Market Segmentation Analysis of Electric Vehicles Market in India

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Overview:

Electric vehicles (EVs), powered by electric motors and often using batteries or external electricity sources, have a long history dating back to the mid-19th century. Initially preferred for their comfort and ease of use, EVs lost ground to internal combustion engines for about 100 years. However, in the 21st century, EVs have experienced a resurgence due to technological advancements and a growing emphasis on renewable energy and environmental sustainability.

As of August 3, 2022, there are approximately 13,92,265 electric vehicles (EVs) being used on Indian roads. The industry's growth has been inconsistent, largely influenced by government incentives. Several manufacturers, such as Hero, Eco, Ather, and Ampere, Tata, Mahindra are committed to advancing the EV sector.

More than 90% of EVs in India are low-speed electric scooters that do not require registration or licenses. These scooters typically use lead batteries, which are prone to failures and have a short lifespan, limiting sales despite government subsidies. Some manufacturers are also working on electric three-wheelers and cycles, with e-rickshaws gaining popularity for last-mile connectivity.

To realize its $100 billion revenue potential, India's EV market needs to grow more than tenfold in volume over the next 6–7 years. This is achievable, but only with focused interventions across five key areas: new product development, GTM/distribution optimization, B2B focus, software development, and scale-up of charging infrastructure.

We know that the Indian automotive market is undergoing a significant transformation with the growing adoption of electric vehicles (EVs). However, the diverse demographics, economic conditions, and varying consumer preferences across different regions of India present a challenge for manufacturers and marketers in effectively targeting potential EV buyers. Traditional market segmentation methods may not adequately capture the unique characteristics and needs of different consumer groups, leading to inefficiencies in marketing strategies, product development, and distribution efforts.

This report seeks to address the problem of identifying and analysing distinct market segments within the Indian EV market. By leveraging data-driven techniques, including clustering analysis, this study aims to uncover the underlying patterns and preferences among various consumer groups. The objective is to provide actionable insights that can guide manufacturers, marketers, and policymakers in developing targeted strategies to accelerate the adoption of EVs in India, enhance customer satisfaction, and optimize resource allocation.

The analysis will focus on demographic, geographic, and behavioural factors, examining how these variables influence the EV purchasing decisions. The outcome will be a clear segmentation of the market, highlighting the key characteristics of each segment and recommending tailored approaches for engaging with each group effectively.

Problem Statement:

"What is the key demographic, geographic, and behavioural factors influencing the market segmentation of electric vehicles (EVs) in India, and how do they vary across different states and consumer profiles?" This encompasses various aspects of market segmentation, including:

Demographic Factors: Age, profession, income, marital status, etc., influencing EV adoption.

Geographic Factors: State-wise vehicle registrations and preferences.

Behavioural Factors: Consumer preferences based on vehicle specifications, price, and performance. Understanding how EV adoption and preferences differ across different regions of India.

Data Pre-Processing:

There are three datasets taken for analysis. The datasets are collected from various sources. Before going for the analysis, the preprocessing of the data is completed. From all the three datasets we have found that there is no null values or missing values are present. After checking all the datasets, we move forward to exploring the data.

