Market Segmentation Analysis of Electric Vehicles Market in India

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Abstract:

Amidst the ongoing depletion of fossil fuels and the subsequent price escalation, the automotive industry is actively exploring alternative energy resources. Electric Vehicles (EVs) have emerged as a promising solution to address environmental concerns and meet the evolving demands of the Indian market. Despite the implementation of government policies, the adoption of EVs in India has encountered challenges. This comprehensive report delves into the substantial potential of EVs within the Indian context. By scrutinizing market segments and strategic locations, the report also provides valuable insights for nascent EV startups, assisting them in navigating this dynamic landscape effectively. Through an in-depth analysis, the report contributes to a more nuanced understanding of the evolving EV ecosystem in India, its challenges, and opportunities for growth.

BACKGROUND

Industries evolve over time due to changes in technology and what customers prefer. In recent years, the electric vehicle (EV) industry has been growing, with governments worldwide getting involved to encourage its development. India, too, is focusing on EVs, aiming for a significant share of vehicle sales to be EVs by 2030. Several Indian states have also created their own EV policies. The government's plan includes making EVs affordable, building places to charge them, and promoting their use in smaller vehicles. This will not only help the environment but also create job opportunities in the country. Many Indian car manufacturers have started introducing EV models.

The EV sector is rapidly advancing in many countries, not only in terms of technology but also in government regulations and consumer demands. Previous studies about EVs might not be relevant anymore due to the fast-paced changes in the industry. While research has been conducted on EVs in other countries, there is limited information about the Indian EV market. This report aims to fill this gap by providing insights into the concerns of Indian consumers regarding EVs. Policymakers and business professionals can use this information to make better decisions and strategies, ultimately encouraging more Indian consumers to adopt EVs.

It's important to keep in mind that the EV industry's growth is closely linked to government policies, technological advancements, and consumers' preferences, all of which are rapidly evolving. This report aims to contribute to a better understanding of these dynamics and their impact on EV adoption in India

DATA SOURCES

1. Ritesh Kate
   https://www.kaggle.com/code/kerneler/starter-evs-one-electric-vehicle-4adc62ea-d

2. Abhishek Kumar
   https://www.kaggle.com/datasets/deadprstkrish/ev-cars-user-reviews-india

3. PiyushSingh
   https://dataspace.mobi/dataset/electric-vehicle-charging-station-list/resource/f39bb18a-bf5b-4e93-a22e-91f13b2ad9a7

   https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset

4. Chirag Jain
   https://www.kaggle.com/datasets/divyanshusingh18/ev-cars-india-2023

5. Alen Sadique
   https://www.kaggle.com/datasets/geoffnel/evs-one-electric-vehicle-dataset

Data Pre-processing

The Libraries that we have used for data preprocessing are as follows:

1. NumPy: NumPy is a fundamental package for scientific computing with Python. It provides support for large, multi-dimensional arrays and matrices, along with a wide range of mathematical functions to operate on these arrays. NumPy is widely used for numerical computations and data manipulation in various fields of science and engineering.

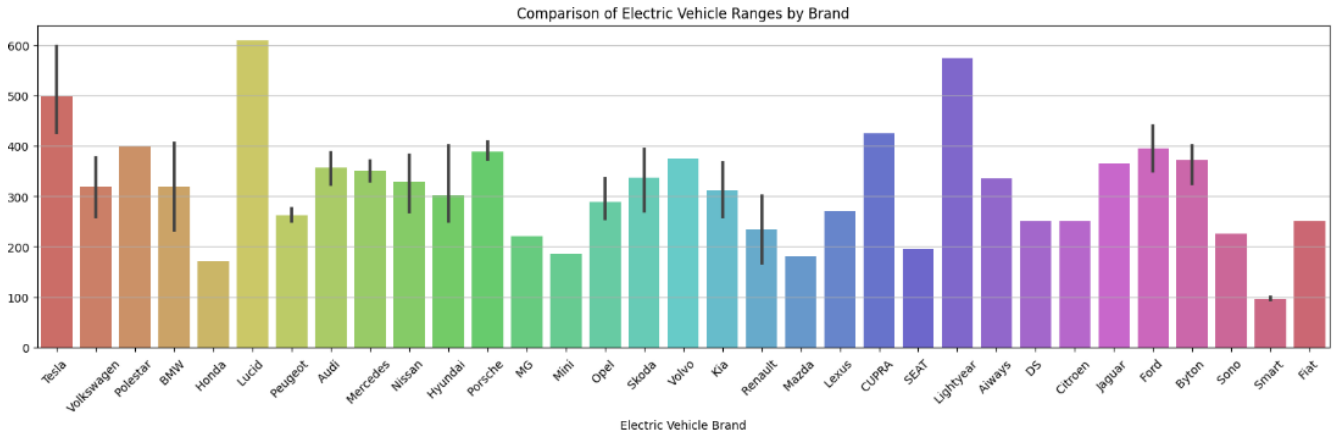
2. Pandas: Pandas is a powerful library for data manipulation and analysis. It provides data structures like DataFrame and Series, which allow you to easily handle and analyze structured data. Pandas is commonly used for data cleaning, transformation, exploration, and basic statistical analysis.

3. Seaborn: Seaborn is a data visualization library based on Matplotlib that provides a higher-level interface for creating attractive and informative statistical graphics. It simplifies the process of creating complex visualizations and supports a wide range of statistical plots like scatter plots, histograms, box plots, and more.

4. Matplotlib: Matplotlib is one of the most widely used data visualization libraries in Python. It provides a flexible and comprehensive set of tools for creating various types of plots, charts, and figures. Matplotlib is highly customizable and allows you to control every aspect of your visualizations.

