Indian Electric Vehicle (EV) market Analysis from 2001 to 2024

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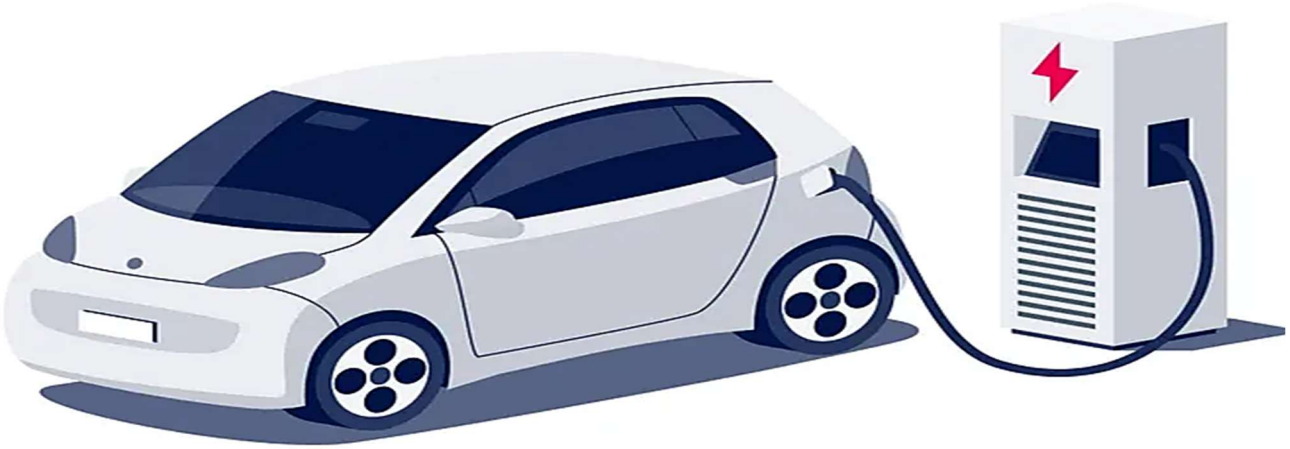
Abstract

This report provides a comprehensive analysis of the Electric Vehicle (EV) market in India from 2001 to 2024, focusing on the evolution of market trends, consumer behaviour, and technological advancements. Using advanced machine learning techniques, we identified key market segments and high-potential customer groups, providing actionable insights for manufacturers, policymakers, and investors. The study also explores the influence of government policies, infrastructure development, and economic factors on EV adoption. Detailed graphs and visualizations are included to illustrate significant patterns, regional variations, and market dynamics. Furthermore, the report outlines strategic recommendations to optimize market entry and expansion, ensuring alignment with current and future industry trajectories.

GitHub link :- [Click Here]

Kaggle Notebook link :- [Click Here]



1. Introduction

The global shift to Electric Vehicles (EVs) is driven by technological advancements, government incentives, and environmental concerns. In India, rapid EV adoption is fuelled by supportive policies, expanding charging infrastructure, and rising consumer demand. This study analyses the Indian EV market (2001–2024) to identify key customer segments and provide strategic recommendations for manufacturers, policymakers, and investors.

2. Scope of Report

- Market Segmentation Analysis (geographic, demographic, psychographic, behavioural).
- Exploratory Data Analysis (EDA) to uncover trends.
- Machine Learning-based Clustering to classify states by EV adoption.
- Strategic Recommendations for optimizing market penetration

3. Data Overview

The analysis leverages datasets from multiple reliable sources, including:

Dataset Name	Description
EV Maker by Place.csv	Lists EV manufacturers and their plant locations.
OperationalPC.csv	Provides data on public charging stations across states.
Vehicle Class - All.csv	Records EV registrations from 2001 to 2024.
ev_cat_01-24.csv	Categorizes EV models manufactured from 2001 to 2024.
ev_sales_by_makers_and_cat_15-24.csv	Contains EV sales data by manufacturers (2015–2024).

This dataset was compiled and web-scraped from the **Vahaan4 Dashboard** and **Sarthi Dashboard**.

4. Segmentation Criteria

- **Geographic Factors**: State-wise adoption and infrastructure.
- **Demographic Factors**: Income levels, age groups, and urban vs. rural distribution.
- **Psychographic Factors**: Consumer preferences for comfort, sustainability, and brand loyalty.
- **Behavioural Factors**: Purchasing behaviour, price sensitivity, and vehicle usage patterns.