1. Exploratory Data Analysis:

The EDA will help us to understand the key factors influencing EV market segmentation in India and guide further analysis or model development.
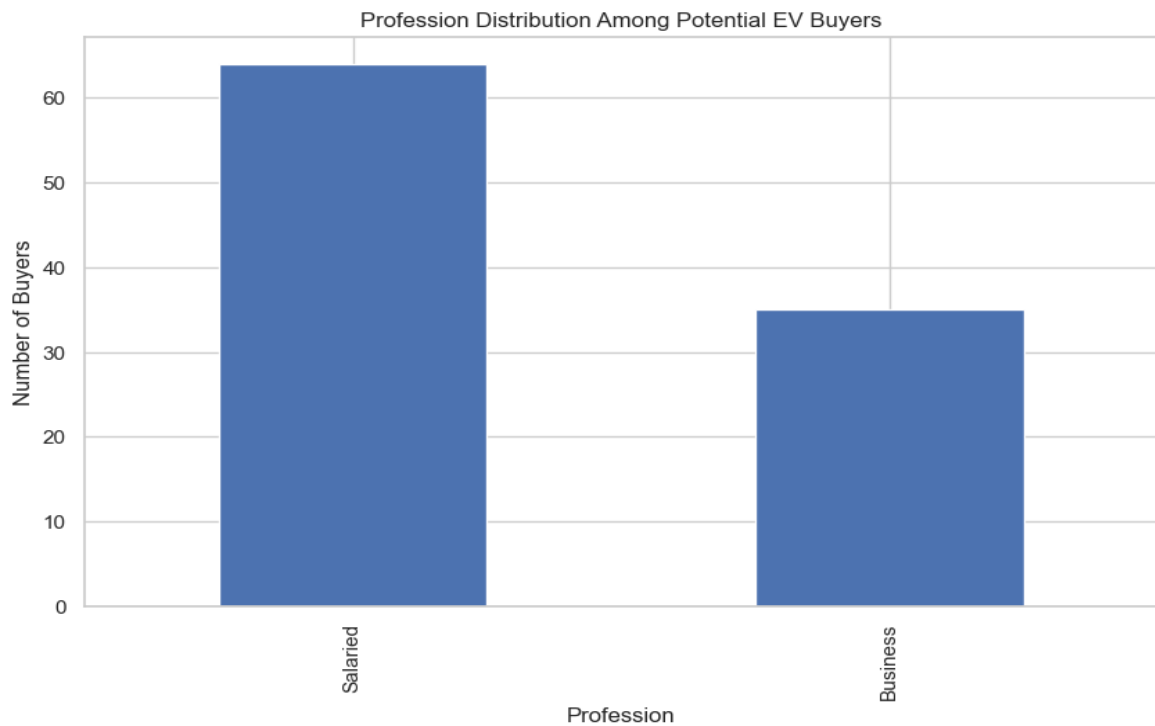
We Explore the data step by step.

1] The age distribution of potential EV car buyers:

Age Distribution of Potential EV Buyers
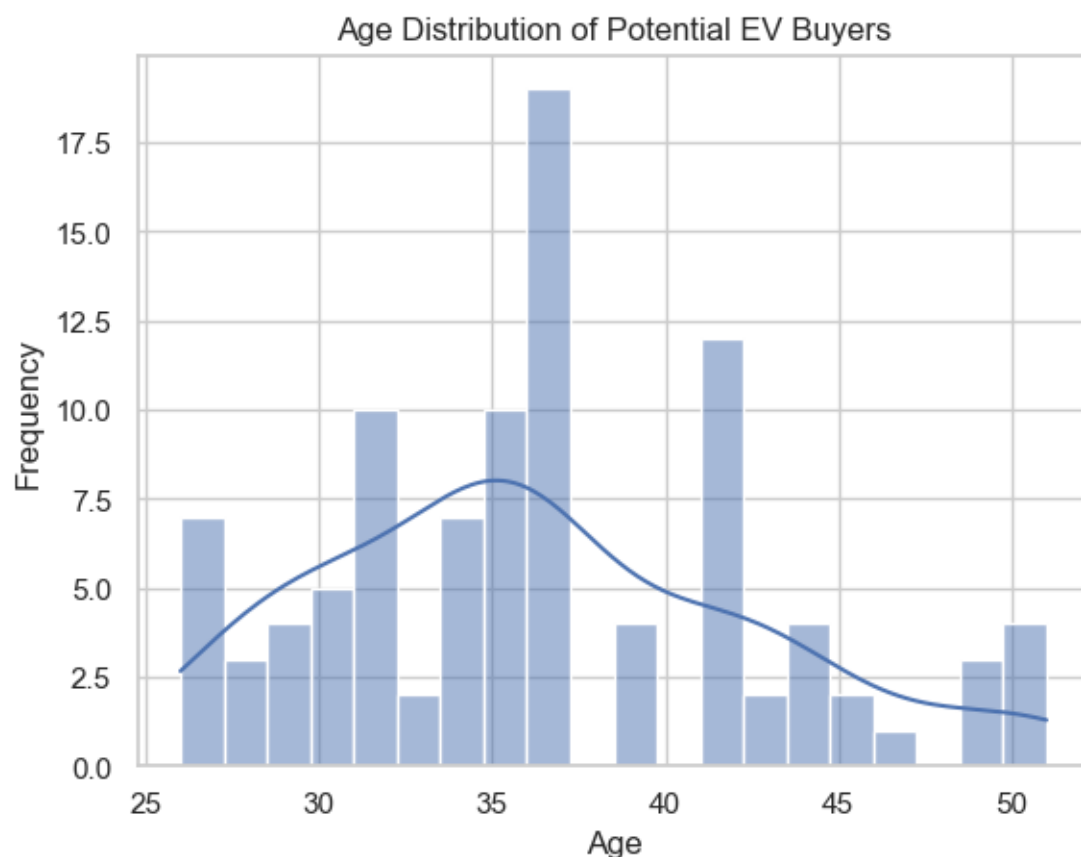
Conclusion:

Here the age group of 36-38 and 43 are the potential EV car buyers in India.