5. scikit-learn (sklearn): Scikit-learn is a widely-used machine learning library in Python. It provides a simple and efficient way to perform various machine learning tasks, including classification, regression, clustering, dimensionality reduction, and more. Scikit-learn is built on top of other scientific Python libraries like NumPy, SciPy, and Matplotlib, making it an essential tool for data preprocessing, feature selection, model training, and evaluation. It also includes various utilities for data splitting, cross-validation, and hyperparameter tuning.

```
# Evaluating Electric Vehicle Brand's Influence on Acceleration
# Create a figure with specified dimensions
figure = plt.figure(figsize=(20, 5))

# Create a bar plot using seaborn, showing the relationship between Brand and Range_Km using data from 'ev' dataframe, wi
sns.barplot(x='Brand', y='Range_Km', data=ev, palette='hls')

# Add gridlines along the y-axis
plt.grid(axis='y')

# Set the title of the plot
plt.title('Comparison of Electric Vehicle Ranges by Brand')

# Label the x and y axes
plt.xlabel('Electric Vehicle Brand')
plt.ylabel('Range per Kilometer')

# Rotate x-axis labels for better readability
plt.xticks(rotation=45)
```



```
result
```

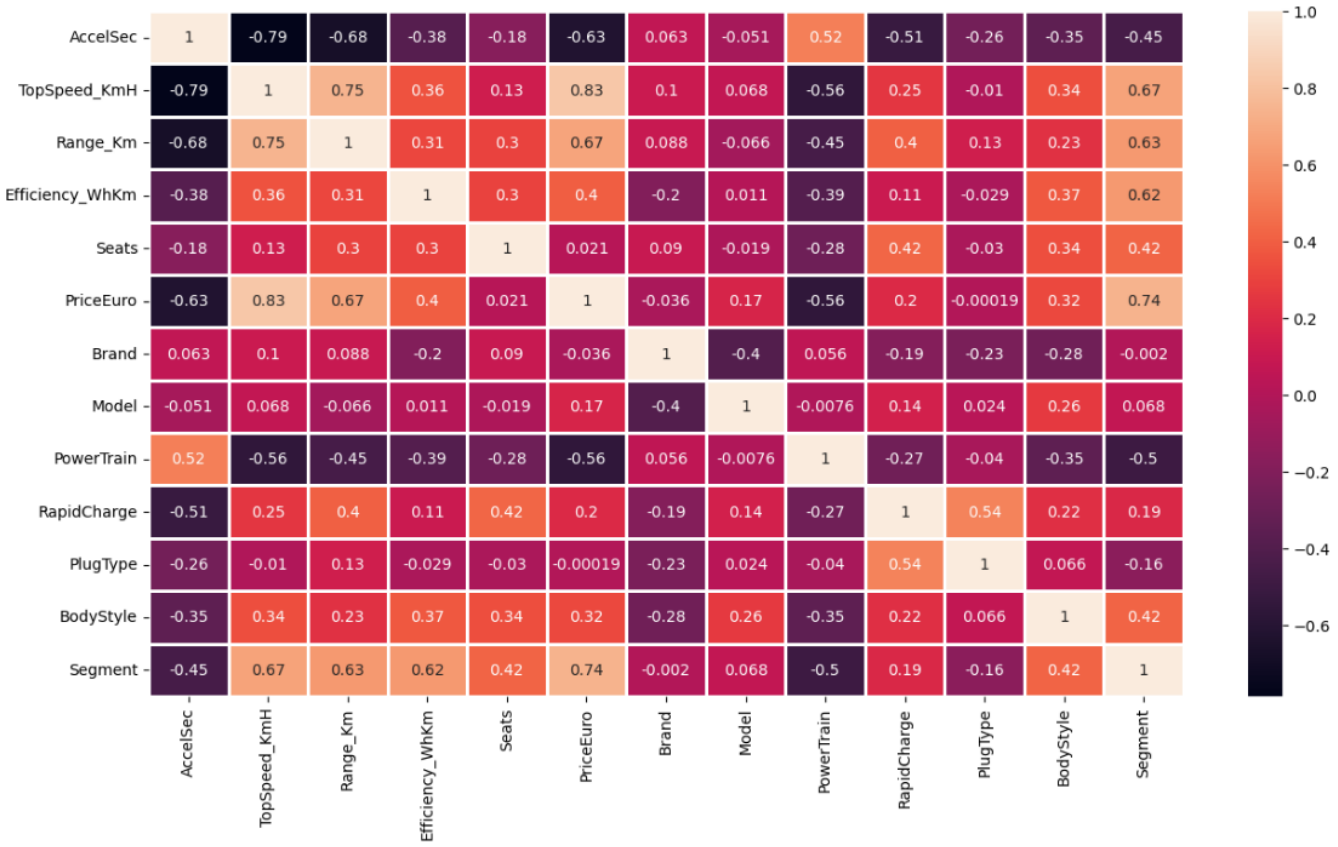
	Brand	Model	PowerTrain	RapidCharge	PlugType	BodyStyle	Segment
1	30.0	46.0	0.0	1.0	2.0	7.0	3.0
2	31.0	33.0	2.0	1.0	2.0	1.0	2.0
3	23.0	0.0	0.0	1.0	2.0	2.0	3.0
4	2.0	101.0	2.0	1.0	2.0	6.0	3.0
5	9.0	78.0	2.0	1.0	2.0	1.0	1.0
...	...	...	...	...	...	...	...
99	20.0	6.0	1.0	1.0	2.0	1.0	2.0
100	1.0	94.0	0.0	1.0	2.0	6.0	4.0
101	20.0	8.0	0.0	1.0	2.0	1.0	2.0
102	20.0	10.0	0.0	1.0	2.0	1.0	2.0
103	3.0	42.0	0.0	1.0	2.0	6.0	4.0

```
ev1[['Brand', 'Model', 'PowerTrain', 'RapidCharge', 'PlugType', 'BodyStyle', 'Segment']] = result[['Brand', 'Model', 'Pow
ev
```

	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	Seats	PriceEuro	Brand	Model	PowerTrain	RapidCh
1	4.6	233	450	161	940	5	55480	30.0	46.0	0.0	
2	10.0	160	270	167	250	5	30000	31.0	33.0	2.0	
3	4.7	210	400	181	620	5	56440	23.0	0.0	0.0	
4	6.8	180	360	206	560	5	68040	2.0	101.0	2.0	
5	9.5	145	170	168	190	4	32997	9.0	78.0	2.0	
...	...	...	...	...	...	...	...	...	...	...	
99	7.5	160	330	191	440	5	45000	20.0	6.0	1.0	
100	4.5	210	335	258	540	5	96050	1.0	94.0	0.0	
101	5.9	200	325	194	440	5	50000	20.0	8.0	0.0	
102	5.1	200	375	232	450	5	65000	20.0	10.0	0.0	
103	7.5	190	400	238	480	5	62000	3.0	42.0	0.0	