Market Segmentation Analysis Step-By-Step

Step 1: Deciding Whether to Segment the Market

- **Why segment the EV market?**
  - Diverse consumer needs require targeted strategies.
  - Infrastructure availability varies by region.
  - Optimized resource allocation helps in better growth planning.

Step 2: Identifying the Ideal Target Customer

- **Urban Professionals** (Tech-savvy, early adopters, willing to pay premium).
- **Fleet Operators** (Ride-sharing, delivery services).
- **Middle-Class** Families (Seeking cost-effective, reliable EV options).

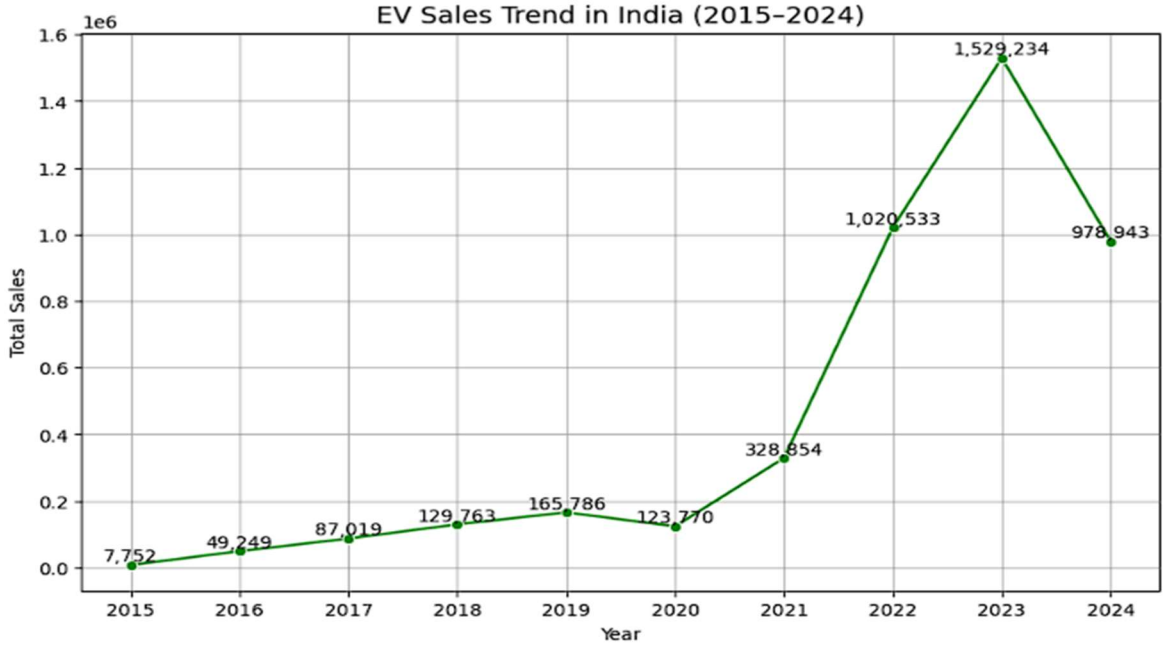
Step 3: Collecting Data

- **Sources**: Government reports, manufacturer sales reports, consumer surveys.
- **Data Focus**: EV sales trends, charging infrastructure, regional adoption rates.