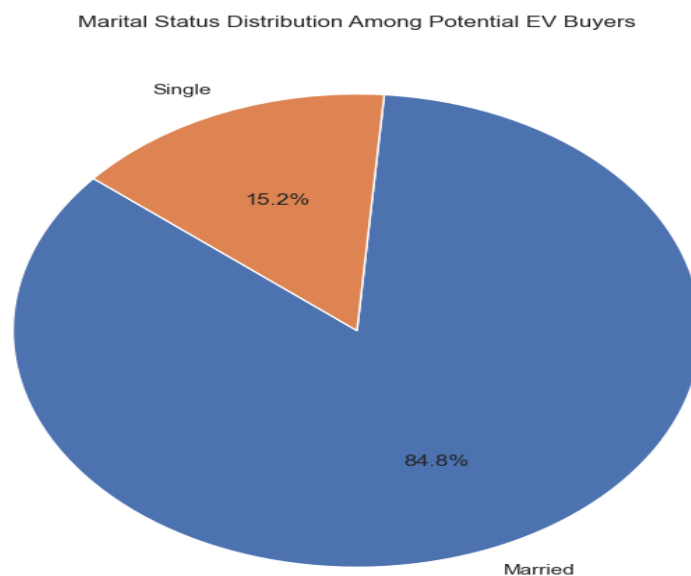**2] Does profession influence EV car purchasing decisions?**

Profession Distribution Among Potential EV Buyers

Conclusion:

Here From the Count plot, we can see that the salaried profession more influences the decision making of EV cars.

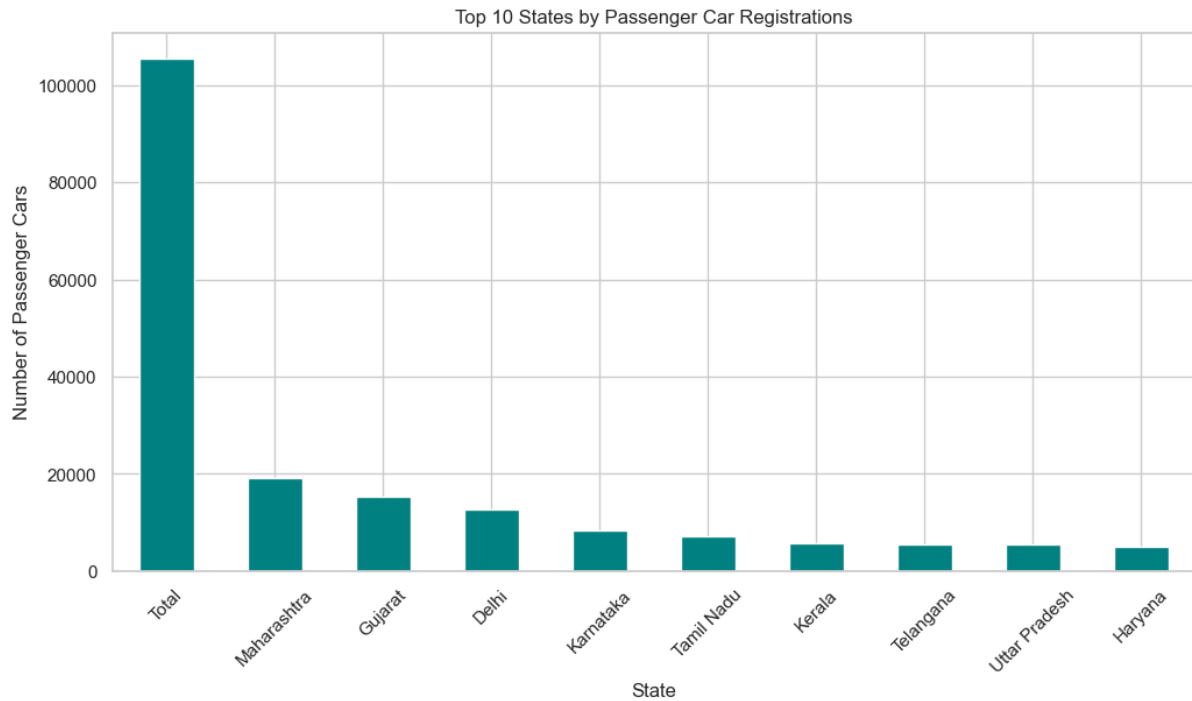**3] Relationship between marital status and EV car purchasing**