	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	Seats	PriceEuro	Brand	Model	PowerTrain	R
AccelSec	1.000000	-0.786195	-0.677062	-0.382904	-0.175335	-0.627174	0.062730	-0.050635	0.521011	
TopSpeed_KmH	-0.786195	1.000000	0.746662	0.355675	0.126470	0.829057	0.101759	0.067814	-0.560538	
Range_Km	-0.677062	0.746662	1.000000	0.313077	0.300163	0.674844	0.088316	-0.066035	-0.451495	
Efficiency_WhKm	-0.382904	0.355675	0.313077	1.000000	0.301230	0.396705	-0.195901	0.010976	-0.394721	
Seats	-0.175335	0.126470	0.300163	0.301230	1.000000	0.020920	0.089589	-0.018943	-0.278882	
PriceEuro	-0.627174	0.829057	0.674844	0.396705	0.020920	1.000000	-0.036023	0.169003	-0.561584	
Brand	0.062730	0.101759	0.088316	-0.195901	0.089589	-0.036023	1.000000	-0.401572	0.056464	
Model	-0.050635	0.067814	-0.066035	0.010976	-0.018943	0.169003	-0.401572	1.000000	-0.007609	
PowerTrain	0.521011	-0.560538	-0.451495	-0.394721	-0.278882	-0.561584	0.056464	-0.007609	1.000000	
RapidCharge	-0.514820	0.251054	0.401290	0.105673	0.423111	0.197208	-0.188137	0.144293	-0.274797	
PlugType	-0.259657	-0.010110	0.131297	-0.028761	-0.029570	-0.000193	-0.231104	0.023750	-0.039763	
BodyStyle	-0.347164	0.339230	0.227477	0.373146	0.342489	0.321713	-0.275860	0.261255	-0.349484	
Segment	-0.451568	0.670403	0.628597	0.623263	0.416744	0.737106	-0.002040	0.068414	-0.497850	

```
#Heatmap (gives the correlation of the data)
ax= plt.figure(figsize=(15,8))
sns.heatmap(ev.corr(),linewidths=1,linecolor='white',annot=True)
```



Segment Extraction

In the context of segment extraction, the K-Means algorithm plays a pivotal role. This algorithm, falling within the realm of unsupervised learning in machine learning, is specifically designed to address clustering challenges. It achieves this by efficiently partitioning datasets into a user-defined number of clusters, denoted as K. The essence of this technique lies in its ability to categorize data points into distinct groups without the need for predefined labels.

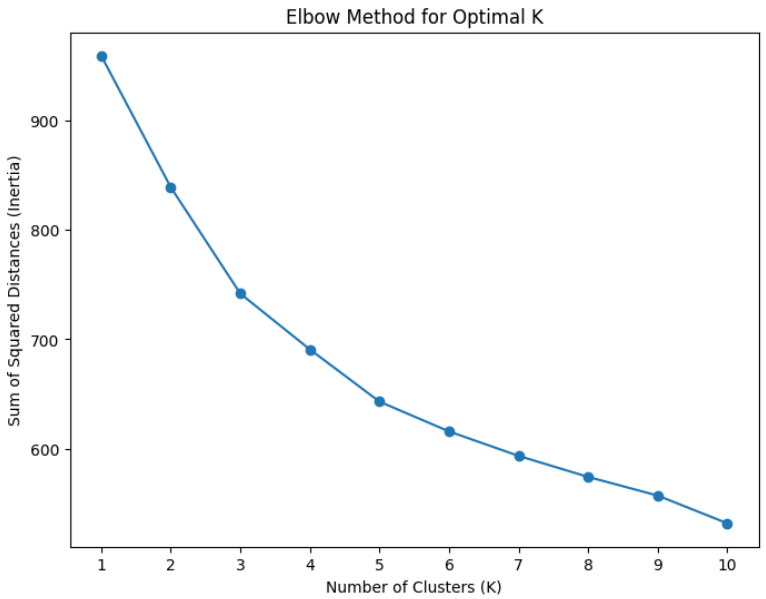
To proceed with segment extraction using the K-Means algorithm, the determination of the appropriate number of clusters is paramount. This number, K, can either be predetermined based on prior knowledge or deduced using a method known as the elbow method. The elbow method aids in pinpointing the optimal K value by successively fitting the model with varying K values and observing the behavior of the cost function, which quantifies the variance of data points within clusters.

The heart of the elbow method is the epsilon curve, which plots the cost function values against different K values. As K increases, the cost function tends to decrease, reflecting improved clustering precision. However, beyond a certain point, the rate of decrease flattens, resembling the bend of an elbow. This juncture on the curve indicates the saturation point of clustering improvement. Consequently, the K value corresponding to the elbow point signifies the optimal number of clusters that provide a meaningful segmentation of the data.

In essence, the K-Means algorithm, coupled with the insightful elbow method, furnishes a systematic approach to uncovering underlying structures within datasets. This technique empowers businesses to distill valuable insights from their data, aiding in targeted decision-making and tailored strategies aligned with the distinct segments identified through the algorithmic process.

```python
# Select the range of k values to consider
k_values = range(1, 11)  # You can adjust the range as needed

# Calculate the sum of squared distances (inertia) for each k value
inertia_values = []
for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(feature_matrix)  # Use your preprocessed feature matrix here
    inertia_values.append(kmeans.inertia_)

# Plot the elbow curve
plt.figure(figsize=(8, 6))
plt.plot(k_values, inertia_values, marker='o')
plt.title('Elbow Method for Optimal K')
plt.xlabel('Number of Clusters (K)')
plt.ylabel('Sum of Squared Distances (Inertia)')
plt.xticks(k_values)
plt.show()
```

The Elbow Method



```
# Perform K-means clustering with the optimal number of clusters
num_clusters = 4
kmeans = KMeans(n_clusters=num_clusters, random_state=42)
kmeans.fit(X_norm)

data['Cluster'] = kmeans.labels_
cluster_counts = data['Cluster'].value_counts().sort_index()

# Print the number of samples for each cluster
print("Number of samples in each cluster:")
print(cluster_counts)

# Display each row with its corresponding cluster label
cluster_table = data[['Brand','Model','Car_price','Cluster']]
print(cluster_table)
```

