum of squares (WCSS) curve. The elbow typically represents the optimal number of clusters.
3. **K-Means Clustering:** Apply the K-Means algorithm with the chosen 'k' to segment the data into distinct clusters.



Cluster Details:

```
[371] # Display the count of samples in each cluster
      print(df['Segment'].value_counts())

      1    19
      0     9
      2     4
      Name: Segment, dtype: int64
      1    19
      0     9
      2     4
      Name: Segment, dtype: int64
```

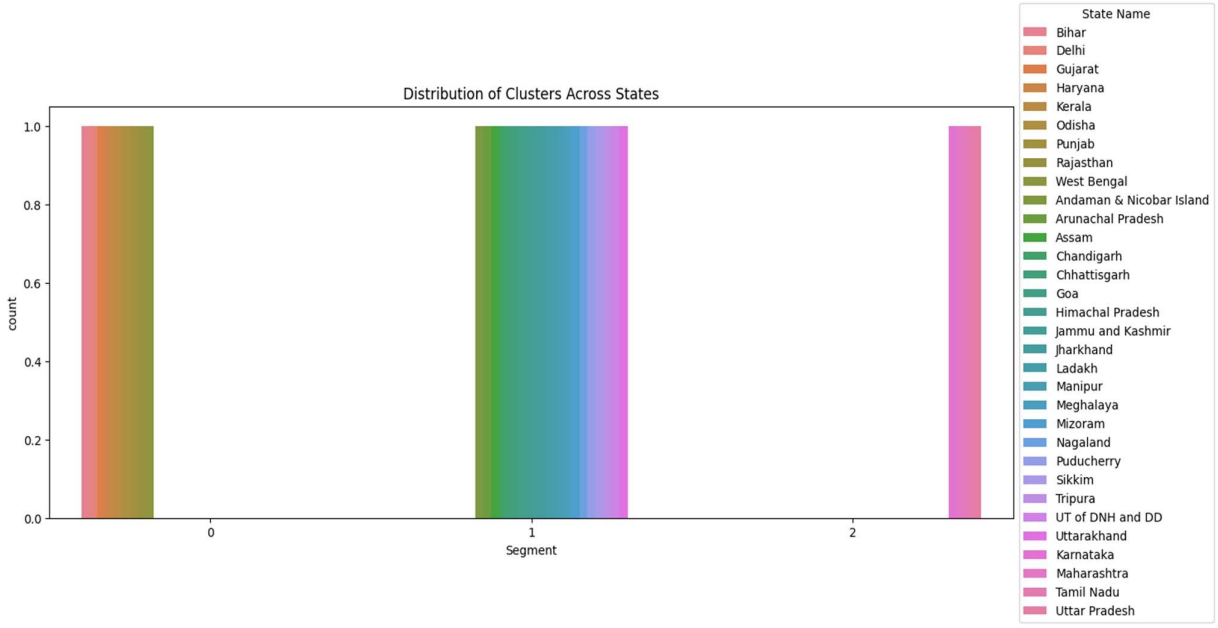
```
[372] # Print details for each cluster
      numeric_columns = ['Total Electric Vehicle', 'Total Non-Electric Vehicle', 'Total']
      cluster_details = df.groupby('Segment')[numeric_columns].mean()

      # Display the details for each cluster
      print(cluster_details)
```

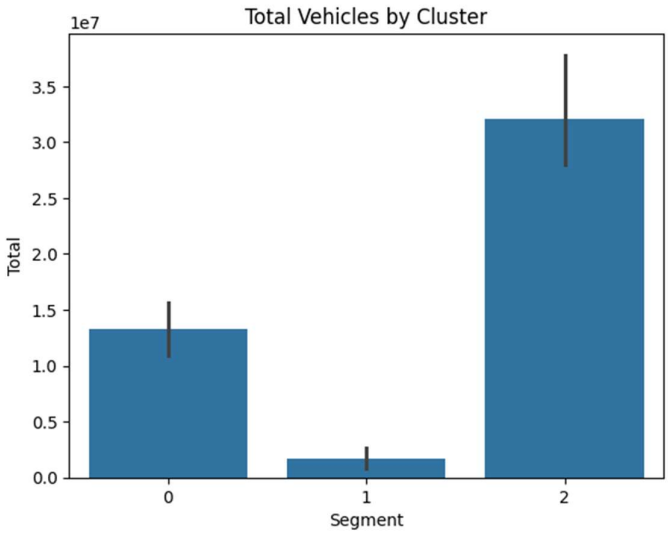
Segment	Total Electric Vehicle	Total Non-Electric Vehicle	Total
0	57898.888889	1.322446e+07	1.328236e+07
1	8257.157895	1.646595e+06	1.654852e+06
2	164102.250000	3.196604e+07	3.213014e+07

Segment	Total Electric Vehicle	Total Non-Electric Vehicle	Total
0	57898.888889	1.322446e+07	1.328236e+07
1	8257.157895	1.646595e+06	1.654852e+06
2	164102.250000	3.196604e+07	3.213014e+07

Details of each cluster – Which state belongs to which cluster



Total vehicles in each cluster

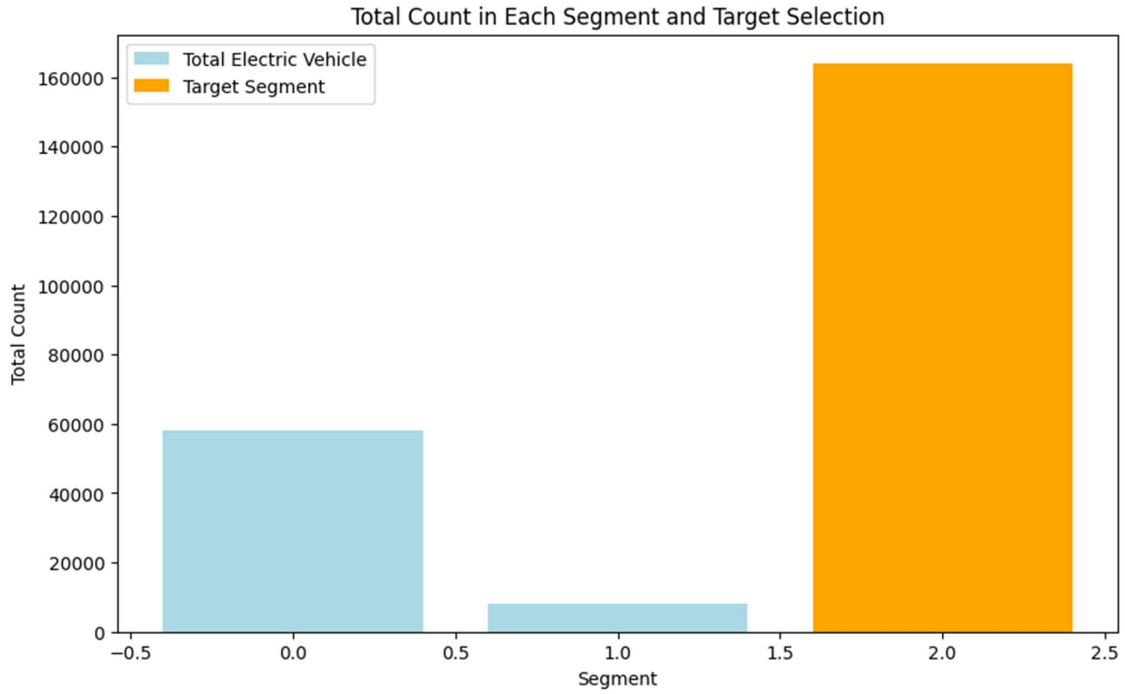


Selecting the Target Segment

Selecting the target segment in the electric vehicle market involves a careful analysis of the "Total Electric Vehicle" and "Total Non-Electric Vehicle" columns. By examining adoption patterns, market potential, and conducting a comparative analysis between electric and non-electric vehicles, businesses can pinpoint specific demographic segments and regions with a higher propensity for embracing electric vehicles. Consideration of government incentives, competitor strategies, and operational feasibility further refines the target segment selection. Keeping an eye on evolving trends ensures adaptability to the dynamic landscape of the electric vehicle market, facilitating a focused and effective market approach.

```
target_segment = segment_profile['Total Electric Vehicle'].idxmax()
print("Target Segment:", target_segment)
```

```
Target Segment: 2
```



Selected Segment – Segment 2

States in segment 2:

	State Name	Total Electric Vehicle	Total Non-Electric Vehicle	Total	EV to Non-EV Ratio	Segment
14	Karnataka	120532.0	26870303.0	26990835.0	0.004486	2
19	Maharashtra	116646.0	31058990.0	31175636.0	0.003756	2
29	Tamil Nadu	82051.0	29842376.0	29924427.0	0.002749	2
34	Uttar Pradesh	337180.0	40092490.0	40429670.0	0.008410	2

Conclusion:

Upon careful analysis of the "Total Electric Vehicle" and "Total Non-Electric Vehicle" data, it is evident that Karnataka, Maharashtra, Tamil Nadu, and Uttar Pradesh emerge as promising target segments. These states exhibit characteristics conducive to the adoption of electric vehicles, with a focus on urban areas known for higher urbanization rates. Furthermore, Uttar Pradesh, with its substantial population, presents a compelling opportunity for market penetration. This conclusion is rooted in the recognition that these regions not only display a propensity for embracing electric vehicles, possibly due to urban lifestyles, but also offer the potential for significant market expansion, particularly in Uttar Pradesh. By strategically introducing our business in these selected segments, we can tap into the urban market dynamics and leverage the high population of Uttar Pradesh, paving the way for a robust and impactful market entry strategy in the electric vehicle sector.

- **Target States:** Karnataka, Maharashtra, Tamil Nadu, and Uttar Pradesh emerge as key target states for introducing our business in the electric vehicle market.
- **Urban Focus:** These states are characterized by high urbanization rates, indicating a strong potential for electric vehicle adoption, particularly in urban areas.

- **Population Dynamics:** Uttar Pradesh, with its substantial population, presents a significant opportunity for market penetration, contributing to the overall growth and market share.
- **Strategic Market Entry:** By strategically entering these regions, we can leverage the urban lifestyle preferences and tap into the promising market dynamics, setting the stage for a robust market entry strategy in the electric vehicle sector.
- **Market Expansion Potential:** The selected states not only exhibit a propensity for electric vehicle adoption but also offer substantial room for market expansion, aligning with our business objectives.

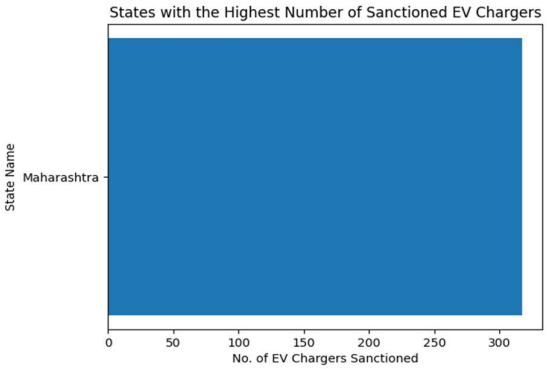
Data Evaluated form other Datasets:

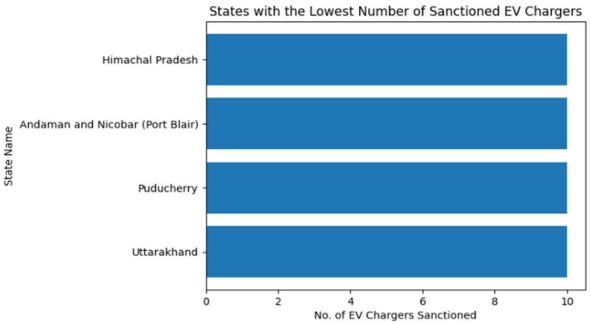
1) This dataset comprises information on the number of Electric Vehicle (EV) chargers sanctioned in different states, with two primary columns: 'State Name' and 'No. of EV Chargers Sanctioned.' The 'State Name' column indicates the specific regions or states under consideration, while the 'No. of EV Chargers Sanctioned' column quantifies the approved count of EV charging stations in each respective state. This dataset is instrumental for assessing the distribution and readiness of EV charging infrastructure across different geographic regions, providing insights into the states actively promoting and facilitating electric vehicle adoption through charger installations.