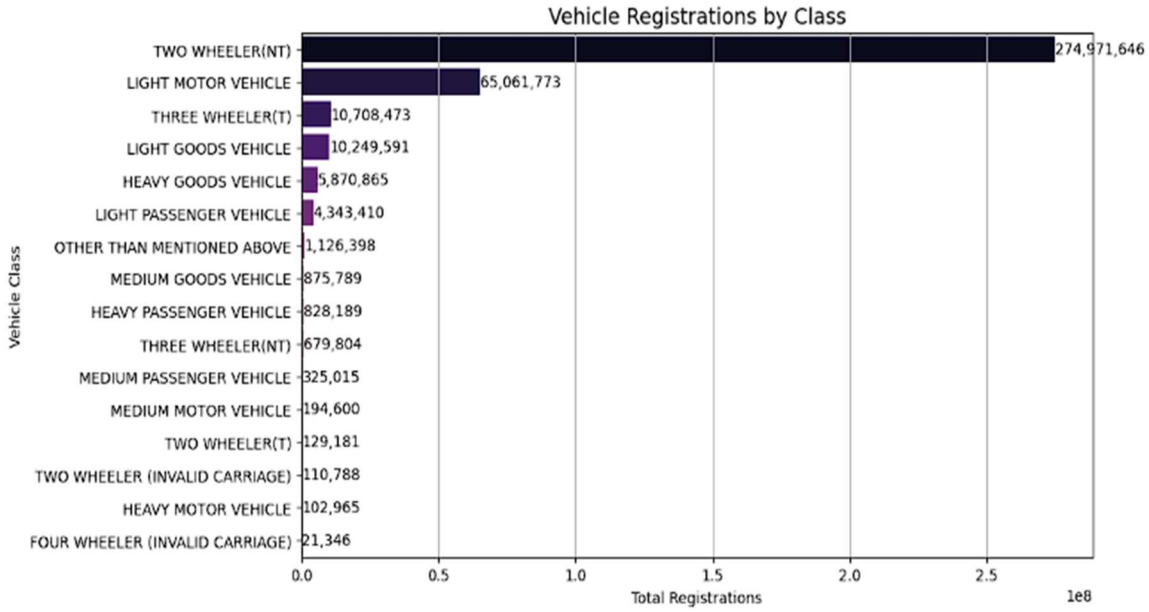
Step 4: Exploring the Data

Exploratory Data Analysis (EDA) revealed key trends:

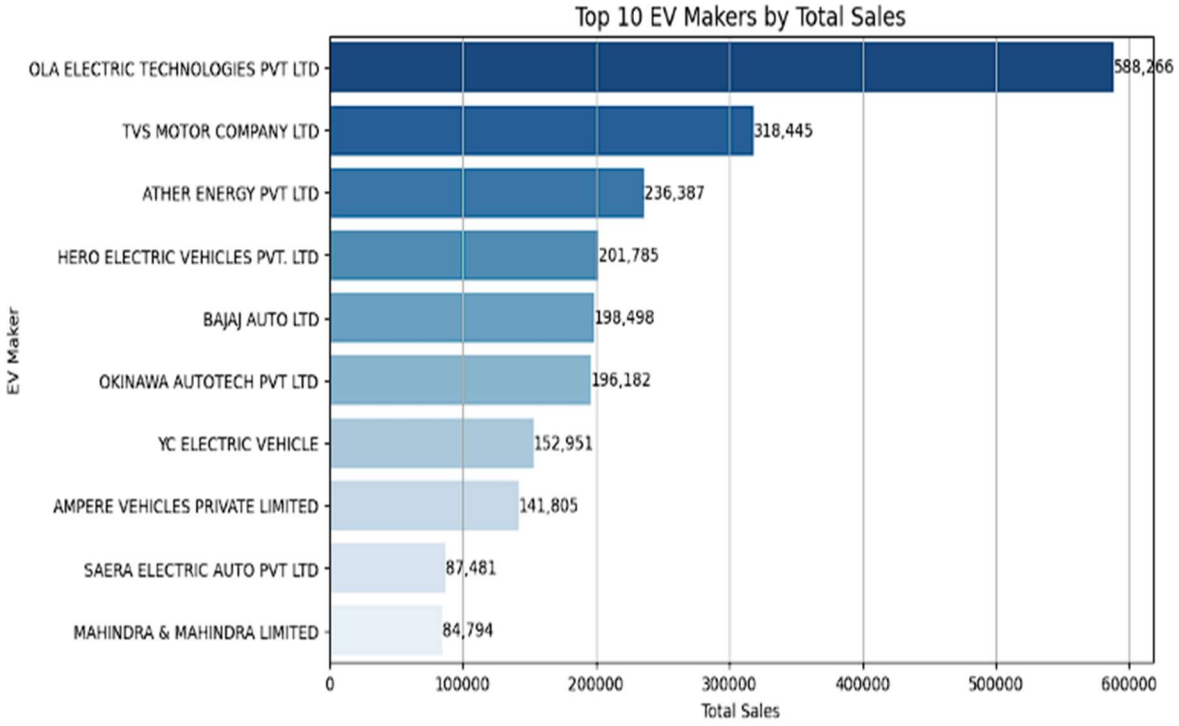
- **EV Sales Trend (2015-2024)**: The graph shows a consistent rise in EV sales, peaking in 2024, indicating a rapidly growing market. This trend reflects increased consumer acceptance, government incentives, and advancements in EV technology.