Marital Status Distribution Among Potential EV Buyers

Conclusion:

From the above pie chart, we can see that married peoples are having more tendency to buy EV car than the single peoples.
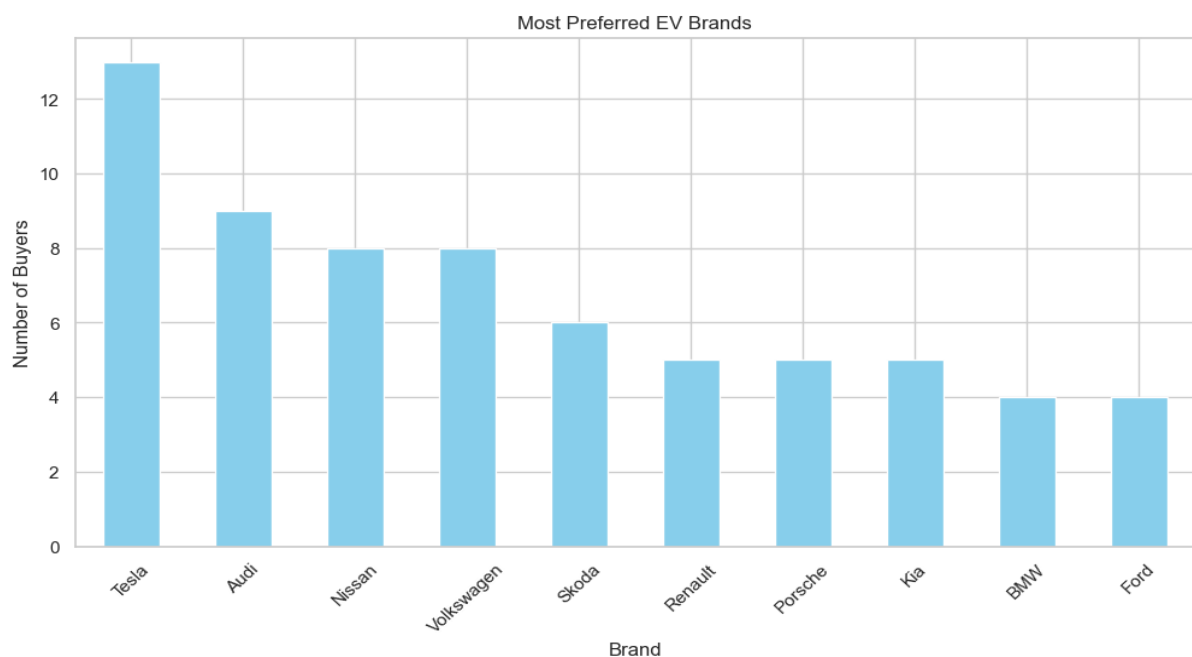
4] States have the highest adoption of passenger cars (four-wheelers)

Top 10 States by Passenger Car Registrations

Conclusion:

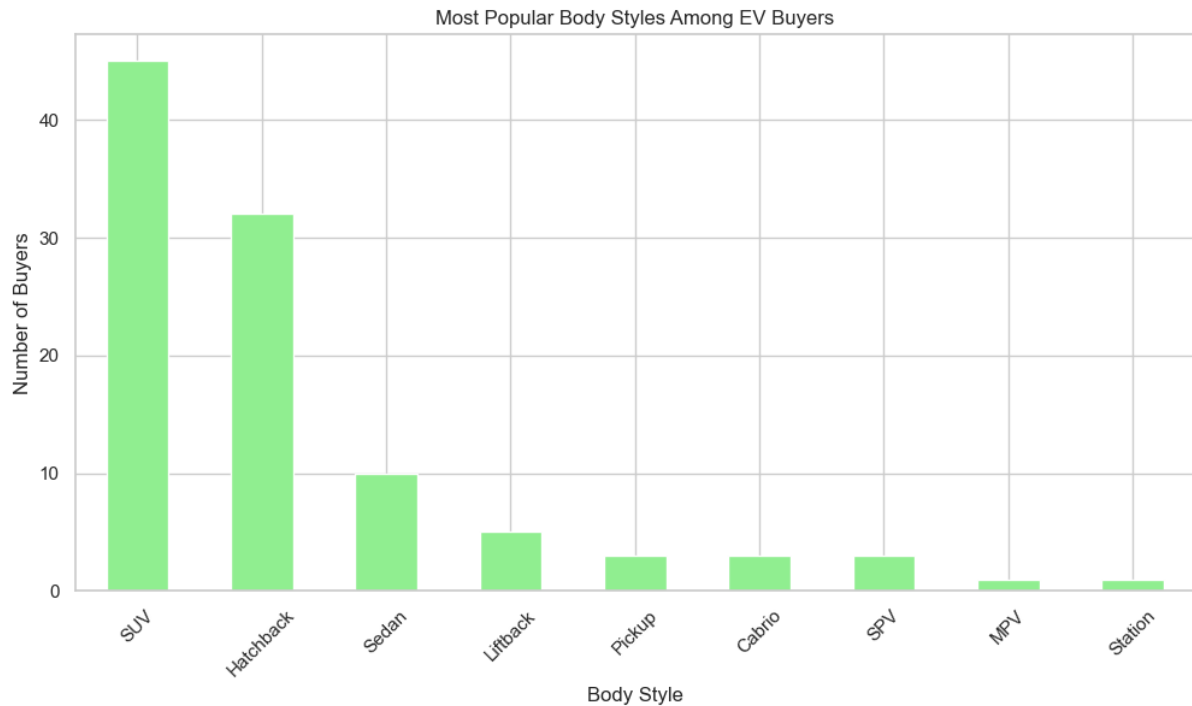From the above bar chart, we can say that Maharashtra state is the highest adoption of passenger's cars.

5] The most preferred EV brand among different consumer segments.

Most Preferred EV Brands

Conclusion:

From the above bar chart, we can say that Tesla, Audi, Nissan etc. are the most preferred EV brand by different consumers segments.

6] The most popular body styles among EV buyers

Most Popular Body Styles Among EV Buyers

Conclusion:

From the above bar chart, we can say that SUV & Hatchback are the most popular body style among EV buyers.

2. Fitting of Model:

Algorithm Selection and Application: (K- Means Clustering)

In the Market Segmentation Project for electric vehicles (EVs) in India, the **K-Means clustering** algorithm was selected as the primary machine learning model. K-Means is a well-established unsupervised learning algorithm that is particularly effective for clustering similar data points into distinct groups based on their attributes. The goal was to identify natural segments within the Indian EV market, based on a combination of demographic, economic, and vehicle-related features.

Why K-Means:

- **Scalability:** K-Means is computationally efficient, making it suitable for large datasets.

- **Interpretability:** The output is easy to understand, with each cluster representing a unique market segment.

- **Adaptability:** It works well with the type of data available, where clear, distinct groupings are expected.