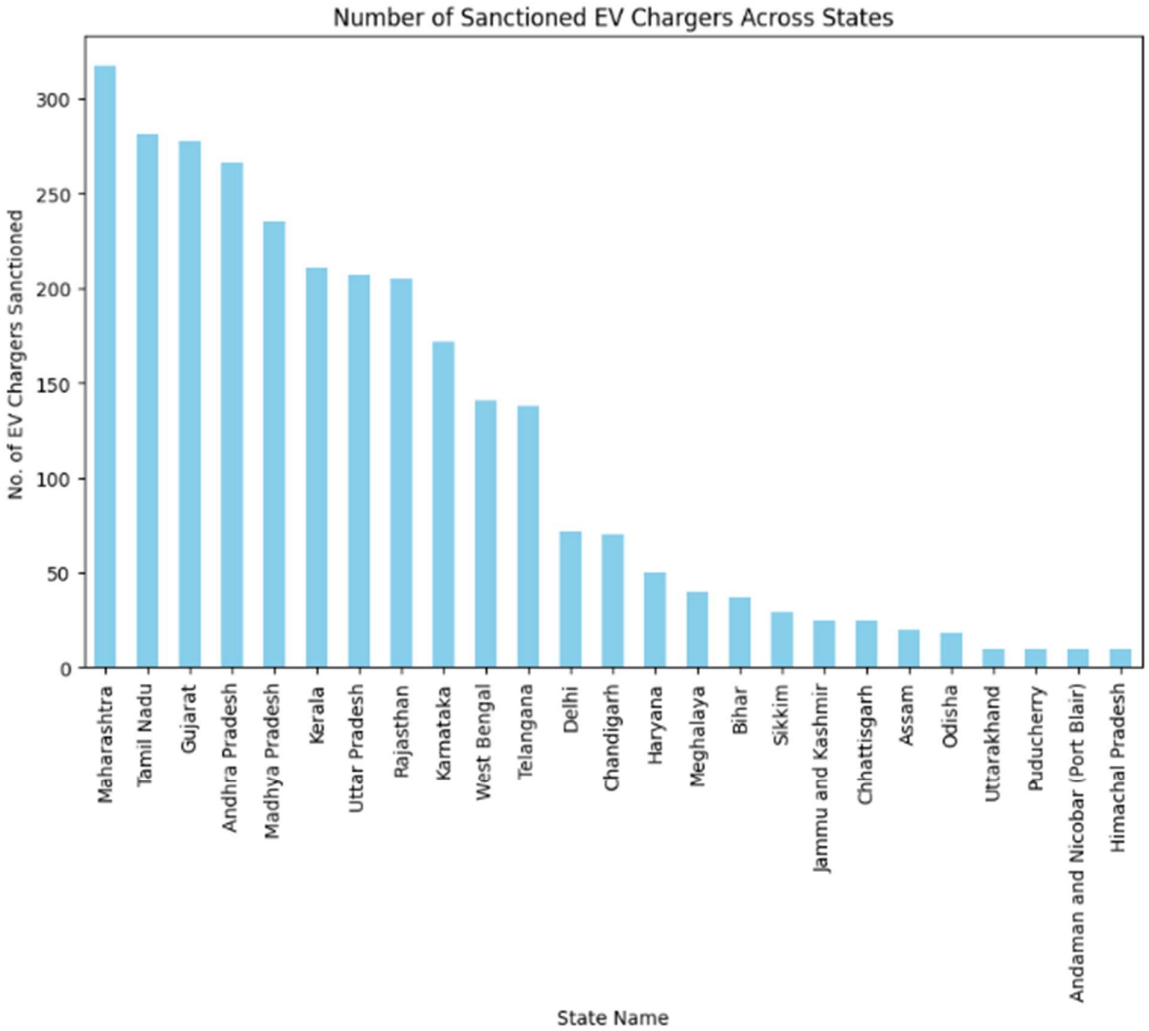
```
[ ]  print(df.columns)
     print(df.head())
```

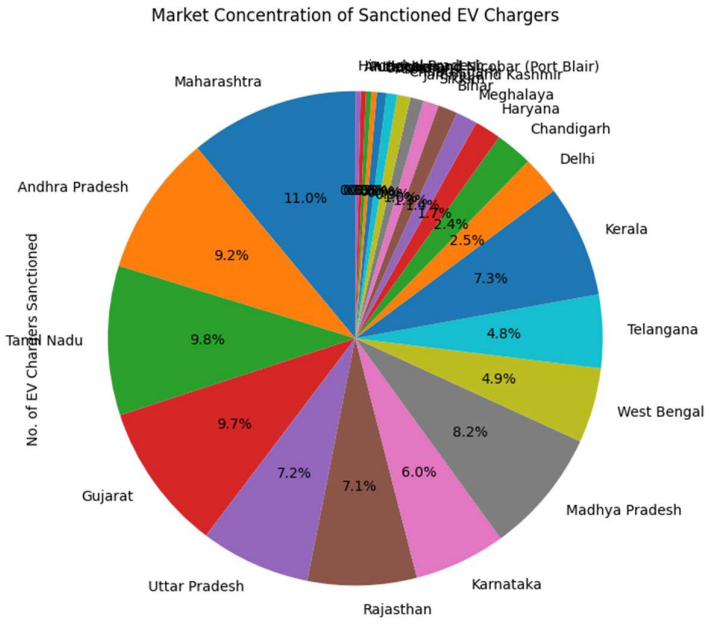
```
Index(['State Name', 'No. of EV Chargers Sanctioned'], dtype='object')
       State Name  No. of EV Chargers Sanctioned
0     Maharashtra                            317
1  Andhra Pradesh                            266
2      Tamil Nadu                            281
3         Gujarat                            278
4   Uttar Pradesh                            207
```

Information Know from Datasets: Visualization –









Analyzing the dataset on the number of EV chargers sanctioned can offer valuable insights into the dynamics of the electric vehicle (EV) market, particularly in terms of charging infrastructure readiness. Here are key points you can glean from the dataset:

1. **Regional EV Adoption Readiness:**
    - The dataset allows an assessment of states that are actively investing in EV charging infrastructure by examining the count of sanctioned chargers. Higher numbers indicate a proactive stance toward fostering electric vehicle adoption.
2. **Urban Emphasis:**
    - Observing a higher concentration of sanctioned chargers in mostly urban states suggests a strategic focus on urban areas. This aligns with the trend that urban centers are pivotal for the success of EVs, where charging infrastructure is essential for addressing range anxiety.
3. **Encouraging EV Adoption:**
    - States with a significant number of sanctioned EV chargers are likely to encourage more people to adopt electric vehicles. A well-established charging network provides convenience and addresses a crucial concern, making EV ownership more appealing.
4. **Infrastructure Equity:**
    - The dataset facilitates an analysis of how evenly distributed the sanctioned chargers are across different states. Identifying potential disparities in

infrastructure can inform strategies to promote more equitable access to charging facilities.

5. **Policy Impact:**
    - Recognizing the correlation between sanctioned chargers and states with supportive policies indicates the influence of government initiatives on charging infrastructure development. Understanding these policies can provide insights into the broader regulatory environment for EVs.
6. **Market Potential:**
    - States with higher numbers of sanctioned chargers may indicate a greater market potential for electric vehicles. Businesses and investors can use this information to target regions where the EV market is likely to thrive due to robust charging infrastructure.
7. **Urban Lifestyle Impact:**
    - The dataset can highlight how urban-centric states are taking the lead in EV infrastructure development. This underscores the interconnectedness of urban lifestyle choices, charging infrastructure, and the overall growth of the electric vehicle market.

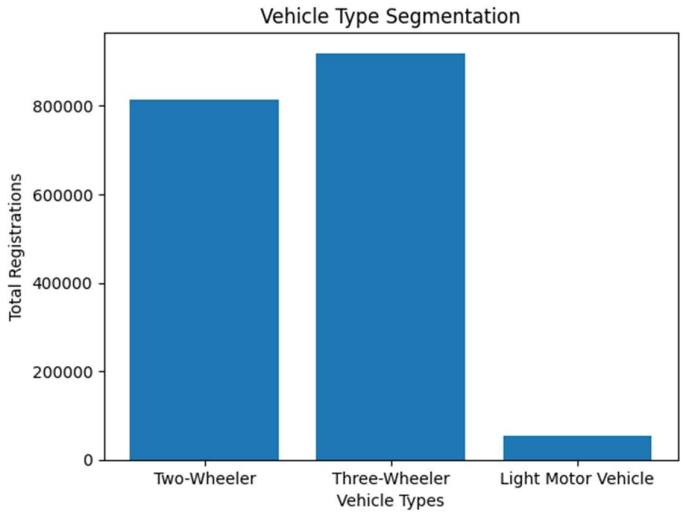
2) This dataset comprises various vehicle categories across different states, with columns specifying the count of registered vehicles in each category. The columns include '2WN' (Two Wheelers Non-Motorized), '2WT' (Two Wheelers Motorized), '2WIC' (Two Wheelers Electric), '3WN' (Three Wheelers Non-Motorized), '3WT' (Three Wheelers Motorized), 'LMV' (Light Motor Vehicles), 'LPV' (Light Passenger Vehicles), 'LGV' (Light Goods Vehicles), '4WIC' (Four Wheelers Electric), 'MMV' (Medium Motor Vehicles), 'MPV' (Medium Passenger Vehicles), 'MGV' (Medium Goods Vehicles), 'HPV' (Heavy Passenger Vehicles), 'HGV' (Heavy Goods Vehicles), 'OTH' (Other Vehicles), and 'Grand Total.' This dataset provides a comprehensive overview of the distribution of registered vehicles across different categories and states, offering insights into the vehicular landscape in terms of diversity and quantity.

```
print(df.head())
```

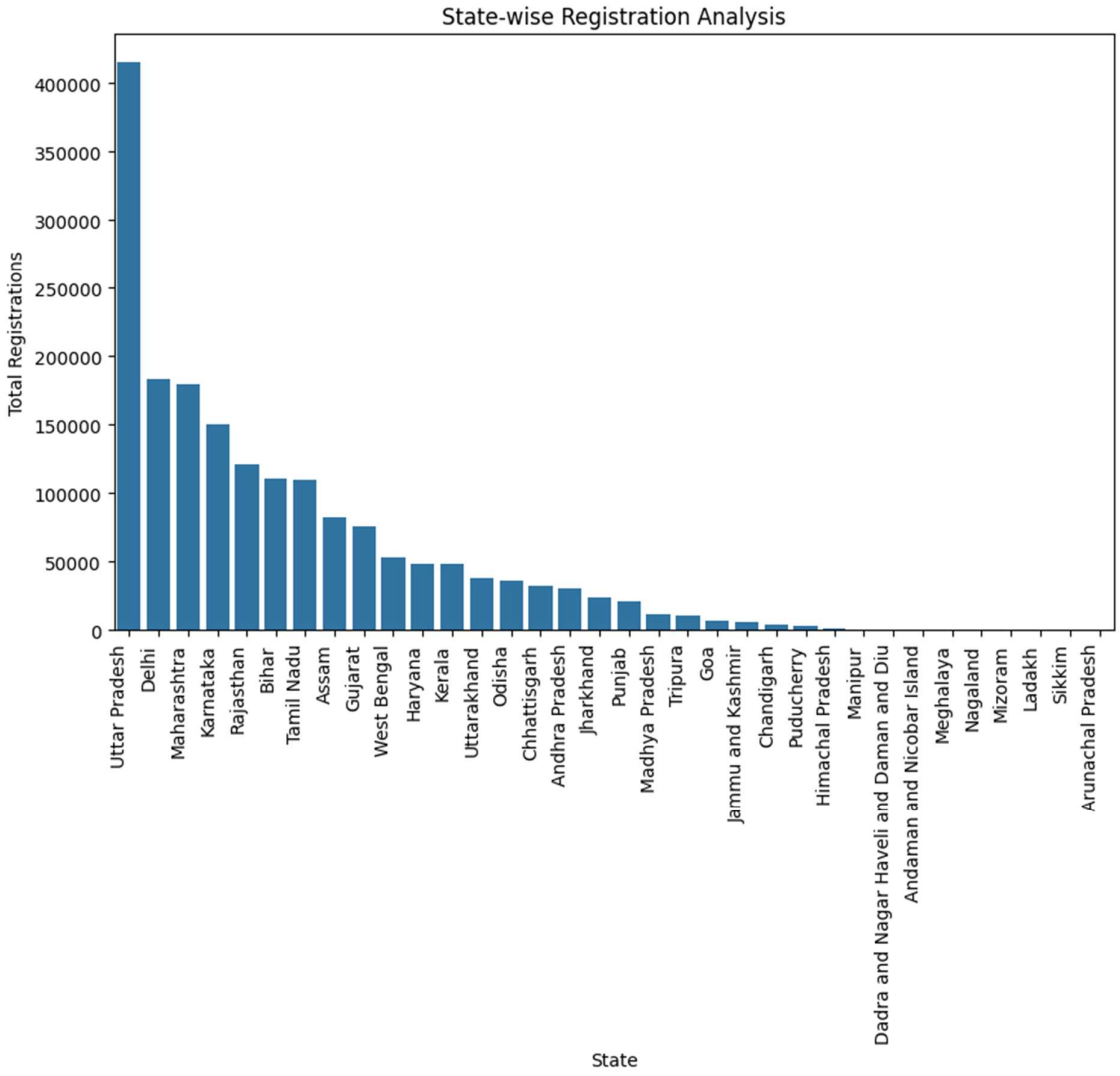
```
   S.No.                State Name    2WN  2WT  2WIC    3WN      3WT   LMV  \
0      1  Andaman and Nicobar Island      2  5.0   NaN    NaN     30.0    86
1      2              Andhra Pradesh  27629  NaN   2.0  374.0    108.0  1050
2      3           Arunachal Pradesh     14  NaN   NaN    NaN      NaN     6
3      4                       Assam   2287  NaN   NaN    NaN  79661.0   233
4      5                       Bihar  13472  NaN   NaN    2.0  96560.0   231

    LPV    LGV  4WIC  MMV  MPV  MGV   HPV  HGV     OTH  Grand Total
0  6.0    NaN   NaN  NaN  NaN  NaN  40.0  NaN     NaN          169
1  3.0  166.0   NaN  NaN  NaN  NaN   NaN  NaN  1117.0        30449
2  1.0    NaN   NaN  NaN  NaN  NaN   NaN  NaN     NaN           21
3  5.0   15.0   NaN  NaN  NaN  NaN  15.0  NaN     NaN        82216
4  8.0   21.0   1.0  NaN  NaN  1.0  27.0  2.0     NaN       110325
```

