DSC680 -Project Milestone 4 - sidbhaumik

April 6, 2024

0.0.1 Dataset: US_Electric_fuel_vehicles.csv

This csv dataset contains a list of all Electric Vehicles (EVs) and Alternative Fuel Vehicles (AFVs) available

in the US, as of July 2022

[2]:
```
# Import required libraries
import pandas as pd
import numpy as np
```

[3]:
```
# Read csv Dataset: US_Electric_fuel_vehicles.csv
# Importing a csv file into DataFrame format. This format is easy to read and␣
 ↪query the data.
vehicle_df = pd.read_csv("US_Electric_fuel_vehicles.csv")
```

[4]:
```
# Reading first 5 rows
vehicle_df.head()
```

[4]:
```
   Vehicle ID  Fuel ID  Fuel Configuration ID  Manufacturer ID  Category ID  \
0       13044       45                    9.0              365           27
1       12854       45                    9.0              377           27
2       12842       45                    9.0              377           27
3       12783       45                    9.0              377           27
4       12782       45                    9.0              377           27

                Model  Model Year  Alternative Fuel Economy City  \
0                 NSX        2022                            NaN
1                  A3        2022                            NaN
2           A3 quattro        2022                            NaN
3  A4 allroad quattro        2022                            NaN
4           A4 quattro        2022                            NaN

   Alternative Fuel Economy Highway  Alternative Fuel Economy Combined  …  \
0                               NaN                                NaN  …
1                               NaN                                NaN  …
2                               NaN                                NaN  …
3                               NaN                                NaN  …
4                               NaN                                NaN  …
```

```
                Manufacturer URL     Category  Fuel Code             Fuel  \
0         http://www.acura.com/  Sedan/Wagon       HYBR  Hybrid Electric
1  http://progress.audiusa.com/  Sedan/Wagon       HYBR  Hybrid Electric
2  http://progress.audiusa.com/  Sedan/Wagon       HYBR  Hybrid Electric
3  http://progress.audiusa.com/  Sedan/Wagon       HYBR  Hybrid Electric
4  http://progress.audiusa.com/  Sedan/Wagon       HYBR  Hybrid Electric

  Fuel Configuration Name Electric-Only Range  PHEV Total Range PHEV Type  \
0         Hybrid Electric                 NaN               NaN       NaN
1         Hybrid Electric                 NaN               NaN       NaN
2         Hybrid Electric                 NaN               NaN       NaN
3         Hybrid Electric                 NaN               NaN       NaN
4         Hybrid Electric                 NaN               NaN       NaN

  Notes Drivetrain
0   NaN        AWD
1   NaN        FWD
2   NaN        AWD
3   NaN        AWD
4   NaN        AWD

[5 rows x 29 columns]
```

[5]:
```
# Total number of rows and columns in the vehicle dataframe
vehicle_df.shape
```

[5]:
```
(3008, 29)
```

[7]:
```
# Creating new Dataframe with useful columns only.
vehicle_df2 = vehicle_df.drop(vehicle_df.columns[[2,7, 8,␣
 ↪10,11,14,16,17,19,23,26,27]], axis=1)
```

[8]:
```
vehicle_df2.head()
```

[8]:
```
   Vehicle ID  Fuel ID  Manufacturer ID  Category ID              Model  \
0       13044       45              365           27                NSX
1       12854       45              377           27                 A3
2       12842       45              377           27          A3 quattro
3       12783       45              377           27  A4 allroad quattro
4       12782       45              377           27          A4 quattro

   Model Year  Alternative Fuel Economy Combined  \
0        2022                                NaN
1        2022                                NaN
2        2022                                NaN
3        2022                                NaN
```

```
4        2022                                  NaN

   Conventional Fuel Economy Combined Transmission Type Engine Size  \
0                                 21.0              Auto        3.5L
1                                 32.0              Auto        2.0L
2                                 31.0              Auto        2.0L
3                                 26.0              Auto        2.0L
4                                 29.0              Auto        2.0L

  Manufacturer     Category Fuel Code             Fuel  Electric-Only Range  \
0        Acura  Sedan/Wagon      HYBR  Hybrid Electric                  NaN
1         Audi  Sedan/Wagon      HYBR  Hybrid Electric                  NaN
2         Audi  Sedan/Wagon      HYBR  Hybrid Electric                  NaN
3         Audi  Sedan/Wagon      HYBR  Hybrid Electric                  NaN
4         Audi  Sedan/Wagon      HYBR  Hybrid Electric                  NaN

   PHEV Total Range Drivetrain
0               NaN        AWD
1               NaN        FWD
2               NaN        AWD
3               NaN        AWD
4               NaN        AWD
```

[52]:
```
# Renaming column names to ease dataframe operations
vehicle_df2.rename({'Vehicle ID': 'Vehicle_ID','Fuel ID': 'Fuel_ID','Fuel Code':
 ↪ 'Fuel_code', 'Model Year': 'Model_yr', 'Manufacturer ID':␣
 ↪'Manufacturer_ID','Transmission Type': 'Transmission_typ', 'Engine Size':␣
 ↪'Engine_Size', 'Electric-Only Range':'Electric_Range','PHEV Total Range':
 ↪'PHEV_range','Alternative Fuel Economy Combined':
 ↪'Alt_fuel_Eco_Combd','Conventional Fuel Economy Combined':
 ↪'Conv_Fuel_Eco_Combd'}, axis=1 , inplace=True)
```

[54]:
```
vehicle_df2.head()
```

[54]:
```
   Vehicle_ID  Fuel_ID  Manufacturer_ID  Category ID              Model  \
0       13044       45              365           27                NSX
1       12854       45              377           27                 A3
2       12842       45              377           27          A3 quattro
3       12783       45              377           27  A4 allroad quattro
4       12782       45              377           27          A4 quattro

   Model_yr  Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd Transmission_typ  \
0      2022                 NaN                 21.0             auto
1      2022                 NaN                 32.0             auto
2      2022                 NaN                 31.0             auto
3      2022                 NaN                 26.0             auto
4      2022                 NaN                 29.0             auto
```

```
  Engine_Size Manufacturer     Category Fuel_code             Fuel  \
0        3.5L        Acura  Sedan/Wagon      HYBR  Hybrid Electric
1        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
2        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
3        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
4        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric

   Electric_Range  PHEV_range Drivetrain
0             NaN         NaN        AWD
1             NaN         NaN        FWD
2             NaN         NaN        AWD
3             NaN         NaN        AWD
4             NaN         NaN        AWD
```

[55]:
```
# Changing the column order to keep the most useful columns in the beginning␣
↪and grouped together
vehicle_df2.iloc[:,[0,1,2,3,10,4,5,12,13,11,14,15,16,6,7,8,9]]
```

