Market segment analysis of the Electric_ vehicle _population

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Github: https://github.com/SushmithaAkula/market-sigmentation-analysis-of-Electric-_vehicle-_population.git

Introduction: Electric vehicle (EV) is a road vehicle which involves with electric propulsion. With this broad definition in mind, electric vehicles may include battery electric vehicles (BEV), hybrid electric vehicle (HEV) and fuel cell electric vehicle (FCEV).

Electric vehicle is a multi-disciplinary subject which covers broad and complex aspects. How ever, it has core technologies, namely chassis and body technology, propulsion technology and energy source technology.

The article begins with reviewing the status of BEV and HEV, then focusing on the engineering philosophy of EV development. Subsequent to the illustration of the configurations of both BEV and HEV, it discusses rather detail the major technologies, namely the propulsion technology, energy source technology and infrastructure technology. Finally the commercialization aspects are discussed

The conclusion summarizes the state of the art and the challenges of BEVH EV and FCEV.

Today BEV, HEV and FCEV are in different stages of development, facing different e challenges and require different strategies. In order to assist the readers appreciate the features and issues of these vehicles before reading the whole text, the major characteristics of these three types vehicles .

It can be seen that the critical issue of BEV is the battery. Therefore, BEV is mainly suitable for small EV for short range low speed community transportation, thus requires only smaller battery size. HEV can meet consumers' meet but cost is the major issue. FCEV has long term potential for future main stream vehicles, however the technology is still in early development stage, its cost and refueling system are the major concerns.

EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Internal combustion engines were the dominant propulsion method for cars and trucks for about 100 years, but electric power remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

In the 21st century, EVs have seen a resurgence due to technological developments, and an increased focus on renewable energy and the potential reduction of transportation's impact on climate change and other environmental issues. Project Drawdown describes electric vehicles as one of the 100 best contemporary solutions for addressing climate change.

what is electric vehicle:

Electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mix of fuel and gases. Therefore, such as vehicle is seen as a possible replacement for current-generation automobile, in order to address the issue of rising pollution, global warming, depleting natural resources, etc. Though the concept of electric vehicles has been around for a long time, it has drawn a considerable amount of interest in the past decade amid a rising carbon footprint and other environmental impacts of fuel-based vehicles.

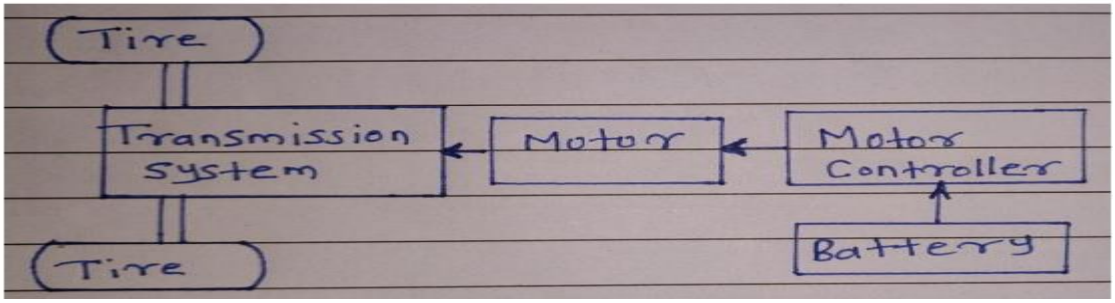
Why Electric Vehicles:

Electric vehicles are more efficiant and that combind with the electricity cost means that charging at electric vehicle is cheaper than filling petrol or diesel for your travel requirments. using renewable energy sources can make the use of electric vehicles more eco friendly.

Let us begin with the investigation of the growth of population and vehicles, the global population will increase from 6 billions to 10 billions and the number of vehicles will increase from 700 millions to 2.5 billions. If all these vehicles are propelled by internal combustion engines, where will the oil come from? And where should the emissions be disseminated? Would the sky be permanently grey? The gloomy answers to these questions compel people to strive for sustainable road transportation for the 21st century.

Construction and working and principle of electric vehicle:

Electric vehicles basically, Electric vehicle is necessary for seving fossil fuel. The figer shows the simple construction of electric vehicle it consists of controller, motor controller which is connected to the transmission system. Here, battery is the energy source which is charged by taking electric current from the grid.



these batteries are recharge label most electric vehicle uses lead acid and battery is charged but a new type electric cars use lithium ion batterys because it can store more energy than lead acid battery is same physical space.