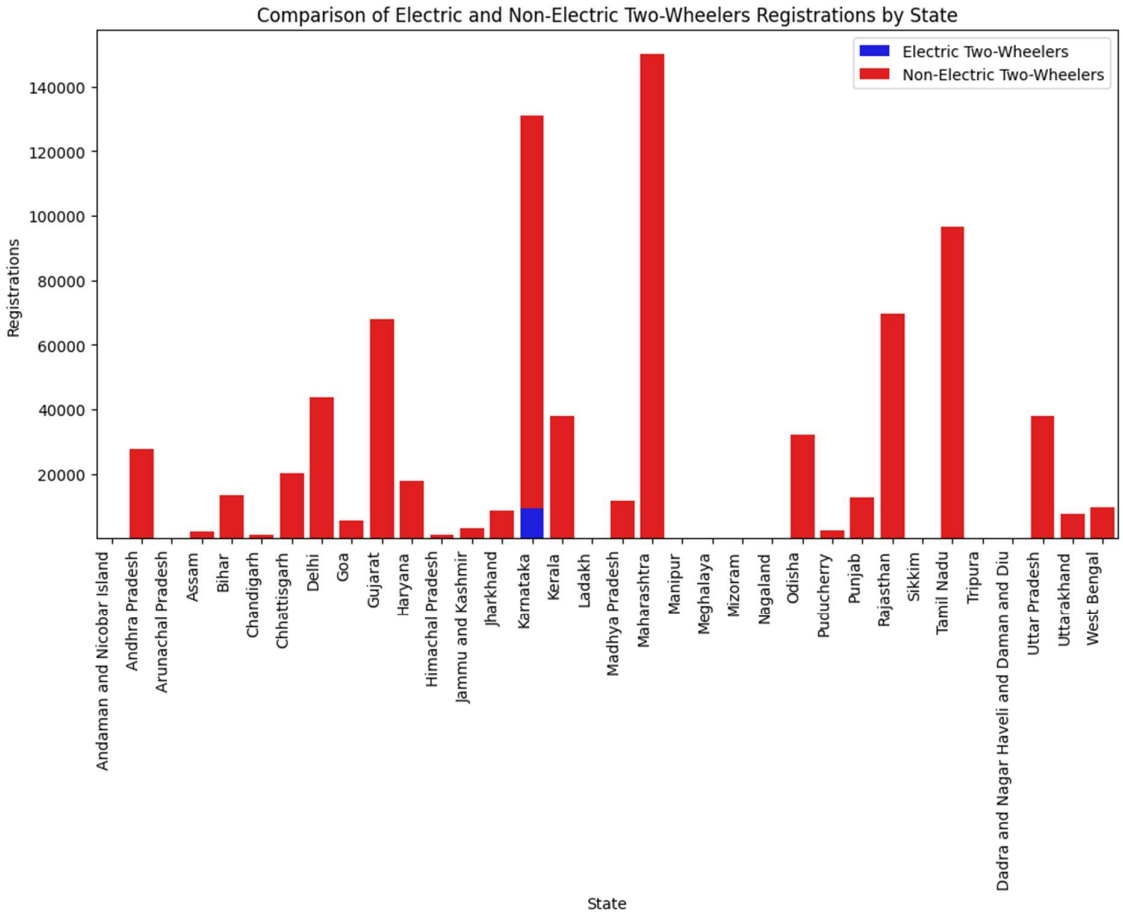
Information Know from Datasets: Visualization –



Can conclude that Three – Vehicle types are more popular



UP has higher population – More vehicles registered



Karnataka a state with urban cities has a higher number of Electric Vehicles

Conclusion:

Upon analyzing the dataset, a clear correlation emerges between states with higher populations and the prevalence of vehicles. This relationship is particularly notable in urban cities, which typically have denser populations. Key observations from the dataset, focusing on two/three-wheelers, and heavy and light vehicles, lead to the following conclusions:

1. **Urbanization Impact:**
    - Urban cities, characterized by higher populations, exhibit a substantial concentration of vehicles. This is prominently reflected in the robust numbers of two/three-wheelers, catering to urban mobility needs efficiently.
2. **Two/Three-Wheelers Dominance:**
    - The prevalence of two/three-wheelers is notable, especially in densely populated urban areas. These vehicles, being more compact and maneuverable, align with the urban lifestyle, contributing significantly to the overall vehicular landscape.
3. **Heavy and Light Vehicles Distribution:**
    - States with larger populations also tend to have a higher count of heavy and light vehicles. This can be attributed to increased economic activities, infrastructure development, and the demand for goods and services in densely populated regions.

4. **Diversity in Urban Mobility:**
    - The dataset reflects the diversity in urban mobility preferences, with a significant number of two/three-wheelers catering to individual commuting needs, and heavy and light vehicles facilitating goods transportation and broader mobility requirements.
5. **Urban Planning Considerations:**
    - The prominence of vehicles in urban areas emphasizes the need for robust urban planning, including sustainable transportation solutions, infrastructure development, and policies that accommodate the diverse vehicular landscape.
6. **Economic and Commercial Significance:**
    - The higher prevalence of heavy vehicles, especially in states with larger populations, suggests heightened economic activities and commercial transactions, indicating the economic significance of these regions.

In conclusion, the dataset underscores the direct relationship between population density, urbanization, and the abundance of vehicles, with a specific emphasis on two/three-wheelers and heavy and light vehicles. These findings are crucial for urban planning, transportation policies, and infrastructure development to ensure sustainable and efficient mobility solutions in regions with varying population sizes.

Please find more details and processing in the following link:
https://github.com/jerushanaomi/market_segmentation

EV Market Segmentation: Charging Station Across Nation

-Harikrishna Nariyanpilly

1. Executive Summary

The report aims to provide insights into the Indian Electric Vehicle (EV) market to aid in the strategic decision making process for entering the market. The analysis primarily focuses on charging station data and will inform the selection of target segments and locations for market entry.

2. Introduction

The Electric Vehicle market in India is experiencing rapid growth driven by various factors including government incentives, environmental concerns, and technological advancements. However, successful entry into this market requires a thorough understanding of customer segments and strategic planning.

3. Analysis of Charging Station Data

Dataset 1: Charging Station Analysis

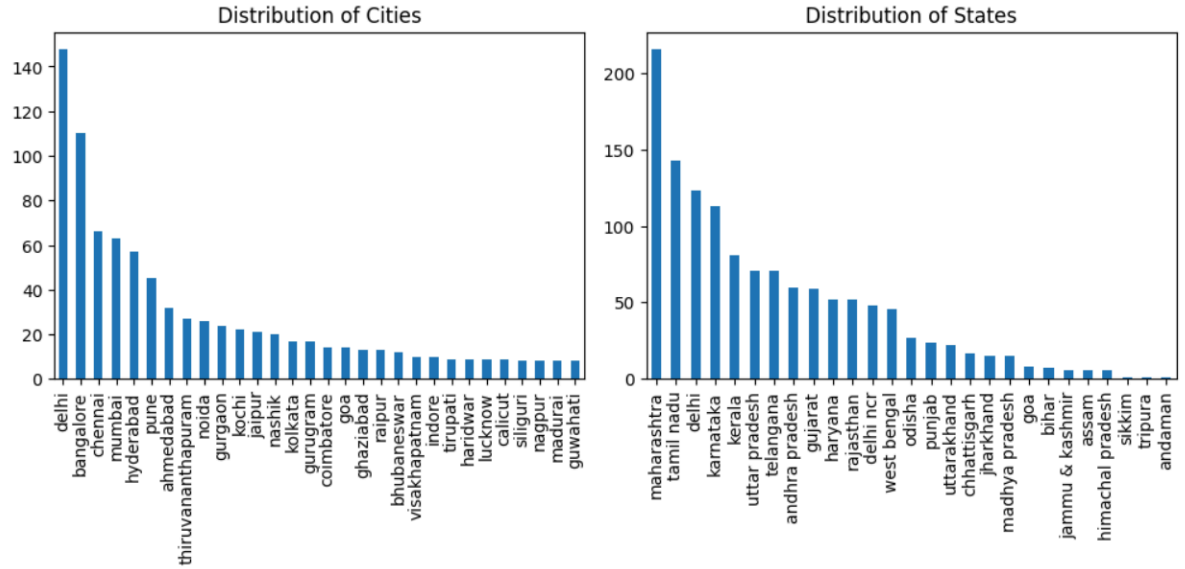
index	name	state	city	lattitude	longitude	type
0	Neelkanth Star DC Charging Station	haryana	gurugram	29.6019	76.9803	12.0
1	Galleria DC Charging Station	haryana	gurugram	28.4673	77.0818	12.0
2	Highway Xpress (Jaipur-Delhi) DC charging station	rajasthan	behror	27.8751	76.276	12.0
3	Food Carnival DC Charging Station	uttar pradesh	khatauli	29.3105	77.7218	12.0
4	Food Carnival AC Charging Station	uttar pradesh	khatauli	29.3105	77.7218	12.0
5	Krishna Hansraj Hotel Una DC charging station	himachal pradesh	una	31.4668	76.2568	12.0
6	SG Jabli DC Charging Station	himachal pradesh	kasauli	30.879	76.9948	12.0
7	SG Jabli AC Charging Station	himachal pradesh	kasauli	30.879	76.9948	12.0
8	SG Karnal DC Charging Station	haryana	karnal	29.7379	76.9756	12.0
9	SG Karnal AC Charging Station	haryana	karnal	29.7379	76.9756	12.0

Dataset 2: Charging Station Characteristics

index	0	1	2	3	4
uid	STATIC12	STATIC14	STATIC15	STATIC16	STATIC17
name	GensolCharge Pvt. Ltd.	REIL	REIL	REIL	BluSmart
vendor_name	GensolCharge Pvt. Ltd.	REIL	REIL	REIL	BluSmart
address	NDSE Grid, BRPL South Extension	Scada office kalka ji	Ashram Chowk Mathura Road	Nizamuddin Railway station	BSES Bhawan, Nehru Place, New Delhi 110048
latitude	28.568238	28.541995	28.571189	28.588991	28.549427
longitude	77.219666	77.260583	77.259806	77.25324	77.254636
city	New Delhi	New Delhi	New Delhi	New Delhi	New Delhi
country	India	India	India	India	India
staff	unstaffed	unstaffed	unstaffed	unstaffed	unstaffed
payment_modes	Card, E-Wallet, UPI	E-Wallet	E-Wallet	Cash/E-Wallet	Cash/E-Wallet
station_type	charging	charging	charging	charging	charging
postal_code	110001	110001	110001	110001	110001
available	1	1	1	1	1
capacity	15 kW	3.3 kW	15 kW	15 kW	15 kW
cost_per_unit	₹0 per unit	₹0 per unit	₹0 per unit	₹0 per unit	₹0 per unit
power_type	DC	AC	DC	DC	DC
total	2	3	2	4	1
type	BEVC DC 001	BEVC AC 001	BEVC DC 001	BEVC DC 001	BEVC DC 001
vehicle_type	['4W']	['2W', '3W', '4W']	['4W']	['4W']	['4W']

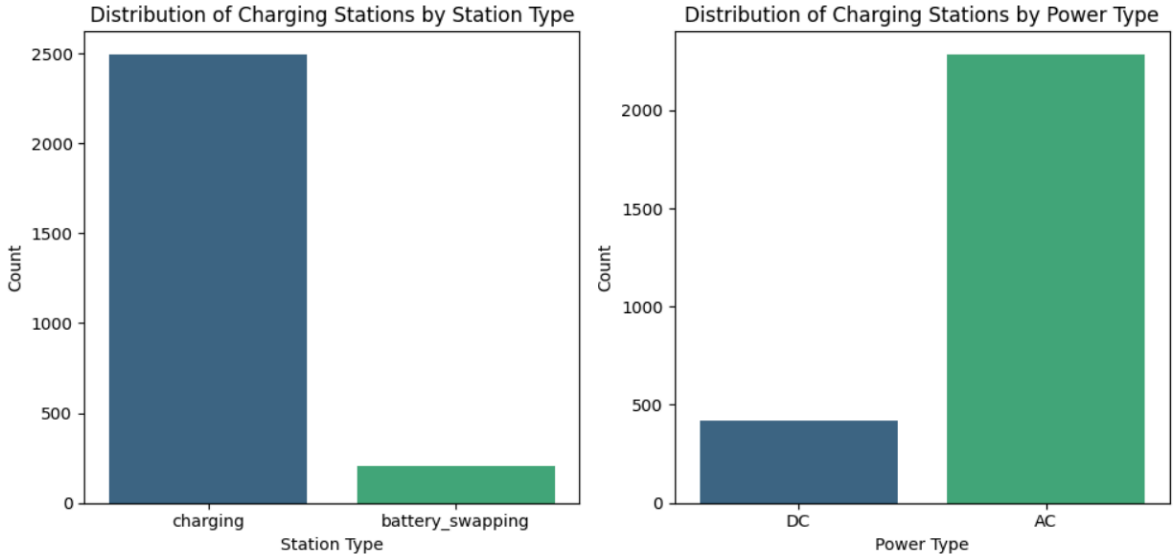
3.1 Geographical Distribution

Visualisation and analysis of charging station distribution across different regions in India.