Implementation: The algorithm was applied to the dataset containing features such as *Age, Salary, Total Salary, Price, Brand, Range, Acceleration, Top Speed, Seats, and Fast Charging capability*. The dataset was normalized to ensure that features with larger scales did not disproportionately influence the clustering results. After several iterations, the optimal number of clusters was determined using the Elbow method, and three distinct market segments were identified.
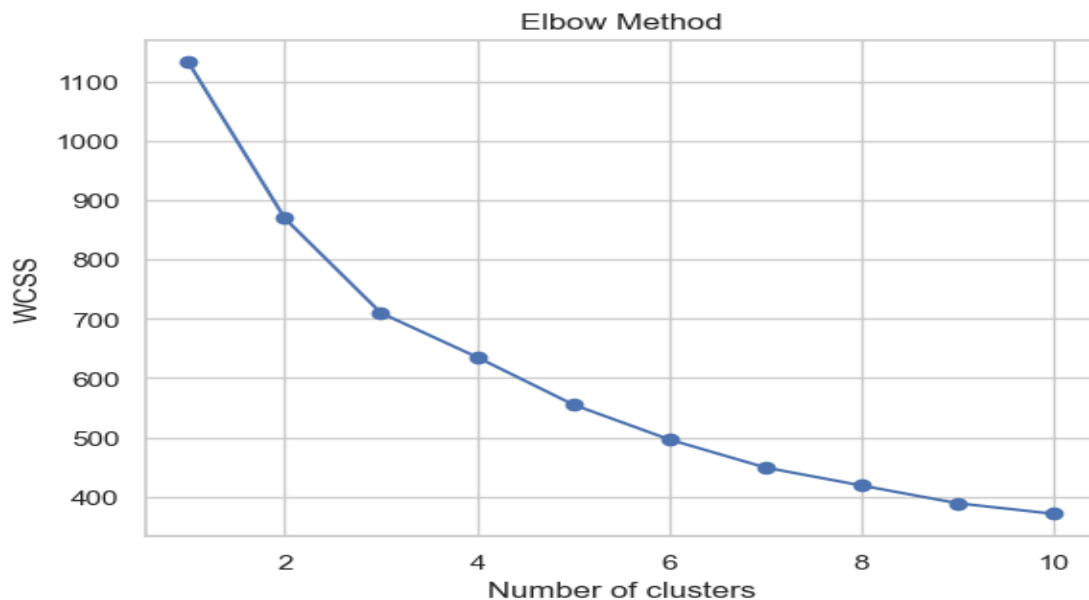
The Elbow Method is a widely used technique to determine the optimal number of clusters (K) in K-Means clustering. It involves plotting the sum of squared distances (inertia) between data points and their assigned cluster centroids against the number of clusters (K). The goal is to identify the "elbow point" in the plot, where the rate of decrease in inertia sharply slows down, indicating the optimal number of clusters.

During the analysis of the Indian EV market, the Elbow Method was applied to determine the optimal number of market segments. The plot typically showed a rapid decrease in inertia as the number of clusters increased, but beyond a certain point, the rate of decrease became minimal.

Optimal K: The elbow point, where the curve bends and the inertia reduction slows, was identified around **K = 3**. This indicates that three clusters (segments) provided a balance between minimizing within-cluster variance and avoiding overfitting.

The Silhouette Score is a measure of how similar data points are within their own cluster compared to other clusters. It ranges from -1 to 1, where:

- **+1:** Indicates that the data point is well matched to its own cluster and poorly matched to neighbouring clusters.

- **0:** Indicates that the data point is on or very close to the decision boundary between two neighbouring clusters.

- **-1:** Indicates that the data point might have been assigned to the wrong cluster.

Silhouette Score Method

The average Silhouette Score for the three-cluster solution was found to be **around 0.6 to 0.7**. The **Silhouette Score** confirmed that these clusters are well-defined, with a reasonable degree of separation between them, indicating the effectiveness of the K-Means clustering model in this project

Cluster Visualization using PCA:

Cluster visualization is an essential step in understanding the distribution of different market segments. When we have a high-dimensional dataset, visualizing clusters can be challenging. PCA (Principal Component Analysis) helps us by reducing the data's dimensionality to two or three principal components, making it easier to visualize clusters.

Clusters Visualization using PCA
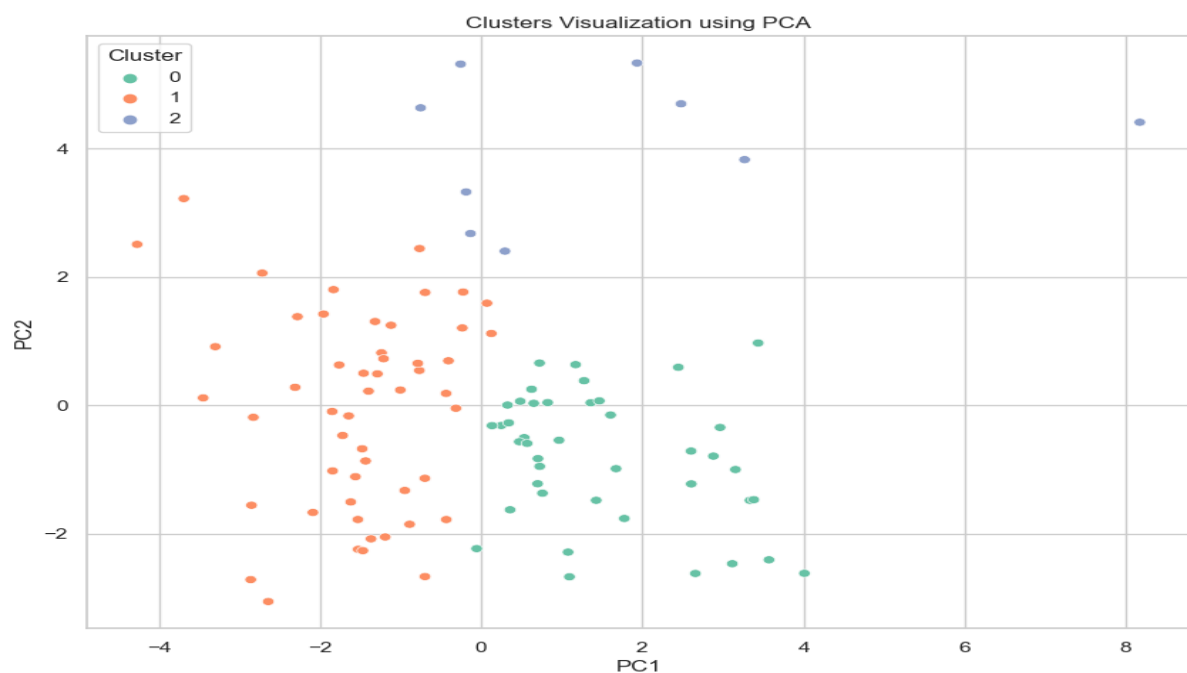
Conclusion:

In our market segmentation project for two-wheelers in India, after applying PCA, we could visualize how different customer segments (e.g., by income, state, age) cluster together. This visualization will help us to understand which segments are distinct and which might require further investigation. The analysis revealed three key segments within the Indian EV market are as follows:

- **Cluster 1 (Young Professionals):** This segment comprises relatively younger individuals with moderate to high income. They tend to prefer mid-range EVs that offer a good balance between performance and price, with a strong focus on tech features and convenience.

- **Cluster 2 (Practical Buyers):** Comprised of slightly older, budget-conscious consumers, this group prefers more economical EV models with lower performance specs. They are likely to use EVs for daily commutes and are more sensitive to price.

- **Cluster 3 (Affluent Buyers):** This segment includes older, wealthier individuals who prefer high-end, luxury EVs with superior performance and features. They are less price-sensitive and more focused on quality, range, and luxury.

3. Improving the Market Segmentation Project with Additional Time & Budget

If we get the opportunity to study further in this segment and if we get the additional time and budget, then we can deep dive into the EV market in India and what are the actual factors that are beneficial for the production of Electric Vehicles, For that the following additional datasets could be collected to enhance the project:

- **Detailed Consumer Behaviour Data:** Columns such as Frequency of EV Use, Preferred Charging Stations, and Environmental Awareness.

- **Socioeconomic Data:** Columns including Household Income, Property Ownership, and Lifestyle Preferences.

- **Competitor Analysis:** Data on market share, pricing strategies, and consumer ratings of competing EV models.

- **Geospatial Data:** Information on EV infrastructure, such as the density of charging stations and urban/rural split.

Additional Machine Learning Models:

To further refine the segmentation:

- **Hierarchical Clustering:** Could be used to understand the nested structures within the data, identifying sub-segments within the broader clusters.

- **Gaussian Mixture Models (GMM):** This probabilistic model could capture the underlying distribution of the data, allowing for more flexible and overlapping clusters.

- **Random Forest Classifier:** Could be used post-clustering to predict the segment for new data points, helping to validate the robustness of the segments.