The efficiently and life span of battery is far better than other type of batteries is far better than other type of batterys, but it is costlier than lead acid battery. After that controller control flow of energy from energy source to the motor. transmit to power to the wheels of the vehicle by the use the transmission system.

Advantages of electric vehicle:

• It is a clean, safe, cheap and convenient source of energy. No fuel and No pollution. It required less maintenance . Total operation noice free. It generates for high starting torque. And We can charge at home. less running cost than gas online power red vehicle. it helps to save fossile fuels . lower maintaince due to an efficient electric vehicle. and better performance.

Disadvantages of electric Vehicle :

- It is quite and Expensive.
- it is not for long range travelling because availability of less number.
- less number of electric charging power station.it requires more time for recharging the battery.

EV market overview:

India electric vehicle market size was valued at USD 220.1 million in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 94.4% from 2021 to 2030. The attractive incentives being offered by the Indian government on the production and purchase of to encourage the adoption of electric vehicles are anticipated to drive the growth of the market over the forecast period.

. The outbreak of the covid-19 pandemic triggered a significant decline in the overall sales of passenger and commercial vehicles in 2020. However, the sales of electric vehicles in India remained unaffected. The post-lockdown sale of pure and hybrid electric vehicles is a prominent driving factor for the electric vehicle market in India. The stringent Green House gas (GHG) emission norms drafted by the government, such as the Bharat Stage (BS) VI emission standards introduced by India's Ministry of Road Transport and Highways (Morth), are also expected to play a decisive role in driving the growth of market.

The increasing prices of conventional fuel are expected to accentuate the development of vehicle electrification. The stringent emission norms being drafted by the government and the growing environmental awareness among Indian consumers are also expected to fuel the demand for electric vehicles.

Furthermore, Indian automakers, such as Tata Motors, and Mahindra and Mahindra Ltd., have embarked upon aggressive efforts to add electrified vehicles to their product portfolio, which is expected to encourage Indian consumers to opt for electric vehicles. All these factors bode well for the growth of the electric vehicle market in India over the forecast period.

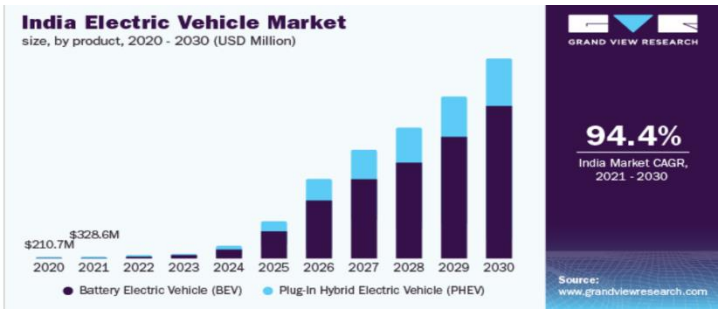
The EV market in India comprised only two electric vehicle models in 2019. As a result, only 0.15% of the new passenger cars registered between April 2019 and March 2020 were BEVs. However, at the beginning of 2021, the India electric vehicle (EV) market consisted of around eight electric vehicle models, thereby offering more options for Indian consumers looking forward to buying electric vehicles.

Moreover, the prices of electric vehicles are also expected to decline over the forecast period, thereby allowing EVs to provide a lower Total Cost of Ownership (TCO) as compared to conventional vehicles. This is expected to pave the way for the mass-market penetration of electric vehicles.

India has been recognized as one of the prominent regions in the automotive industry globally. Several companies are aggressively establishing manufacturing facilities in India. For instance, in September 2020, Dana TM4 Inc. announced plans to establish a manufacturing facility in Pune, India.

The new 4,600 square-meter facility would produce Dana TM4 low- to high-voltage inverters, electric motors, and vehicle control units. Meanwhile, the Phase-II of the Indian government's Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme envisages further enhancing the adoption of electric mobility and the development of its manufacturing eco-system.

Phase-II of the FAME scheme would be implemented through the following verticals, namely incentivizing the demand for EVs; running awareness campaigns, including publicity, and information, education & communication (IEC) activities; and establishing a charging station network.