Delhi boasts the highest number of charging stations across the nation, while the state of Maharashtra leads with the maximum number of charging stations.

3.2 Distribution of Charging Stations type:



3.2.1 Standard Charging Stations vs. BatterySwapping Stations:

Preference for Standard Charging Infrastructure: The barplot reveals that the majority of charging stations are of the standard charging type. This preference suggests that current market dynamics favour traditional charging methods over battery swapping solutions.

Potential Reasons for Preference:

- Familiarity and Convenience: Standard charging stations are more familiar to consumers and offer convenience similar to refuelling at traditional gas stations.
- Infrastructure Compatibility: EV manufacturers have heavily invested in standard charging infrastructure, making it more widely available and accessible to consumers.
- Cost Considerations: Standard charging infrastructure may be more cost effective to install and maintain compared to battery swapping stations, influencing the distribution of charging infrastructure.

3.2.2 Distribution of Power Types:

AC Power vs. DC Power: The analysis reveals a notable difference in the distribution of power types, with more stations providing AC power than DC power.

Implications of Power Type Distribution:

- Compatibility and Versatility: AC power stations are compatible with a broader range of electric vehicles, including plugin hybrids and slower charging EV models. This compatibility enhances the accessibility of charging infrastructure to a wider consumer base.
- Need for FasterCharging Capabilities: The presence of DC power stations indicates a recognition of the need for faster charging capabilities in certain locations. These stations cater to EV owners who prioritise shorter charging times, such as long distance travellers or individuals with limited charging time availability.

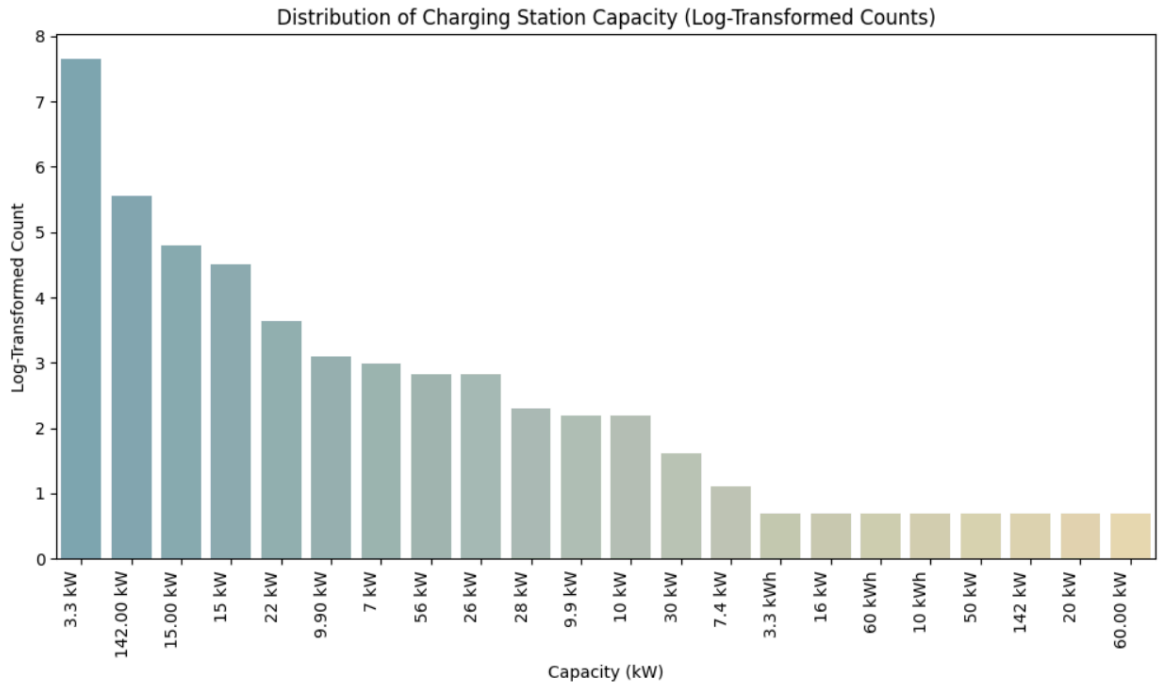
3.2.3 Strategic Considerations based on distribution of charging station type:

Product Development: Insights from the distribution of charging stations can inform the design and development of EV models. Startups may prioritise models compatible with standard charging infrastructure while also considering the demand for faster charging capabilities in certain market segments.

Infrastructure Investment: Understanding the prevalence of standard charging infrastructure vs. battery swapping solutions can guide startups in allocating resources for infrastructure development and deployment. This may involve partnerships with charging station operators or strategic investments in expanding charging networks.

Market Positioning: Startups can leverage insights from the distribution of charging stations to differentiate their offerings and position themselves competitively in the market. This may include highlighting compatibility with existing charging infrastructure or emphasising the convenience and efficiency of alternative charging solutions.

4. Distribution of Charging Station Capacities:



Prevalence of Lower Power Capacities: The bar plot indicates that the majority of charging stations have a capacity of 3.3 kW or lower. This suggests that many charging stations are designed to accommodate lower power requirements, likely catering to smaller vehicles with lower energy demands.

4.1 Reasons for Lower Capacities:

- Residential and Workplace Charging: Lower capacity charging stations are commonly installed in residential areas and workplace parking lots to provide convenient charging options for daily commuting. These stations are suitable for overnight charging or during extended periods of vehicle parking.
- Urban Settings: In densely populated urban areas, where space and infrastructure constraints may limit the installation of high power charging stations, lower capacity stations offer a practical solution for EV owners to top up their vehicles' batteries during short stops or while running errands.

4.2 Recognition of Fast Charging Needs:

- Presence of Higher Capacities: Despite the prevalence of lower power capacities, the analysis identifies the presence of charging stations with higher capacities, such as 142 kW. This indicates a recognition of the need to support fast charging capabilities for larger vehicles or to meet the demand for rapid charging in certain locations.

4.3 Implications of Higher Capacities:

- Support for Larger Vehicles: Charging stations with higher capacities accommodate larger vehicles, including electric buses, trucks, and high performance electric cars, which require faster charging rates to minimise downtime.

- Demand for Rapid Charging: Locations with higher capacity charging stations, such as highways, major thoroughfares, and commercial hubs, cater to EV owners who prioritise rapid charging to facilitate long distance travel or reduce charging wait times.

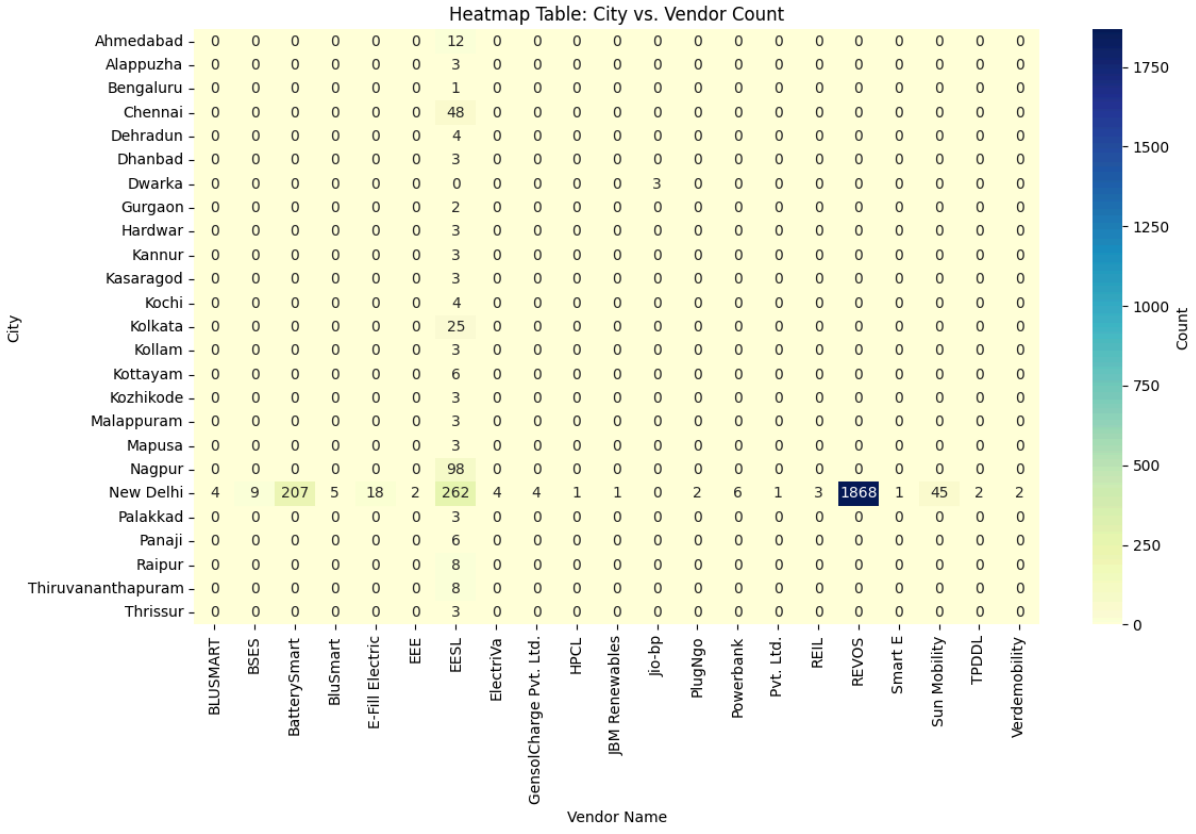
4.4 Infrastructure Planning and Deployment:

- Importance of Understanding Capacity Distribution: Understanding the distribution of charging station capacities is essential for electric vehicle infrastructure planning and deployment.

- Appropriate Sizing and Location: By analysing the distribution of charging station capacities, stakeholders can ensure that charging facilities are appropriately sized and located to meet the diverse needs of electric vehicle users across different regions and vehicle types.

- Balancing Demand and Supply: Strategic placement of charging stations with varying capacities can help balance demand and supply, optimising the utilisation of charging infrastructure while enhancing the overall EV charging experience for consumers.

5. Vendor Distribution Analysis:

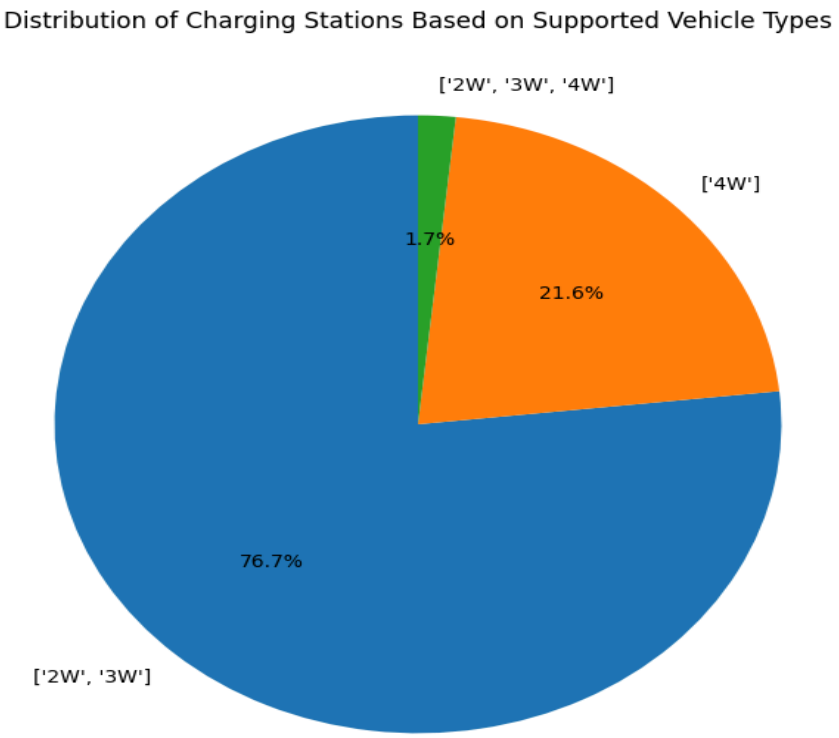


5.1 Strategic Considerations:

- Market Penetration and Expansion:
  Understanding the distribution of charging station vendors can inform strategic decisions regarding market penetration and expansion.
  Charging station providers can leverage insights from vendor distribution analysis to identify underserved markets, target specific customer segments, and tailor their offerings to meet the unique needs of different geographic regions.

- Partnerships and Collaborations:
  Charging station providers may explore partnerships and collaborations with local governments, businesses, and community organisations to enhance their presence in target markets and accelerate the deployment of charging infrastructure.
  By aligning their strategies with local stakeholders and market dynamics, charging station providers can strengthen their market position and contribute to the growth of the EV ecosystem.

6. Charging Station Distribution by Vehicle Type:



Prevalence of Stations for 2-Wheelers and 3-Wheelers:
The pie chart illustrates that the majority of charging stations are built for 2-wheelers and 3-wheelers, accounting for over 77% of the total.
Lower Representation for 4-Wheelers:
In contrast, charging stations dedicated to 4-wheelers constitute just over 22% of the total distribution.