[55]:
```
      Vehicle_ID  Fuel_ID  Manufacturer_ID  Category ID Manufacturer  \
0          13044       45              365           27        Acura
1          12854       45              377           27         Audi
2          12842       45              377           27         Audi
3          12783       45              377           27         Audi
4          12782       45              377           27         Audi
…            …       …                …            …          …
3003         656        3              225            9        Dodge
3004         660       49              225           27        Dodge
3005         658       49              219            9         Ford
3006         650       49              215           27    Chevrolet
3007         649       49              219           27         Ford

                        Model  Model_yr Fuel_code  \
0                         NSX      2022      HYBR
1                          A3      2022      HYBR
2                  A3 quattro      2022      HYBR
3           A4 allroad quattro      2022      HYBR
4                  A4 quattro      2022      HYBR
…                          …       …         …
3003             Ram Van B250      1992       CNG
3004              Spirit FFV       1992  M85_GSLN
3005  Econoline-Fleet Demo FFV      1992  M85_GSLN
3006              Lumina FFV       1991  M85_GSLN
3007              Taurus FFV       1991  M85_GSLN

                            Fuel     Category  Electric_Range  PHEV_range  \
0                 Hybrid Electric  Sedan/Wagon             NaN         NaN
```

```
1                  Hybrid Electric  Sedan/Wagon             NaN          NaN
2                  Hybrid Electric  Sedan/Wagon             NaN          NaN
3                  Hybrid Electric  Sedan/Wagon             NaN          NaN
4                  Hybrid Electric  Sedan/Wagon             NaN          NaN
…                              …            …               …          …
3003  CNG - Compressed Natural Gas          Van             NaN          NaN
3004                      Methanol  Sedan/Wagon             NaN          NaN
3005                      Methanol          Van             NaN          NaN
3006                      Methanol  Sedan/Wagon             NaN          NaN
3007                      Methanol  Sedan/Wagon             NaN          NaN

     Drivetrain  Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd Transmission_typ  \
0           AWD                 NaN                 21.0             auto
1           FWD                 NaN                 32.0             auto
2           AWD                 NaN                 31.0             auto
3           AWD                 NaN                 26.0             auto
4           AWD                 NaN                 29.0             auto
…         …                   …                   …               …
3003        NaN                 NaN                  NaN              NaN
3004        NaN                 NaN                  NaN              NaN
3005        NaN                 NaN                  NaN              NaN
3006        NaN                 NaN                  NaN              NaN
3007        NaN                 NaN                  NaN        automatic

     Engine_Size
0           3.5L
1           2.0L
2           2.0L
3           2.0L
4           2.0L
…           …
3003       3.3 L
3004         NaN
3005         NaN
3006         NaN
3007       3.0 L

[3008 rows x 17 columns]
```

[56]:
```
# Check for duplicates in key column
print("The column Vehicle_ID has duplicate - {}".format(any(vehicle_df2.
 ↪Vehicle_ID.duplicated())))
```

```
The column Vehicle_ID has duplicate - False
```

[57]:
```
# Check for duplicates in the entire dataframe
```

```
print("Vehicle_df2 dataframe has duplicate - {}".format(any(vehicle_df2.
 ↪duplicated())))
```

```
Vehicle_df2 dataframe has duplicate - False
```

[58]:
```
# Checking outliers
print('Null values in PHEV_range column: ',vehicle_df2['PHEV_range'].isnull().
 ↪sum())
```

```
Null values in PHEV_range column:  2965
```

[59]:
```
# Checking for Unique values in Transmission_typ column
vehicle_df2['Transmission_typ'].unique()
```

[59]:
```
array(['auto', nan, 'manual', 'ecvt', 'auto / man', 'automatic / 6 speed',
       'semi-automatic', 'automatic / 4 speed', 'automatic',
       'automatic / 1 speed', 'automatic / 5 speed', '6 speed automatic',
       'cvt', 'manual / 6 speed', '3 mode / 1 speed',
       'automatic / 7 speed', 'ecvt / 8 speed', 'automatic / variable',
       'automatic / 8 speed', 'manual / 5 speed', 'none',
       '5-speed automatic', 'v6, hybrid, 3.5l', 'automatic cvt',
       'continuously variable', '4-speed automatic', '6-speed automatic',
       'variable automatic', 'automatic evt', 'sohc', 'direct drive',
       '7-speed automatic', 'multispeed automatic', '6-speed manual',
       '4 speed automatic', '5 speed automatic', '4-speed automatic,',
       'manual 5-speed or cvt', '5-speed auto with o/d',
       'automatic (cvt)', 'electronic, 4-speed automatic',
       'electronic 4-speed automatic', '4-speed automatic, overdrive',
       'single-speed automatic', '4-speed auto or 5 speed manual',
       'a/t 5 speed overdrive', 'transaxle w/2-stage gear set',
       'single speed', '4-speed automatic/5 spd manual', 'single-speed',
       'automatic overdrive', 'type single-speed automatic',
       'single speed w/dual reduction', 'manual 5 or 6 speed/automatic',
       'single-speed, fixed ratio', '3-speed automatic',
       '4-speed automatic w/overdrive', 'cd4e, 4-speed automatic',
       'single-speed, reduction gear'], dtype=object)
```

[60]:
```
# Transmission_typ can be an useful column. So, need to fix the casing to all␣
 ↪lowercase
vehicle_df2['Transmission_typ'] = vehicle_df2['Transmission_typ'].str.lower()
```

[61]:
```
# Checking the vehicle_df2 dataframe for Transmission_typ column casing changes
vehicle_df2.head()
```

[61]:

	Vehicle_ID	Fuel_ID	Manufacturer_ID	Category ID	Model	\
0	13044	45	365	27	NSX	
1	12854	45	377	27	A3	

```
2       12842       45              377           27          A3 quattro
3       12783       45              377           27  A4 allroad quattro
4       12782       45              377           27          A4 quattro

   Model_yr  Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd Transmission_typ  \
0      2022                 NaN                 21.0             auto
1      2022                 NaN                 32.0             auto
2      2022                 NaN                 31.0             auto
3      2022                 NaN                 26.0             auto
4      2022                 NaN                 29.0             auto

  Engine_Size Manufacturer     Category Fuel_code             Fuel  \
0        3.5L        Acura  Sedan/Wagon      HYBR  Hybrid Electric
1        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
2        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
3        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
4        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric

   Electric_Range  PHEV_range Drivetrain
0             NaN         NaN        AWD
1             NaN         NaN        FWD
2             NaN         NaN        AWD
3             NaN         NaN        AWD
4             NaN         NaN        AWD
```

[62]:
```
# Checking for Unique values in Fuel_code column
vehicle_df2['Fuel_code'].unique()
```

[62]:
```
array(['HYBR', 'PHEV', 'ELEC', 'BD', 'E85_GSLN', 'H2', 'LPG_GSLN',
       'CNG_GSLN', 'CNG', 'LPG', 'M85_GSLN'], dtype=object)
```

[63]:
```
# I am only interested in Electric or Hybrid vehicles. So, filtering the rest␣
 ↪from my dataframe.
df1 = vehicle_df2[((vehicle_df2.Fuel_code=='HYBR') | (vehicle_df2.
 ↪Fuel_code=='PHEV') | (vehicle_df2.Fuel_code=='ELEC') | (vehicle_df2.
 ↪Fuel_code=='H2'))]

df1.head()
```