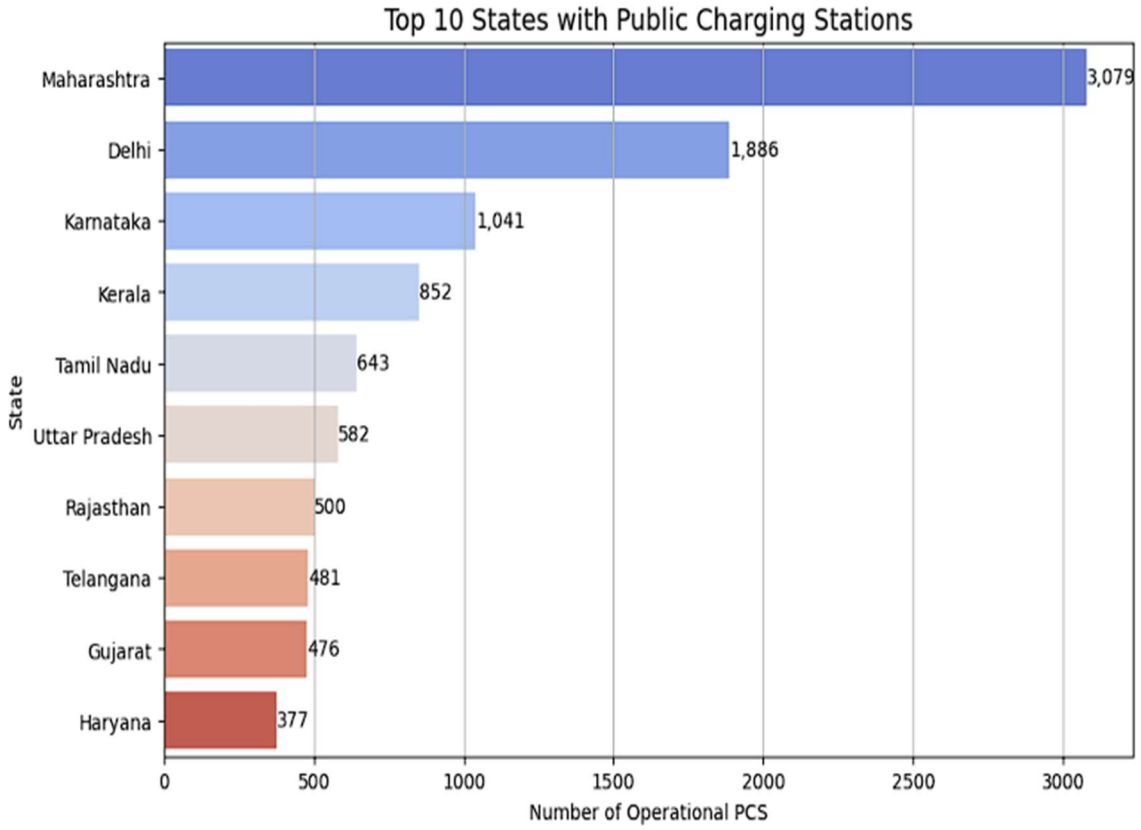
- **Vehicle Registrations by Class**: Two-wheelers dominate the EV market, followed by three-wheelers and four-wheelers. This highlights the affordability and practicality of smaller vehicles in the Indian market.



- **Top 10 EV Makers by Sales**: Major manufacturers include **Tata Motors**, **Hero Electric**, and **Ather Energy**. These companies lead the market due to their wide range of offerings, strong brand presence, and innovative technology.