6.1 Implications of Charging Station Distribution:

- Focus on Smaller Vehicles:
  The distribution underscores a significant focus on catering to the needs of smaller vehicles, such as motorcycles and auto-rickshaws, compared to larger vehicles like cars.
  This suggests that charging infrastructure development has prioritised accommodating the charging needs of smaller and more affordable electric vehicles, which are prevalent in urban and densely populated areas.

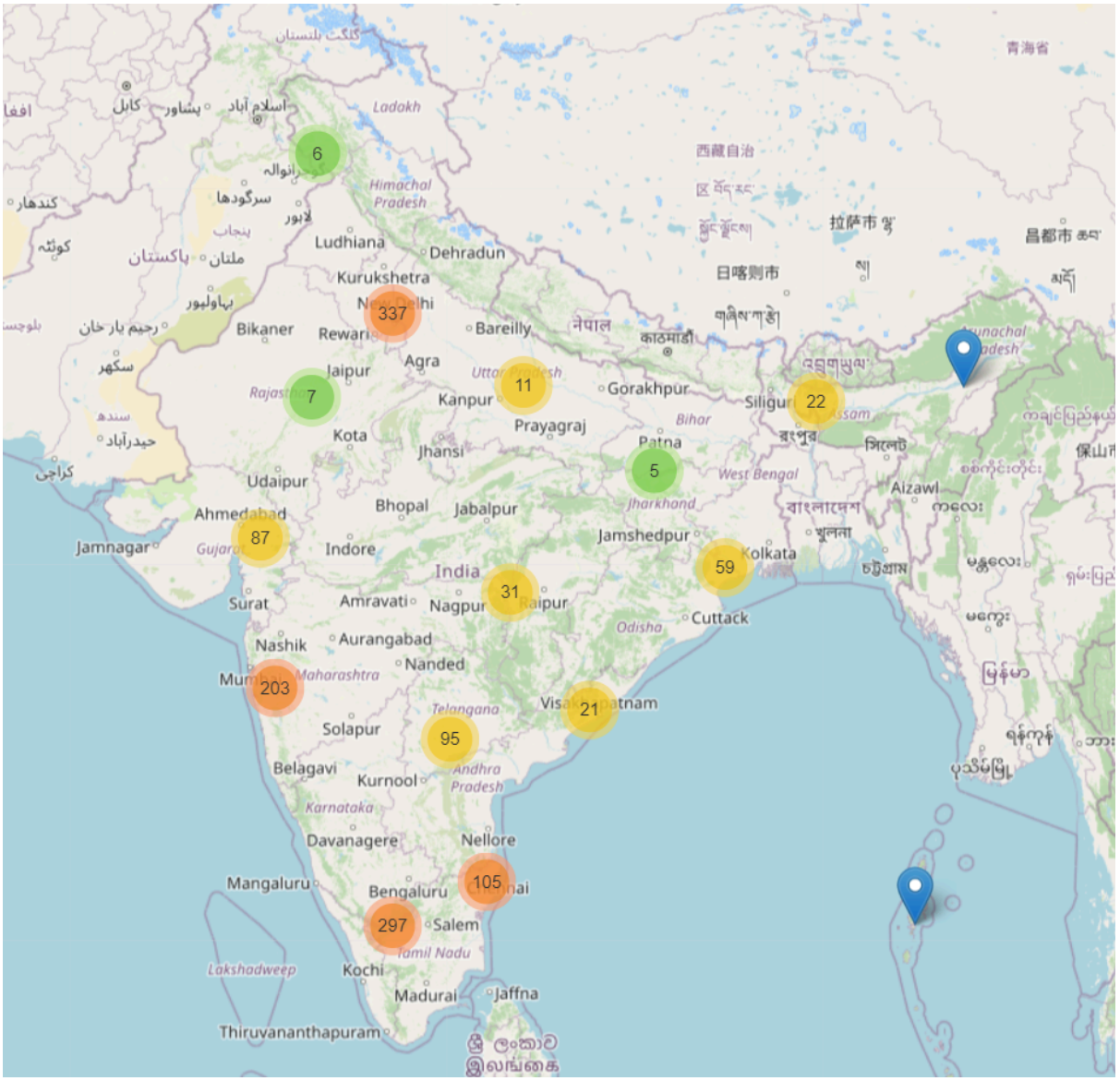
- Alignment with Market Dynamics:
  The emphasis on charging stations for 2-wheelers and 3-wheelers reflects market dynamics, where these vehicle types are more common and accessible to a broader segment of the population, particularly in urban and peri-urban areas.
  Electric 2-wheelers and 3-wheelers are often preferred for short-distance commuting, last-mile connectivity, and commercial transportation, driving the demand for charging infrastructure tailored to these vehicle segments.

7. Geographic Focus

- Geographic Distribution: The map visually represents the locations of charging stations across different regions, helping stakeholders understand the coverage and accessibility of charging infrastructure.

- Cluster Analysis: Using MarkerCluster, you can group nearby charging stations together, revealing clusters of charging infrastructure. This can help identify areas with high concentrations of charging stations, indicating potential market hotspots or areas with high demand for EVs.

- Market Segmentation: By overlaying demographic or socio-economic data onto the map, you can analyse the correlation between charging station locations and target market segments. This allows for more targeted marketing efforts and infrastructure investments.



Note: To interact with the map clustering based on location, find the map's html file in the Github link attached below.

8. Target Market Segments

Utilising the Innovation Adoption Life Cycle framework, prioritise regions in India that exhibit early adopter characteristics. These regions are likely to have higher EV adoption rates and can serve as a launchpad for market penetration.

- Urban Commuters:
  Rationale: Urban areas with high population density often experience congestion and pollution issues, making them prime candidates for sustainable transportation solutions like EVs.
  Evidence: According to census data and urban development reports, major cities in India such as Delhi, Mumbai, Bangalore, and Kolkata have some of the highest population densities in the country. High population density leads to increased traffic

congestion and air pollution, creating a demand for cleaner and more efficient transportation alternatives like EVs.

- Fleet Operators:
  Description: Businesses and organisations operating fleets of vehicles for logistics, delivery, transportation, or ride-sharing services.
  Rationale: Fleet operators stand to benefit significantly from the adoption of electric vehicles due to lower operating costs, reduced emissions, and potential government incentives.
  Strategy: Offer tailored solutions such as fleet electrification packages, charging infrastructure partnerships, and fleet management software to optimize electric vehicle usage and maintenance.
- Commercial Establishments:
  Description: Shopping malls, hotels, restaurants, office complexes, and other commercial establishments with parking facilities.
  Rationale: Commercial establishments can attract environmentally-conscious customers and enhance their corporate social responsibility (CSR) initiatives by offering EV charging facilities.
  Strategy: Collaborate with commercial establishments to install charging stations, offer incentives for EV owners, and leverage branding opportunities to promote sustainable transportation options.
- Shared Mobility Providers:
  Description: Companies offering car-sharing, bike-sharing, scooter-sharing, and ride-hailing services in urban areas.
  Rationale: Shared mobility providers can reduce urban congestion and pollution by transitioning their fleets to electric vehicles.
  Strategy: Form partnerships with shared mobility providers to deploy electric vehicles in their fleets, integrate EV charging infrastructure into their operations, and incentivize users to choose electric options.
- Residential Communities:
  Description: Apartment complexes, gated communities, and housing societies with dedicated parking facilities.
  Rationale: Residents of residential communities are potential EV owners who require convenient access to charging infrastructure for their vehicles.
  Strategy: Work with property developers and homeowners associations to install EV charging stations in residential parking areas, provide education and incentives for EV adoption, and promote community-wide sustainability initiatives.
- Tourist Destinations:
  Description: Tourist attractions, resorts, national parks, and recreational areas frequented by visitors.
  Rationale: Tourist destinations can enhance visitor experiences and promote sustainable tourism by offering EV charging facilities.
  Strategy: Partner with tourist destinations to install charging stations, promote eco-friendly transportation options, and leverage tourism marketing campaigns to raise awareness of EV adoption.

- Government and Public Sector:
  Description: Government agencies, municipalities, and public institutions responsible for urban planning, transportation, and infrastructure development.
  Rationale: Governments play a crucial role in promoting EV adoption through policy incentives, funding support, and infrastructure development.
  Strategy: Engage with government stakeholders to advocate for EV-friendly policies, secure grants or subsidies for EV infrastructure projects, and participate in public-private partnerships for sustainable urban development.

Pricing Strategy:

Implement a strategic pricing range for EV products, considering the psychographics of early adopters. Offer competitive pricing while highlighting the long term cost savings associated with EV ownership, including lower fuel and maintenance expenses.

Conclusion:

The analysis of charging station data provides valuable insights into the Indian EV market landscape. By targeting specific market segments, focusing on key geographic areas, and implementing a strategic pricing strategy, the Electric Vehicle Startup can position itself for success in the burgeoning Indian EV market.

Github Link:

https://github.com/harikrsna23/Indian-EV-market-segment

Find the datasets, steps performed for analysis and html file of Maps for the clustering of regions in the above link.

Market Segmentation

Utilizing market segmentation analysis for Electric Vehicles in India.

By
Mr. Rohan Safar
rohansafar1416@gmail.com

GitHub link: https://github.com/RohanIncantato/EV_Market_Segmentation

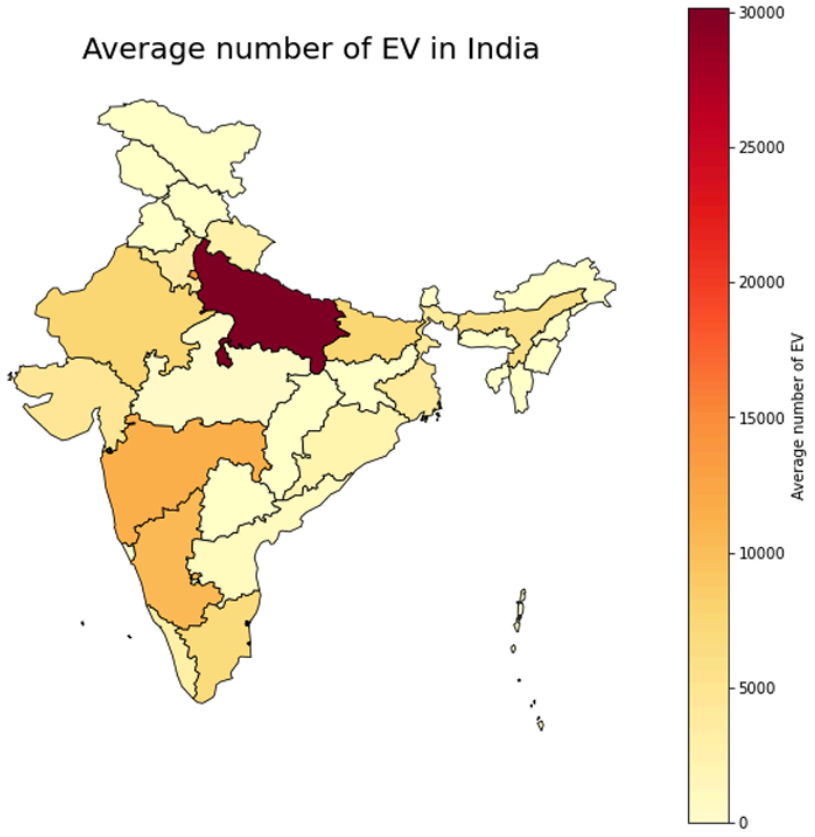
Introduction:

Conducted a detailed market segmentation analysis of India's electric vehicle (EV) market to identify and prioritize consumer segments with the greatest potential for EV adoption. Based on the available data, this analysis took into account a variety of segmentation criteria, including geographic, demographic, psychographic, behavioral, and any other relevant aspects. The goal is to recommend a strategic entry strategy for our Electric Vehicle Startup by focusing on the most promising customer segments, identifying their specific needs, preferences, and adoption barriers, and providing actionable insights to tailor our products, marketing, and distribution strategies accordingly. This report should be based on a thorough data gathering, research, and analysis of the Indian EV market.

Market Analysis:

The electric vehicle (EV) market has increased during the last year. The 999,949 EVs sold in 2022 represent a 210% increase over the 322,871 units sold in 2021. The two- and three-wheeler segments, known as the "close to the bottom peaches" of the EV industry, account for the majority of the growth. They are the primary drivers of EV sales since they are less expensive than the electric passenger or commercial vehicle markets. According to the Economic Survey 2023, India's domestic electric car sector will increase at a CAGR of 94.4 percent between 2022 and 2030, reaching 10 million sales per year by that time. Furthermore, it is projected that by 2030.

The overall number of electric vehicles (EVs) in each state, as well as a graphic representation of their saturation from below , provide useful insights regarding EV adoption and distribution across areas.



Electric Vehicle Market in India by 2030, India's vehicle sector, which presently ranks sixth globally, is expected to overtake the United States as the largest. According to the India Energy Storage Alliance (IESA), the Indian EV industry is expected to expand at a 36% CAGR.By 2030, NITI Aayog expects EV market penetration of 70% for all commercial vehicles, 30% for private vehicles, 40% for buses, and 80% for two- and three-wheelers. The goal of reaching net zero carbon emissions by 2070 aligns with this.

Datasets:
https://drive.google.com/drive/folders/1gzxyxEEA1GPgoUelU7rragjX4FXZ4OpF

DataSet1:
This dataset provides insights into the vehicle registration statistics for different categories of vehicles in various states of India, as per the Central Motor Vehicles Rules.

