Market Segmentation Analysis

Team - Bharathi

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Electric Vehicle Market Segmentation

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Problem Statement

The task is to analyse the Electric Vehicle (EV) Market in India utilizing Segmentation Analysis and develop a viable strategy for market entry, targeting segments most inclined to adopt electric vehicles. The segmentation analysis will encompass Geographic, Demographic, Psychographic, and Behavioural factors.

This report aims to explore the Electric Vehicle Market in India, focusing on segment like Brand, Model, AccelSec, Top Speed, Range, Efficiency, Fast Charge,

Rapid Charge, Power style, PlugType, seater, Segments, Price. Here our analysis is to find which has highest efficiency? How does price relate to rapid charging? Here we are using Fermi Estimation, which means, The process typically involves breaking down a complex problem into simpler components, making assumptions about each component, and then combining these assumptions to arrive at an estimate for the overall quantity. Fermi estimation is valuable because it allows one to quickly gauge the order of magnitude of a quantity and make decisions or draw conclusions based on that rough estimate.

Abstract:

The advent of electric vehicles (EVs) presents a transformative opportunity in India's automotive landscape, offering sustainable mobility solutions while addressing environmental concerns. This report endeavours to identify and target segments most likely to adopt EVs in India, with a focus on efficiency and premium pricing. Through thorough market segmentation, efficiency analysis, and price sensitivity evaluation, key consumer groups are delineated. Urban professionals, environmentally conscious individuals, and early technology adopters emerge as primary targets. Efficiency metrics such as range per charge, charging time, and energy consumption are scrutinized to discern optimal offerings. Additionally, pricing strategies and consumer perceptions regarding EV costs are examined to identify segments willing to invest in premium EV models. Marketing strategies tailored to resonate with identified segments are proposed, leveraging digital channels and strategic partnerships. The report concludes with forward-looking insights into emerging trends and recommendations for EV manufacturers to bolster adoption rates among target segments.

Data Collection:

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

Link for script:
https://github.com/jeyaprojects/feynnlab_project2/blob/main/EV_Car_Price%20Effiency.ipynb

Each column explained:

- Brand: The manufacturer or company that produces the electric vehicle.
- Model: The specific name or designation given to a particular type or version of an electric vehicle by its manufacturer.
- AccelSec: The time it takes for the vehicle to accelerate from 0 to a certain speed, usually measured in seconds.
- TopSpeed: The maximum speed that the electric vehicle can reach under normal operating conditions.
- Range: The distance that the electric vehicle can travel on a single charge of its battery.
- Efficiency: How effectively the electric vehicle utilizes its energy source (battery) to power its operation, often measured in miles or kilometres per unit of energy consumed.
- Fast Charge: The capability of the electric vehicle's charging system to rapidly replenish its battery charge to a significant level in a short amount of time.
- Rapid Charge: Similar to fast charging, this refers to the ability of the electric vehicle's charging system to quickly recharge its battery.
- Power style: The manner in which power is delivered to the electric vehicle's wheels, such as through front-wheel drive, rear-wheel drive, or all-wheel drive.
- PlugType: The specific type of connector or plug used to charge the electric vehicle's battery.
- Seater: The number of occupants the electric vehicle can accommodate, typically referring to the number of seats available.
- Segments: The market segments or categories into which the electric vehicle is classified based on factors such as size, functionality, or target audience.
- Price: The cost of purchasing the electric vehicle, often expressed in a specific currency (e.g., dollars, rupees).

Data Preprocessing:

Data preprocessing is all about making sure your data is clean, organized, and ready to be used to build models.

In data preprocessing, we changed the "Rapid Charge" and "FastCharge_KmH" columns from text to whole numbers for easier processing. We also added a new "INR

(10e3)" column to convert prices from euros to Indian rupees, adjusting the scale accordingly. This makes the data more consistent and ready for analysis or modelling.

Exploratory Data Analysis (EDA):

Exploratory Data Analysis (EDA) serves as the compass guiding our journey through the data landscape, illuminating key insights and potential pathways. It involves a systematic examination of the dataset to unearth hidden patterns, relationships, and anomalies, thereby laying the groundwork for informed decision-making and further analysis.

Key Components of EDA:

- Understanding the Data: We begin by comprehensively understanding the structure and nature of our dataset, identifying its variables, and discerning between numerical, categorical, and text data.
    1. Viewing Data Summary and Display basic information about the dataset
       dd.info()
    2. Display the first few rows of the dataset:
       dd.head(5)

- Descriptive Statistics: Descriptive statistics offer a panoramic view of the dataset, providing summary measures such as mean, median, standard deviation, and quartiles to elucidate its central tendencies and dispersion.

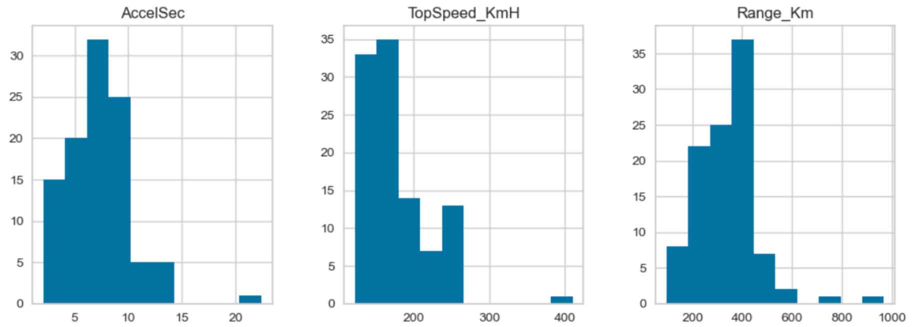
```
In [76]: dd.describe()
```

Out[76]:

	AccelSec	TopSpeed_KmH	Range_Km	Efficiency_WhKm	FastCharge_KmH	Seats	PriceEuro	INR(10e3)
count	103.0000	103.0000	103.0000	103.0000	103.0000	103.0000	103.0000	103.0000
mean	7.3961	179.1942	338.7864	189.1650	434.5631	4.8835	55811.5631	4643.5221
std	3.0174	43.5730	126.0144	29.5668	219.6601	0.7958	34134.6653	2840.0042
min	2.1000	123.0000	95.0000	104.0000	0.0000	2.0000	20129.0000	1674.7328
25%	5.1000	150.0000	250.0000	168.0000	260.0000	5.0000	34429.5000	2864.5344
50%	7.3000	160.0000	340.0000	180.0000	440.0000	5.0000	45000.0000	3744.0000
75%	9.0000	200.0000	400.0000	203.0000	555.0000	5.0000	65000.0000	5408.0000
max	22.4000	410.0000	970.0000	273.0000	940.0000	7.0000	215000.0000	17888.0000

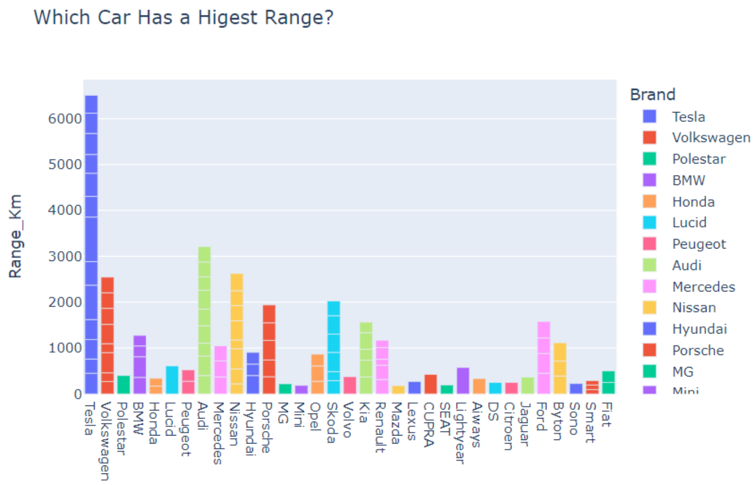
➢ Visualization Techniques: Utilizing a diverse array of graphs, charts, and plots, we visually depict the data to unravel intricate patterns, trends, and distributions. Visualization facilitates intuitive comprehension and aids in the identification of outliers and clusters.

```
In [81]: #Histogram of the each attributes
plt.rcParams['figure.figsize'] = (12,14)
dd.hist()
plt.show()
```



➢ Relationship Exploration: EDA endeavours to uncover relationships and dependencies among variables, discerning correlations, associations, and causal connections that underlie the data's structure.

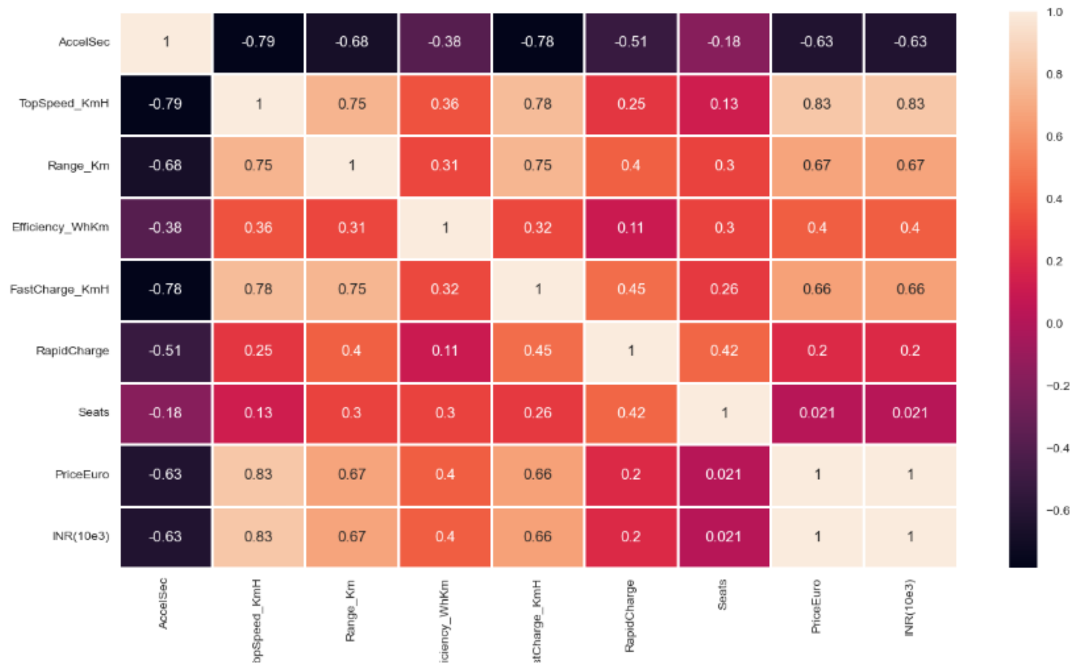
```
In [25]: fig = px.bar(dd,x='Brand',y = 'Range_Km',color = 'Brand',title = 'Which Car Has a Higest Range?',labels = {'x':'Car Brands','y':
pio.show(fig)
```



Correlation Matrix:

A correlation matrix is a table showing correlation coefficients between variables in a dataset. Each cell in the table represents the correlation between two variables, ranging from -1 to 1. A correlation of 1 indicates a perfect positive relationship, -1 a perfect negative relationship, and 0 no relationship. It's a valuable tool for understanding how variables interact and can aid in tasks like feature selection and predictive modelling. Python libraries like Pandas make it easy to compute correlation matrices from data.

```
In [32]: ax= plt.figure(figsize=(15,8))
         sb.heatmap(dd.corr(),linewidths=1,linecolor='white',annot=True)

C:\Users\sarav\AppData\Local\Temp\ipykernel_7892\617222163.py:2: FutureWarning:

The default value of numeric_only in DataFrame.corr is deprecated. In a future version, it will default to False. Select only v
alid columns or specify the value of numeric_only to silence this warning.

Out[32]: <Axes: >
```



- ➢ Handling Missing Data: Addressing missing data is pivotal in ensuring the integrity of our analysis. EDA involves assessing the extent of missingness, exploring potential patterns, and implementing strategies for imputation or exclusion as deemed appropriate.
- ➢ Outlier Detection: Outliers, as aberrant data points, warrant meticulous scrutiny during EDA. Their identification and characterization shed light on anomalous behaviour or data quality issues, guiding subsequent data cleaning and analysis efforts.
- ➢ Feature Engineering Insights: EDA often engenders novel insights and feature engineering opportunities, inspiring the creation of new variables or transformations that enhance the richness and predictive power of the dataset.