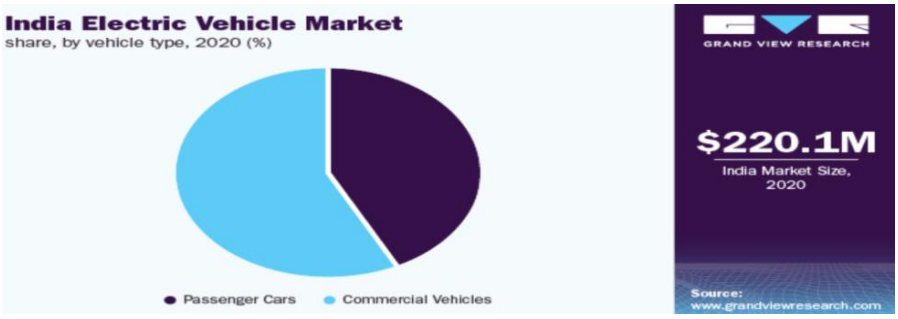
EV market insights:

The comeritial vehicle segment accounted for the largest share of around 57% of the overall market in 2020. The growth of the segment can be attributed to the continued introduction of electric light-duty commercial trucks and electric buses in the country.

Electric buses are already gaining traction as the government is pursuing aggressive plans to have more and more electric vehicles plying on the roads to reduce vehicular pollution in major cities across the nation. Companies, such as Tata Motors, Mahindra and Mahindra Ltd, and Olectra Greentech Limited, are already offering electric light-duty commercial vehicles and electric buses in the country.

The passenger cars segment is projected to register a CAGR of over 106% over the forecast period. The diesel and gasoline-based passenger vehicle market is witnessing a shift toward electric passenger vehicles owing to increasing investments by the government in EV infrastructure, along with tax benefits offered to consumers.

For instance, the Indian government's National Electric Mobility Mission Plan (NEMMP) 2020 envisages promoting the adoption of hybrid vehicles and electric vehicles while achieving national fuel security.

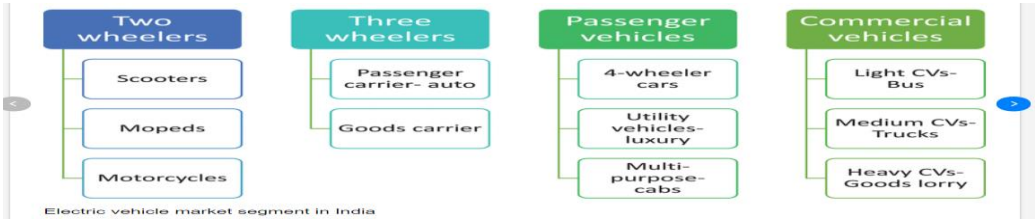


Ev Market segmentation:

The Indian Electric Vehicle Market is segmented by Vehicle Type and Power Source. By Vehicle Type, the market is segmented into Passenger Cars, Commercial Vehicles, and Two- and Three-wheelers. By Power Source Type, the market is segmented into Battery Electric Vehicle, Plug-in Electric Vehicle, and Hybrid Electric Vehicle. India is the second most populated country in the world after China, and just like China, which has the largest electric bus fleet in the world. India is also pushing hard for the electrification of buses. Many state governments have already started procuring electric buses from Chinese and local electric bus manufacturers. With the growing need for controlling GHG (Greenhouse gases) emissions emitted by vehicles, the government is encouraging the use of electric-powered vehicles across various states, boosting the demand for electric buses in India. The market is driven by factors such as the increase in domestic manufacturing, rapid urbanization, and a rise In February 2020, the Union Transport minister inaugurated India's first inter-

city electric bus service. These buses were manufactured by Mitra Mobility Solution, with a range of 300 km on a full charge.

Many local bus manufacturers who are in collaboration with some Chinese manu facturersare trying to cater to the rising demand for electric buses in India.



Electric vehicle market segment in India

EV cars market growthing :

The Indian electric car market sales is expected to reach 37,792 unit in 2022. and it is expected to reach 376,000 unit in 2030, with a growth rate of 33.3% during 2022-2030.the major factor behind this exponential growth are the rising forign direct inversment , construction manufacturing, hubs and amplifying push to improve the charging infrastrure for the Electric vehicle in industry is slowly gathering momentum with the support of the government and surge and crude oil prices, as people are looking for ways to lessen their monthly bills.

The pair agreement which aims to curb carbon emissions, improve the quality air of the air in cities, and decrease oil imports, is the foundation for Indians strategy. with the growing population and demand for vehicles conventional energy resources are not viable, as India imports the majority of its crude oil. Thus , the government is focusing on no of increasing the no of EVs, including cars, in line with the goal to accomplish net zero carbon emission by 2070.