[63]:
```
   Vehicle_ID  Fuel_ID  Manufacturer_ID  Category ID              Model  \
0       13044       45              365           27                NSX
1       12854       45              377           27                 A3
2       12842       45              377           27          A3 quattro
3       12783       45              377           27  A4 allroad quattro
4       12782       45              377           27          A4 quattro

   Model_yr  Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd Transmission_typ  \
```

```
0      2022                NaN                21.0            auto
1      2022                NaN                32.0            auto
2      2022                NaN                31.0            auto
3      2022                NaN                26.0            auto
4      2022                NaN                29.0            auto

  Engine_Size Manufacturer     Category Fuel_code             Fuel  \
0        3.5L        Acura  Sedan/Wagon      HYBR  Hybrid Electric
1        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
2        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
3        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric
4        2.0L         Audi  Sedan/Wagon      HYBR  Hybrid Electric

   Electric_Range  PHEV_range Drivetrain
0             NaN         NaN        AWD
1             NaN         NaN        FWD
2             NaN         NaN        AWD
3             NaN         NaN        AWD
4             NaN         NaN        AWD
```

So, now I have a cleaner dataset with only useful columns and rows which I need to analyze further on growing Electric vehicle market and its future in US.

[64]:
```
# Descriptive statistics and data visualization
print(df1.describe())
```

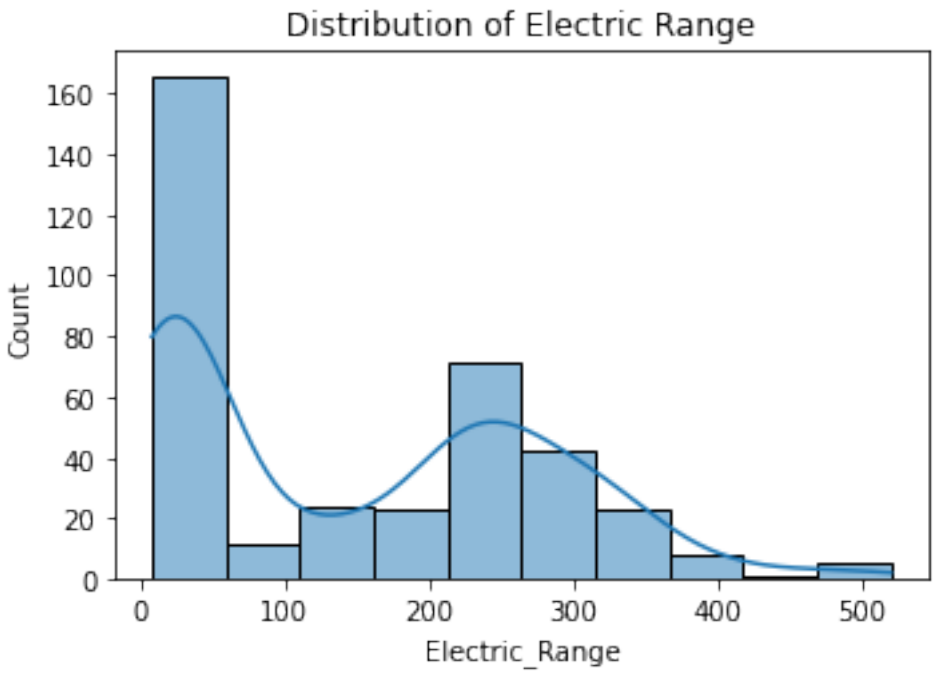
```
         Vehicle_ID      Fuel_ID  Manufacturer_ID  Category ID     Model_yr  \
count   1506.000000  1506.000000      1506.000000  1506.000000  1506.000000
mean   10825.573041    45.382470       278.893758    27.099602  2017.067729
std     3700.268695     7.864792        73.758063     2.841208     5.508018
min        1.000000     9.000000       209.000000     3.000000  1995.000000
25%    11342.250000    41.000000       219.000000    27.000000  2015.000000
50%    12154.500000    45.000000       239.000000    27.000000  2019.000000
75%    12661.750000    45.000000       361.000000    29.000000  2021.000000
max    13105.000000    57.000000       470.000000    29.000000  2022.000000

       Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd  Electric_Range  PHEV_range
count          376.000000           588.000000      374.000000   43.000000
mean            86.218085            29.705782      148.251337  450.465116
std             25.643823            10.745793      128.708353   93.042578
min             42.000000            15.000000        8.000000  290.000000
25%             66.000000            22.000000       21.000000  380.000000
50%             84.000000            26.000000      126.000000  460.000000
75%            108.000000            37.000000      254.750000  520.000000
max            142.000000            59.000000      520.000000  640.000000
```

[65]:
```
# Importing visualization libraries
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LinearRegression
from sklearn.cluster import KMeans

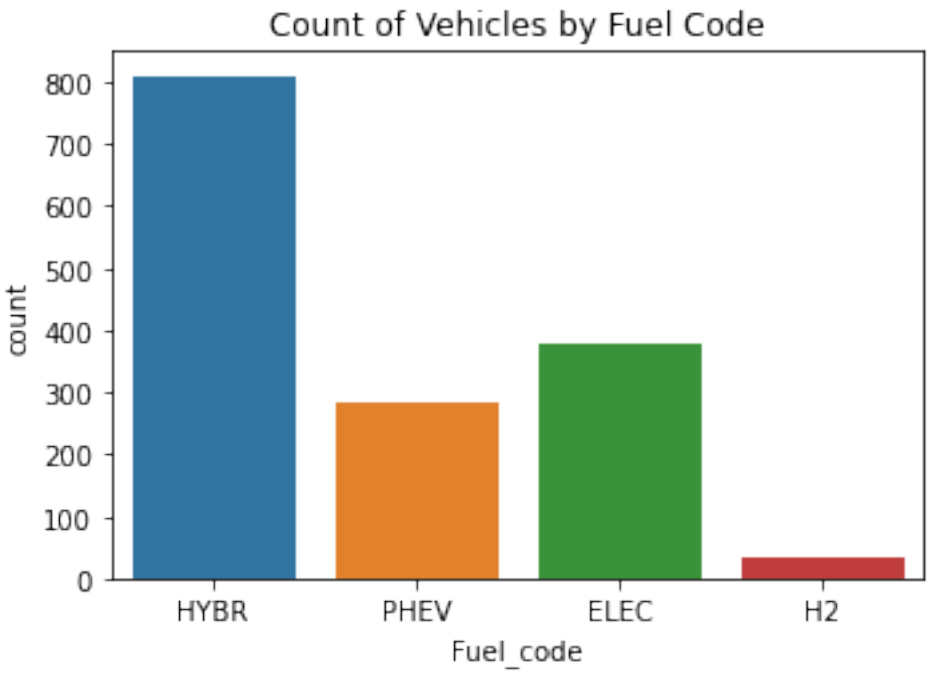
# Visualize the distribution of different variables
plt.figure(figsize=(12, 8))
plt.subplot(2, 2, 1)
sns.histplot(df1['Electric_Range'], kde=True)
plt.title('Distribution of Electric Range')
```