Extracting Segment:

Dendrogram:

In our analysis, we employed hierarchical clustering, a method for grouping similar data points into clusters based on their proximity to each other. Hierarchical clustering produces a dendrogram, a tree-like structure that visually represents the clustering process.

Methodology:

- Perform Hierarchical Clustering: We utilized the hierarchical clustering algorithm, specifically the linkage function from the SciPy library, on our dataset. This algorithm computes the pairwise distances between data points and iteratively merges the closest clusters until all data points belong to a single cluster.

- Visualize the Dendrogram: The resulting dendrogram provides a graphical representation of the hierarchical clustering process. Each branch in the dendrogram corresponds to a cluster, and the height of the branches represents the distance between clusters at the time of merging.

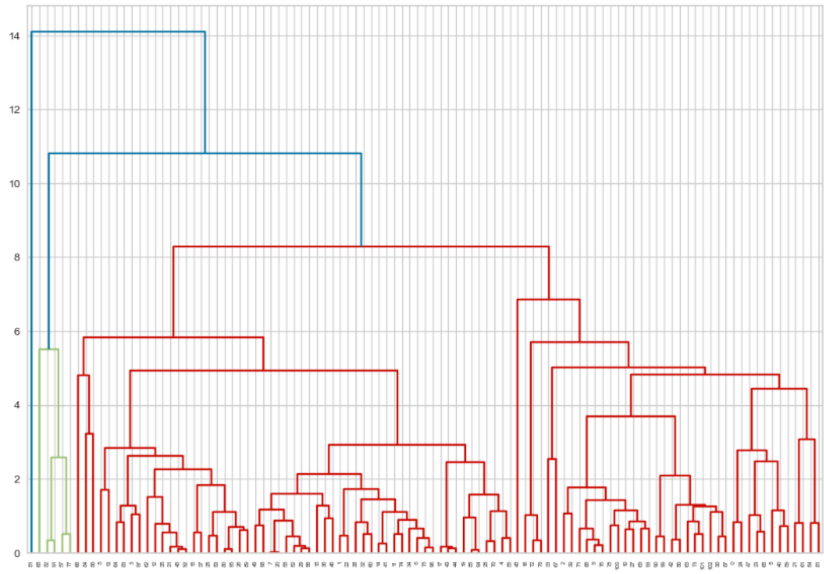
- Define a Cut-off Threshold: To extract segments from the dendrogram, we applied a cut-off threshold. This threshold determines the level at which the dendrogram is cut, forming distinct clusters or segments. The choice of cut-off threshold depends on the specific requirements of our analysis.

- Extract Segments: Using the fcluster function from the SciPy library, we identified clusters in the dendrogram based on the specified cut-off threshold. Each data point was assigned a cluster label, indicating its membership in a particular segment.

By extracting segments from the dendrogram, we obtained distinct clusters of data points that share similar characteristics or patterns. These segments provide valuable insights into the underlying structure of our dataset and can inform subsequent analyses, such as pattern recognition, anomaly detection, or customer segmentation.

Dendrogram plots of our dataset:

In [63]:
```
linked = linkage(data2, 'complete')
plt.figure(figsize=(13, 9))
dendrogram(linked, orientation='top')
plt.show()
```



Elbow Method:

The elbow method is a straightforward technique used to determine the optimal number of clusters in a dataset for clustering analysis. By testing different numbers of clusters and evaluating cluster quality metrics, such as total within-cluster variance, the method identifies a point where adding more clusters does not significantly improve the model's performance. This point, known as the "elbow point," strikes a balance between capturing meaningful patterns in the data and avoiding excessive complexity. Choosing the number of clusters at the elbow point allows for more interpretable and actionable insights from the data, facilitating tasks such as customer segmentation and pattern recognition.

Analysis and Approaches used for Segmentation:

Clustering:

Clustering is a method used in machine learning to uncover hidden structures within datasets by organizing similar data points into groups, or clusters. Unlike supervised learning, where data is labelled, clustering operates on unlabelled data, allowing for exploration and discovery of patterns without prior knowledge of the groups. The primary objective of clustering is to identify natural groupings in the data based on similarity or distance metrics. This technique finds application in diverse fields such as marketing, biology, finance, and image processing. Clustering algorithms vary in their approach, with some algorithms, like k-means, partitioning the data into a predetermined number of clusters, while others, such as hierarchical clustering, create a hierarchy of clusters. The choice of clustering algorithm depends on the characteristics of the dataset and the desired outcome of the analysis. Overall, clustering provides valuable insights into the underlying structure of data, enabling better decision-making and understanding of complex systems.

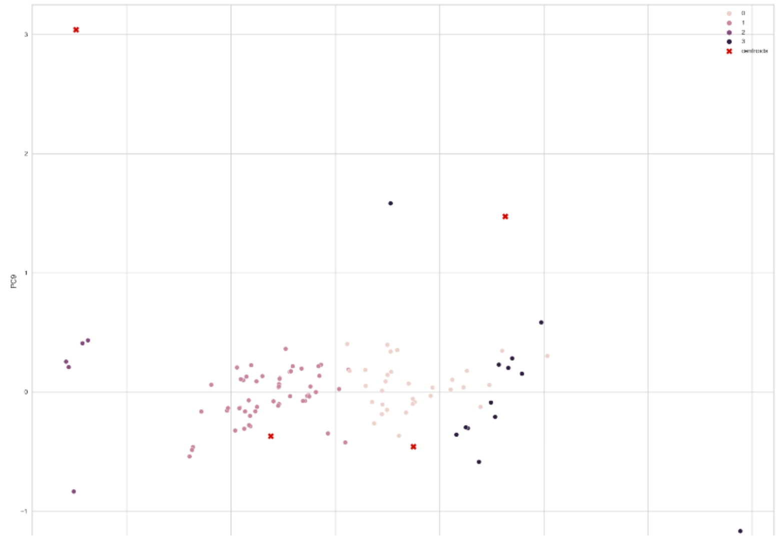
K-Mean Algorithms:

The k-means algorithm is a widely used method for partitioning a dataset into a predefined number of clusters (k). It iteratively assigns each data point to the nearest cluster centroid and then recalculates the centroids based on the mean of the data points assigned to each cluster. This process continues until the centroids no longer change significantly or a specified number of iterations is reached. K-means aims to minimize the within-cluster variance, where data points within the same cluster are as close to each other as possible, while also maximizing the separation between clusters. Despite its simplicity, k-means is highly effective in identifying compact, spherical clusters in high-dimensional data. However, its performance may be influenced by the initial placement of centroids, and the algorithm may converge to local optima. Preprocessing steps such as feature scaling and careful initialization of centroids can mitigate these issues. K-means is widely used in various fields, including customer segmentation, image compression, and anomaly detection, owing to its simplicity, scalability, and interpretability.

According to elbow method ,we took k=4 cluster to train the model

```
In [68]: #K-means clustering

         kmeans = KMeans(n_clusters=4, init='k-means++', random_state=0).fit(t)
         dd['cluster_num'] = kmeans.labels_ #adding to df
         print (kmeans.labels_) #Label assigned for each data point
         print (kmeans.inertia_) #gives within-cluster sum of squares.
         print(kmeans.n_iter_) #number of iterations that k-means algorithm runs to get a minimum within-cluster sum of squares
         print(kmeans.cluster_centers_) #Location of the centroids on each cluster.

         D:\anaconda\Lib\site-packages\sklearn\cluster\_kmeans.py:1416: FutureWarning:

         The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress the warnin
         g

         D:\anaconda\Lib\site-packages\sklearn\cluster\_kmeans.py:1440: UserWarning:

         KMeans is known to have a memory leak on Windows with MKL, when there are less chunks than available threads. You can avoid it
         by setting the environment variable OMP_NUM_THREADS=1.

         [3 1 0 1 1 3 1 1 1 0 0 1 1 0 1 1 3 1 1 1 1 0 1 3 3 1 1 0 1 1 0 1 1 0 1 1 1
          1 1 0 3 1 0 1 1 1 1 3 3 1 0 3 1 1 0 1 1 2 1 3 1 0 0 0 1 3 1 0 2 0 1 0 3 0
          1 1 0 2 0 3 1 0 2 1 0 1 0 0 0 1 0 2 1 0 1 1 1 1 1 0 0 0 0]
         354.3939547498791
         4
         [[ 1.49513 -0.45952  0.74981 -0.07565 -0.1012  -0.19196  0.16665  0.0294
            0.05299]
          [-1.23431 -0.3704  -0.48236  0.11617 -0.10852  0.12902 -0.05388  0.02073
           -0.04087]
          [-4.97444  3.0402   1.8459   0.2366   1.16331 -0.53549  0.07533  0.0564
            0.09278]
          [ 3.26512  1.47191 -0.5891  -0.37841  0.24411  0.15247 -0.21951 -0.17861
            0.0005 ]]

In [69]: #To see each cluster size

         Counter(kmeans.labels_)
```

```
In [70]:
#Visulazing clusters
sb.scatterplot(data=data2, x="PC1", y="PC9", hue=kmeans.labels_)
plt.scatter(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1],
            marker="X", c="r", s=80, label="centroids")
plt.legend()
plt.show()
```



Predicting Prices of Electric Cars using Linear Regression:

Linear regression, a supervised machine learning algorithm, is employed for regression tasks, aiming to predict a target value based on independent variables. Widely used for establishing relationships between variables and making forecasts, linear regression models are particularly useful for predicting prices in various industries. In this analysis, we utilize a linear regression model to forecast the prices of electric cars across different manufacturers.

Methodology:

We begin by preparing our dataset, where the independent variables (X) represent features such as mileage, battery capacity, and manufacturer, while the dependent variable (y) denotes the prices to be predicted. To train our model, we split the data into training and testing sets using a 40:60 ratio, with 40% of the data reserved for training.

We then employ the LinearRegression().fit(X_train, y_train) command to fit the dataset to our model, allowing it to learn the underlying patterns and relationships between the independent variables and the target prices.

Model Evaluation:

Upon completion of the training process, we evaluate the performance of our model by testing the remaining 60% of the data. We compare the predicted values generated by the model with the original test dataset for the dependent variable. The evaluation is visualized using a scatter plot, where the alignment of predicted values with the original data points is indicative of the model's accuracy. A linear relationship between the predicted and actual values suggests a good fit of the model to the data.