4. Estimated Market Size for the Indian EV Market

The Indian EV market is currently at a growing stage. In the first quarter of 2024, India saw a more than 50% increase in EV sales, which suggests that the market is gaining momentum. This, along with other factors, could lead to 17 million EV sales in 2024, which would be more than 20% higher than 2023 and would give EVs a share of over 20% of total car sales. The India electric vehicle market size accounted for USD **11.36 billion** in 2024 and is predicted to be worth around USD 1,053.10 billion by 2034, growing at a solid CAGR of 57.3% from 2024 to 2034.
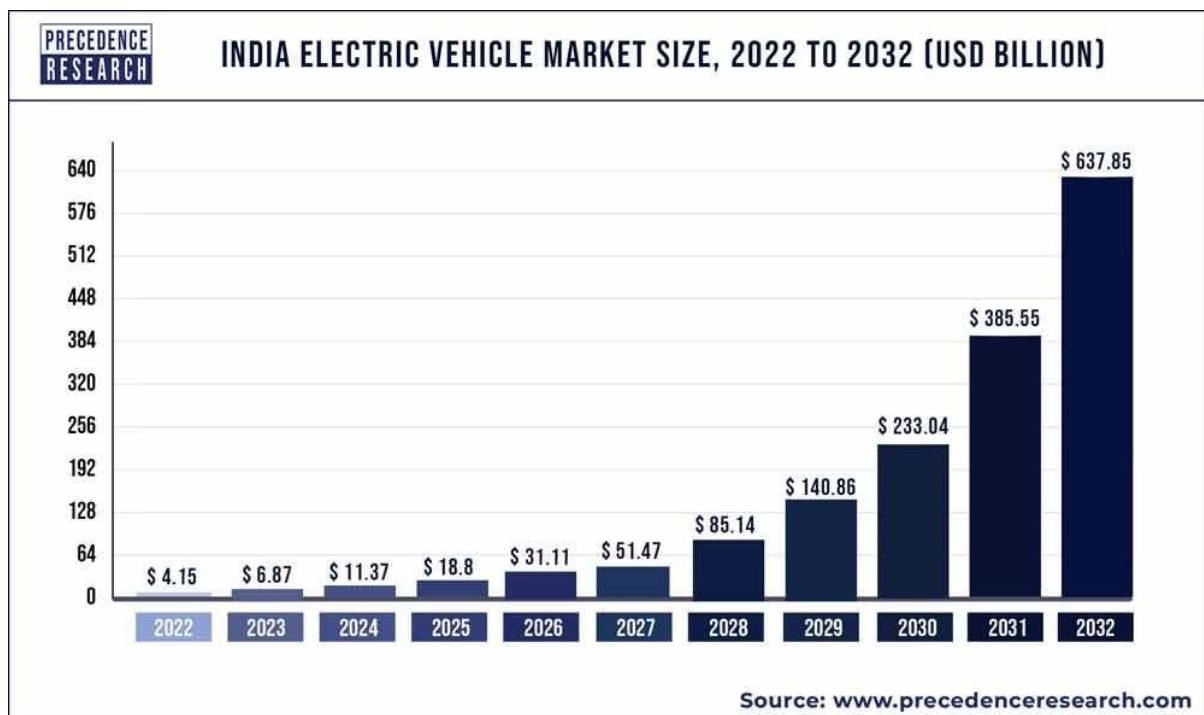
From above graph we can estimate the Indian electric vehicle market size up to 2032. And it goes around USD 637.85 Bn.

To identify the top features that can be used to create the most optimal market segments for market domain consists of following things.

- **State**: Segmenting by state allows us to improve marketing strategies and product offerings to the specific needs and characteristics of each region.
- **Income/Salary:** Higher-income segments may prefer premium or higher-end two-wheelers, while lower-income groups might opt for more affordable models. Segmenting based on income can help in identifying the potential for premium versus budget segments in the market.
- **Age**: Age impacts consumer preferences, with younger buyers potentially favouring sportier or more modern models, and older consumers possibly preferring comfort and reliability. So, segmenting by age allows for targeted marketing campaigns that resonate with the specific needs and desires of different age groups.

- **Brand**: Brand loyalty and preference can significantly influence purchasing decisions. Segmenting by brand preference helps in understanding the competitive landscape and identifying areas where particular brands dominate or have growth potential.

These four features are the most probable optimal market segments that will impact the EV market domain in the future. So, this analysis will give us a quick overview of electric vehicle market in India and the major features that are responsible for the growth of the field.

Conclusion:

The analysis of the Electric Vehicle (EV) market in India reveals a rapidly growing industry with distinct consumer segments that hold significant implications for manufacturers, marketers, and policymakers. The study identified three primary market segments: young professionals who prioritize technology and convenience, budget-conscious practical buyers, and affluent individuals who favor luxury EVs. These segments are shaped by key demographic factors such as age, profession, and marital status, as well as geographic preferences, with Maharashtra leading in EV adoption. The market is projected to experience substantial growth, potentially reaching a size of USD 1,053.10 billion by 2034. However, this growth hinges on addressing challenges like infrastructure development and regional disparities. Strategic, targeted marketing, infrastructure investment, and product diversification are essential to harness the full potential of the EV market in India, ultimately accelerating adoption, improving customer satisfaction, and optimizing resource allocation.

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- https://straitsresearch.com/report/indian-ev-market

GitHub:

- https://github.com/Ashishparkar/EV-Market-Analysis-in-India