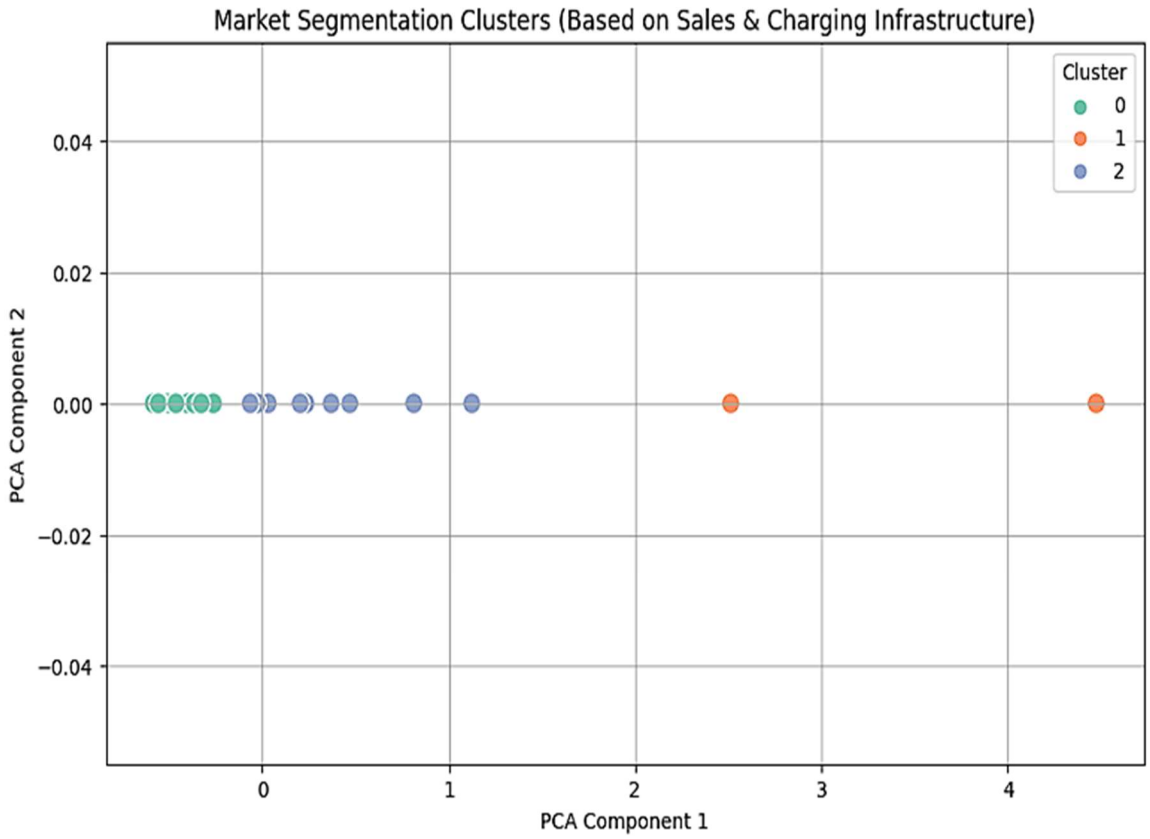
- **Top 10 States with Public Charging Stations**: States like **Maharashtra**, **Karnataka**, and **Delhi** lead in charging infrastructure, which is a critical factor for EV adoption. This infrastructure growth supports consumer confidence in EV viability.



Step 5: Creating Market Segments

This section analyses and segments the Indian Electric Vehicle (EV) market using sales data and charging infrastructure across states. **K-Means Clustering**, an unsupervised machine learning algorithm, was used to group states with similar characteristics, helping to identify regions with high growth potential and areas needing infrastructure improvements. The **Elbow Method** determined the optimal number of clusters, balancing accuracy and simplicity in the segmentation process.

- **Cluster 0 (21 States)**:- Includes Assam, Bihar, and Chandigarh—low EV adoption and charging infrastructure.
- **Cluster 1 (2 States)**:- Delhi and Maharashtra—high EV sales and robust charging networks.
- **Cluster 2 (11 States)**:- Andhra Pradesh, Gujarat, Karnataka—moderate growth with developing infrastructure.



Cluster 0: 21 States -> Andaman & Nicobar, Arunachal Pradesh, Assam, Bihar, Chandigarh, Chhattisgarh, D&D and DNH, Goa, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Lakshadweep, Manipur, Meghalaya, Nagaland, Odisha, Pondicherry, Punjab, Sikkim, Tripura, Uttarakhand

Cluster 2: 11 States -> Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, West Bengal

Cluster 1: 2 States -> Delhi, Maharashtra

Step 6: Understanding Each Customer Group

Segment	Characteristics	Challenges
Cluster 0 (Low adoption states)	Rural consumers, price-sensitive, limited infrastructure.	Lack of awareness, high upfront costs.
Cluster 1 (High adoption states)	Urban professionals, early adopters, strong infrastructure.	Range anxiety, limited model variety.
Cluster 2 (Moderate growth states)	Middle-class consumers, growing infrastructure, emerging demand.	Uncertainty about long-term benefits.