Additionally, we assess the distribution of prediction errors using density functions, aiming for a normally distributed pattern. A well-distributed density function indicates that the model's predictions are unbiased and consistent across the dataset

```
In [71]: #regression for data2
         X=data2[['PC1', 'PC2','PC3','PC4','Pc5','PC6', 'PC7','PC8','PC9']]
         y=dd['INR(10e3)']

In [72]: X_train, X_test, y_train, y_test = train_test_split(X, y,test_size=0.4, random_state=101)
         lm=LinearRegression().fit(X_train,y_train)

In [73]: print(lm.intercept_)

         4643.522050485438

In [74]: lm.coef_

Out[74]: array([ 1050.51269,   982.73452,   202.46698,  -151.64849,   241.89067,
                 1571.09433, -1339.28395,  -313.32264,  1198.03226])

In [75]: X_train.columns

Out[75]: Index(['PC1', 'PC2', 'PC3', 'PC4', 'Pc5', 'PC6', 'PC7', 'PC8', 'PC9'], dtype='object')

In [76]: cdf=pd.DataFrame(lm.coef_, X.columns, columns=['Coeff'])
         cdf
```

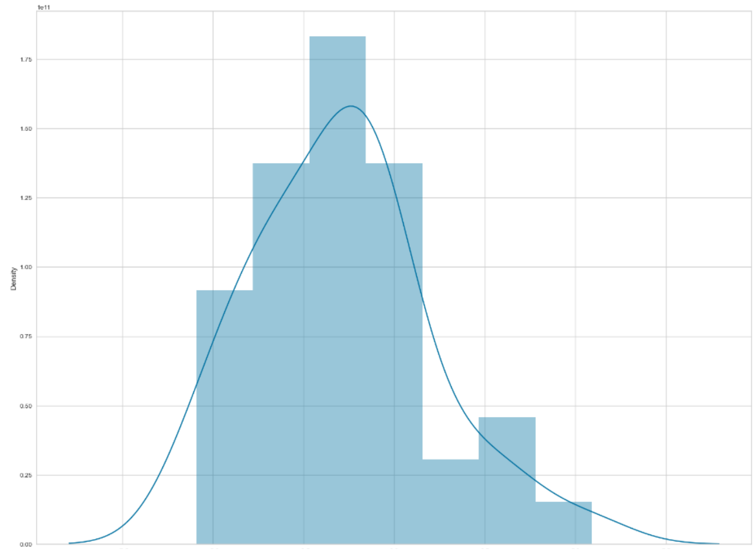

```
In [76]: cdf=pd.DataFrame(lm.coef_, X.columns, columns=['Coeff'])
         cdf
```


```
Out[76]:
```

	Coeff
PC1	1050.5127
PC2	982.7345
PC3	202.4670
PC4	-151.6485
Pc5	241.8907
PC6	1571.0943
PC7	-1339.2840
PC8	-313.3226
PC9	1198.0323

```
In [77]: predictions=lm.predict(X_test)
         predictions

Out[77]: array([ 3744.    ,  2496.    ,  5233.28  ,  3243.7184,  3064.8384,
                 5459.584 ,  2903.68  ,  3328.    ,  3952.    ,  2594.5088,
                 2654.08  ,  3744.    ,  2041.2288, 15040.9792,  6609.824 ,
                 3170.336 ,  4451.2   ,  2866.9888,  3744.    , 17888.    ,
                 4877.184 ,  5660.928 ,  5876.4992,  2062.528 , 12396.8   ,
                 8565.024 , 12338.6432,  3328.    ,  4695.808 ,  5408.    ,
```

```
[80]: <Axes: xlabel='INR(10e3)', ylabel='Density'>
```



Through this approach, we aim to develop a robust predictive model capable of accurately forecasting prices for electric cars from various manufacturers. By leveraging the power of linear regression and carefully selected independent variables, we can provide valuable insights into pricing trends and assist stakeholders in making informed decisions within the electric vehicle market.

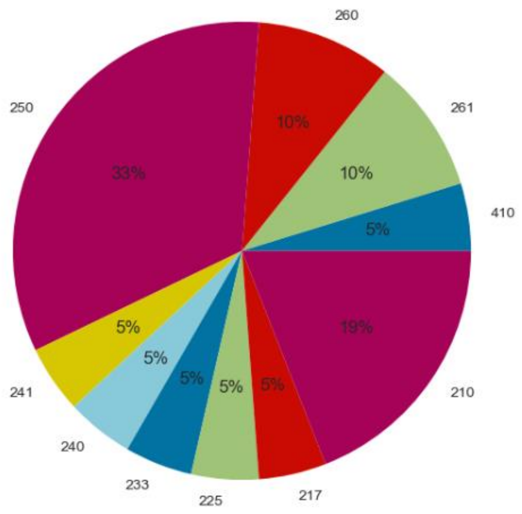
The metric of the algorithm, Mean absolute error, Mean squared error and mean square root error are described in the below figure:

```
In [83]: print('MAE:',metrics.mean_absolute_error(y_test,predictions))
         print('MSE:',metrics.mean_squared_error(y_test,predictions))
         print('RMSE:',np.sqrt(metrics.mean_squared_error(y_test,predictions)))

         MAE: 2.306218708067068e-12
         MSE: 8.089629443003717e-24
         RMSE: 2.8442273894686616e-12

In [84]: metrics.mean_absolute_error(y_test,predictions)

Out[84]: 2.306218708067068e-12

In [85]: metrics.mean_squared_error(y_test,predictions)

Out[85]: 8.089629443003717e-24

In [87]: np.sqrt(metrics.mean_squared_error(y_test,predictions))

Out[87]: 2.8442273894686616e-12
```

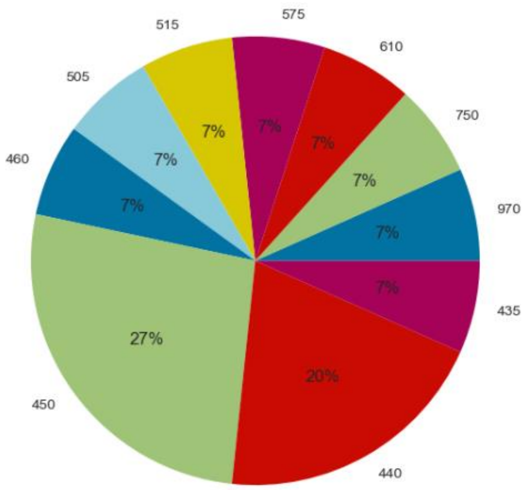
Profiling and Describing the Segment:

Sorting the Top Speeds and Maximum Range in accordance to the Price with head ()we can view the Pie Chart.

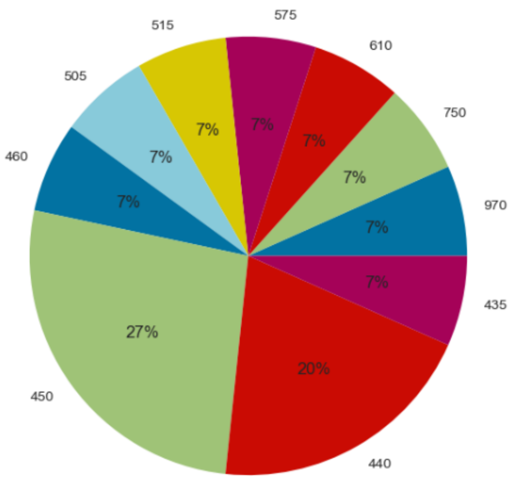
Cost based on Top Speed



Cost based on Maximum Range



Top Speeds based on Maximum Range



Target Segments Analysis:

Based on our analysis, the ideal target segment for electric cars is defined by a few key factors. Firstly, consumers in this segment prioritize affordability, with prices ranging from 16 lakhs to 1.8 crores. Additionally, they value efficiency, seeking vehicles that offer great performance while being environmentally friendly. Moreover, top speed capabilities are important, indicating a desire for cars that offer both speed and efficiency. Lastly, cars with five seats are preferred, suggesting a preference for spacious and versatile options. By focusing on these simple criteria, manufacturers can effectively target and attract consumers within this segment, driving adoption and market growth for electric vehicles.

Electric Vehicle Market Segmentation

Kunta Sravani

EV MARKET SEGMENTATION ANALYSIS

This study presents a thorough segmentation analysis of the Electric Vehicle (EV) market, leveraging data from two distinct datasets encompassing specifications and prices. By employing Exploratory Data Analysis (EDA) and advanced visualization techniques, I derivedactionable insights into the EV landscape, shedding light on market trends and consumer preferences.

- Range of vehicle is proportional to Battery Pack Capacity
- Price of vehicle is proportional battery pack capacity
- EV's which cost less have higher acceleration (0-100 Km/hr) time in order to maximize range
- High performance EV's have lower efficiency
- Most of the vehicles costing less than 50,000 Euros are Front Wheel Drive
- Most of the vehicles costing over 50,000 Euros are either All wheel drive or Rear wheel drive and have better acceleration
- The Scatter plot Battery Vs range is proportional and the price of the vehicle is increasing if Battery capacity is increasing.

Final Conclusion
The EV market is segmented to cater to different consumer preferences and budget constraints. Key insights include:

Budget Segment (Under 50,000 Euros):

- Focus on maximizing range and cost-efficiency.
- Predominantly FWD configurations.
- Higher acceleration times as a trade-off for range efficiency.

Premium Segment (Over 50,000 Euros):

- Emphasis on superior performance and driving dynamics.
- Predominantly AWD or RWD configurations.
- Better acceleration but lower overall efficiency.

These trends indicate that while budget-friendly EVs are designed for practical, cost-effective transportation with extended range, premium EVs are engineered for performance-oriented consumers willing to invest more for advanced features and driving experiences.

Dataset 1: EV_clean_me

Dataset 2:EV_tech_specs

Electric Vehicle Market Segmentation

Kayyala Pavan Kumar

EV Vehicle Market Segmentation Analysis

Abstract

Market segmentation becomes a crucial tool for evolving transportation technology such as electric vehicles (EVs) in emerging markets to explore and implement for extensive adoption. EVs adoption is expected to grow phenomenally in the near future as low emission and low operating cost vehicles, and thus, it drives a considerable amount of forthcoming academic research curiosity.

The main aim of this study is to explore and identify distinct sets of potential buyer segments for EVs based on psychographic, behavioural, and socio-economic characterization.

Target Market

The target market of Electric Vehicle Market Segmentation can be categorized into Geographic, Sociodemographic, Behavioural, and Psychographic Segmentation.

Behavioural Segmentation: searches directly for similarities in behaviour or reported behaviour. Example: prior experience with the product, amount spent on the purchase, etc.

Psychographic Segmentation: grouped based on beliefs, interests, preferences, aspirations, or benefits sought when purchasing a product. Suitable for lifestyle segmentation. Involves many segmentation variables.

Socio-Demographic Segmentation: includes age, gender, income, and education. Useful in industries.

Process Flow:

1.Data Cleaning and Data Collection.

Data set link: https://github.com/Kayyalapavankumar/EV_Market_Seg_Analysis/blob/main/data%20(1).csv

2.Exploratory Data Analysis. We have done the analysis on the following segments-

1. Which car has top speed?
2. Which car has fast acceleration?
3. Pair plot.
4. Analysed different brands in the dataset.
5. Top speed achieved by each brand.

6. Maximum Range achieved by each brand.
7. Efficiency achieved by each brand.
8. Seats in a car.
9. Price range of the cars.
10. Comparison on car speeds.

Target Segments:

So, from the analysis we can see that the optimum targeted segment should be belonging to the following categories:

Behavioural: Mostly from our analysis there are cars with 5 seats.

Demographic:

- Top Speed & Range: With a large area of market the cost is dependent on Top speeds and Maximum range of cars.
- Efficiency: Mostly the segments are with most efficiency

Psychographic:

- Price: From the above analysis, the price range is between 16,00,000 to 1,80,00,000.

Finally, our target segment should contain cars with most Efficiency, contains Top Speed and price between 16 to 180 lakhs with mostly with 5 seats

Electric Vehicle Market Segmentation

Yogeshwar Chaudhari

-Report-

EV Market Segmentation

Identifies and discusses recent developments in electric mobility across the globe.

Abstract

The Global EV Outlook is an annual publication that identifies and assesses recent developments in electric mobility across the globe. It is developed with the support of members of the Electric Vehicles Initiative (EVI). Combining analysis of historical data with projections – now extended to 2035 – the report examines key areas of interest such as the deployment of electric vehicles and charging infrastructure, battery demand, investment trends, and related policy developments in major and emerging markets. It also considers what wider EV adoption means for electricity and oil consumption and greenhouse gas emissions. The report includes analysis of lessons learned from leading markets, providing information for policy makers and stakeholders on policy frameworks and market systems that support electric vehicle uptake. This edition also features analysis of electric vehicle affordability, second-hand markets, lifecycle emissions of electric cars and their batteries, and grid impacts from charging medium- and heavy-duty electric trucks. Two online tools are made available alongside the report: the Global EV Data Explorer and the Global EV Policy Explorer, which allow users to interactively explore EV statistics and projections, and policy measures worldwide.