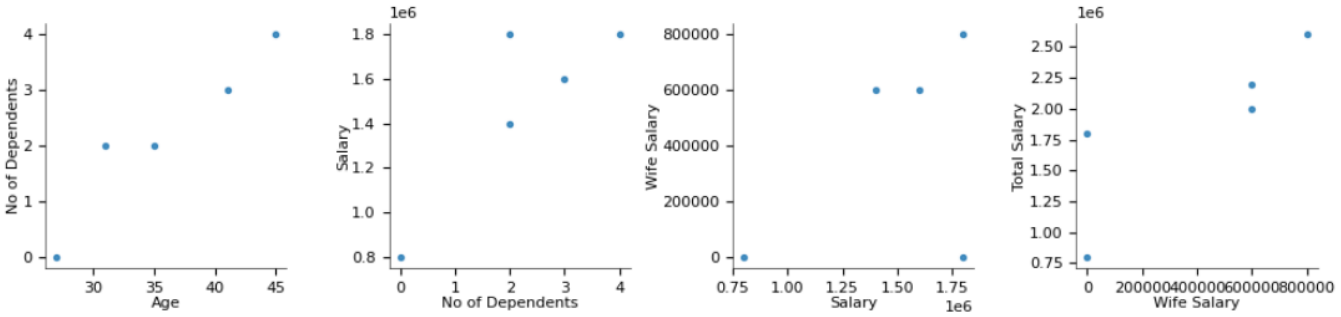
Profiling and describing potential segments

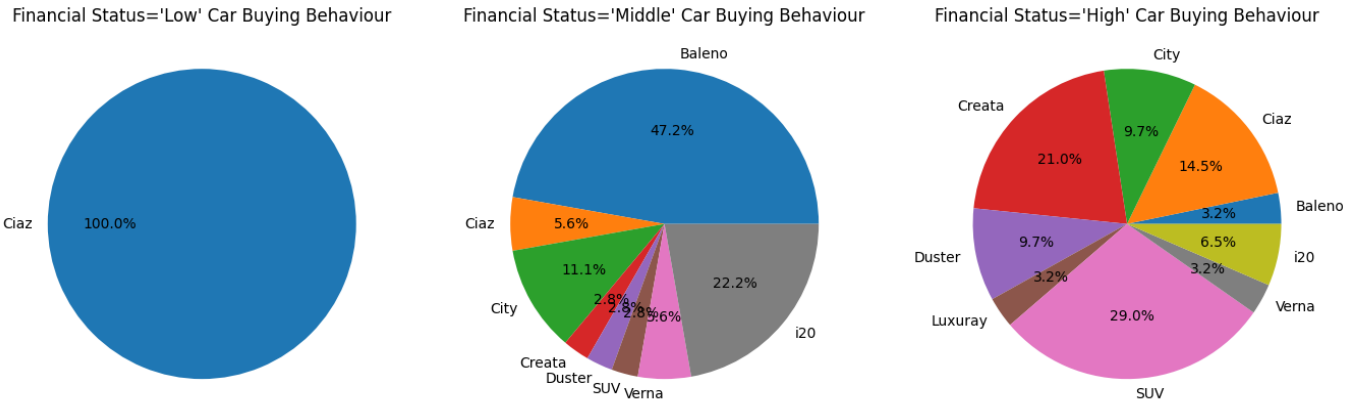
After segmenting the dataset, the subsequent step involves profiling these segments. Profiling can be achieved by creating a perceptual map, revealing the dominant columns within each segment. This map will help identify the key attributes that characterize each segment.

The is potential data that will buy ev car:

	Age	Profession	Marrital Status	Education	No of Dependents	Personal loan	House Loan	Wife Working	Salary	Wife Salary	Total Salary	Make	Price
0	27	Salaried	Single	Post Graduate	0	Yes	No	No	800000	0	800000	i20	800000
1	35	Salaried	Married	Post Graduate	2	Yes	Yes	Yes	1400000	600000	2000000	Ciaz	1000000
2	45	Business	Married	Graduate	4	Yes	Yes	No	1800000	0	1800000	Duster	1200000
3	41	Business	Married	Post Graduate	3	No	No	Yes	1600000	600000	2200000	City	1200000
4	31	Salaried	Married	Post Graduate	2	Yes	No	Yes	1800000	800000	2600000	SUV	1600000

The below data show us the age , salary , wife salary:





The provided pie charts present a comparison of the financial statuses among Indian consumers. The data highlights distinct preferences based on financial status. Individuals with a low financial status predominantly opt for Sedan car types, owing to their affordability. In contrast, middle-class consumers exhibit a preference for Hatchback car types, surpassing SUVs and Sedans. Conversely, those with high financial status lean towards SUVs over Sedans or Hatchbacks. Evidently, a consumer's financial status significantly influences their car selection.

Leveraging this valuable information, the company can strategically target specific consumer segments and develop Electric Cars tailored to their preferences. To effectively utilize this data for segmentation purposes, categorical data is converted into numerical data. This conversion involves the use of dictionaries, where categorical values are assigned corresponding numerical values. By implementing these dictionaries, the dataset transforms from categorical to numerical representation, facilitating enhanced segmentation and analysis.

These insights provide the company with a clear direction to strategize its approach in the electric car market. By tailoring its offerings to cater to the preferences of these distinct financial segments, the company can effectively capture their attention and loyalty. Furthermore, to harness the full potential of this data for segmentation, categorical information is systematically transformed into numerical data. This conversion process is achieved through the creation of dictionaries, where categorical values are assigned corresponding numerical representations. Once integrated into the dataset, this numeric transformation empowers advanced segmentation techniques, enabling the company to precisely target its audience and design electric cars that resonate with their preferences and financial capabilities**.**

Selection of target segment

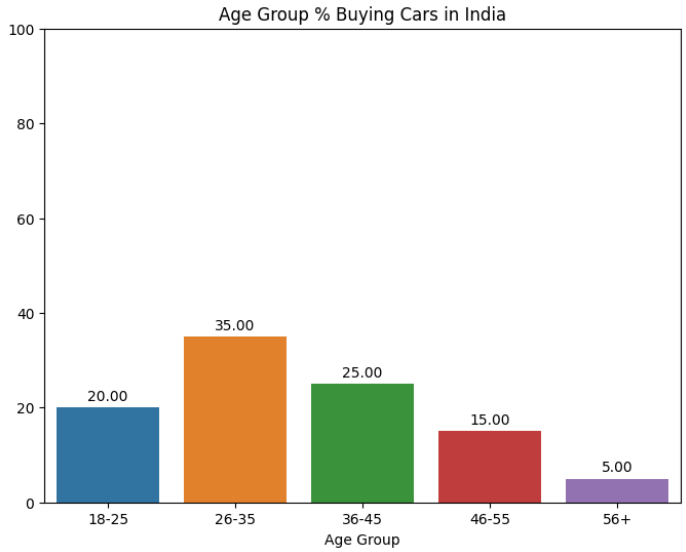
This below information will tell what are Profiling and potential segments of the EV market.