Step 7: Describing the Segments in Detail

- **Behavioural Factors:** Preferences for affordability, efficiency, and acceleration.
- **Psychographic Factors:** Value for money, comfort, and environmental consciousness.
- **Geographic Factors:** Focused on states with robust infrastructure like Maharashtra and Karnataka.

Step 8: Target Segments Selection

- **Primary Focus:** Cluster 1 (Delhi, Maharashtra) and Cluster 2 (Emerging States).
- **Long-Term Strategy:** Cluster 0 (Low adoption areas).

Step 9: Creating a Marketing Plan for Each Group

Segment	Marketing Focus	Strategies
Cluster 0	Low-cost models, government subsidies.	Awareness campaigns, affordability-driven ads.
Cluster 1	Premium EVs, high-tech features.	Digital marketing, influencer partnerships.
Cluster 2	Reliability, affordability.	Financing options, infrastructure expansion.

Step 10: Monitoring Performance

Performance will be tracked through:

- **Sales Growth Rate** to measure adoption.
- **Customer Feedback Analysis** for service improvement.
- **Market Share Changes** to assess competitive positioning.
- **Infrastructure Expansion Metrics** for EV charging stations.

Final Conclusion & Insights

The Indian EV market has experienced significant growth between 2001 and 2024, driven by government policies, technological advancements, and increasing consumer awareness. Key trends include a surge in two-wheeler EV adoption, rapid infrastructure expansion, and a growing presence of leading manufacturers like Tata Motors and Hero Electric. Segmentation analysis highlights Delhi and Maharashtra as high-potential markets, while emerging states like Gujarat and Karnataka present moderate growth opportunities. Addressing affordability and infrastructure gaps in low-adoption regions will be crucial for nationwide EV penetration.

Future Improvements with Additional Resources

- **Enhanced Data Collection**: Incorporating real-time data from IoT-enabled vehicles and consumer behaviour analytics.
- **Advanced Predictive Models**: Using deep learning and geospatial analytics to predict future adoption rates and charging infrastructure needs.
- **Consumer Sentiment Analysis**: Leveraging AI-driven insights from social media and surveys to understand evolving preferences.
- **Collaboration with Industry Stakeholders**: Partnering with battery manufacturers, auto companies, and policymakers to optimize the supply chain and EV affordability.

Estimated Market Size

- **2024 Market Value:** Estimated at ₹1.5 lakh crore (~$18 billion), growing at a CAGR of 36%.
- **Total EV Sales (2024):** Over 1.2 million units, led by two-wheelers (~55%), three-wheelers (~30%), and four-wheelers (~15%).
- **Charging Infrastructure:** Over 15,000+ public charging stations across India, with Maharashtra, Karnataka, and Delhi leading.
- **Projected Growth (2025-2030):** Expected to surpass ₹5 lakh crore (~$60 billion), with increasing battery efficiency and cost reduction.

Key Variables for Optimal Market Segments

- **Geographic Factors:** State-wise EV adoption, infrastructure availability, and government incentives.
- **Demographic Factors:** Income levels, age groups, urban vs. rural distribution.
- **Psychographic Factors:** Consumer preferences for sustainability, premium features, and affordability.
- **Behavioural Factors:** Purchase motivations, brand loyalty, and price sensitivity.

Marketing Strategy (4Ps)

- **Product**: Expanding the EV portfolio with affordable, mid-range, and premium models to cater to diverse consumer segments.
- **Price**: Implementing flexible financing options, government subsidies, and competitive pricing strategies.
- **Place**: Strengthening distribution networks in high-adoption states while expanding outreach in emerging and low-adoption regions.
- **Promotion**: Digital campaigns, influencer marketing, corporate partnerships, and government-backed awareness programs.

Key Recommendations

- Prioritize investments in high-adoption states like Delhi and Maharashtra.
- Expand public charging infrastructure, especially in moderate and low-adoption areas.
- Introduce lower-cost EV models with attractive EMI plans for affordability.
- Leverage machine learning to analyse customer preferences and optimize inventory.
- Collaborate with the government to enhance EV incentives, tax benefits, and infrastructure development.

Conclusion

India's EV market is poised for substantial growth, with strong momentum in urban regions and rising interest in emerging states. While infrastructure and affordability challenges persist, strategic investments, data-driven decision-making, and policy-driven support can drive mass adoption. The next phase of growth will depend on sustained innovation, robust marketing strategies, and collaborative efforts across industry stakeholders.