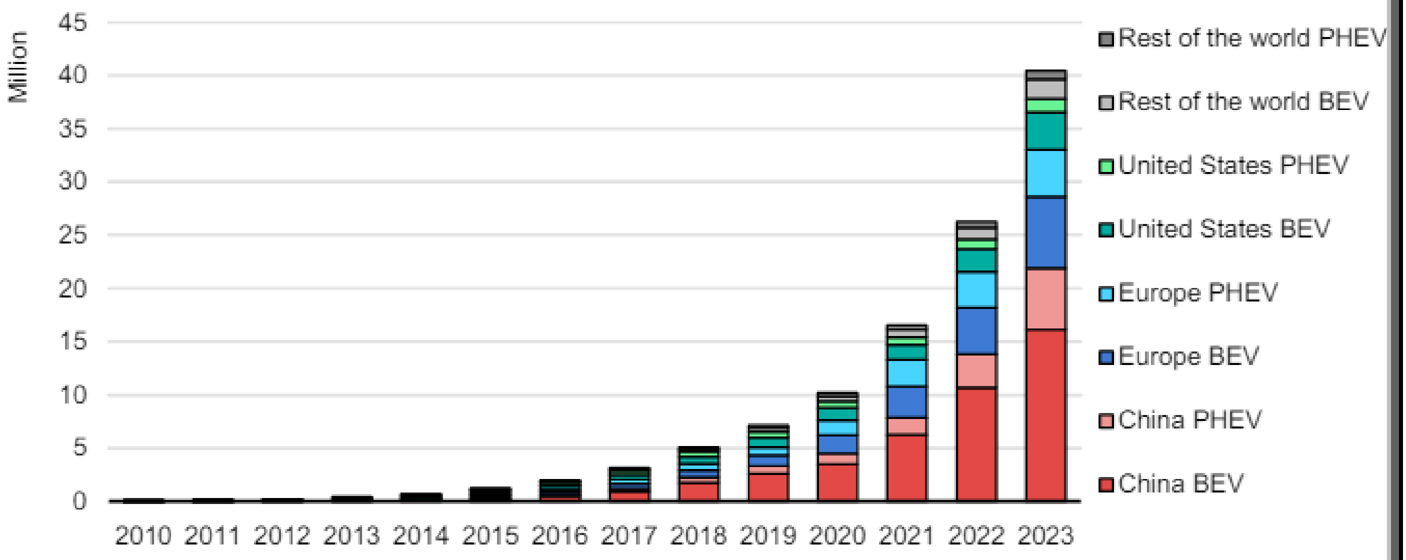
1. Trends in electric cars

Electric car sales Nearly one in five cars sold in 2023 was electric

Electric car sales neared 14 million in 2023, 95% of which were in China, Europe and the United States

Almost 14 million new electric cars1 were registered globally in 2023, bringing their total number on the roads to 40 million, closely tracking the sales forecast from the 2023 edition of the Global EV Outlook (GEVO-2023). Electric car sales in 2023 were 3.5 million higher than in 2022, a 35% year-on-year increase. This is more than six times higher than in 2018, just 5 years earlier. In 2023, there were over 250 000 new registrations per week, which is more than the annual total in 2013, ten years earlier. Electric cars accounted for around 18% of all cars sold in 2023, up from 14% in 2022 and only 2% 5 years earlier, in 2018. These trends indicate that growth remains robust as electric car markets mature. Battery electric cars accounted for 70% of the electric car stock in 2023.

Global electric car stock trends, 2010-2023



Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid vehicle. Includes passenger cars only.
Sources: IEA analysis based on country submissions and data from ACEA, EAFO, EV Volumes and Marklines.

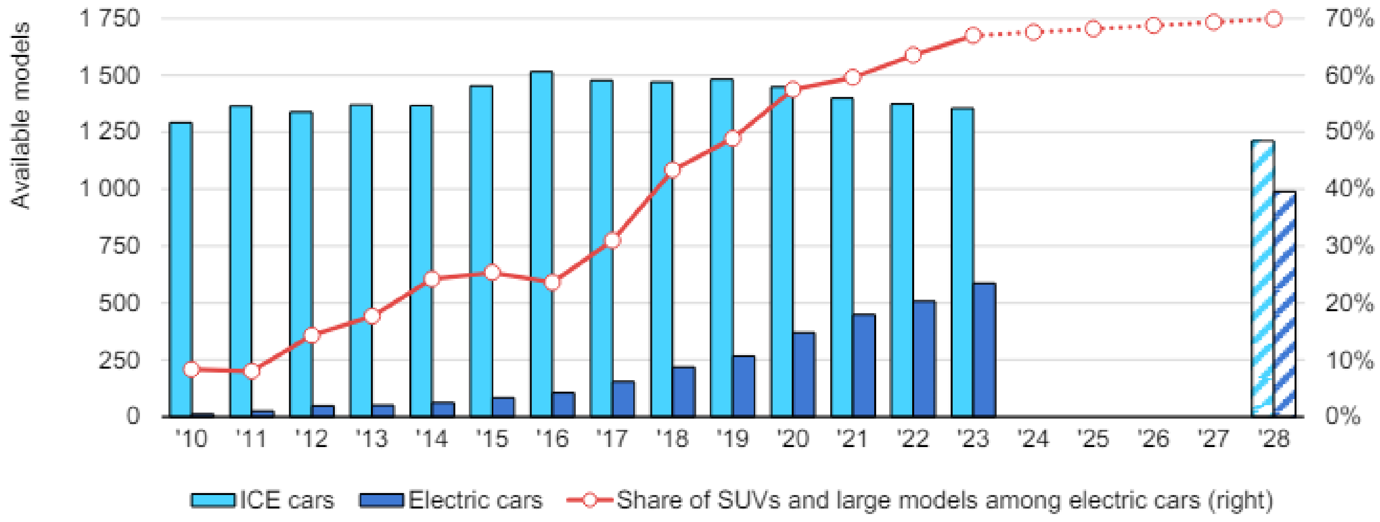
Electric car availability and affordability

More electric models are becoming available, but the trend is towards larger ones

The number of available electric car models nears 600, twothirds of which are large vehicles and SUVs

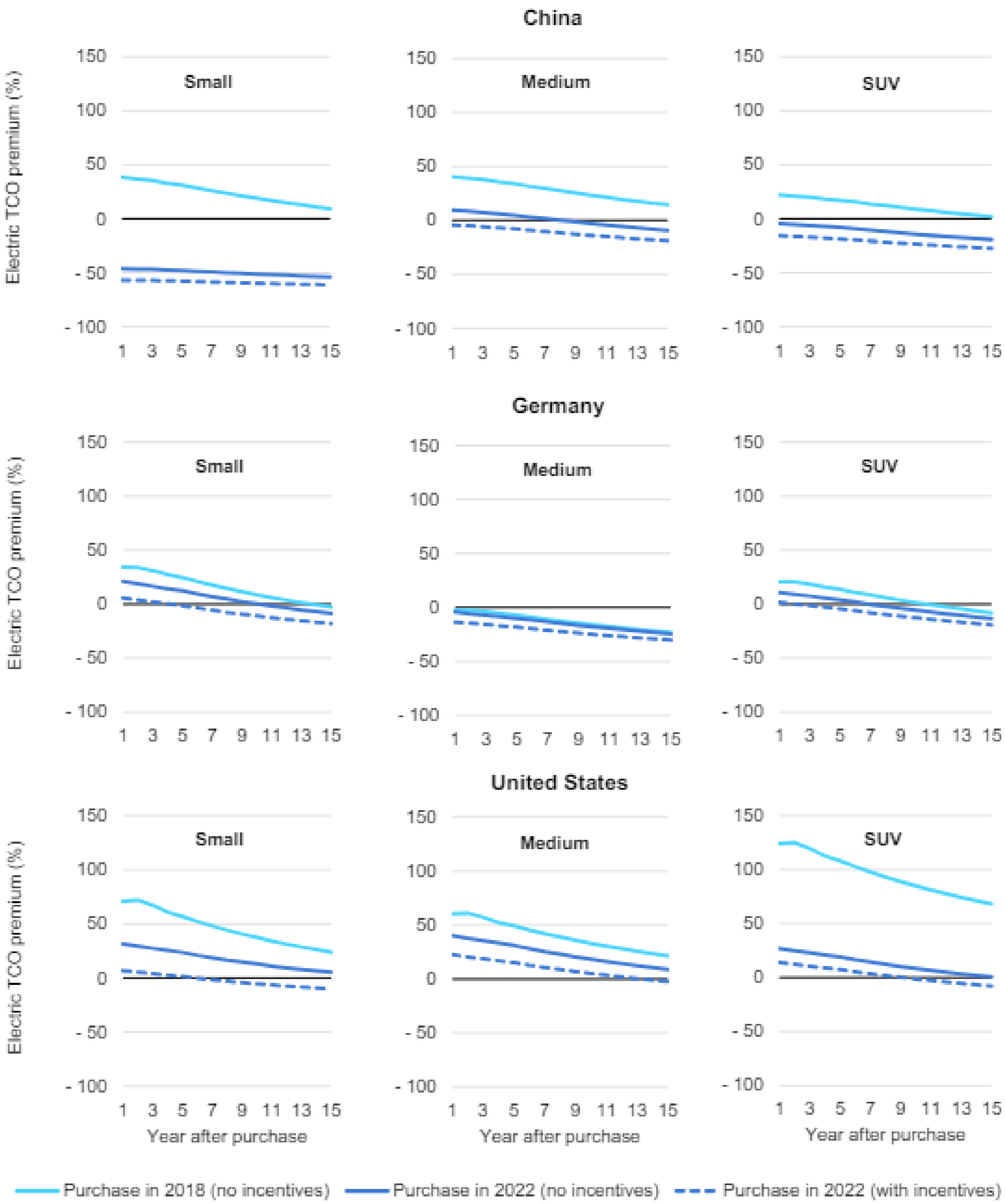
In 2023, the number of available models for electric cars increased 15% year-onyear to nearly 590, as carmakers scaled up electrification plans, seeking to appeal to a growing consumer base. Meanwhile, the number of fully ICE models (i.e. excluding hybrids) declined for the fourth consecutive year, at an average of 2%. Based on recent original equipment manufacturer (OEM) announcements, the number of new electric car models could reach 1 000 by 2028. If all announced new electric models actually reach the market, and if the number of available ICE car models continues to decline by 2% annually, there could be as many electric as ICE car models before 2030.

Car model availability by powertrain over 2010-2023 and in 2028 based on announced launches, and share of SUVs and large models among electric cars



Notes: ICE = internal combustion engine. SUVs = sports utility vehicle. ICE does not include hybrids. Electric cars include BEV and PHEV cars. Analysis based on models for which there was at least one new registration in a given year; a model on sale but never sold is not counted, and as such actual model availability may be underestimated. Large cars include E and F segments, multi-purpose vehicles and B segments with SUV body type. The SUV category encompasses segments C to F with SUV body type. The two columns for 2028 are based on electric model announcements, which are available only until 2028, and on a sustained decrease in the number of ICE models based on the trend over 2020-2023.
Source: IEA analysis based on data from EV Volumes and Marklines.

Difference in total cost of ownership for a battery electric vehicle and a conventional car purchased in 2018 and 2022, by country and segment, over time after purchase



Notes: TCO = total cost of ownership; SUV = sports utility vehicle. First owner cumulative cost of ownership with depreciation considered. Incentives include subsidies, vehicle purchase tax exemptions and tax credits. All calculation assumptions are listed in Table 1 located in the general annex of this document.