[65]:
```
Text(0.5, 1.0, 'Distribution of Electric Range')
```



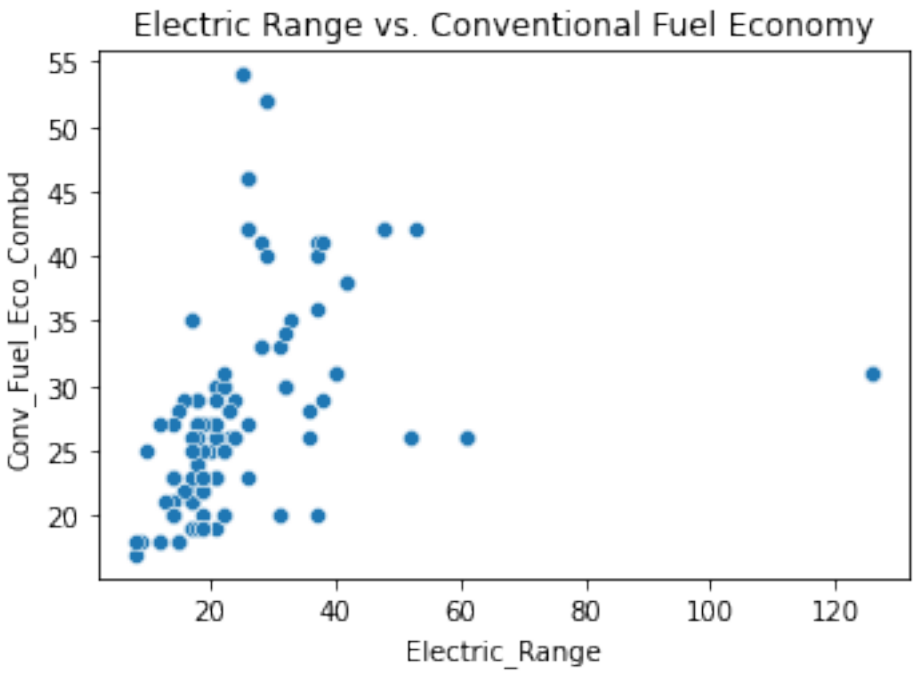
[66]:
```
plt.figure(figsize=(12, 8))
plt.subplot(2, 2, 2)
sns.countplot(x='Fuel_code', data=df1)
plt.title('Count of Vehicles by Fuel Code')
```

[66]:
```
Text(0.5, 1.0, 'Count of Vehicles by Fuel Code')
```



[69]:
```
plt.figure(figsize=(12, 8))
plt.subplot(2, 2, 4)
sns.scatterplot(x='Electric_Range', y='Conv_Fuel_Eco_Combd', data=df1)
plt.title('Electric Range vs. Conventional Fuel Economy')
```

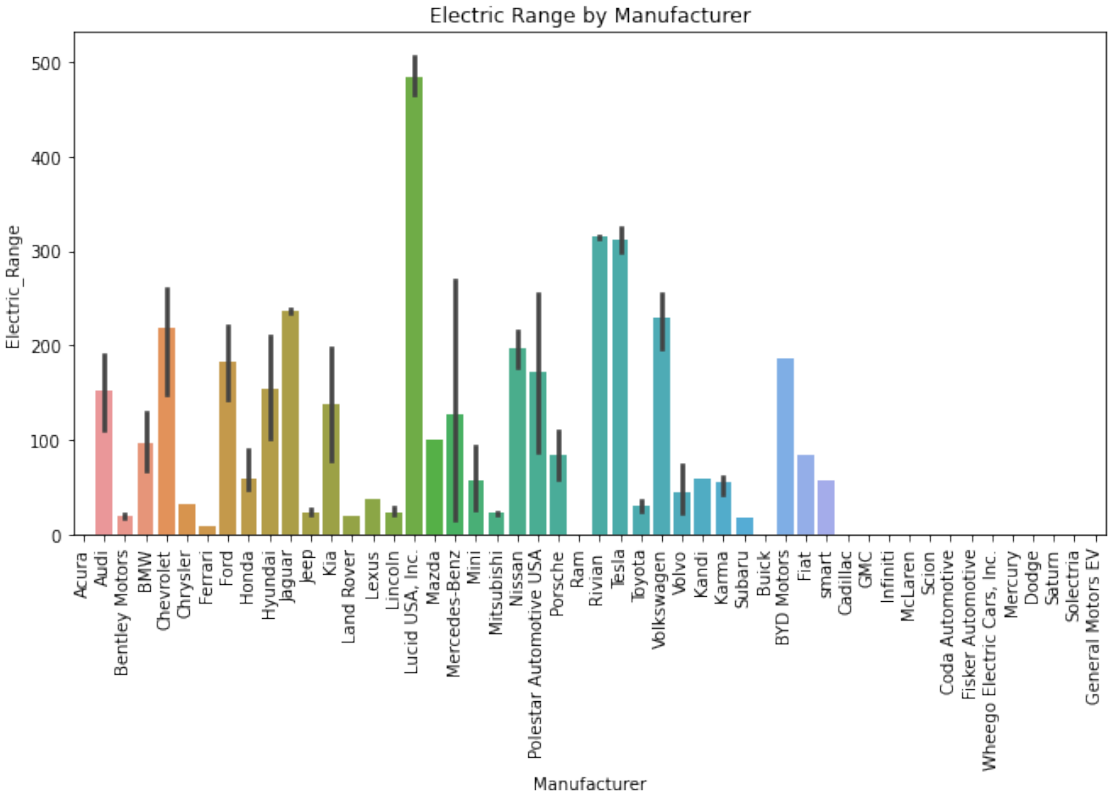
[69]:
```
Text(0.5, 1.0, 'Electric Range vs. Conventional Fuel Economy')
```



[70]:
```
import warnings
# Suppress all warnings
warnings.filterwarnings("ignore")

plt.figure(figsize=(24, 12))
plt.subplot(2, 2, 4)
sns.barplot(x='Manufacturer', y='Electric_Range', data=df1)
plt.xticks(rotation=90)
plt.title('Electric Range by Manufacturer')
```

[70]:
```
Text(0.5, 1.0, 'Electric Range by Manufacturer')
```



[76]:
```
# Check the column names
print(df1.columns)
```

```
Index(['Vehicle_ID', 'Fuel_ID', 'Manufacturer_ID', 'Category ID', 'Model',
       'Model_yr', 'Alt_fuel_Eco_Combd', 'Conv_Fuel_Eco_Combd',
       'Transmission_typ', 'Engine_Size', 'Manufacturer', 'Category',
       'Fuel_code', 'Fuel', 'Electric_Range', 'PHEV_range', 'Drivetrain'],
      dtype='object')
```

0.0.2 Regression analysis

[77]:
```
X = df1[['Electric_Range', 'PHEV_range', 'Conv_Fuel_Eco_Combd']]
y = df1['Alt_fuel_Eco_Combd']

# Fill missing values with 0 for regression
X = X.fillna(0)
y = y.fillna(0)  # Fill NaN values in the target variable

model = LinearRegression()
model.fit(X, y)

print("Coefficient of determination (R-squared):", model.score(X, y))
```

```
print("Coefficients:", model.coef_)
```

```
Coefficient of determination (R-squared): 0.7041390414337791
Coefficients: [0.36327423 0.1016857  0.34842643]
```