Further, in November 2021, at the conference of the parties COP26 summit in Glasgow, India launched the website e-AMRIT, which will serve as a non-stop resource for all information on electric cars. It discusses important points related to EVs and their purches, including the locations of charging stations and EV financing choices well as offering the datails of investment opportunities, regulations and manufactures.

In addition to the more-well-known Advanteges , such as lower carbon dioxide Emitions and air and noise pollution EVs also segment efficiency gains and have the potential to become a storage source for renwable energy. Vechicle owners and first time customer s are looking for less expensive solutions and cars meet the bills especially when considering the long term maintenence costs associated with them. OEMs are dedicatedly working on imparting training to their sales and teams EVs. Mean while the entire, ecosystem of manufacturing central and states, dealers and investors is concentraiting on ensuring that everyone in the supply chain has significant know how about handling and maintaining of the vehicle and battery.

Exportory Data analysis:

The main purpose of EDA is to help look at data before making any assumptions. It can help identify obvious errors, as well as better understand patterns within the data, detect outliers or anomalous events, find interesting relations among the variables.

Data scientists can use exploratory analysis to ensure the results they produce are valid and applicable to any desired business outcomes and goals. EDA also helps stakeholders by confirming they are asking the right questions. EDA can help answer questions about standard deviations, categorical variables, and confidence intervals. Once EDA is complete and insights are drawn, its features can then be used for more sophisticated data analysis or modeling, including mchine learning.

EDA Tools:

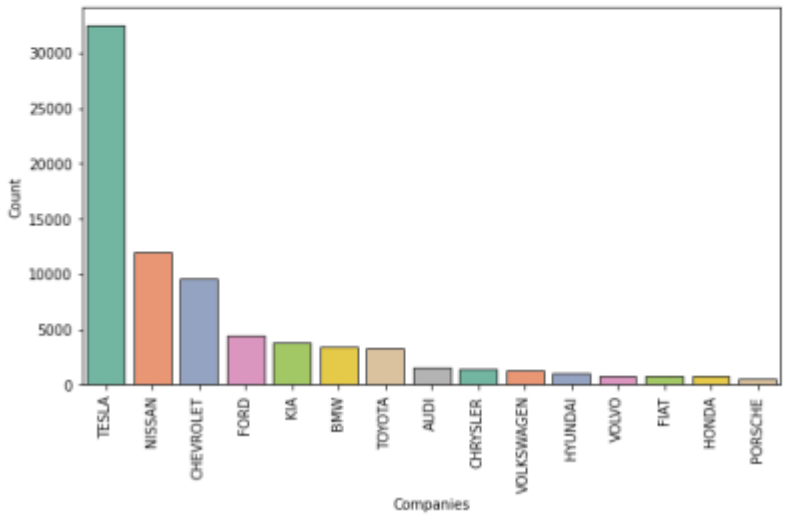
Clustering and dimension reduction techniques, which help create graphical displays of high-dimensional data containing many variables.

- Univariate visualization of each field in the raw dataset, with summary statistics.
- Bivariate visualizations and summary statistics that allow you to assess the relationship between each variable in the dataset and the target variable you're looking at.
- Multivariate visualizations, for mapping and understanding interactions between
- different fields in the data.

- K-means Clustering is a clustering method in un supervised learning where data points are assigned into K groups, i.e. the number of clusters, based on the distance from each group's centroid. The data points closest to a particular centroid will be clustered under the same category. K-means Clustering is commonly used in market segmentation, pattern recognition, and image compression.
- Predictive models, such as linear regression, use statistics and data to predict outcomes.

In [18]:

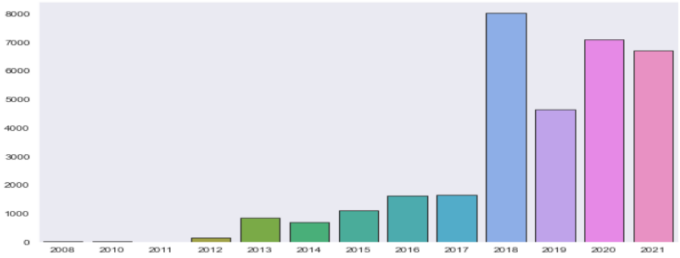
```
Companies = df.groupby('Make').count().sort_values(by='City',ascending=False)['City'].ir
values = df.groupby('Make').count().sort_values(by='City',ascending=False)['City'].value


plt.figure(figsize=(9,5))
sns.barplot(x=list(Companies)[:15],y=values[:15],edgecolor='.2',palette='Set2')
plt.xticks(rotation='90')
plt.xlabel('Companies')
plt.ylabel('Count')
plt.show()
```