2. Trends in other light-duty electric vehicles

Electric two- and three-wheelers

India, China and Association of Southeast Asian Nations (ASEAN) countries are the biggest two- and three-wheeler (2/3W)9 markets worldwide. In 2023, sales of 2/3Ws in these markets, including both electric and ICE powertrains, reached 19 million, 17 million and 14 million units, respectively. Indonesia, Viet Nam, the Philippines and Thailand are the biggest markets among ASEAN countries, with sales of 2/3Ws far outnumbering sales of LDVs, highlighting their importance in the region. Likewise, the number of 2/3Ws in India is 157 per 1 000 people, compared with only 35 passenger cars. Despite having smaller 2/3W markets overall, 2/3Ws also play a critical role in Latin America and Africa for daily passenger and commercial transportation. Electrifying 2/3Ws is therefore a promising lever for decarbonising mobility and improving urban air quality in these regions. In 2023, the sales share of electric 2/3Ws was just 13% globally, while in terms of stock shares, 2/3Ws represent the most electrified road transport segment, with about 8% of 2/3Ws being electric. China sold the most electric 2/3Ws in 2023, with over 30% of the 2/3W sales being electric (decreasing from about 50% in 2022), followed by India (8%) and ASEAN countries (3%)

India overtakes China as the largest market for electric three-wheelers as global sales continue to grow

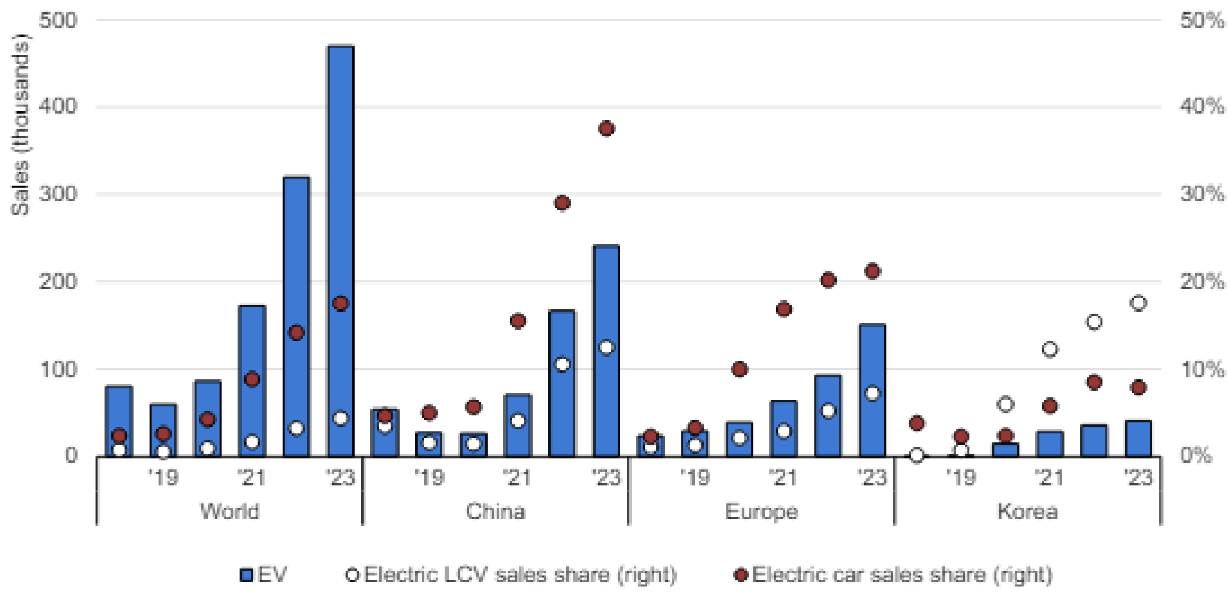
Globally, the three-wheeler (3W) market grew 13% in 2023, to reach 4.5 million sales, 21% of which were electric, compared to 18% in 2022. Almost 1 million electric 3Ws were sold in 2023, reflecting 30% growth compared to 2022. The market is highly concentrated, with China and India together accounting for more than 95% of all electric and 80% of conventional 3W sales. India overtook China in 2023 to become the biggest market for electric 3Ws, with over 580 000 sales. India saw its sales increase by 65% with respect to 2022, thanks to government financial incentives and resulting reductions in the cost of ownership of electric 3Ws. Sales in China declined 8% in 2023, to 320 000, making the country the second-largest electric 3W market.

Electric light commercial vehicles

One in twenty-five light commercial vehicles sold in 2023 was electric, following the path set by passenger cars

The market for electric light commercial vehicles (LCVs) continued to increase in 2023. Global electric LCV sales grew by more than 50%, and the sales share grew to just under 5%. Two of the biggest electric LCV markets, China and Europe, saw a large increase in sales in 2023, as part of a broader trend of increasing LCV sales – both electric and ICE. In China, electric LCV sales exceeded 240 000, and in Europe, the electric LCV market leapt by 60% to reach almost 150 000. As the electric LCV market matures, several OEMs have announced new electric models and new partnerships. Some of these new models are designed specifically for niche commercial activities, such as the B-ON Pelkan electric delivery van. In a partnership with Uber, Kia announced a modular van design with a body that can be swapped from shuttling to last-mile delivery depending on activity. The average range of new LCVs increased by 55% between 2015 and 2023. For example, the two most popular electric LCV models in 2015 (Nissan e-NV200 and the Renault Kangoo BEV) had a range of around 170 km. This compares to a much longer range – between 210 and 260 km – demonstrated by two very popular models (Hyundai Porter and Ford E-Transit) in 2023. Despite this increase, companies expanding their electric fleets have called for improvements in the accuracy of range labelling. Korea is the only country in which the penetration of electric LCVs is moving faster than electric passenger cars. In Korea, the Hyundai Porter and the Kia Bongo are the only electric LCV models sold. Both are produced by local manufacturers, and seem particularly suited for the Korean light freight market, which is characterised by shorter distances. These models are also favourably priced compared to ICE equivalents: The Kia Bongo 3 EV, for example, sells for around USD 25 000, including a subsidy of USD 7 700.

Electric light commercial vehicle sales and sales shares, 2018-2023



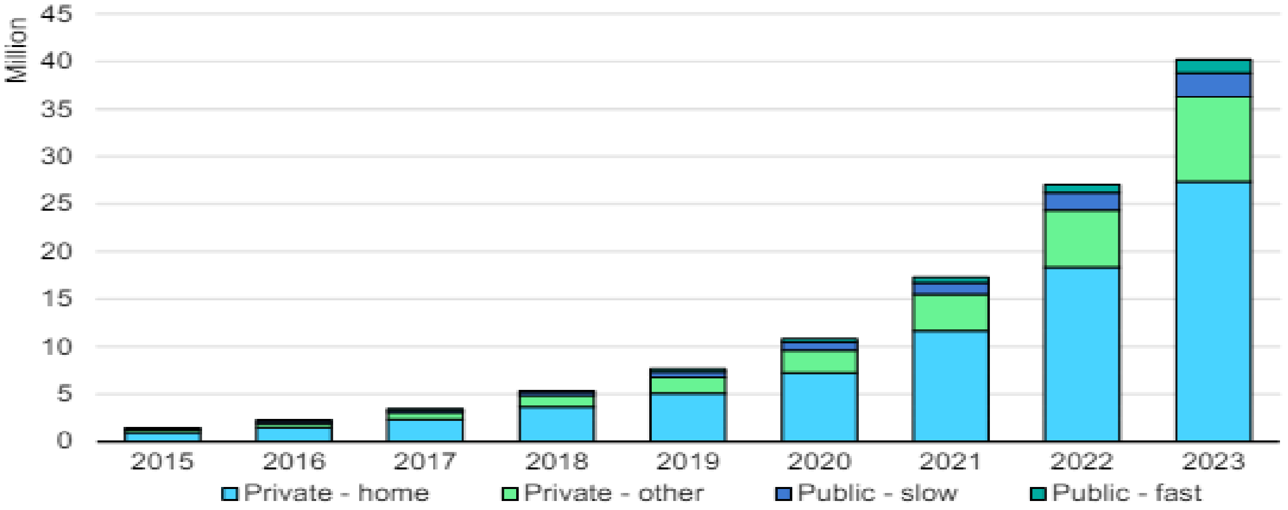
Notes: EV = electric vehicle; LCV = light commercial vehicle where weight is less than 3.5 tonnes. In China, LCVs include small-sized buses, some light-duty trucks and mini trucks. To better align with IEA classifications, a share of the light-duty trucks are considered as medium-duty trucks (defined here as having a gross vehicle weight greater than 3.5 tonnes and less than 15 tonnes).

Sources: IEA analysis based on country submissions data from EV Volumes, and Interact Analysis.

3. Trends in electric vehicle charging Charging for electric light-duty vehicles There are almost ten times as many private chargers as public ones, with most owners charging at home

Home charging is currently the most common means of charging electric cars. EV owners with access to a private parking space that can be equipped for charging can charge overnight, which is not only convenient but also typically takes advantage of lower electricity prices while demand is relatively low. The availability of home charging varies substantially between regions and is linked to differences in urban, suburban and rural populations, as well as income bracket. In dense cities, where most people live in multi-unit dwellings, access to home charging is more limited and EV owners rely more heavily on public charging. This is most apparent in Korea, which is one of the world's most densely populated countries and has the highest ratio of public charging capacity to EVs. Though access to charging is different to actual use, it is a useful proxy for the levels of home charging among EV owners across countries. The share of EVs in new car sales is over 90% in Norway, whereas it stands at under 2% in Mexico, yet the shares of EV owners reportedly charging at home are similar, at 82% and 71%, respectively. The United Kingdom has one of the highest reported shares of access to home charging, at 93%, more than half of which are smart chargers.12 This is partly due to the United Kingdom being the first country to release smart charge point regulations, but, importantly, it could also be attributed to the high share of early EV adopters that also own a home in which a charger can be installed. In India, 55% of consumers state that they have access to home charging today. Changes to building regulations in order to mandate chargers, as have been proposed by the European Union, are an effective way of increasing access over time, especially for people who live in rented accommodation.

Installed public and private light-duty vehicle charging points by power rating (public) and by type (private), 2015-2023



Notes: "Private – other" refers to charging points that are neither publicly accessible nor charging points at private residences. Home charging stock is estimated based on electric light-duty vehicle stock and regional assumptions on electric vehicle supply equipment (EVSE)/electric vehicle (EV) ratios.

Sources: IEA analysis based on country submissions.

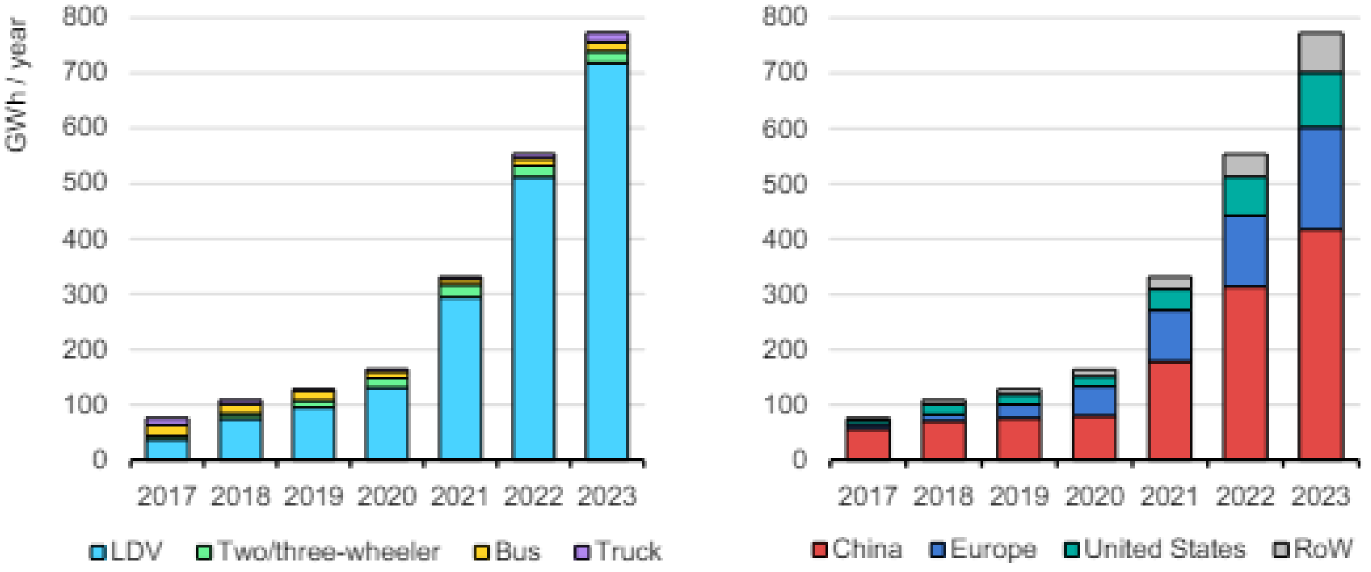
4. Trends in electric vehicle batteries

Battery supply and demand

Demand for batteries and critical minerals continues to grow, led by electric car sales