1. Sl. No: Serial number
2. State: Name of the Indian state for which the vehicle registration data is provided.
3. Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules): Number of two-wheelers registered in categories L1 and L2 as per the Central Motor Vehicles Rules.

4. Two Wheelers (Category L2 (CMVR)): Number of two-wheelers registered in category L2 as per the CMVR.
5. Two Wheelers (Max power not exceeding 250 Watts): Number of two-wheelers with maximum power not exceeding 250 Watts.
6. Three Wheelers (Category L5 slow speed as per CMVR): Number of three-wheelers registered in category L5 as per the CMVR, specifically for slow-speed vehicles.
7. Three Wheelers (Category L5 as per CMVR): Number of three-wheelers registered in category L5 as per the CMVR.
8. Passenger Cars (Category M1 as per CMVR): Number of passenger cars registered in category M1 as per the CMVR.
9. Buses: Number of buses registered in the state.
10. Total in state: Total number of registered vehicles in the state, summing up across all categories.

DataSet2:
This dataset gives information about the availability of EV charging infrastructure along various expressways and highways, which is crucial for supporting the adoption and usage of electric vehicles for long-distance travel.

1. Sl. No: Serial number or index of the data entry.
2. Category: Specifies the category of infrastructure, which in this case differentiates between expressways and highways.
3. Expressways/Highways: Indicates the specific expressway or highway route for which the data is provided.
4. EV Charging Stations Sanctioned: Represents the number of EV charging stations that have been sanctioned or approved for installation along the specified expressway or highway route.

DataSet3:
This dataset contains information about EV charging stations, including their location details, type, power capacity, and any additional services provided.
1. No:
2. Region:
3. Address:
4. Aux Address
5. Latitude:
6. Longitude:
7. Type:
8. Power
9. Service:

DataSet4:
This dataset provides information about the monthly sales or registrations of electric vehicles in India

1. Month: This column likely represents the time period for which the data is recorded, typically in monthly intervals.
2. Electric vehicle: (India): This column contains the number of electric vehicles sold or registered in India for each corresponding month.

a) Geographic and Demographic Research:

The analysis of total electric cars (EVs) by state provides useful insights into EV uptake and distribution across different regions. By analyzing the overall number of EV registrations in each state, we discovered regions with greater adoption rates. States with larger populations or more incentives for electric vehicle adoption may have higher numbers.

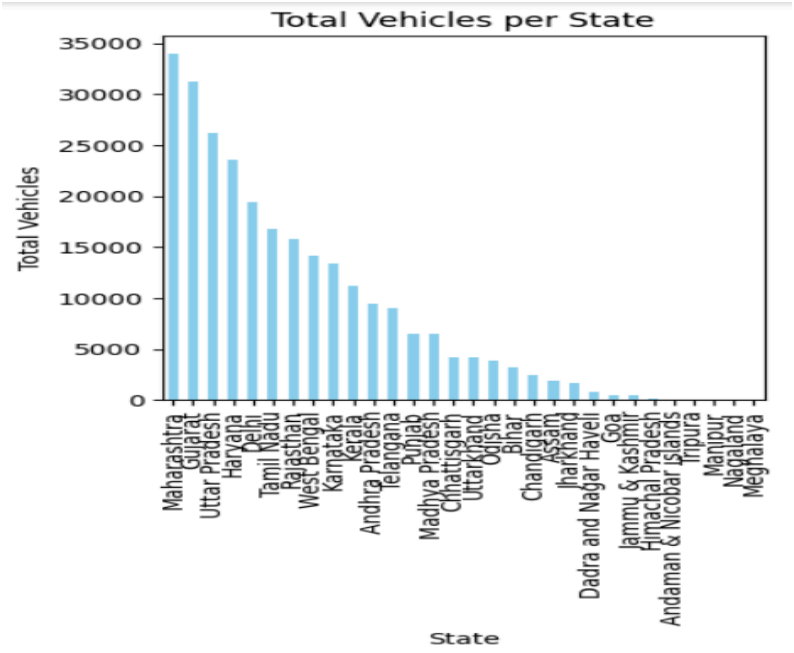
Demographics of states with increased EV adoption can assist segment the market. For example, urban locations with a younger, more ecologically conscious populace may have higher adoption rates than rural areas. Identifying states with lower EV adoption rates opens up potential for market expansion and targeted marketing initiatives. These areas could benefit from awareness campaigns, incentives, or better infrastructure to increase EV adoption.

Geographic segmentation involves dividing the market by consumer geography and targeting locations with higher EV adoption rates for marketing and sales.

Targeting specific demographics, such as urban dwellers, tech-savvy folks, or environmentally sensitive consumers, can increase the likelihood of EV adoption.

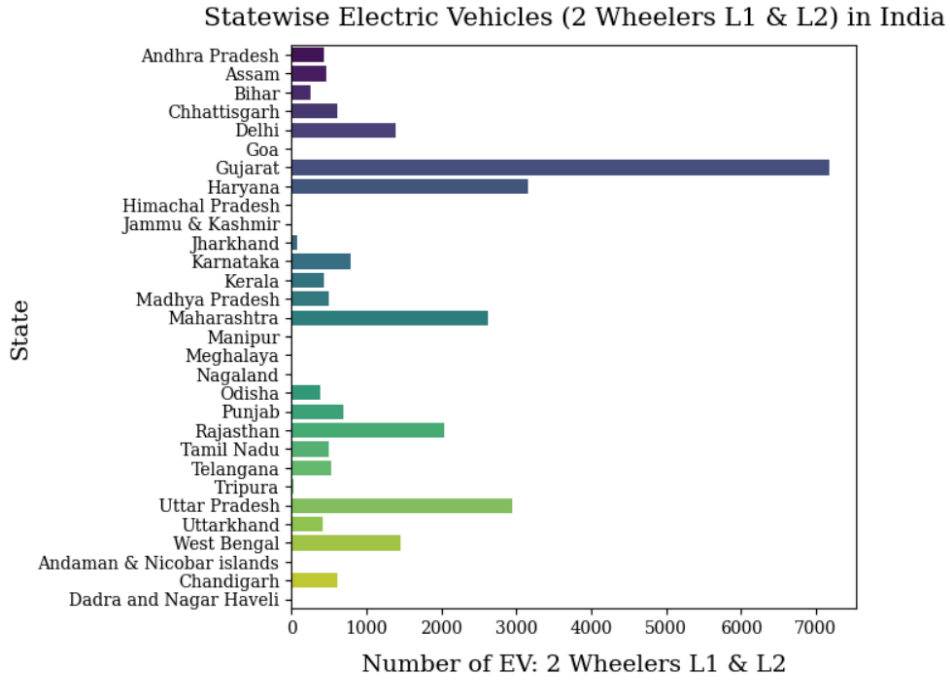
Behavioral segmentation involves categorizing consumers based on their attitudes, beliefs, and behaviors towards EV adoption, and adapting marketing messages and incentives appropriately.

The total number of electric vehicles (EVs) per state is presented here, providing significant insights on the adoption and distribution of EVs throughout different regions.

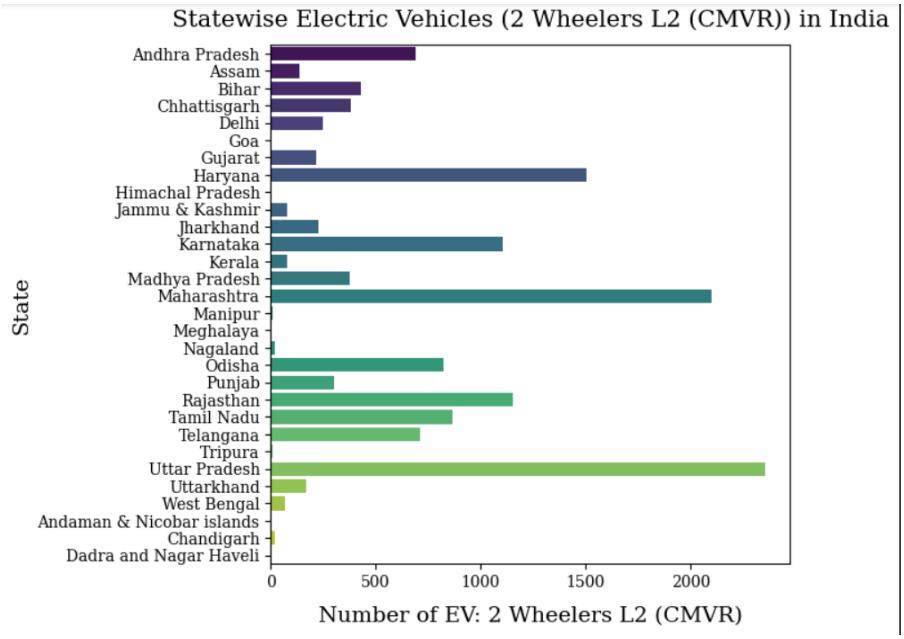


- Representing the demographic views of different types of vehicles as per the Central Motor Vehicles Rules (CMVR). Here's what each category typically refers to:

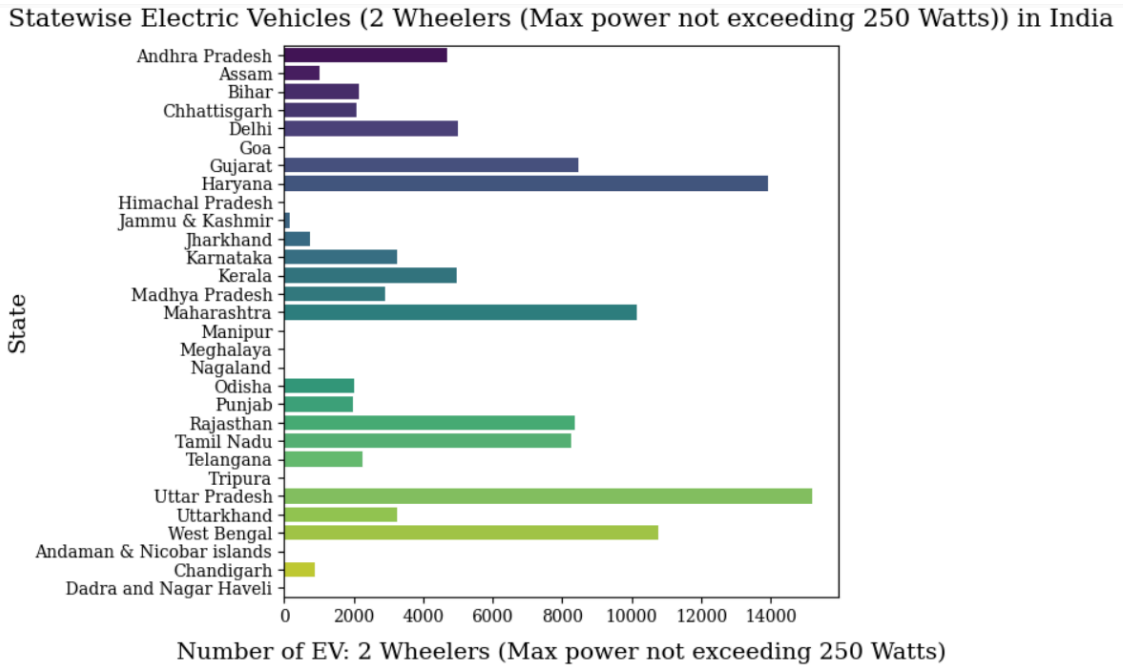
1. **Two Wheelers (Category L1 & L2 as per Central Motor Vehicles Rules):**
   Number of two-wheelers registered in categories L1 and L2 as per the Central Motor Vehicles Rules. These categories include different types of two-wheelers based on engine capacity, type, and other factors.



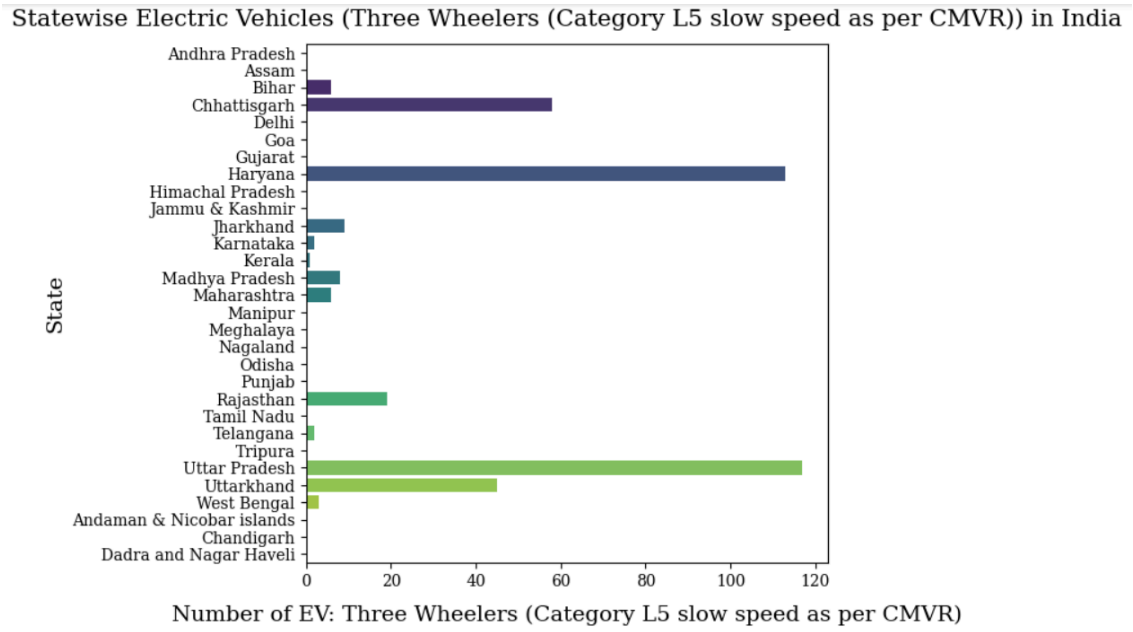
2. **Two Wheelers (Category L2 (CMVR))**:
   Number of two-wheelers registered in category L2 as per the CMVR. This category likely represents a specific subcategory of two-wheelers.