0.0.3 Cluster analysis

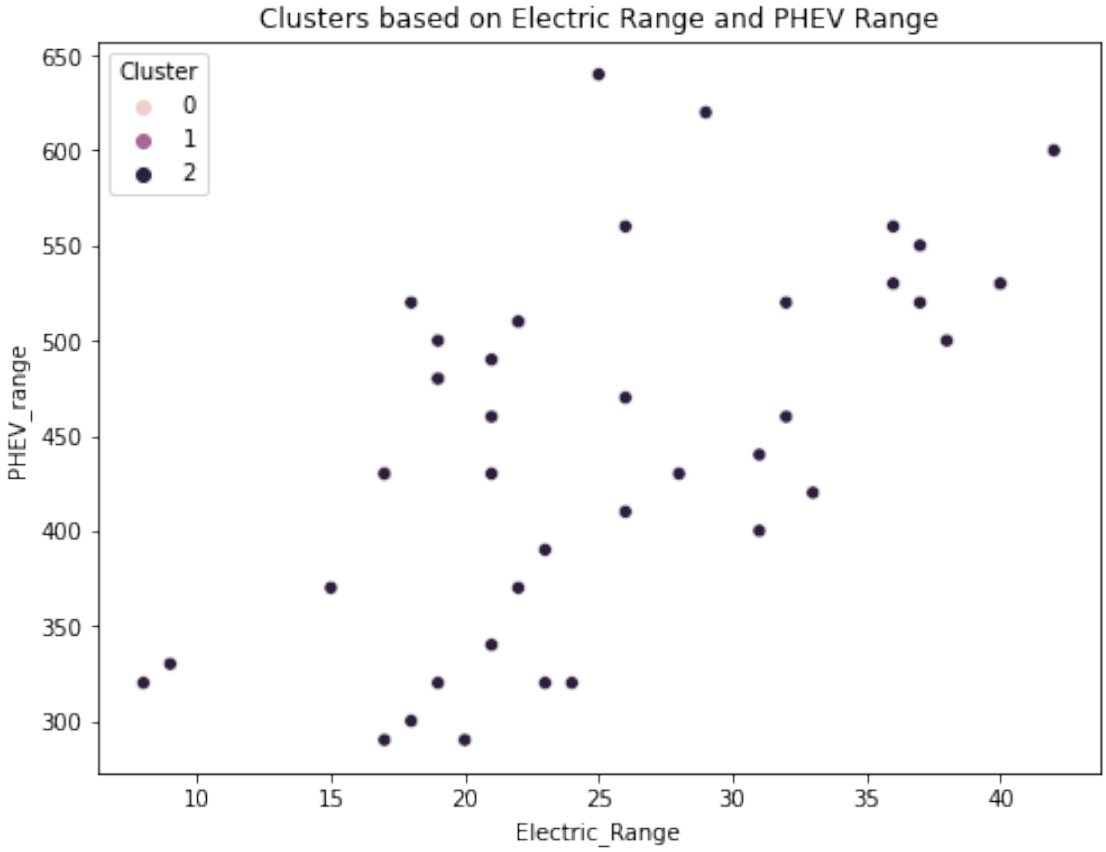
[78]:
```
X = df1[['Electric_Range', 'PHEV_range', 'Conv_Fuel_Eco_Combd',␣
 ↪'Alt_fuel_Eco_Combd']]
X = X.fillna(0)  # Fill missing values with 0 for clustering

kmeans = KMeans(n_clusters=3, random_state=0)
labels = kmeans.fit_predict(X)

df1['Cluster'] = labels

plt.figure(figsize=(8, 6))
sns.scatterplot(x='Electric_Range', y='PHEV_range', hue='Cluster', data=df1)
plt.title('Clusters based on Electric Range and PHEV Range')
plt.show()

print(df1.groupby('Cluster').mean())
```



```
           Vehicle_ID    Fuel_ID  Manufacturer_ID  Category ID     Model_yr  \
Cluster
0        12692.051813  41.497409       292.709845    27.683938  2020.927461
1        10469.418110  45.579528       275.151181    27.001575  2016.314173
2        12967.116279  57.000000       327.418605    27.372093  2022.000000

         Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd  Electric_Range  PHEV_range
Cluster
0                100.829016            31.000000      260.409326         NaN
1                 71.664286            29.808905       29.768116         NaN
2                 68.023256            28.232558       25.093023  450.465116
```

0.0.4 Dataset 2 : https://en.wikipedia.org/wiki/Electric_car

0.0.5 Description: Overall wiki information of currently available Electric vehicles and the top selling one's across the globe.

[80]:
```
# Import required libraries
# pip install requests
import requests
from lxml import etree as et
from bs4 import BeautifulSoup # library to parse HTML documents

# Making a GET request
r = requests.get('https://en.wikipedia.org/wiki/Electric_car')

# check status code for response received
# success code - 200
print(r)
```

```
<Response [200]>
```

[81]:
```
# parse data from the html into a beautifulsoup object
soup = BeautifulSoup(r.text, 'html.parser')
elec_table=soup.find('table',{'class':"wikitable"})

print(elec_table)
```

```
<table class="wikitable sortable mw-collapsible plainrowheaders"
id="Top_BEV_models">
<caption>All-time top-selling highway-capable<sup>(1)</sup> all-electric
passenger car nameplates
</caption>
<tbody><tr>
<th scope="col">Company
</th>
```