In [26]:

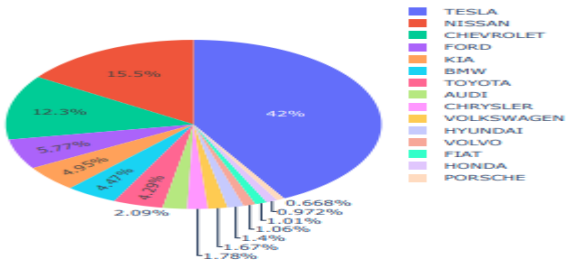
```
plt.figure(figsize=(10,6))
top_10_year_TESLA = list(data_TESLA.groupby('Model Year').count().sort_values(by='City',ascending=False)['City'].index)[:15]
values = list(data_TESLA.groupby('Model Year').count().sort_values(by='City',ascending=False)['City'].values)[:15]
sns.barplot(x = top_10_year_TESLA,y=values,edgecolor='.2')
```

Out[26]: <AxesSubplot:>

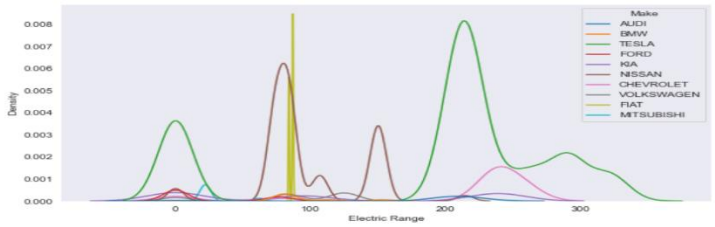


In [19]:

```
px.pie(names=list(Companies)[:15],values=values[:15],width=500,height=600)
```



Out[23]: <AxesSubplot:xlabel='Electric Range', ylabel='Density'>

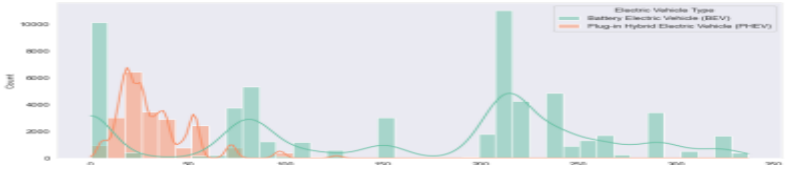


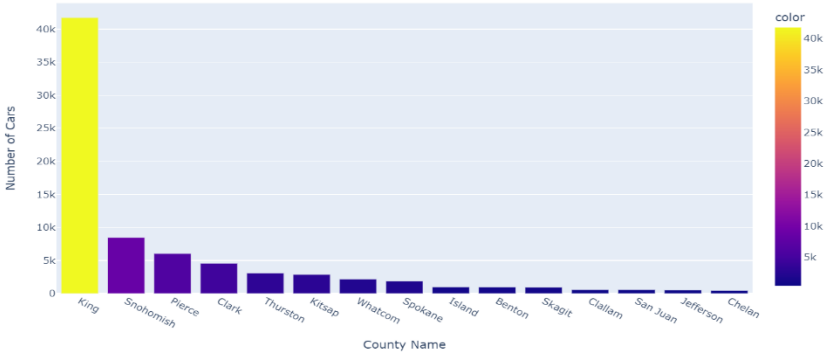
In [24]:
```
data_TESLA = df[df['Make']=='TESLA']
top_10_states_TESLA = list(data_TESLA.groupby('State').count().sort_values(by='City',ascending=False)['City'].index)[:10
values = list(data_TESLA.groupby('State').count().sort_values(by='City',ascending=False)['City'].values)[:10]
```

In [22]:
```
#Lets see the electric range difference between PHEV and BEV
plt.figure(figsize=(12,5))
sns.set_style(style='dark')
sns.histplot(x = 'Electric Range',data=df,kde=True,hue='Electric Vehicle Type',palette='
```

Out[22]:

<AxesSubplot:xlabel='Electric Range', ylabel='Count'>





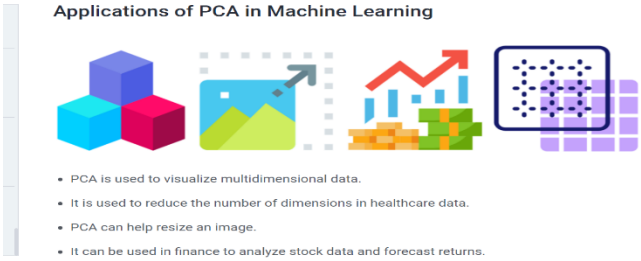
```
In [28]: cor_matrix=df.corr()

In [29]: sns.heatmap(cor_matrix,annot=True)
         plt.show()
```