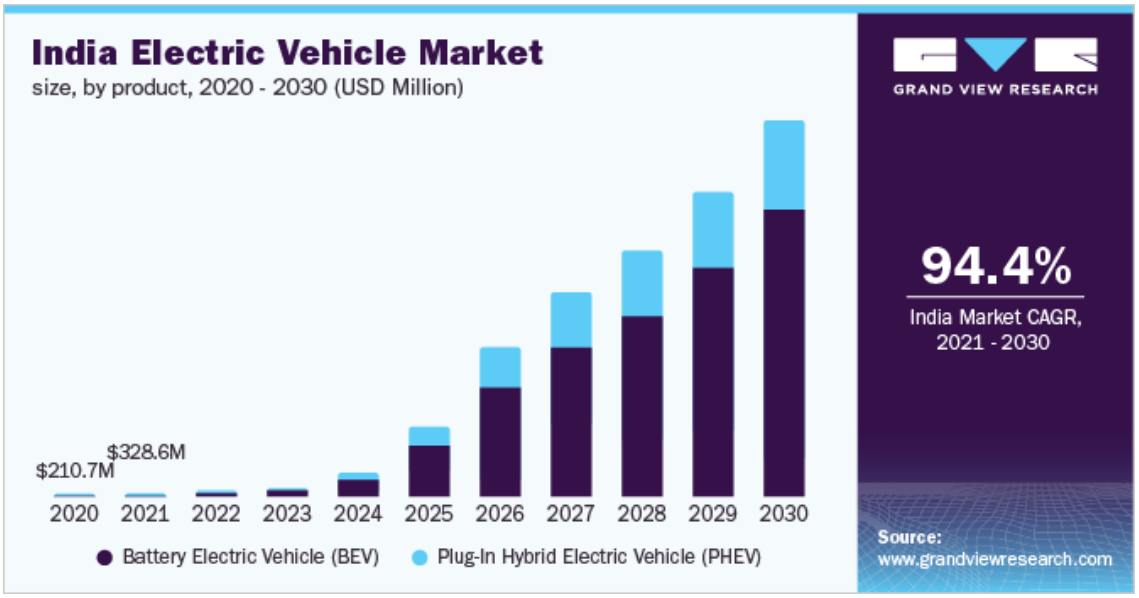
The exclusive report delves into an analysis of the Electric and Hybrid Car Market. While there is a prevailing notion about the global relevance of electric vehicles, a more realistic assessment reveals that widespread adoption of electric vehicles in India remains a distant prospect. This observation particularly holds true for the passenger car segment, which commands the majority of global attention. Interestingly, there exists a prevailing belief that other vehicle categories will embrace electric vehicles at a swiffer pace. Notably, the economic dynamics of electric vehicles prove to be more favorable compared to internal combustion engines, even in the absence of incentives.

Anticipations point toward a substantial surge in the penetration of electric vehicles into the market over the forthcoming years. The advantages of owning an electric vehicle over an internal combustion engine vehicle are undergoing continuous amplification. Projections from ACG indicate that the Indian electric car market is poised to grasp an augmented market share ranging from 30 to 35 percent within the passenger vehicle segment. By 2030, the Indian electric car market is predicted to achieve sales amounting to USD 11.8 billion, driven by an anticipated Compound Annual Growth Rate (CAGR) of 87 percent spanning from 2019 to 2030.

Within the realm of vehicle segment development, progress and innovation permeate every step. On the horizon is the emergence of hydrogen fuel cell cars, poised to supplant Battery Electric Vehicles (BEVs) in the near future. The technology of hydrogen fuel cells boasts numerous advantages over BEVs, and the triumph and market positioning of hydrogen fuel cell cars will pivot significantly on variables such as fuel cell costs and the establishment of refueling stations.

Below Information will let you know what age group of people buy ev so we have understanding of our potential buy by age.