<th scope="col">Model
</th>
<th class="unsortable" scope="col">Image
</th>
<th scope="col">Market launch
</th>
<th scope="col">Lifetime global sales
</th>
<th scope="col">Total sales through
</th>
<th scope="col">Annual global sales
</th>
<th>Status
</th>
<th class="unsortable" scope="col"><abbr title="Reference(s)">Ref</abbr>
</th></tr>
<tr align="center">
<td><a class="mw-file-description"
href="/wiki/File:Tesla_T_symbol.svg"><img class="mw-file-element" data-file-
height="254" data-file-width="255" decoding="async" height="35" src="//upload.wi
kimedia.org/wikipedia/commons/thumb/b/bb/Tesla_T_symbol.svg/35px-
Tesla_T_symbol.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/b
/bb/Tesla_T_symbol.svg/53px-Tesla_T_symbol.svg.png 1.5x,
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<td>2020-03</td>
<td data-sort-value="1840,000">~2.49 million</td>
<td>2023-12</td>
<td>1,211,601 (2023)
</td>
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</td>
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href="#cite_note-GlobalTopEVs2022-175">[175]</sup><sup class="reference"
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Tesla_T_symbol.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/b
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width="130"/></td>
<td>2017-07</td>
<td data-sort-value="2060,000">~2.06 million</td>
<td>2023-06</td>
<td>529,287 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
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href="#cite_note-GlobalTopEVs2022-175">[175]</sup><sup class="reference"
id="cite_ref-GlobalTopEVs2021_176-3"><a href="#cite_note-
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srcset="//upload.wikimedia.org/wikipedia/commons/thumb/1/16/Wuling-logo.svg/90px-Wuling-logo.svg.png 1.5x, //upload.wikimedia.org/wikipedia/commons/thumb/1/16/Wuling-logo.svg/120px-Wuling-logo.svg.png 2x" width="60"/>
SAIC-GM-Wuling</td>
<td>Wuling Hongguang Mini EV
</td>
<td align="left"></td>
<td>2020-07</td>
<td data-sort-value="1097,872">1,218,640</td>
<td>2023-12</td>
<td>118,834 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
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</td></tr>
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.org/wikipedia/commons/thumb/d/de/Nissan_Leaf_2018_%2831874639158%29_%28cropped%
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width="130"/></a></span></td>
<td>2010-12</td>
<td data-sort-value="650,000">~650,000</td>
<td>2023-07</td>
<td>64,201 (2021)
</td>
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href="#cite_note-GlobalTopEVs2021-176">[176]</a></sup><sup class="reference"
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mb/e/e2/BYD_Auto_2022_logo.svg/75px-BYD_Auto_2022_logo.svg.png 1.5x, //upload.wi
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BYD_Auto_2022_logo.svg.png 2x" width="50"/></a></span> <br/><a
href="/wiki/BYD_Auto" title="BYD Auto">BYD</a>
</td>
<td><a href="/wiki/BYD_Atto_3" title="BYD Atto 3">BYD Yuan Plus / Atto 3</a>
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3/3e/BYD_Atto_3_1X7A6491.jpg/195px-BYD_Atto_3_1X7A6491.jpg 1.5x, //upload.wikime
dia.org/wikipedia/commons/thumb/3/3e/BYD_Atto_3_1X7A6491.jpg/260px-
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<td>2022-02
```

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</td>
<td>614,260
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<td>2023-12
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<td>412,202 (2023)
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href="#cite_note-:8-205">[205]</a></sup><sup class="reference"
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BYD_Auto_2022_logo.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thu
mb/e/e2/BYD_Auto_2022_logo.svg/75px-BYD_Auto_2022_logo.svg.png 1.5x, //upload.wi
kimedia.org/wikipedia/commons/thumb/e/e2/BYD_Auto_2022_logo.svg/100px-
BYD_Auto_2022_logo.svg.png 2x" width="50"/></a></span> <br/><a
href="/wiki/BYD_Auto" title="BYD Auto">BYD</a>
</td>
<td><a href="/wiki/BYD_Dolphin" title="BYD Dolphin">BYD Dolphin</a>
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mb/6/60/2021_BYD_Dolphin_EV_%28front%29.jpg/260px-2021_BYD_Dolphin_EV_%28front%2
9.jpg 2x" width="130"/></a></span>
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<td>2021-08
</td>
<td>602,434
</td>
<td>2023-12
</td>
<td>367,419 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-GlobalTopEVs2022_175-4"><a
href="#cite_note-GlobalTopEVs2022-175">[175]</a></sup><sup class="reference"
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ng/35px-%D7%9C%D7%95%D7%92%D7%95_%D7%A9%D7%9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC
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</td>
<td>2019-05
</td>
<td>485,369
</td>
<td>2023-12
</td>
<td>222,227 (2023)
</td>
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GlobalTopEVs062023-199">[199]</sup><sup class="reference" id="cite_ref-
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BYD_Auto_2022_logo.svg.png 2x" width="50"/>
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mons/thumb/6/61/BYD_Qin_Plus_EV_005_%28cropped%29.jpg/260px-
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</td>
<td>2016-03
</td>
<td>454,157
</td>
<td>2023-12
</td>
<td>154,774 (2023)
</td>
<td style="background: #D5F5E3">In production
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o.svg/70px-2021_Renault_Group_logo.svg.png 2x" width="35"/>
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<td>Renault Zoe
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width="130"/></td>
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<td>413,975</td>
<td>2023-06</td>
<td>15,706 (2023)
</td>
<td style="background: #D5F5E3">In production
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</td>
<td>2020-09
</td>
<td>493,219
</td>
<td>2023-12
</td>
<td>192,686 (2023)
</td>
<td style="background: #D5F5E3">In production
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href="#cite_note-GlobalTopEVs2022-175">[175]</a></sup><sup class="reference"
id="cite_ref-GlobalTopEVs2021_176-7"><a href="#cite_note-
GlobalTopEVs2021-176">[176]</a></sup><sup class="reference" id="cite_ref-
VWID4_2020_217-0"><a href="#cite_note-VWID4_2020-217">[217]</a></sup><sup
class="reference" id="cite_ref-:11_202-2"><a
href="#cite_note-:11-202">[202]</a></sup>
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class="mw-file-element" data-file-height="620" data-file-width="971"
decoding="async" height="22" src="//upload.wikimedia.org/wikipedia/commons/thumb
/d/dc/%D7%9C%D7%95%D7%92%D7%95_%D7%A9%D7%9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC.p
ng/35px-%D7%9C%D7%95%D7%92%D7%95_%D7%A9%D7%9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC
.png" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/d/dc/%D7%9C%D7%95%D
7%92%D7%95_%D7%A9%D7%9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC.png/53px-%D7%9C%D7%95
%D7%92%D7%95_%D7%A9%D7%9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC.png 1.5x, //upload.
wikimedia.org/wikipedia/commons/thumb/d/dc/%D7%9C%D7%95%D7%92%D7%95_%D7%A9%D7%9C
_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC.png/70px-%D7%9C%D7%95%D7%92%D7%95_%D7%A9%D7%
9C_%D7%A7%D7%91%D7%95%D7%A6%D7%AA_GAC.png 2x" width="35"/></a></span><br/> <a
href="/wiki/GAC_Group" title="GAC Group">GAC Group</a>
```

```
</td>
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130px-2021_GAC_Aion_Y_%28front%29.jpg" srcset="//upload.wikimedia.org/wikipedia/
commons/thumb/6/6c/2021_GAC_Aion_Y_%28front%29.jpg/195px-2021_GAC_Aion_Y_%28fron
t%29.jpg 1.5x, //upload.wikimedia.org/wikipedia/commons/thumb/6/6c/2021_GAC_Aion
_Y_%28front%29.jpg/260px-2021_GAC_Aion_Y_%28front%29.jpg 2x"
width="130"/></a></span>
</td>
<td>2021-04
</td>
<td>383,350
</td>
<td>2023-12
</td>
<td>229,555 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-:7_206-3"><a
href="#cite_note-:7-206">[206]</a></sup><sup class="reference"
id="cite_ref-:8_205-3"><a href="#cite_note-:8-205">[205]</a></sup><sup
class="reference" id="cite_ref-:9_211-1"><a
href="#cite_note-:9-211">[211]</a></sup>
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<tr align="center">
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href="/wiki/File:BYD_Auto_2022_logo.svg"><img class="mw-file-element" data-file-
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ikimedia.org/wikipedia/commons/thumb/e/e2/BYD_Auto_2022_logo.svg/50px-
BYD_Auto_2022_logo.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thu
mb/e/e2/BYD_Auto_2022_logo.svg/75px-BYD_Auto_2022_logo.svg.png 1.5x, //upload.wi
kimedia.org/wikipedia/commons/thumb/e/e2/BYD_Auto_2022_logo.svg/100px-
BYD_Auto_2022_logo.svg.png 2x" width="50"/></a></span> <br/><a
href="/wiki/BYD_Auto" title="BYD Auto">BYD</a>
</td>
<td><a href="/wiki/BYD_Han" title="BYD Han">BYD Han EV</a>
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2020_BYD_Han_EV_front.jpg" srcset="//upload.wikimedia.org/wikipedia/commons/thum
b/b/bd/2020_BYD_Han_EV_front.jpg/195px-2020_BYD_Han_EV_front.jpg 1.5x, //upload.
```