Principle component analysis:

The Principal Component Analysis is a popular unsupervised learning technique for reducing the dimensionality of data. It increases interpretability yet, at the same time, it minimizes information loss. It helps to find the most significant features in a dataset and makes the data easy for plotting in 2D and 3D. PCA helps in finding a sequence of linear dataset and makes the data easy for plotting in 2D and 3D. PCA helps in finding a sequence of linear combinations of variables. The Principal Components are a straight line that captures most of the combinations of variables. The Principal Components are a straight line that captures most of the variance of the data. They have a direction and magnitude. Principal components are orthogonal projections (perpendicular) of data onto lower-dimensional space.

- Now that you have understood the basics of PCA, let's look at the next topic on PCA in Machine Learning. PCA is used to visualize multidimensional data.
- It is used to reduce the number of dimensions in healthcare data.
- PCA can help resize an image.
- It can be used in finance to analyze stock data and forecast returns.

- PCA helps to find patterns in the high-dimensional datasets.




```
In [51]: from sklearn.preprocessing import StandardScaler
         sc = StandardScaler()
         x = sc.fit_transform(x)

In [52]: from sklearn.decomposition import PCA
         pca_model = PCA(n_components=15)
         x_PCA = pca_model.fit_transform(x)

In [53]: pca_model.explained_variance_ratio_
Out[53]: array([1.78444593e-01, 1.13900292e-01, 9.97819324e-02, 9.01390547e-02,
                8.82027945e-02, 7.43801855e-02, 7.04183261e-02, 6.85851572e-02,
                5.69727295e-02, 4.76542824e-02, 4.41496947e-02, 3.31887554e-02,
                2.44178576e-02, 9.76434472e-03, 1.17700961e-33])

In [54]: X = df.iloc[:,[3,4]].values
```

```
In [28]: cor_matrix=df.corr()

In [29]: sns.heatmap(cor_matrix,annot=True)
         plt.show()
```

K-Means Clustering:

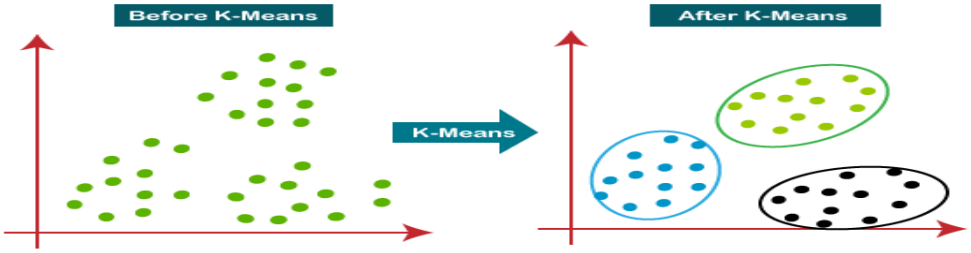
K-Means Clustering is an unsupervised learning algorithm that is used to solve the clustering problems in machine learning or data science. In this topic, we will learn what is K-means clustering algorithm, how the algorithm works, along with the Python implementation of k-means clustering. K-Means Clustering unsupervised algorithem which groups the unlabeled dataset into different clusters. Here K defines the number of pre-defined clusters that need to be created in the process, as if

K=2, there will be two clusters, and for K=3, there will be three clusters, and so on. It allows us to cluster the data into different groups and a convenient way to discover the categories of groups in the unlabeled dataset on its own without the need for any training. It is a centroid-based algorithm, where each cluster is associated with a centroid. The main aim of this algorithm is to minimize the sum of distances between the data point and their corresponding clusters.

The k-means clustering algorithm mainly performs two tasks Determines the best value for K center points or centroids by an iterative process.

How to Choose k -means Algorithem

The performance of the K-means clustering algorithm depends upon highly efficient clusters that it forms. But choosing the optimal number of clusters is a big task. There are some different ways to find the optimal number of clusters, but here we are discussing the most appropriate method to find the number of clusters or value of K. The method is given below: Assigns each data point to its closest k-center. Those data points which are near to the particular k-center, create a cluster. The below diagram explainstheworkingoftheK-meansClusteringAlgorithm.