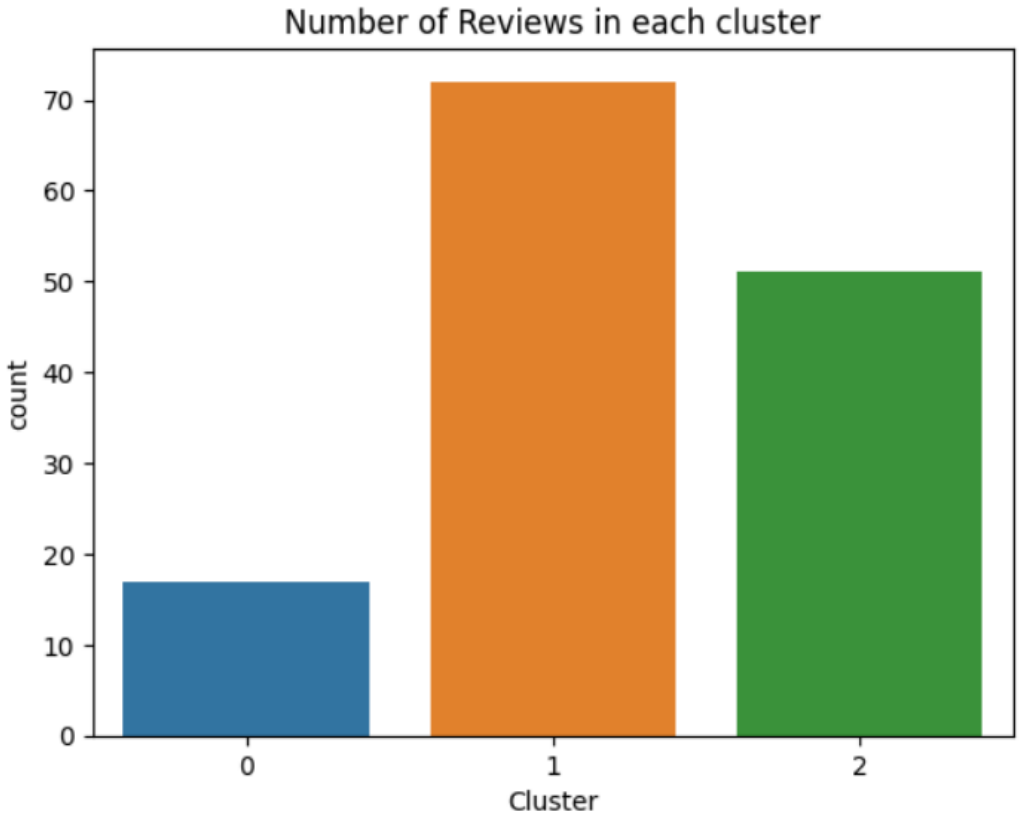


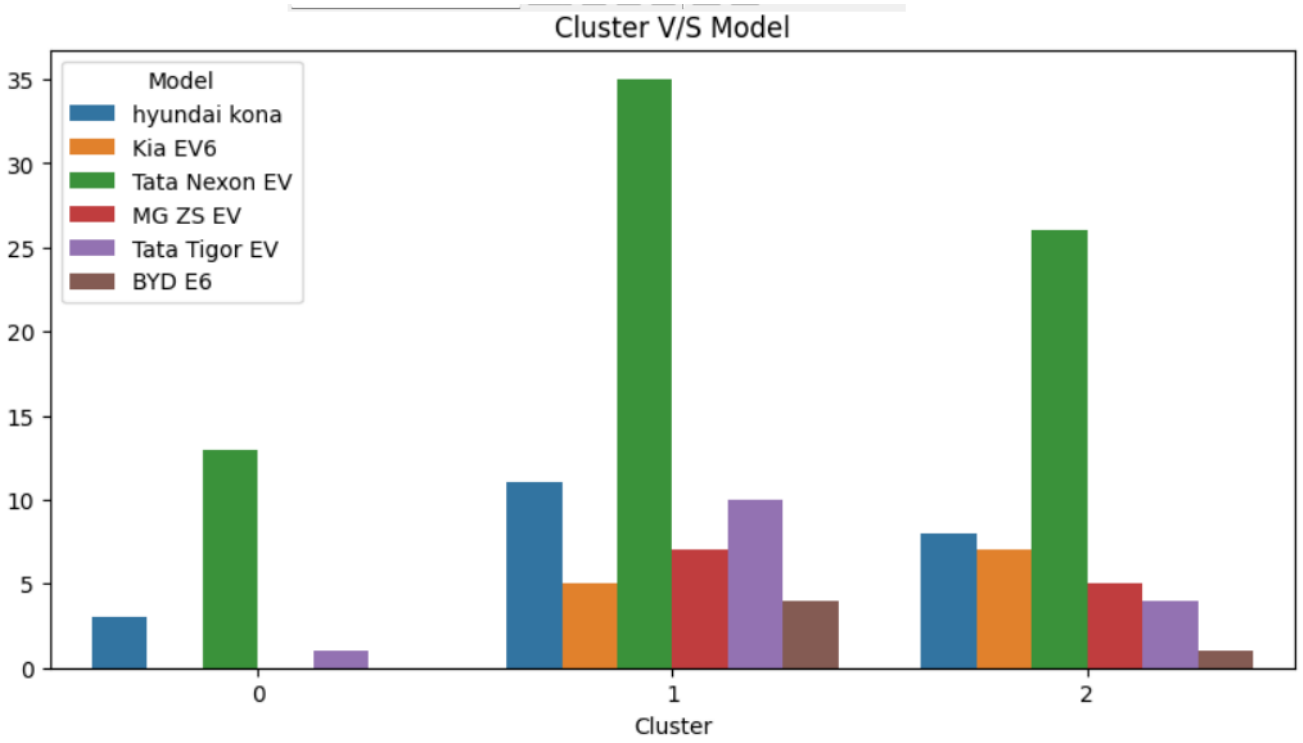

India Electric Vehicle Market
size, by product, 2020 - 2030 (USD Million)
$210.7M
$328.6M
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Battery Electric Vehicle (BEV)
Plug-In Hybrid Electric Vehicle (PHEV)
GRAND VIEW RESEARCH
94.4%
India Market CAGR, 2021 - 2030
Source: www.grandviewresearch.com

India Electric Vehicle Market Report Scope

Report Attribute	Details
Market size value in 2021	**USD 383.5 million**
Revenue forecast in 2030	**USD 152.21 billion**
Growth rate	**CAGR of 94.4% from 2021 to 2030**
Base year for estimation	**2020**
Historical data	2016 - 2019
Forecast period	2021 - 2030
Quantitative units	Revenue in USD Million, Volume in Units, and CAGR from 2021 to 2030
Report coverage	Revenue forecast, volume forecast, company share, competitive landscape, growth factors, and trends
Segments covered	Product, vehicle type
Country scope	India
Key companies profiled	Audi AG; BMW AG; Hyundai Motor India; Jaguar Land Rover Limited; Mahindra & Mahindra Ltd; Mercedes-Benz AG; MG Motor India Pvt. Ltd.; Olectra Greentech Limited; Tata Motors; Toyota Motor Corporation
Customization scope	Free report customization (equivalent up to 8 analysts working days) with purchase. Addition or alteration to country, regional & segment scope.
Pricing and purchase options	Avail customized purchase options to meet your exact research needs. Explore purchase options

```
sns.countplot(data = four_wheeler, x = 'Cluster')
plt.title('Number of Reviews in each cluster')
plt.xlabel('Cluster')
```