wikimedia.org/wikipedia/commons/thumb/b/bd/2020_BYD_Han_EV_front.jpg/260px-2020_
BYD_Han_EV_front.jpg 2x" width="130"/>
</td>
<td>2020-03
</td>
<td>367,129
</td>
<td>2023-12
</td>
<td>106,502 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-:7_206-4"><a
href="#cite_note-:7-206">[206]</sup><sup class="reference"
id="cite_ref-:8_205-4">[205]</sup><sup
class="reference" id="cite_ref-:9_211-2"><a
href="#cite_note-:9-211">[211]</sup><sup class="reference"
id="cite_ref-:10_212-1">[212]</sup>
</td></tr>
<tr align="center">
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Tesla_T_symbol.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/b
/bb/Tesla_T_symbol.svg/53px-Tesla_T_symbol.svg.png 1.5x,
//upload.wikimedia.org/wikipedia/commons/thumb/b/bb/Tesla_T_symbol.svg/70px-
Tesla_T_symbol.svg.png 2x" width="35"/>
 <a
href="/wiki/Tesla,_Inc." title="Tesla, Inc.">Tesla, Inc.</td>
<td>Tesla Model S
</td>
<td align="left"><a class="mw-file-description"
href="/wiki/File:Tesla_Model_S_(2023)_Motorworld_Munich_1X7A0025.jpg"><img
class="mw-file-element" data-file-height="1370" data-file-width="2226"
decoding="async" height="80" src="//upload.wikimedia.org/wikipedia/commons/thumb
/9/99/Tesla_Model_S_%282023%29_Motorworld_Munich_1X7A0025.jpg/130px-
Tesla_Model_S_%282023%29_Motorworld_Munich_1X7A0025.jpg" srcset="//upload.wikime
dia.org/wikipedia/commons/thumb/9/99/Tesla_Model_S_%282023%29_Motorworld_Munich_
1X7A0025.jpg/195px-Tesla_Model_S_%282023%29_Motorworld_Munich_1X7A0025.jpg 1.5x,
//upload.wikimedia.org/wikipedia/commons/thumb/9/99/Tesla_Model_S_%282023%29_Mot
orworld_Munich_1X7A0025.jpg/260px-
Tesla_Model_S_%282023%29_Motorworld_Munich_1X7A0025.jpg 2x"
width="130"/></td>
<td>2012-06</td>
<td data-sort-value="363,900">~363,900</td>
<td>2022-12</td>
<td data-sort-value="35,000">~35,000 (2022)

```
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-TopModelZSW2022_218-0"><a
href="#cite_note-TopModelZSW2022-218">[218]</a></sup>
</td></tr>
<tr align="center">
<td><a href="/wiki/Chery" title="Chery">Chery</a>
</td>
<td><a href="/wiki/Chery_eQ1" title="Chery eQ1">Chery eQ1</a>
</td>
<td align="left"><span typeof="mw:File"><a class="mw-file-description"
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" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/a/a6/2022_Chery_eQ1_%28
facelift%2C_front%29.jpg/195px-2022_Chery_eQ1_%28facelift%2C_front%29.jpg 1.5x,
//upload.wikimedia.org/wikipedia/commons/thumb/a/a6/2022_Chery_eQ1_%28facelift%2
C_front%29.jpg/260px-2022_Chery_eQ1_%28facelift%2C_front%29.jpg 2x"
width="130"/></a></span>
</td>
<td>2017-03
</td>
<td>338,051
</td>
<td>2023-12
</td>
<td>29,744 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-219"><a
href="#cite_note-219">[219]</a></sup><sup class="reference" id="cite_ref-220"><a
href="#cite_note-220">[220]</a></sup><sup class="reference" id="cite_ref-221"><a
href="#cite_note-221">[221]</a></sup>
</td></tr>
<tr align="center">
<td><span typeof="mw:File"><a class="mw-file-description"
href="/wiki/File:Hyundai_Motor_Company_logo.svg"><img class="mw-file-element"
data-file-height="129" data-file-width="1000" decoding="async" height="10" src="
//upload.wikimedia.org/wikipedia/commons/thumb/4/44/Hyundai_Motor_Company_logo.s
vg/80px-Hyundai_Motor_Company_logo.svg.png" srcset="//upload.wikimedia.org/wikip
edia/commons/thumb/4/44/Hyundai_Motor_Company_logo.svg/120px-
Hyundai_Motor_Company_logo.svg.png 1.5x, //upload.wikimedia.org/wikipedia/common
s/thumb/4/44/Hyundai_Motor_Company_logo.svg/160px-
Hyundai_Motor_Company_logo.svg.png 2x" width="80"/></a></span> <br/><a
href="/wiki/Hyundai_Motor_Company" title="Hyundai Motor Company">Hyundai</a>
```

```
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<td><a class="mw-redirect" href="/wiki/Hyundai_Kona_Electric" title="Hyundai
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<td align="left"><span typeof="mw:File"><a class="mw-file-description"
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Hyundai_Kona_Electric_%28SX2%29_1X7A1554.jpg" srcset="//upload.wikimedia.org/wik
ipedia/commons/thumb/e/ed/Hyundai_Kona_Electric_%28SX2%29_1X7A1554.jpg/195px-
Hyundai_Kona_Electric_%28SX2%29_1X7A1554.jpg 1.5x, //upload.wikimedia.org/wikipe
dia/commons/thumb/e/ed/Hyundai_Kona_Electric_%28SX2%29_1X7A1554.jpg/260px-
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</td>
<td>2018-05
</td>
<td>329,643
</td>
<td>2023-12
</td>
<td>70,871 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-:23_222-0"><a
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</td></tr>
<tr align="center">
<td><span typeof="mw:File"><a class="mw-file-description"
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load.wikimedia.org/wikipedia/commons/thumb/6/6d/Volkswagen_logo_2019.svg/35px-
Volkswagen_logo_2019.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/t
humb/6/6d/Volkswagen_logo_2019.svg/53px-Volkswagen_logo_2019.svg.png 1.5x, //upl
oad.wikimedia.org/wikipedia/commons/thumb/6/6d/Volkswagen_logo_2019.svg/70px-
Volkswagen_logo_2019.svg.png 2x" width="35"/></a></span><br/> <a
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ad.wikimedia.org/wikipedia/commons/thumb/2/22/2020_Volkswagen_ID.3_1st_Front.jpg
/195px-2020_Volkswagen_ID.3_1st_Front.jpg 1.5x, //upload.wikimedia.org/wikipedia
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/commons/thumb/2/22/2020_Volkswagen_ID.3_1st_Front.jpg/260px-2020_Volkswagen_ID.
3_1st_Front.jpg 2x" width="130"/>
</td>
<td>2019-11
</td>
<td>325,770
</td>
<td>2023-12
</td>
<td>139,268 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-223"><a
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href="#cite_note-224">[224]</sup><sup class="reference" id="cite_ref-225"><a
href="#cite_note-225">[225]</sup><sup class="reference"
id="cite_ref-:11_202-3">[202]</sup>
</td></tr>
<tr align="center">
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//upload.wikimedia.org/wikipedia/commons/thumb/4/44/Hyundai_Motor_Company_logo.s
vg/80px-Hyundai_Motor_Company_logo.svg.png" srcset="//upload.wikimedia.org/wikip
edia/commons/thumb/4/44/Hyundai_Motor_Company_logo.svg/120px-
Hyundai_Motor_Company_logo.svg.png 1.5x, //upload.wikimedia.org/wikipedia/common
s/thumb/4/44/Hyundai_Motor_Company_logo.svg/160px-
Hyundai_Motor_Company_logo.svg.png 2x" width="80"/>
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</td>
<td>Hyundai Ioniq 5
</td>
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Hyundai_Ioniq_5.jpg" srcset="//upload.wikimedia.org/wikipedia/commons/thumb/4/4d
/Hyundai_Ioniq_5.jpg/195px-Hyundai_Ioniq_5.jpg 1.5x,
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Hyundai_Ioniq_5.jpg 2x" width="130"/>
</td>
<td>2021-03
</td>
<td>280,430
</td>
<td>2023-12
</td>

<td>114,988 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
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href="#cite_note-:23-222">[222]</sup>
</td></tr>
<tr align="center">
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href="/wiki/File:BYD_Auto_2022_logo.svg"><img class="mw-file-element" data-file-
height="480" data-file-width="1920" decoding="async" height="13" src="//upload.w
ikimedia.org/wikipedia/commons/thumb/e/e2/BYD_Auto_2022_logo.svg/50px-
BYD_Auto_2022_logo.svg.png" srcset="//upload.wikimedia.org/wikipedia/commons/thu
mb/e/e2/BYD_Auto_2022_logo.svg/75px-BYD_Auto_2022_logo.svg.png 1.5x, //upload.wi
kimedia.org/wikipedia/commons/thumb/e/e2/BYD_Auto_2022_logo.svg/100px-
BYD_Auto_2022_logo.svg.png 2x" width="50"/>
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href="/wiki/BYD_Auto" title="BYD Auto">BYD
</td>
<td>BYD Seagull
</td>
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ont%29.jpg/130px-2023_%D0%92YD_Seagull_%28front%29.jpg" srcset="//upload.wikimed
ia.org/wikipedia/commons/thumb/0/09/2023_%D0%92YD_Seagull_%28front%29.jpg/195px-
2023_%D0%92YD_Seagull_%28front%29.jpg 1.5x, //upload.wikimedia.org/wikipedia/com
mons/thumb/0/09/2023_%D0%92YD_Seagull_%28front%29.jpg/260px-2023_%D0%92YD_Seagul
l_%28front%29.jpg 2x" width="130"/>
</td>
<td>2023-04
</td>
<td>280,217
</td>
<td>2023-12
</td>
<td>280,217 (2023)
</td>
<td style="background: #D5F5E3">In production
</td>
<td align="left"><sup class="reference" id="cite_ref-:6_208-1"><a
href="#cite_note-:6-208">[208]</sup>
</td></tr>
<tr class="sortbottom">
<td colspan="9"><small>Notes:
(1) Vehicles are considered highway-
capable if able to achieve at least a top speed of 100 km/h (62 mph).</small>
</td></tr></tbody></table>

[82]:
```
# Convert Wikipedia Table into a Python Dataframe
df=pd.read_html(str(elec_table))
# convert list to dataframe
df=pd.DataFrame(df[0])