Increasing EV sales continue driving up global battery demand, with fastest growth in 2023 in the United States and Europe The growth in EV sales is pushing up demand for batteries, continuing the upward trend of recent years. Demand for EV batteries reached more than 750 GWh in 2023, up 40% relative to 2022, though the annual growth rate slowed slightly compared to in 2021-2022. Electric cars account for 95% of this growth. Globally, 95% of the growth in battery demand related to EVs was a result of higher EV sales, while about 5% came from larger average battery size due to the increasing share of SUVs within electric car sales. The United States and Europe experienced the fastest growth among major EV markets, reaching more than 40% year-on-year, closely followed by China at about 35%. Nevertheless, the United States remains the smallest market of the three, with around 100 GWh in 2023, compared to 185 GWh in Europe and 415 GWh in China. In the rest of the world, battery demand growth jumped to more than 70% in 2023 compared to 2022, as a result of increasing EV sales. In China, PHEVs accounted for about one-third of total electric car sales in 2023 and 18% of battery demand, up from one-quarter of total sales in 2022 and 17% of sales in 2021. PHEV batteries are smaller than those used in BEVs, thereby contributing less to increasing battery demand. In recent years, Chinese carmakers have also been marketing more extended-range EVs (EREVs), which use an electric motor as their unique powertrain but have a combustion engine that can be used to recharge the battery when needed. EREVs typically have a battery size about twice that of a PHEV, enabling a real-world electric range of around 150 km compared to 65 km for traditional PHEVs. With an ICE on board, EREVs can reach ranges of around 1 000 km when needed. In 2023, EREVs accounted for 25% of PHEV sales in China, up from about 15% in 2021-2022. Negligible EREV sales are recorded in other regions.

Electric vehicle battery demand by mode and region, 2017-2023



Notes: LDV = light-duty vehicle, including cars and vans; RoW = rest of the world.
Source: IEA analysis based on data from EV Volumes.

Battery prices Electric vehicle battery prices start falling again

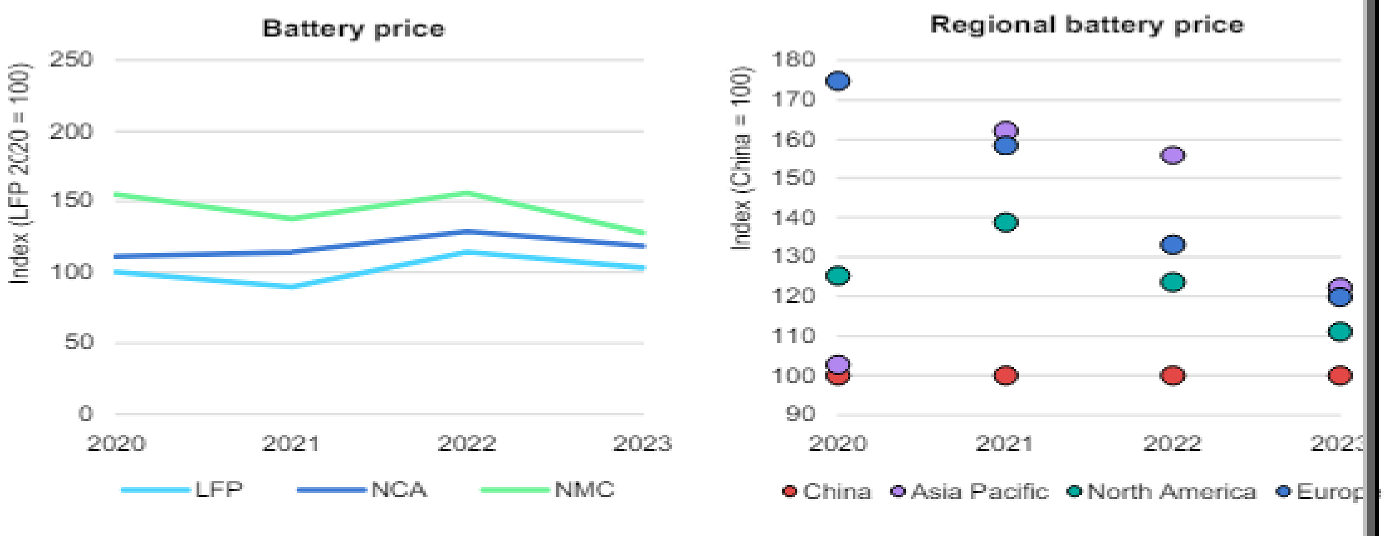
Stabilising critical mineral prices led battery pack prices to fall in 2023

Turmoil in battery metal markets led the cost of Li-ion battery packs to increase for the first time in 2022, with prices rising to 7% higher than in 2021. However, the price of all key battery metals dropped during 2023, with cobalt, graphite and manganese prices falling to lower than their 2015-2020 average by the end of 2023. This led to an almost 14% fall in battery pack price between 2023 and 2022, despite lithium carbonate prices at the end of 2023 still being about 50% higher than their 2015-2020 average. The last year in which battery price experienced a similar price drop was 2020.

6. Trends in the electric vehicle industry

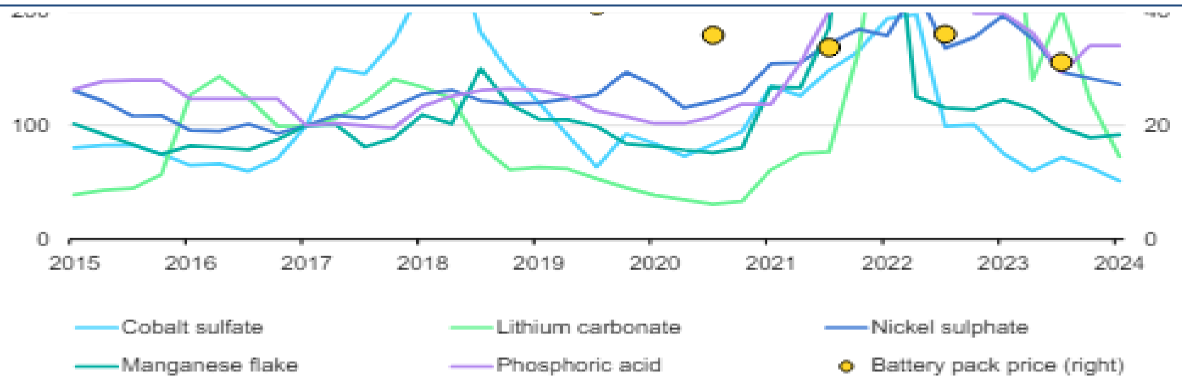
Electric vehicle company strategy and market competition

Average battery price index by selected battery chemistry and region, 2020-2023



IEA. CC BY 4.0

Notes: LFP = lithium iron phosphate; NMC = lithium nickel manganese cobalt oxide; NCA = lithium nickel cobalt aluminium oxide. Asia Pacific excludes China. Each year is indexed with respect to China price (100). Battery prices refer to the average battery price in a given region, including locally produced batteries and imports.
Sources: IEA analysis based on data from Bloomberg New Energy Finance.



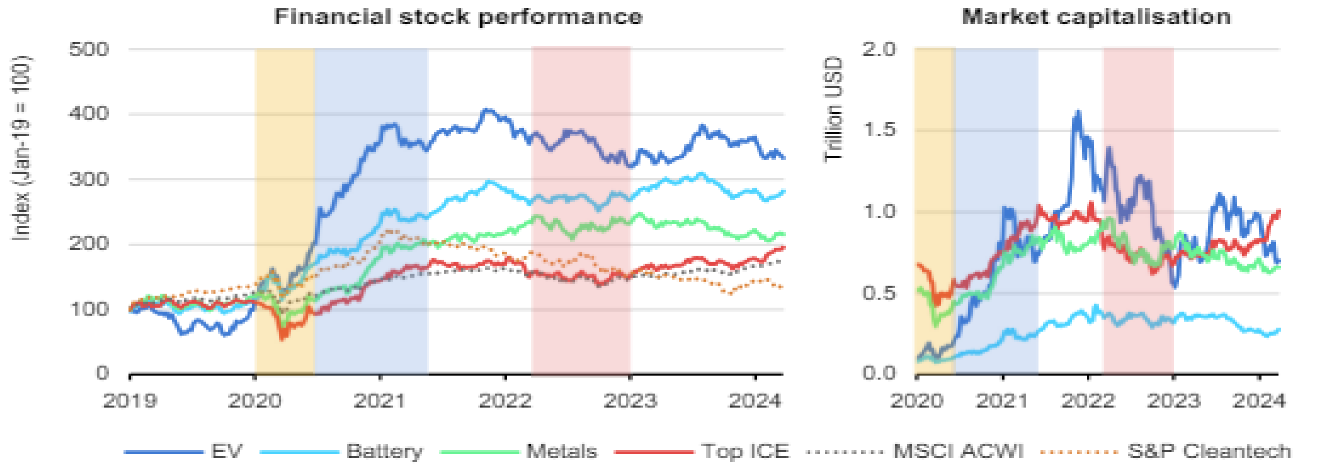
IEA. CC BY 4.0.

Note: "Battery pack price" refers to the volume-weighted average pack price of lithium-ion batteries over all sectors.
Sources: IEA analysis based on data from Bloomberg and Bloomberg New Energy Finance Lithium-Ion Price Survey (2023).

Electric vehicle companies perform well in financial markets, but volatility and competition raise concern

Since 2019, the stocks of EV companies – including vehicle and battery manufacturers and companies involved in the extraction or processing of battery metals – have consistently outperformed general stock markets, major traditional carmakers, and other segments of clean technology. Return on investment has increased more over the 2019-2023 period for these companies than it has for others, in relative terms. The combined market capitalisation of pure play EV makers boomed from USD 100 billion in 2020 to USD 1 trillion at the end of 2023, with a peak over USD 1.6 trillion at the end of 2021, though this trend was primarily driven by Tesla. The market capitalisation of battery makers and battery metal companies also increased significantly over the same period. Behind this overall upward trend, however, there has been significant volatility. Supply chain disruptions and battery metal price fluctuations – notably in the wake of Russia's invasion of Ukraine – as well as increasing competition, price wars among OEMs and expectations of slower relative annual growth as major EV markets mature, and of possible consolidation, are having an important downward impact on investor confidence and EV stocks. For example, Tesla's shares were on average 15% lower in 2023 than in 2021-2022; BYD's average stock also fell 15% in

Key financial indicators for major car, battery, mining and cleantech companies



Notes: EV = electric vehicle; ICE = internal combustion engine; ACWI = All Country World Index. Data through Q1 2024 included. Performance is measured via arithmetic returns, which refer to the sum of quarterly returns on a given stock (capital gains and dividends). The area highlighted in yellow represents a credit crisis, and in blue, a recovery period for capital markets followed by the pandemic-induced credit shock in Q1 2020. The red highlight shows the months following Russia's invasion of Ukraine. Weekly financial performance of selected EV, battery and battery mineral and metal companies is plotted against the major conventional carmakers, the broader public equity market benchmark (MSCI ACWI), and the S&P Renewable Energy and Clean Technologies benchmark, at an index level. The major conventional carmakers index is equal-weighted, giving equal importance to each constituent company regardless of market capitalisation or share (BMW, Ford, GM, Honda, Hyundai, Kia, Mercedes-Benz, Nissan, Renault, Stellantis, Toyota, and Volkswagen). The EV index consists of ten pure play EV companies (BYD, Fisker, Leap, Li Auto, Lucid, Nikola, NIO, Rivian, Tesla, and XPeng), and the battery index of eight battery and component manufacturing companies (Contemporary Amperex Technology, Ecopro BM, Eve Energy, Gotion High-tech, L&F, LG Energy Solution, Panasonic Holdings, and Samsung SDI), weighted based on the shares of these companies within the Bloomberg EV Price Return Index. The battery mineral and metal index includes over 40 companies selected in the S&P Global Core Battery Metals Index. Financial performance and market capitalisation do not necessarily reflect actual profits or losses, but rather investor expectations of future returns.