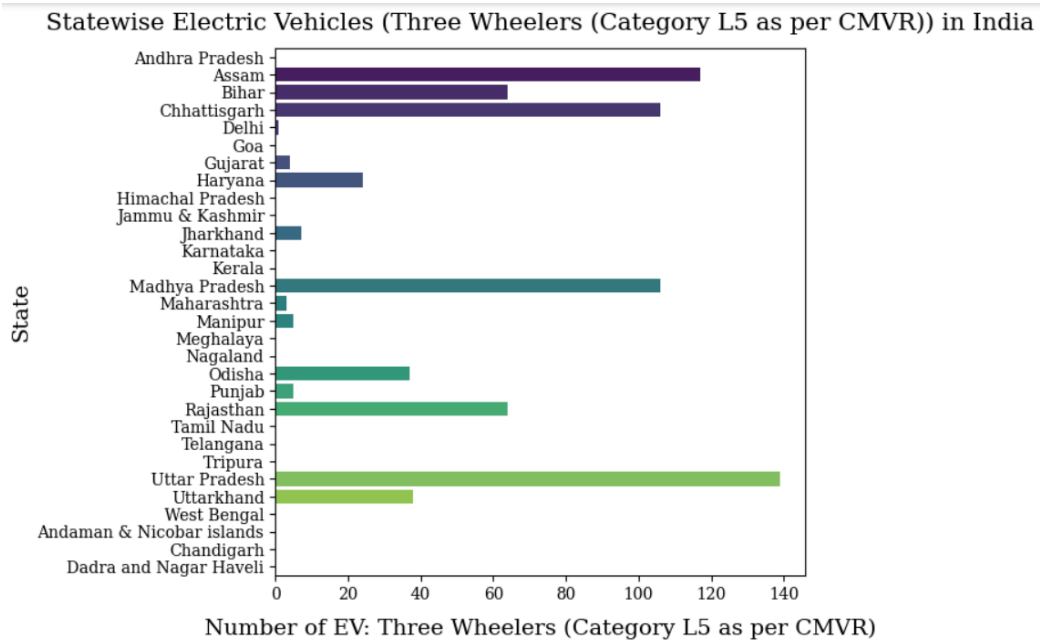
3. **Two Wheelers (Max power not exceeding 250 Watts)**:
   Number of two-wheelers with maximum power not exceeding 250 Watts. These are electric bicycles or scooters with low power ratings.



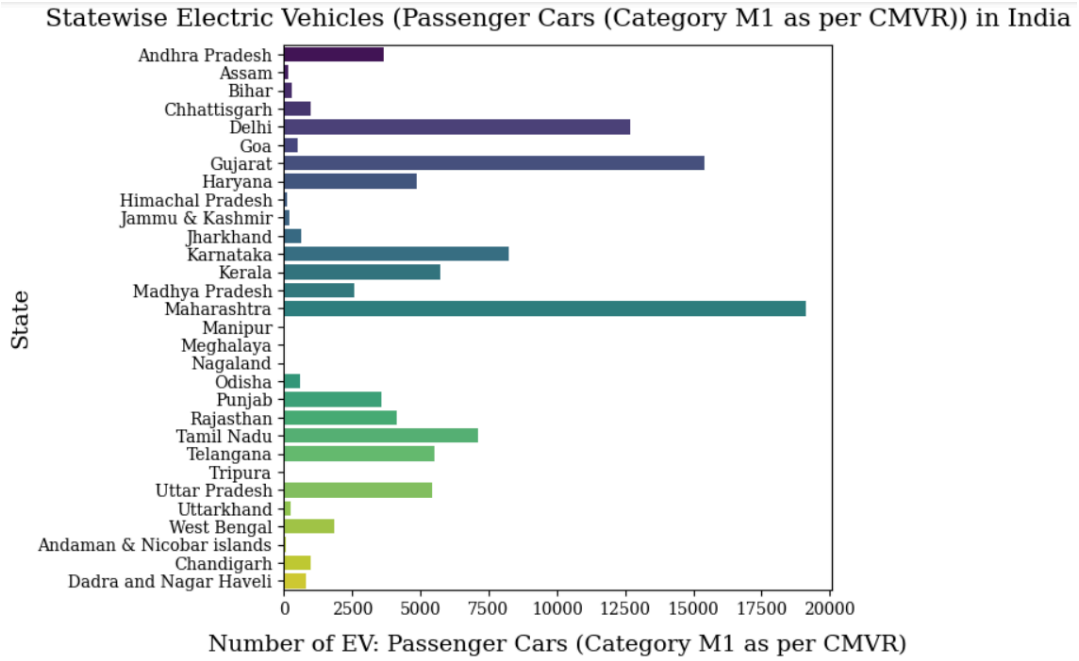
4. **Three Wheelers (Category L5 slow speed as per CMVR)**:
   Number of three-wheelers registered in category L5 as per the CMVR, specifically for slow-speed vehicles.



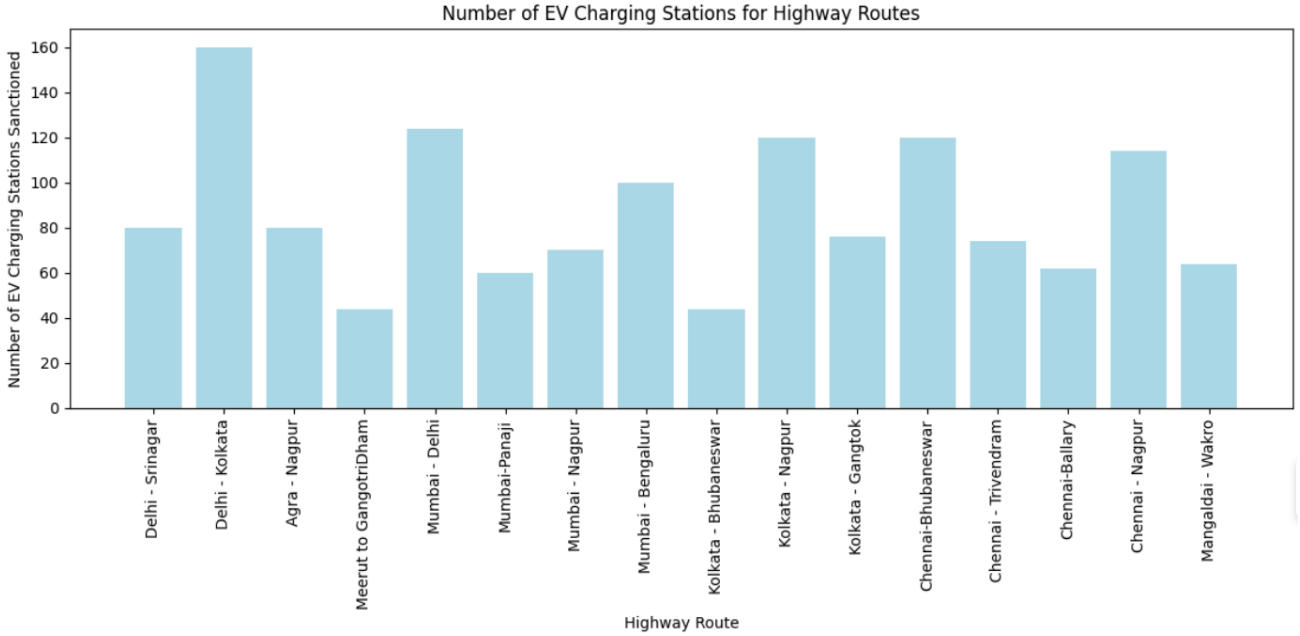
5. **Three Wheelers (Category L5 as per CMVR)**:
   Number of three-wheelers registered in category L5 as per the CMVR. This category may represent a specific type or class of three-wheelers.



6. **Passenger Cars (Category M1 as per CMVR)**:
   Number of passenger cars registered in category M1 as per the CMVR. Category M1 typically includes cars designed to carry passengers with a maximum of eight seats (excluding the driver's seat)

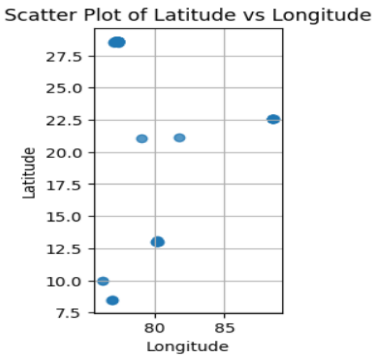


- **EV charging infrastructure:**
  The installation of charging stations in important cities along this corridor, including Delhi, Chennai, Kolkata, and Nagpur, ensures that electric freight vehicles have access to charging infrastructure at strategic transit points.



Based on the information presented above, we can see the importance of the Delhi-Kolkata Freight Corridor. The Delhi-Kolkata freight corridor is critical to India's transportation infrastructure, allowing for the efficient transit of products and commodities between the country's northern and eastern areas. This corridor is crucial to the logistics and supply chain business.

The availability of electric vehicle charging infrastructure along various highway routes A scatter plot of latitude and longitude depicts the spatial distribution of electric car charging stations, which can help with electric vehicle infrastructure planning, analysis, and decision-making.



Electric Vehicle Sales Growth:

Electric vehicle (EV) sales in India remained relatively stagnant until 2016. After that, there was a significant uptick in growth, with a remarkable Compound Annual Growth Rate (CAGR) of 40.3%.

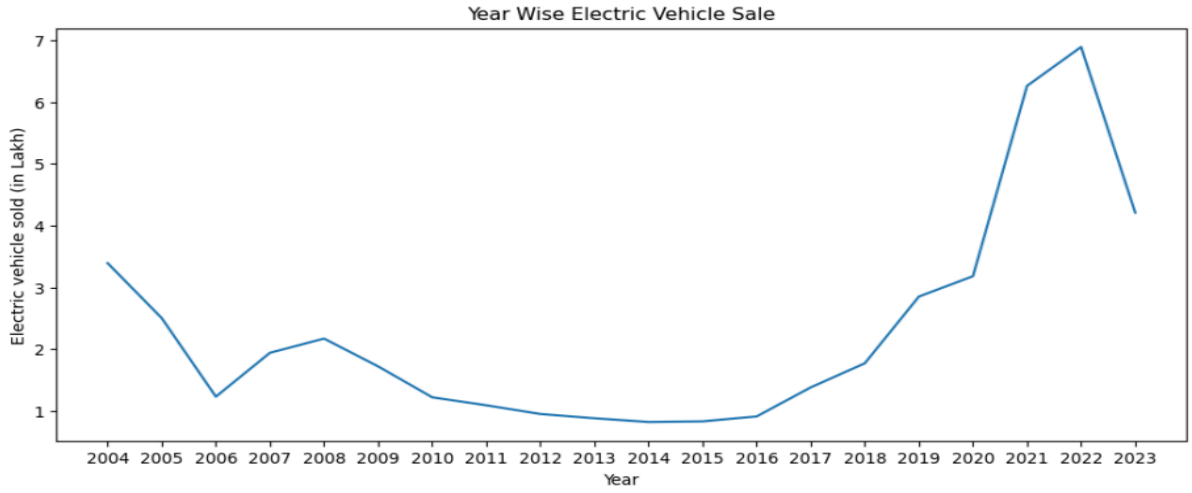


Fig 1: Year wise Electric vehicle production

Now , Sales Peaks that are notable :

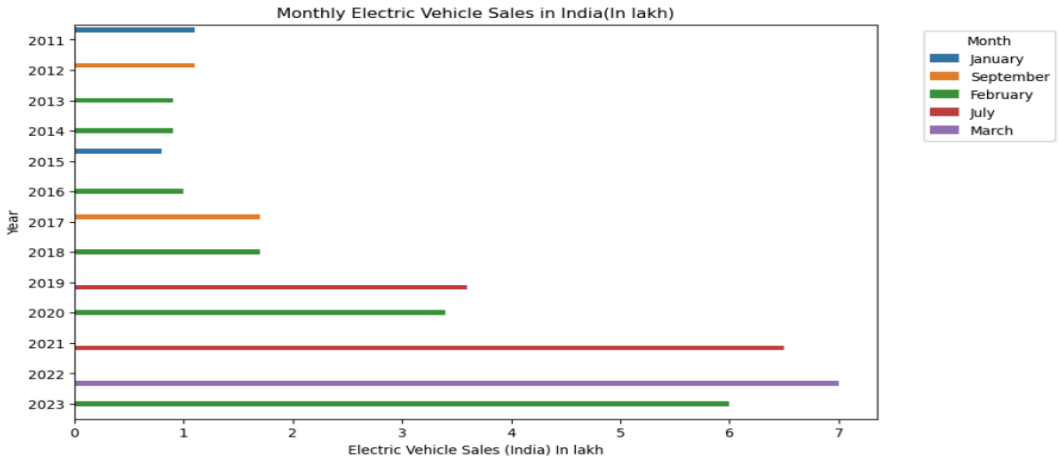


Fig 2 . Electric vehicle sales

Now , Seasonal Sales Peaks that are notably the highest EV sales occur typically in the months of January, February, March, July, and September. Mainly due Indian customer behavior at the festival.