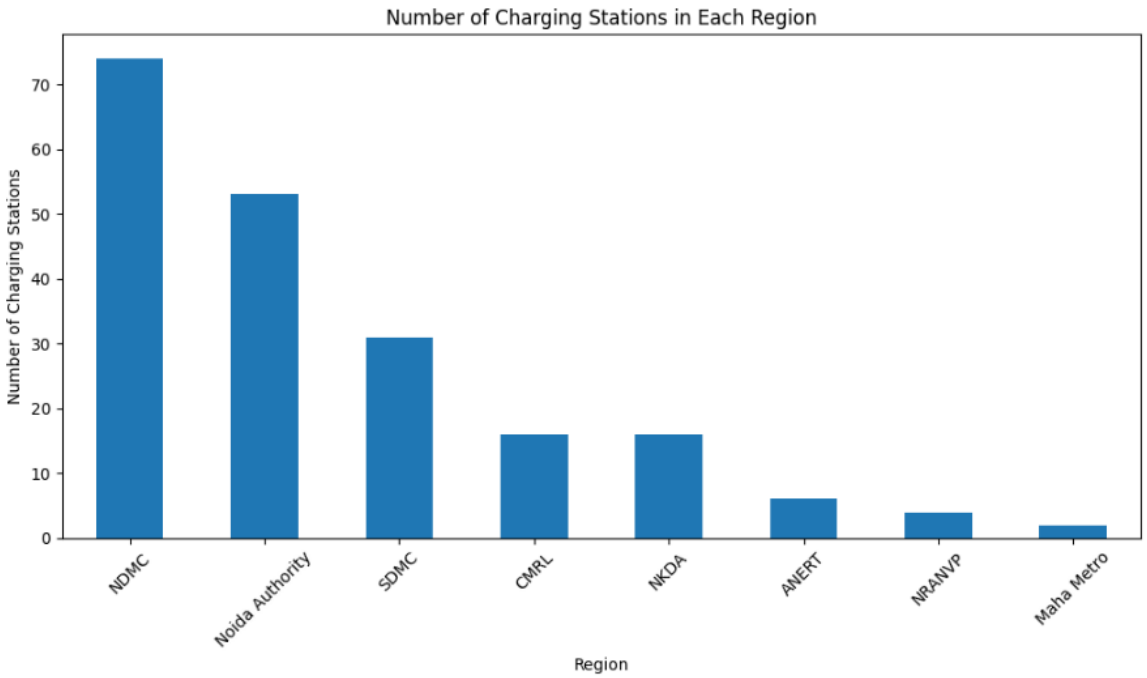


Marketing Mix

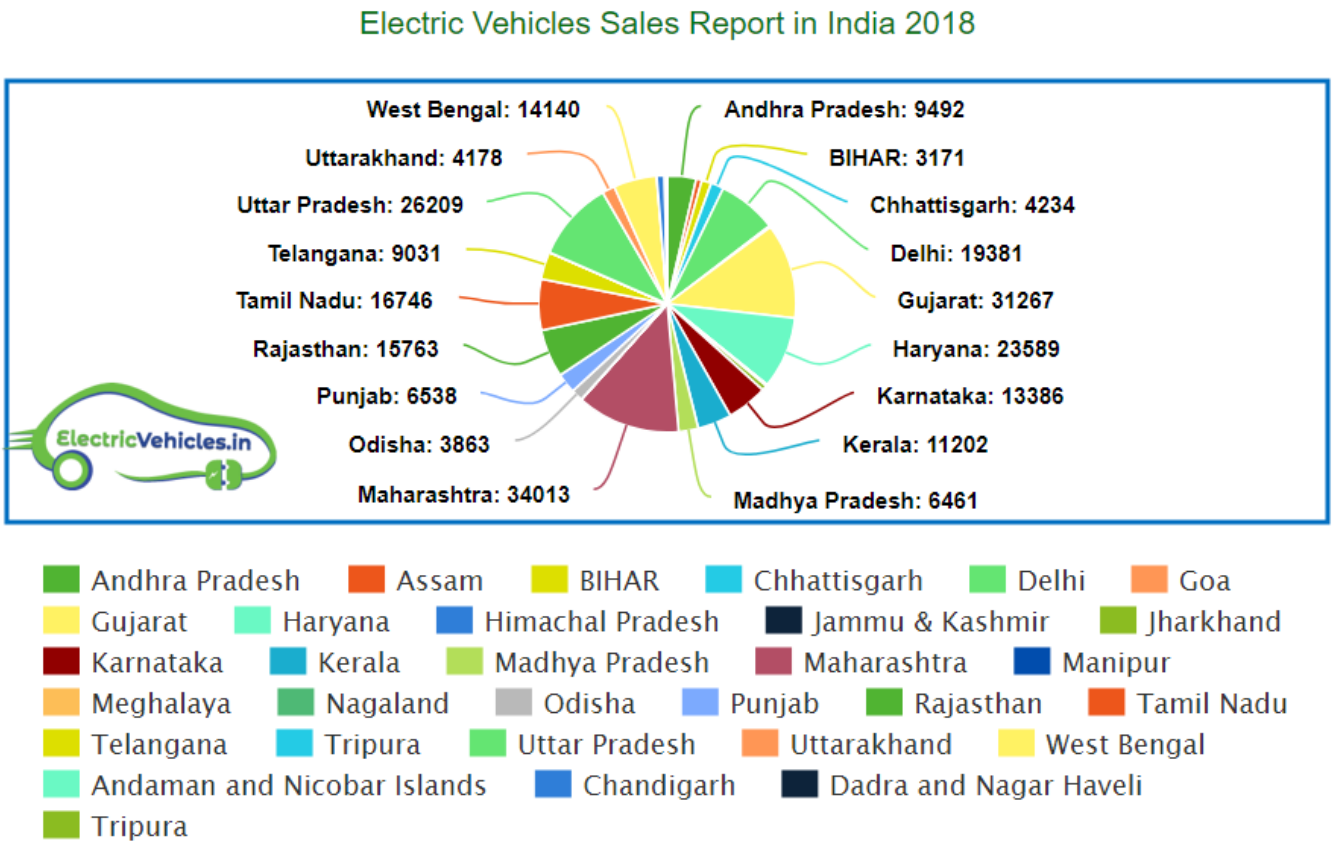
For marketing, geometric segmentation plays an important and crucial role.
Geographic segmentation categorizes the target market into segments where marketers can better serve customers in a specific region. This kind of Market segmentation is based on the geographical entities themselves (countries, states, city, etc.), but also depends on various geographical factors such as climate, culture, etc. settings, population, etc.
Geographic segmentation includes segmentation Target users based on where they live or work. You can do this any number of times: Group customers by country of residence or smaller geographical countries Department from region to city to postal code.
Geographic segmentation is probably the simplest market segmentation. Please look back. However, there are still many opportunities that companies will never take advantage of. The size of the target area should be changed as needed for business. In general, the bigger the company, the bigger the area it belongs to alignment. Ultimately a wider potential audience targeting each zip code individually is not cost effective.
After our analysis and research we came to the conclusion that in India there are 4-5 states such as Uttar Pradesh, Delhi, Maharashtra, Karnataka, Tamil Nadu etc which provide suitable locations for EV startups to start their operations. These states have announced several policies for the growth of EV Vehicles and hence are ideal destinations for any EV Start-up company to start their operation