Pakegs/ tools:

Data pre-processing:

The first step will be the data pre-processing, as we did in our earlier topics of Regression and Classification. But for the clustering problem, it will be different from other models. Let's discuss it:

Importing libraries:

As we did in previous topics, firstly, we will import the libraries for our model, which is part of data pre-processing. The code is given below: In the above code, the **numpy** we have imported for the performing mathematics calculation, **matplotlib** is for plotting the graph, and **pandas** are for managing the dataset.

```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        %matplotlib inline
        import seaborn as sns
        !pip install bioinfokit
        import plotly.express as px
```

```
In [2]: df = pd.read_csv("C:\\Users\\HP\\Downloads\\Electric_Vehicle_Population_Data.csv")
        df.head()
Out[2]:
```

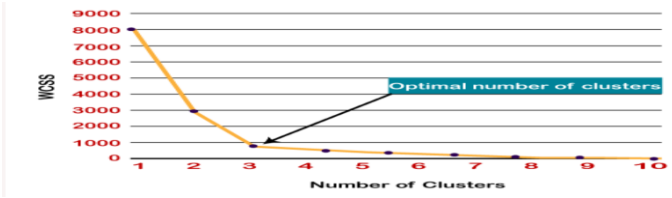
VIN (1-10)	County	City	State	ZIP Code	Model Year	Make	Model	Electric Vehicle Type	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric Range	Base MSRP	Legislative District	DOL Vehicle ID	Vehicle Locat
WA1AAAGE2M	Kitsap	POULSBO	WA	98370	2021	AUDI	E-TRON	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	222	0	23.0	148815901	PO (-122.63339300000 47.7484
WBY8P2C00L	King	SEATTLE	WA	98122	2020	BMW	I3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	153	0	37.0	132197810	POINT (-122.303- 47.610
5YJXCBE21K	Cowlitz	SILVERLAKE	WA	98645	2019	TESLA	MODEL X	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	289	0	20.0	154341673	POINT (-122.772 46.3205
1FTZR081XY	King	SEATTLE	WA	98117	2000	FORD	RANGER	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	58	0	36.0	169378338	POINT (-122.379: 47.6875
WBY1Z6C55H	King	SEATTLE	WA	98119	2017	BMW	I3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	81	0	36.0	192605101	PO (-122.3677210000(47.6392

Lable Encoading

```
In [48]: from sklearn.preprocessing import LabelEncoder
         def labelling(x):
             df[x] = LabelEncoder().fit_transform(df[x])
             return df
         cat = ['VIN (1-10)', 'County', 'City', 'State', 'ZIP Code', 'Model Year', 'Make','Base MSRP','Legislative District','Vehicle Loca
                'Model', 'Electric Vehicle Type', 'Clean Alternative Fuel Vehicle (CAFV) Eligibility', 'Electric Range','DOL Vehicle ID']
         for i in cat:
             labelling(i)
         df
```

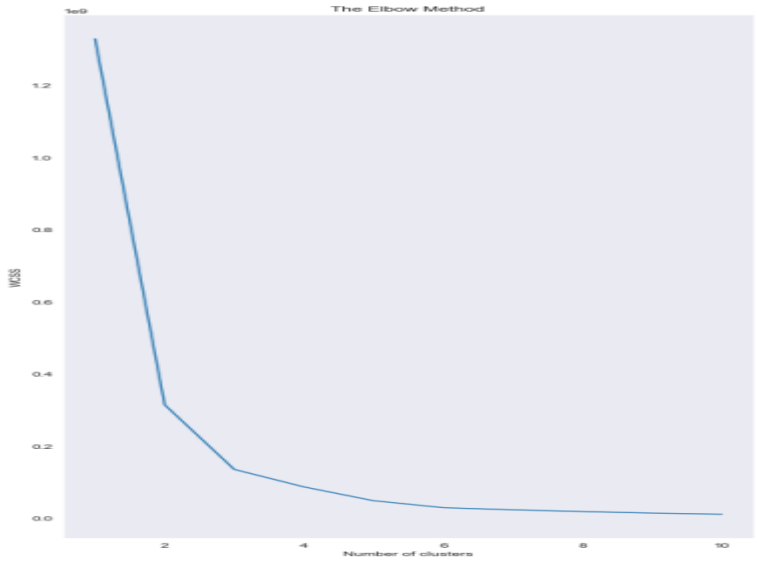
The first step will be after the data is pre-processed with segmentation of population we calculate the no of clusters by using the elbow method.