Source: IEA analysis based on Bloomberg.

2023 relative to 2022; and the combined market capitalisation of pure play EV carmakers fell by nearly 20% on average relative to 2022, while that of major incumbent carmakers remained flat. Many emerging EV players – such as VinFast from Viet Nam, Polestar from Europe, and Canoo, Fisker, Lucid and Nikola from the United States – are missing sales targets and trading low. Fiercer competition and shrinking profits also have an impact upstream, among EV battery makers: in the first weeks of 2024, CATL was trading near a three-year low, with a market capitalisation at its lowest point since the end of 2020. In the first quarter of 2024, the combined market capitalisation of pure play EV players fell below that of major incumbents, even if their financial stock performance remained robust.

6. Outlook for electric mobility

Scenario overview

In this part of the report, we focus on pathways to electrify road transport over the period to 2035, expanding the time horizon by five years compared with previous editions of the Global EV Outlook. A scenario-based approach is used to explore the outlook for electric mobility, based on recent market trends, policy drivers and technology developments. The purpose of the scenarios is to assess plausible futures for global electric vehicle (EV) markets and their potential implications. The scenarios do not make predictions about the future. Rather, they aim to provide insights to inform decision-making by governments, companies and other stakeholders about the future of EVs. The projections in the Stated Policies Scenario (STEPS) and Announced Pledges Scenario (APS) consider historical data through the end of 2023, as well as stated policies and ambitions as of the end of March 2024. The Net Zero Emissions by 2050 Scenario (NZE Scenario) is consistent with the 2023 update to the IEA Net Zero Roadmap and the World Energy Outlook 2023. Deployment of electric vehicles is projected by road transport mode and by region. Regional results are presented for the STEPS and APS, while the discussion of the projections in the NZE Scenario focuses on global results. These projections are then compared to announcements by original equipment manufacturers (OEMs) and battery manufacturing capacity expansion announcements. These scenario projections incorporate GDP assumptions from the International Monetary Fund and population assumptions from the United Nations.

Stated Policies Scenario

The Stated Policies Scenario (STEPS) reflects existing policies and measures, as well as firm policy ambitions and objectives that have been legislated by governments around the world. It includes current EV-related policies, regulations and investments, as well as market trends based on the expected impacts of technology developments, announced deployments and plans from industry stakeholders. The STEPS aims to hold up a mirror to the plans of policy makers and illustrate their consequences.

Announced Pledges Scenario

The Announced Pledges Scenario (APS) assumes that all announced ambitions and targets made by governments around the world are met in full and on time. With regards to electromobility, it includes all recent major announcements of electrification targets and longer-term net zero emissions and other pledges, regardless of whether these have been anchored in legislation or in updated Nationally Determined Contributions. For example, the APS assumes that countries that have signed on to the Conference of the Parties (COP 26) declaration on accelerating the transition to 100% zero emissions cars and vans will achieve this goal, even if there are not yet policies or regulations in place to support it. In countries that have not yet made a net zero emissions pledge or set electrification targets, the APS considers the same policy framework as the STEPS. Non-policy assumptions for the APS, including population and economic growth, are the same as in the STEPS. The difference between the APS and the STEPS represents the "implementation gap" that exists between the policy frameworks and measures required to achieve country ambitions and targets, and the policies and measures that have been legislated.

Net Zero Emissions by 2050 Scenario

The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a normative scenario that sets out a narrow but achievable pathway for the global energy sector to achieve net zero CO2 emissions by 2050. The scenario is compatible with limiting the global temperature rise to 1.5°C with no or limited temperature overshoot, in line with reductions assessed by the Intergovernmental Panel on Climate Change in its Special Report on Global Warming of 1.5°C. There are many possible paths to achieve net zero CO2 emissions globally by 2050 and many uncertainties that could affect them. The NZE Scenario is therefore a path and not the path to net zero emissions. The difference between the NZE Scenario and the APS highlights the "ambition gap" that needs to be closed to achieve the goals under the 2015 Paris Agreement.

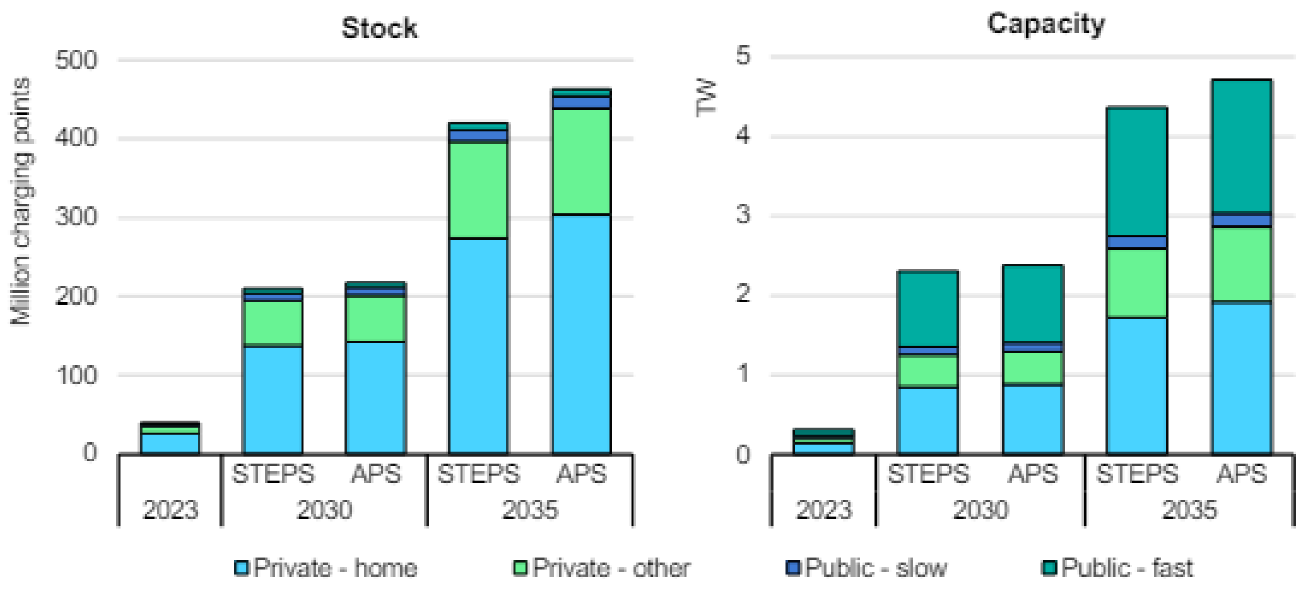
7. Outlook for electric vehicle charging infrastructure

Light-duty vehicle charging

Public charging could increase sixfold by 2035, helping mass-market consumers switch to electric

Large-scale adoption of EVs hinges on the simultaneous roll-out of accessible and affordable charging. The early adopters of electric cars have tended to live in single-family detached homes with affordable and convenient access to home charging. As a result, most charging to date has been private (at home and other private locations). At the same time, public chargers have tended to be installed in urban areas, where utilisation rates are likely to be higher. Looking forward, however, chargers must also be installed outside of urban areas to enable continued adoption beyond cities and suburbs. In a 2021 survey of EV drivers in the United Kingdom, over 90% of the respondents reported having access to home chargers, whereas a 2023 study showed that only 55% of Indian consumers had such access. The build-out of charging in workplaces and publicly accessible areas will be key for increasing adoption among groups without access to home charging. Charging speed – slow or fast – is also an important consideration for consumers looking to switch to electric, especially when considering a vehicle for long journeys. Charging services should also be easy to use, reliable and transparently priced. Further, ensuring interoperability is important when making investments in charging infrastructure and services, so that a wide customer base is able to benefit. In the STEPS and APS, the global number of public charging points exceeds 15 million by 2030, up four-fold compared to the almost 4 million operating in 2023. By 2035, this number reaches almost 25 million in the APS, a sixfold increase relative to 2023. Among today's major EV markets, China is where the population's access to home charging

Global light-duty vehicle charger stock and capacity, 2023-2035



is most limited and where public charging has been most widely rolled out as a result. China accounted for 70% of global public LDV charging in 2023 and is expected to remain a leader with a similar share in 2035 in the STEPS. While the current availability of public chargers in China already appears to be above the global average infrastructure. The number of electric LDVs per public charging point increases from around 10 in 2023 to around 15 in 2035 in the APS, remaining lower than other major markets. Currently, China has one of the highest shares of fast chargers out of total public charging stock, at around 45%. In both the

STEPS and APS, the stock of public fast chargers reaches around 7.5 million in 2035, almost six times 2023 levels. The number of slow chargers reaches 8.2 million in 2035 in the APS.

8. Outlook for battery and energy demand

Battery demand

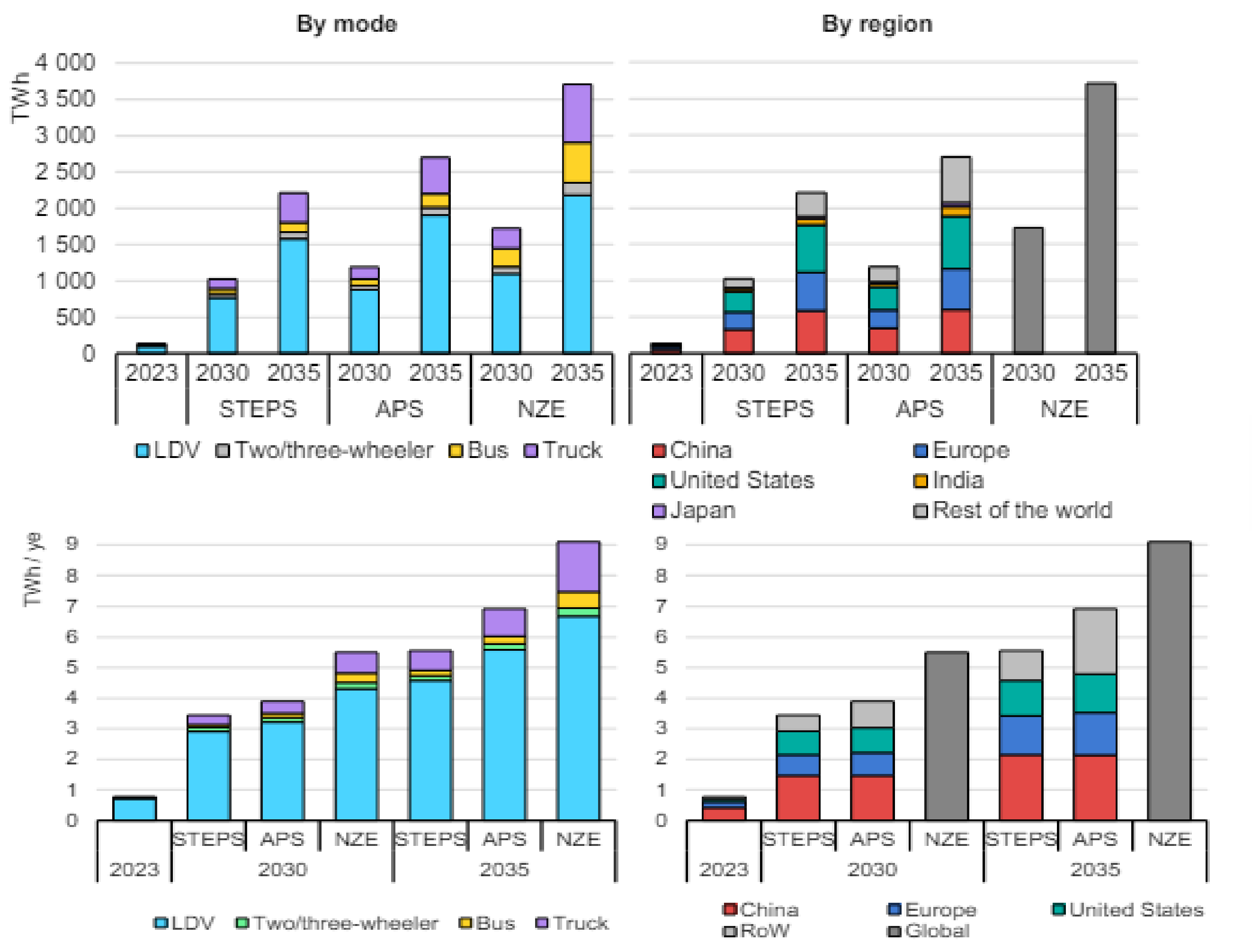
Battery demand for electric vehicles jumps tenfold in ten years in a net zero pathway