We can collect the geographic which will be perfect for EV market which you can see below :

```
# Bar chart of the number of charging stations in each region
region_counts = data['region'].value_counts()
plt.figure(figsize=(10, 6))
region_counts.plot(kind='bar')
plt.title('Number of Charging Stations in Each Region')
plt.xlabel('Region')
plt.ylabel('Number of Charging Stations')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



Potential Customer Base for Business Markets



During the period spanning 2017-2018, the sale of electric vehicles stood at 87,554 units, a number that surged to 131,554 units in 2018-2019. Subsequent years witnessed further growth, with the tally reaching 161,308 units by 2019-2020. However, the advent of Covid-19 led to a reduction, settling at 119,650 units. This diverse range of sales encompasses two-wheelers, three-wheelers, four-wheelers, and buses, with a clear inclination towards the two-wheeler segment. Notably, two-wheelers and three-wheelers contribute significantly to the electric vehicle landscape in the country

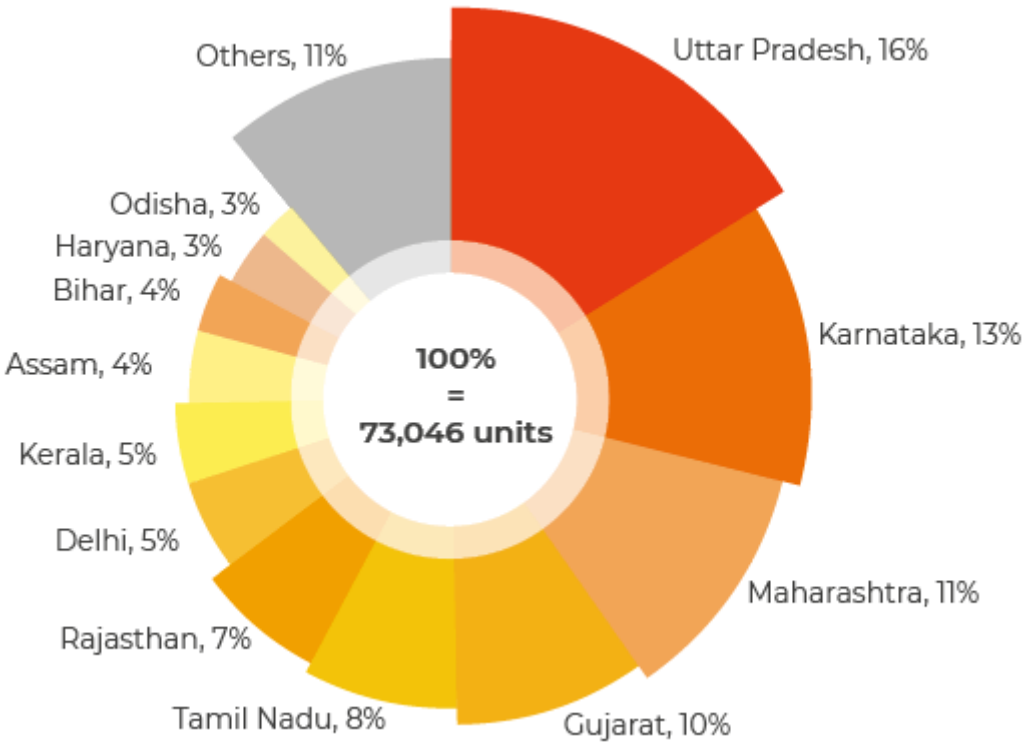
Remarkable advancements mark each vehicle category:

Electric 2-Wheeler sales soared by an astonishing 463.61% between FY 2021 and FY 2022. The momentum remains strong, projecting a sale range of 400,000 to 450,000 units in FY 2023.
Electric 3-Wheeler sales surged by an impressive 212.45% from FY 2021 to FY 2022, with an anticipated range of 75,000 to 80,000 units in FY 2023.
Electric 4-Wheeler sales exhibited remarkable growth of 344.65% from FY 2021 to FY 2022, further projecting a sales range of 50,000 to 55,000 units in FY 2023.
The regional landscape plays a pivotal role in shaping electric vehicle adoption:

Notably, high-speed 2-wheeler electric vehicles have found strong footing in Karnataka, Tamil Nadu, Maharashtra, Telangana, and Rajasthan, collectively capturing 67% of sales share.
Uttar Pradesh, Bihar, Delhi, and Assam lead in L3 category 3-wheeler electric vehicle sales.
The high-speed L5 category electric 3-wheeler vehicle sales are notably concentrated in Telangana, Karnataka, and Delhi.
Maharashtra leads in 4-wheeler EV sales, accounting for 26% in 2021, followed closely by Delhi and Telangana (13% each).
The e-Bus segment is dominated by Maharashtra and Gujarat, contributing 47% and 18% of the total units sold, respectively.
Predicting potential profits requires a strategic approach:

Electric 2-Wheeler's per-unit average price of Rs 1,00,000, coupled with a projected sale of approximately 4,25,000 units, underscores a potential profit of Rs 42.5 billion for India. Karnataka is anticipated to yield a profit of Rs 3.5 billion, and both Maharashtra and Tamil Nadu present the prospect of Rs 3 billion each.
Electric 3-Wheelers, priced at Rs 2,00,000 per unit, with a projected sale of around 150

The Most Optimal Market Segments



Key Regional Sales:

The southern states of Karnataka, Tamil Nadu, and Telangana, along with Maharashtra and Rajasthan, collectively contribute to 67% of the high-speed 2-wheeler electric vehicle sales.

On the other hand, the northern states of Uttar Pradesh, Bihar, and Delhi, as well as Assam, lead in L3 category 3-wheeler electric vehicle sales.

Telangana, Karnataka, and Delhi are the top regions with the highest number of high-speed L5 category electric 3-wheeler vehicle sales.

Maharashtra has taken the lead in 4-wheeler EV sales, accounting for 26% of the total market share in 2021, closely followed by Delhi and Telangana, both contributing 13% each.

The states of Maharashtra and Gujarat stand out in the e-Bus category, capturing a significant share of 47% and 18% in sales, respectively.

Potential Profits:

Focusing on electric 2-wheelers, where the average price per unit is projected at Rs 1,00,000, the potential profit for India is anticipated to be a substantial Rs 42.5 billion. Karnataka is expected to

generate Rs 3.5 billion in potential profit, while Maharashtra and Tamil Nadu each contribute Rs 3 billion.

Electric 3-wheelers, with an estimated average price of Rs 2,00,000 per unit, could potentially yield a profit of Rs 30 billion for India. Uttar Pradesh is forecasted to generate Rs 13 billion in potential profit.

The electric 4-wheeler segment, with an average price of Rs 15,00,000 per unit, could lead to a potential profit of Rs 75 billion. Maharashtra is projected to generate Rs 7.5 billion in potential profit, while Delhi and Telangana are each expected to contribute Rs 3.75 billion.

Link to github profile with codes and datasets well documented.

1. Ritesh Kate https://github.com/ritesh9096/Feynn-labs-2nd-Project
2. Abhishek Kumar https://github.com/Abhishek-IITKGP/EV-Market-segmentation
3. Piyush Singh https://github.com/Piyush4455/EV-MARKET-SEGMENTATION-ANALYSIS
4. Chirag Jain https://github.com/chiragjain8/Feynn_labs_Project2
5. Alen Sadique https://github.com/alensadiquepm/EV_Range_Prediction