- **Conclusion:**

1. Maximum no. of charging stations are installed at Delhi-Kolkata i.e. Nearly 160. Chennai, Kolkata, Nagpur, Delhi are top cities through which the highway passes which has the highest no. of charging stations.

2. EV sales growth was stagnant until 2016 after that it grew significantly with 40.3% CAGR Maximum Sales can be observed in either January, February, March or July, September month.

3. Most charging stations in India are in Maharashtra followed by Karnataka, Delhi and Tamil Nadu which have popular cities.

4. 70% of the total electric vehicles are manufactured in such a way that they contain 5 seats. But the most efficient cars are 6 seater cars. Almost 60% of the electric cars are Automatic transmission rather than manual.

5. The adoption of electric vehicles in India is still in its early stages, but there are evidence that this trend is shifting. The Indian government has been pushing the use of electric vehicles for several years, and efforts are underway to eliminate the current barriers to their adoption. While there are still challenges to solve, the future of transportation in India may be electric, which could help to lower the country's carbon footprint and improve air quality in major cities.

Project Report

Electric Vehicle Market Segmentation

Subodh Wasekar

Objective

The objective of this project is to analyze and segment customers in the electric vehicle market based on their vehicle type, battery type, charging type, and battery capacity. The primary goal is to optimize product features and identify a target segment that exhibits specific characteristics, ultimately improving market competitiveness and customer satisfaction.

Data Source

The dataset is taken from the report of Electric vehicle charging Infrastructure and its Grid Integration in India by GILAB@IITB.The dataset includes information about various electric vehicles, such as vehicle type, battery type, charging type, and battery capacity.

Methodology

1. **Data Exploration**
    - The dataset is loaded and examined to understand its structure and basic statistics.
    - Initial exploration involves checking for missing values, data types, and identifying potential features for segmentation.

```
df.head()
```

	Vehicle type	Model	Battery technology	Charging type	Battery capacity (kWh)
0	2W	Electric Photon HX	Li-Ion	AC slow\ncharging	1.872
1	2W	Nyx HX (Dual\nBattery)	Li-Ion	AC slow\ncharging	3.072
2	2W	NYX LX	Li-Ion	AC slow\ncharging	1.536
3	2W	OPTIMA LX\n(VRLA)	VRLA	AC slow\ncharging	0.96
4	2W	Optima LX	Li-Ion	AC slow\ncharging	1.536

2. **Feature Engineering and Preprocessing**
    - Relevant features, including 'Vehicle type,' 'Battery type,' 'Charging type,' and 'Battery capacity (kWh),' are selected for segmentation.
    - Categorical features are encoded using LabelEncoder to prepare the data for clustering.

- Numerical features are standardized using StandardScaler to ensure uniform scaling.

```
df.head()
```

	Vehicle type	Model	Battery technology	Charging type	Battery capacity (kWh)
0	0	Electric Photon HX	0	1	1.872
1	0	Nyx HX (Dual\nBattery)	0	1	3.072
2	0	NYX LX	0	1	1.536
3	0	OPTIMA LX\n(VRLA)	2	1	0.96
4	0	Optima LX	0	1	1.536

3. Dimensionality Reduction with PCA

- Principal Component Analysis (PCA) is applied to reduce the dimensionality of the feature set.
- This step helps in visualizing and clustering the data effectively.

```
# Extracting features for pca
X=df[['Vehicle type','Battery technology','Charging type','Battery capacity (kWh)']]
```

```
# Standardizing the features
scaler=StandardScaler()
X_scaled=scaler.fit_transform(X)
```

```
X_scaled
```

```
array([[-0.92238026, -0.78219274, -0.52530028, -0.38671826],
       [-0.92238026, -0.78219274, -0.52530028, -0.3222505 ],
       [-0.92238026, -0.78219274, -0.52530028, -0.40476924],
```

4. Clustering with K-means

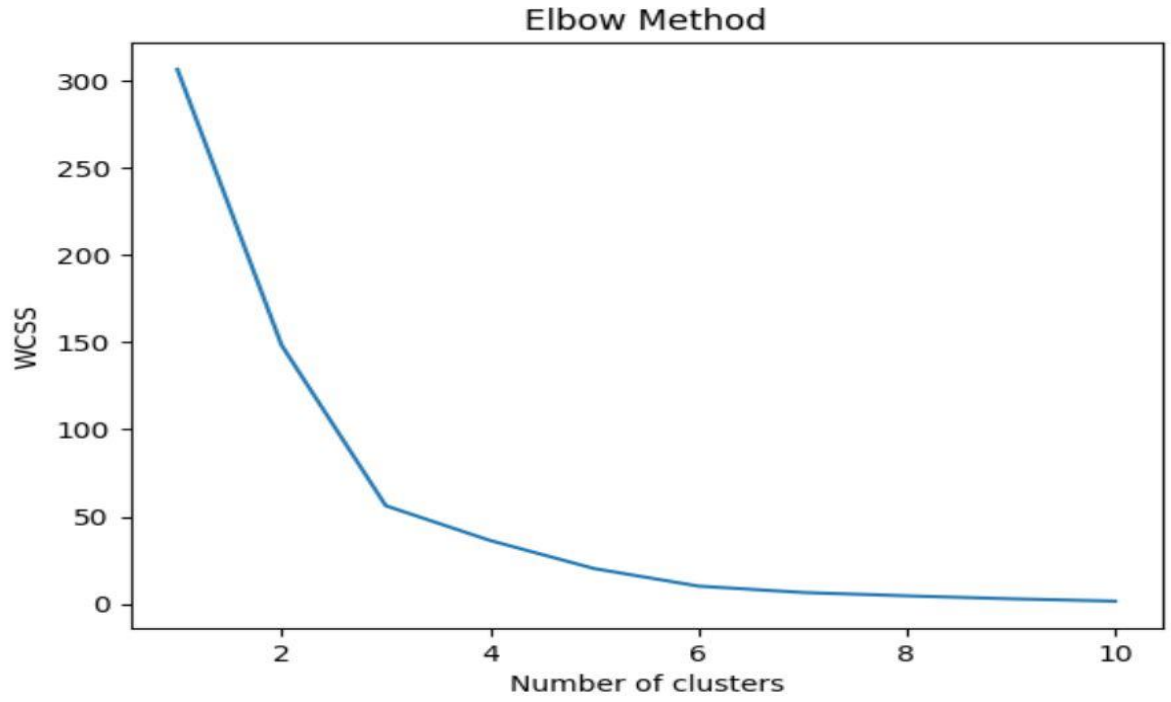
- The K-means clustering algorithm is utilized to group customers into segments based on their reduced feature set.
- The Elbow Method is employed to determine the optimal number of clusters (k).

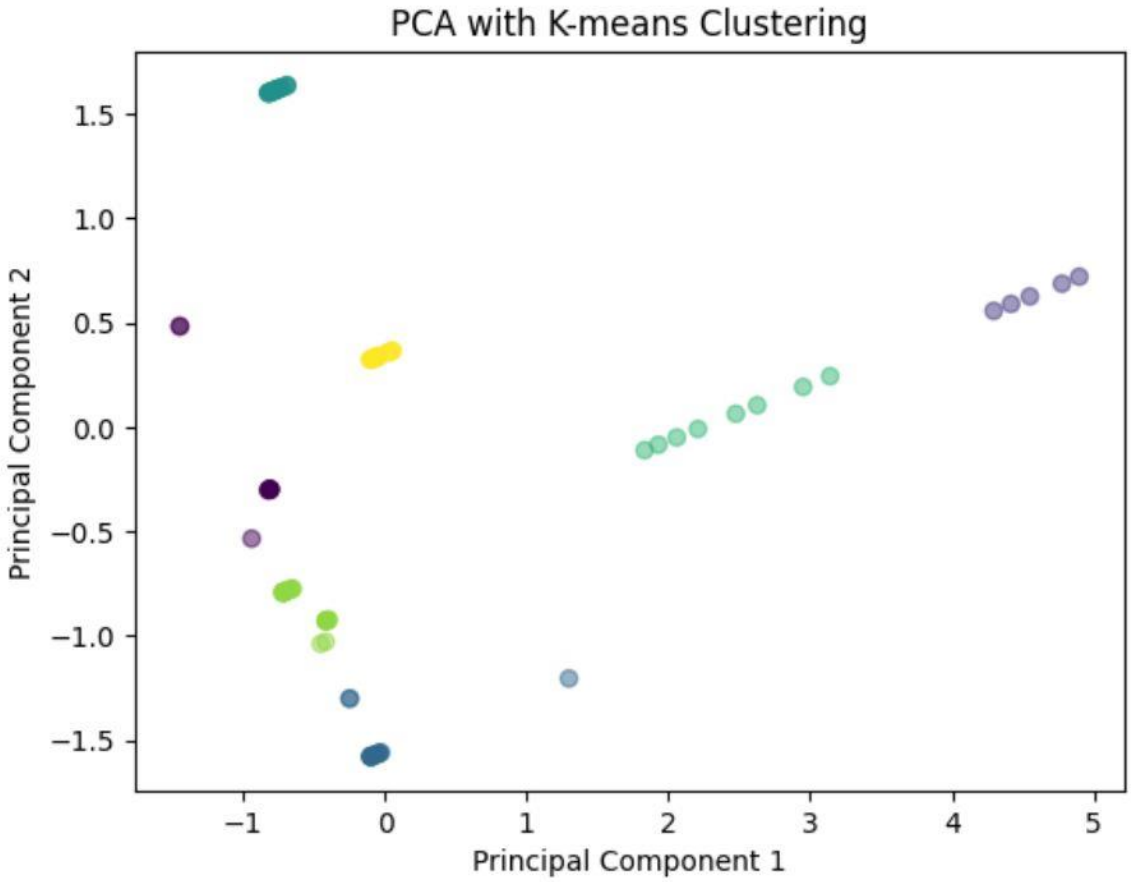
5. Elbow Method

- The Elbow Method involves running K-means clustering for a range of values of k and plotting the Within-Cluster Sum of Squares (WCSS) against k.
- The "elbow" point in the graph helps identify the optimal number of clusters, providing a balance between model complexity and segmentation effectiveness.

```
# Finding the  optimal number of clusters using the Elbow Method
wcss = [] #wcss: within cluster sum of squares
for i in range(1, 11):
    kmeans = KMeans(n_clusters=i, init='k-means++', max_iter=300, n_init=10, random_state=42)
    kmeans.fit(X_pca)
    wcss.append(kmeans.inertia_)
```

- Below plots show the optimal number of clusters and PCA with k-means clustering.





6. **Segment Profiling**
    - After clustering, the mean of each feature within each cluster is calculated to create segment profiles.
    - Segment profiling allows for a deeper understanding of the characteristics and preferences of different customer groups.

```
# Calculating mean of each features within each clusters
segment_profile = df.groupby('Segment')[numeric_columns].mean()
print(segment_profile)
```

```
         Vehicle type  Battery technology  Charging type  \
Segment
0              0.0000            1.818182       3.090909
1              2.0000            0.000000       5.000000
2              0.0625            0.000000       4.000000
3              1.0000            2.000000       0.000000
4              2.0000            0.000000       5.000000
5              0.0000            0.304348       2.000000
6              1.0000            0.000000       0.000000

         Battery capacity (kWh)  Segment
Segment
0                     1.131636      0.0
1                    84.740000      1.0
2                     2.418250      2.0
3                     4.983478      3.0
4                    23.968750      4.0
5                     2.281130      5.0
6                     5.495333      6.0
```

7. **Target Segment Selection**
    - The target segment is selected based on specific criteria, such as the highest average 'Battery capacity (kWh)', 'Vehicle type' and 'Battery technology' within the segment profiles.
    - This step aligns with the project objective of optimizing product features to meet the preferences of the identified target customer group.

```
# Based on  highest battery capacity
target_segment = segment_profile['Battery capacity (kWh)'].idxmax()
print("Target Segment:", target_segment)
```

```
Target Segment: 1
```

```python
# Based on vehicle type and battery technology
segment_profile[['Vehicle type', 'Battery technology']]
selected_segment = segment_profile[(segment_profile['Vehicle type'] == 1) & (segment_profile['Battery technology'] == 0)]
print("Selected Segment:\n", selected_segment)
```

```
Selected Segment:
          Vehicle type  Battery technology  Charging type  \
Segment
6                 1.0                 0.0            0.0

         Battery capacity (kWh)  Segment
Segment
6                      5.495333      6.0
```

8. Conclusion

By implementing K-means clustering and utilizing the Elbow Method for cluster number selection, this project successfully segments customers in the electric vehicle market. The resulting target segment, identified through objective criteria, provides actionable insights for optimizing product features and tailoring offerings to specific customer preferences.

Github Link