As EV sales continue to increase in today's major markets in China, Europe and the United States, as well as expanding across more countries, demand for EV batteries is also set to grow quickly. In the STEPS, EV battery demand grows fourand-a-half times by 2030, and almost seven times by 2035 compared to 2023. In the APS and the NZE Scenario, demand is significantly higher, multiplied by five and seven times in 2030 and nine and twelve times in 2035, respectively. To put this in context, in the APS in 2035, there could be as much EV battery demand per week as there was in the entire year of 2019. Cars remain the primary driver of EV battery demand, accounting for about 75% in the APS in 2035, albeit down from 90% in 2023, as battery demand from other EVs grows very quickly. In the STEPS, battery demand for EVs other than cars jumps eightfold by 2030 and fifteen-fold by 2035. In the APS, these numbers reach tenfold by 2030 and more than twenty-fold by 2035. Battery requirements differ across modes, with a 2/3W requiring a battery about 20 times smaller than a BEV, while buses and trucks require batteries that are between 2 and 5 times bigger than for a BEV. This also affects trends in different regions, given that 2/3Ws are significantly more important in emerging economies than in developed economies. As EVs increasingly reach new markets, battery demand outside of today's major markets is set to increase. In the STEPS, China, Europe and the United States account for just under 85% of the market in 2030 and just over 80% in 2035, down from 90% today. In the APS, nearly 25% of battery demand is outside today's major markets in 2030, particularly as a result of greater demand in India, Southeast Asia, South America, Mexico and Japan. In the APS in 2035, this share increases to 30%. Stationary storage will also increase battery demand, accounting for about 400 GWh in STEPS and 500 GWh in APS in 2030, which is about 12%

of EV battery demand in the same year in both the STEPS and the APS.

Electricity demand

Electricity demand by mode and by region, 2023-2035



Notes: STEPS = Stated Policy Scenario; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario; LDV = light-duty vehicle, including cars and vans; RoW = Rest of the world.

Electric vehicles could account for 6-8% of total electricity demand by 2035, up from 0.5% today

Electric Vehicle Market Segmentation

Sharmila T K

INTRODUCTION:

Overview of the electric Vehicle (EV) market in India. Importance of conducting Exploratory Data Analysis (EDA) to understand trends, patterns, and insights in EV sales data.

DATA COLLECTION:

Gather data from various sources, including government agencies, research organizations, EV manufacturers, and industry reports. Relevant datasets may include information on EV sales, charging infrastructure, government incentives, vehicle specifications, demographic factors, and environmental conditions.

DATA CLEANING AND PREPROCESSING:

Clean the data to address missing values, outliers, and inconsistencies. Preprocess the data by encoding categorical variables, scaling numerical features, and handling any data-specific challenges unique to the Indian context, such as regional variations in data reporting standards.

DESCRIPTIVE STATISTICS:

Compute descriptive statistics to summarize key aspects of the Indian EV market. This includes calculating measures such as total EV sales, market share by vehicle type (e.g., two-wheelers, four-wheelers), average vehicle range, charging station density, and distribution of EV adoption across different states and cities.

DATA VISUALIZATION:

Visualize the data using plots and charts to gain insights into EV trends and patterns in India. Create visualizations such as time series plots of EV sales over time, geographical maps showing the distribution of charging infrastructure, and bar charts comparing EV adoption rates across states.

MARKET SEGMENTATION:

Explore potential segmentation of the Indian EV market based on factors such as vehicle type, price range, customer demographics, and geographic location. Use clustering algorithms to identify distinct market segments and analyze differences in adoption patterns, consumer preferences, and purchase motivations.

POLICY ANALYSIS:

Investigate the impact of government policies and incentives on the Indian EV market. Analyze datasets related to subsidies, tax incentives, regulatory frameworks, and infrastructure investments to understand their influence on EV adoption rates, market dynamics, and industry growth.

CHARGING INFRASTRUCTURE:

Assess the availability and accessibility of charging infrastructure in India. Analyze data on the number of charging stations, their locations, charging speeds, and usage patterns to identify areas with gaps in infrastructure and opportunities for expansion.

ENVIRONMENTAL IMPACT:

Explore the environmental benefits of EV adoption in India, such as reductions in greenhouse gas emissions, air pollution, and dependence on fossil fuels. Use datasets on energy consumption, vehicle efficiency, and emissions factors to quantify the environmental impact of EVs compared to conventional vehicles.

CONSUMER BEHAVIOR:

Investigate consumer attitudes, perceptions, and behaviors related to EVs in India. Analyze survey data, social media sentiment, and market research reports to understand factors influencing purchasing decisions, barriers to adoption, and strategies for promoting EV awareness and acceptance.

CONCLUSION:

Implications for stakeholders in the EV industry, including policymakers, manufacturers, investors, and consumers.

Recommendations for future research and data collection efforts to further understand and support the growth of the electric vehicle market in India.

Electric Vehicle Market Segmentation

Harini M R

Introduction:

Overview of the electric Vehicle (EV) market in India. Importance of conducting Exploratory Data Analysis (EDA) to understand trends, patterns, and insights in EV sales data.

Data Collection and Description:

Sources of EV sales data in India, such as government reports, industry publications, and market research firms.

Description of the dataset, including variables, time period covered, and any limitations or missing data.

Data Preprocessing:

Cleaning the dataset by handling missing values, duplicates, and outliers.

Transforming variables, such as converting date formats and categorizing data for analysis.

Summary statistics of EV sales, including mean, median, range, and standard deviation.

Visualizations such as histograms, box plots, and density plots to explore the distribution of EV sales.

Trends Over Time:

Time series analysis of EV sales trends over the study period.

Visualization of monthly, quarterly, and annual sales trends to identify seasonal patterns and long-term growth trends.

Regional Analysis:

Geospatial visualization of EV sales across different states and regions in India.

Comparison of sales volume and growth rates between urban and rural areas.

Vehicle Type Analysis:

Breakdown of EV sales by vehicle type, such as electric cars, electric two-wheelers, and electric buses.

Comparison of sales trends and market share between different vehicle segments.

Price Analysis:

Analysis of EV prices and their impact on sales trends.

Visualization of price distributions and correlations with sales volume.

Policy Impact Analysis:

Assessment of government policies and incentives on EV sales, such as subsidies, tax breaks, and infrastructure investments.

Examination of policy changes and their effects on market dynamics.

Consumer Behavior Analysis:

Study of consumer preferences, motivations, and barriers to EV adoption.

Analysis of factors influencing purchase decisions, such as range anxiety, charging infrastructure, and total cost of ownership.

Conclusion:

Summary of key findings from the EDA report.

Implications for stakeholders in the EV industry, including policymakers, manufacturers, investors, and consumers.

Recommendations for future research and data collection efforts to further understand and support the growth of the electric vehicle market in India.

Electric Vehicle Market Segmentation

Bharathi Patil (Team Lead)

EV Market Segmentation

Selection of Target Segment

- The strategic target segments for the electric vehicle market are identified as Segment 1 (39% of consumers) and Segment 2 (33% of consumers).
- Segment 1's diverse preferences and dissatisfaction points present an opportunity for improving customer satisfaction and loyalty by directly addressing their specific demands. Segment 2 values visual appeal, reliability, service experience, and comfort, offering a chance to customize electric vehicles to meet these expectations and emphasize value for money.
- The strategy involves addressing dissatisfaction points in Segment 1 and enhancing positive elements in Segment 2, aligning electric vehicles with the distinct expectations of each segment to ensure competitive advantage and sustained market growth.

Customizing the Market Mix

In our electric vehicle market strategy, customization of the marketing mix is crucial for appealing to Segment 1 and Segment 2, our target segments.

- Product customization involves enhancing features based on specific desires, addressing dissatisfaction points for Segment 1, and emphasizing visual appeal and value for money for Segment 2. Diverse offerings cater to varied tastes and budgets within each segment.
- Price customization includes competitive pricing for Segment 1 and a slightly higher price point for value-added features in Segment 2.
- Promotion customization focuses on targeted advertising and tailored promotional events for each segment's preferences.
- Place customization establishes accessible distribution channels in urban areas for Segment 1 and suburban/semi-urban regions for Segment 2, with a strong emphasis on online presence and customer support.
- People and Process Customization involves training customer service representatives to address segment-specific concerns and ensuring efficient processes for customization requests and service appointments. This tailored approach ensures our electric vehicles align with the distinct needs of Segment 1 and Segment 2, enhancing market relevance and customer preference.

Potentially Early Market Customer Base

- In the analysis of the early market customer base, two primary segments are identified: Segment 1 with 330 members (39% of consumers) and Segment 2 with 277 members (33% of consumers).

- The target price range for Segment 1 falls between ₹51,094 and ₹1,67,844, and for Segment 2, it ranges from ₹51,094 to ₹1,37,890. By multiplying the number of potential customers in each segment by the targeted price range, potential profits can be calculated.

- For example, with a target price of ₹1,20,000 for Segment 1, the potential profit amounts to ₹39.60 crores, and for Segment 2 with a target price of ₹1,10,000, the potential profit is ₹30.47 crores.

- Segment 1, being larger in potential market share, is the primary focus for early market penetration efforts due to its significant profit opportunity.

Most Optimal Market Segments

- After thorough analysis and evaluation, Segment 1, constituting 39% of consumers, has been identified as the optimal market segment for electric two-wheeler vehicles.

- With a significant customer base and a balanced blend of technical specifications and price range, this segment offers substantial market potential. The recommended technical specifications for Segment 1 include a price range of ₹70,688 to ₹1,29,063, riding range of 89 to 180 km, top speed of 58 to 116 kmph, weight of 76 to 120 kg, battery charging time of 3 to 5 hours, and rated power of 1200 to 5500 W.

- This targeted approach ensures alignment with the diverse needs and preferences of the market, laying the foundation for a successful and sustainable venture into the electric vehicle market.

Conclusion

- In summary, our in-depth analysis of India's electric vehicle market led us to identify Segment 1 as the optimal target.

- With a significant 39% consumer base, this segment represents a substantial market opportunity. By tailoring our electric two-wheeler specifications to meet the preferences of this segment, we ensure our products align seamlessly with the demands of a large customer base.

- This strategic decision is grounded in a thorough understanding of market segmentation, consumer behaviour, and technical specifications. These insights provide a clear direction for our market entry, emphasizing precision and relevance in both product development and marketing strategies.

- Moving forward, this approach equips us with a solid foundation, ensuring our offerings resonate effectively within India's evolving electric vehicle landscape.

GitHub Links

Name	GitHub Link
Jeyaselvalakshmi	https://github.com/jeyaprojects/feynn_lab_project2/tree/main
Kunta Sravani	https://github.com/Sravani0099/EV_Analysis
Kayyala Pavan Kumar	https://github.com/Kayyalapavankumar/EV_Market_Seg_Analysis
Yogeshwar Chaudhari	https://github.com/YogeshwarChaudhari9/Fenn-Lab-project-Task-2
Sharmila T K	https://github.com/sh23sharmi/Electric_Vehicle_Fenny_lab_intenship
Harini M R	https://github.com/harini-mr/Electric_vehicle_sales_in_india-fenny_labs-internship
Bharathi Patil	https://github.com/PatilBharathi/Fenn-Labs.git