Elbow method: The elbow method is a technique used in data analysis to determine the optimal number of clusters in a dataset. It involves plotting the within-cluster sum of squares (WSS) against the number of clusters, and identifying the "elbow" point in the graph where adding more clusters does not significantly reduce the WSS. The optimal number of clusters is then chosen at this elbow point. The WSS is calculated as the sum of the squared distances between each point and the centroid of its assigned cluster. The idea behind the elbow method is that as the number of clusters increases, the WSS generally decreases, since each point is closer to its assigned centroid. However, beyond a certain number of clusters, the reduction in WSS becomes less significant, and adding more clusters may lead to overfitting or a loss of interpretability



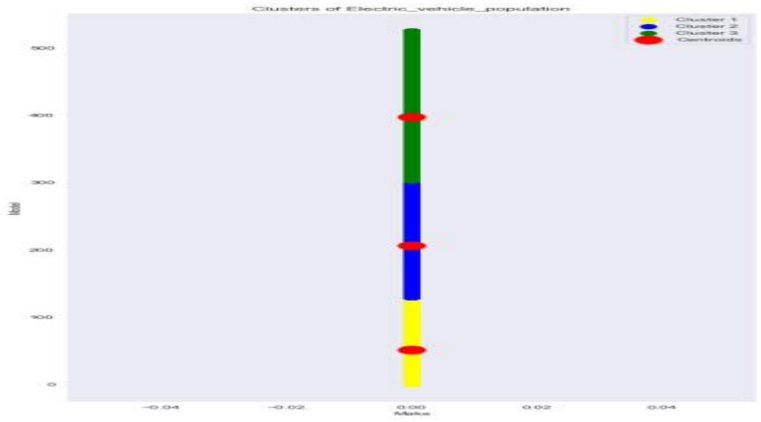

```
In [57]: wcss
Out[57]: [1328957249.9840012,
          314294678.4677549,
          135019505.17092726,
          86574080.20231578,
          48266749.99067938,
          28996394.16967954,
          22933193.055935137,
          18223294.409017555,
          13888757.80920052,
          10900144.928630024]
```

```
plt.plot(range(1,11), wcss)
plt.title('The Elbow Method')
plt.xlabel('Number of clusters')
plt.ylabel('WCSS')
plt.show()
```



The first step we get the no of clusters as3 the clustering of make and model Is as follows

```
In [69]: kmeans = KMeans(n_clusters = 3,init = 'k-means++', random_state = 42)

In [70]: y_kmeans = kmeans.fit_predict(X)

In [71]: plt.scatter(X[y_kmeans == 0, 0], X[y_kmeans == 0, 1],
                     s = 100, c = 'yellow', label = 'Cluster 1')
         plt.scatter(X[y_kmeans == 1, 0], X[y_kmeans == 1, 1],
                     s = 100, c = 'blue', label = 'Cluster 2')
         plt.scatter(X[y_kmeans == 2, 0], X[y_kmeans == 2, 1],
                     s = 100, c = 'green', label = 'Cluster 3')
         plt.scatter(kmeans.cluster_centers_[:, 0], kmeans.cluster_centers_[:, 1],
                     s = 300, c = 'red', label = 'Centroids')
         plt.title('Clusters of Electric_vehicle_population')
         plt.xlabel('Make')
         plt.ylabel('Model')
         plt.legend()
         plt.show()
```



The output image is clearly showing the three different clusters with different colors. The clusters are formed between two parameters of the dataset; make cluster of electric vehice and model. We can change the colors and labels as per the requirement or choice. We can also observe some points from the above patterns, which are given below:

Cluster1: shows the population with average EV making and average model so we can categorize these population as

Cluster2: shows the population with average EVmaking has a high but average model, so we can categorize them as **careful**.

Cluster3 : shows the low model and also low making so they can be categorized as sensible.

EV target segment: The EV market mainly targets those in higher income brackets who are able to afford then and also may view the vehicle as a status symbol. another target market in those intrested in the social change. Target segments are groups of customers or markets that a business aims to attract or serve with its products or services. Based on the analysis of customer data, certain characteristics are identified that define the optimal target segments for the business. In the context of electric cars, the analysis suggests that the optimum target segment should belong to the following categories:

Conclusion:

Cluster1: shows the population with average EV making and average model so we can categorize these population as

Cluster2: shows the population with average EVmaking has a high but average model, so we can categorize them as **careful**.

Cluster3 : shows the low model and also low making so they can be categorized as sensible