df.head()
```

[82]:

	Company	Model	Image	Market launch	Lifetime global sales	Total sales through	Annual global sales	Status	Ref
0	Tesla, Inc.	Tesla Model Y	NaN	2020-03	~2.49 million	2023-12	1,211,601 (2023)	In production	[175][176][199][200][201][202]
1	Tesla, Inc.	Tesla Model 3	NaN	2017-07	~2.06 million	2023-06	529,287 (2023)	In production	[175][176][203][199][202]
2	SAIC-GM-Wuling	Wuling Hongguang Mini EV	NaN	2020-07	1218640	2023-12	118,834 (2023)	In production	[175][176][199][204][205]
3	Nissan	Nissan Leaf	NaN	2010-12	~650,000	2023-07	64,201 (2021)	In production	[176][191]
4	BYD	BYD Yuan Plus / Atto 3	NaN	2022-02	614260	2023-12	412,202 (2023)	In production	[205][206]

[85]:
```
# Renaming column names to ease dataframe operations
df.rename({'Market launch': 'Market_launch_dt','Lifetime global sales':
 ↪'Lifetime_global_sales','Annual global sales': 'Annual_global_sales','Total␣
 ↪global sales': 'Total_global_sales', 'Total sales through':␣
 ↪'Total_sales_through'}, axis=1 , inplace=True)
```

[86]:
```
# Display top 5 rows after renaming header
df.head()
```

[86]:

	Company	Model	Image	Market_launch_dt	Lifetime_global_sales	Total_sales_through	Annual_global_sales
0	Tesla, Inc.	Tesla Model Y	NaN	2020-03	~2.49 million	2023-12	1,211,601 (2023)
1	Tesla, Inc.	Tesla Model 3	NaN	2017-07	~2.06 million	2023-06	529,287 (2023)
2	SAIC-GM-Wuling	Wuling Hongguang Mini EV	NaN	2020-07			
3	Nissan	Nissan Leaf	NaN	2010-12			
4	BYD	BYD Yuan Plus / Atto 3	NaN	2022-02			

```
2              1218640             2023-12      118,834 (2023)
3             ~650,000             2023-07       64,201 (2021)
4               614260             2023-12      412,202 (2023)

          Status                                  Ref
0  In production  [175][176][199][200][201][202]
1  In production       [175][176][203][199][202]
2  In production       [175][176][199][204][205]
3  In production                       [176][191]
4  In production                       [205][206]
```

[87]:
```
# Creating new Dataframe with useful columns only.
vehicle_df = df.drop(['Ref'], axis=1)
```

[88]:
```
# Display top 5 rows after dropping REF column
vehicle_df.head()
```

[88]:
```
          Company                     Model Image Market_launch_dt  \
0     Tesla, Inc.              Tesla Model Y   NaN          2020-03
1     Tesla, Inc.              Tesla Model 3   NaN          2017-07
2  SAIC-GM-Wuling  Wuling Hongguang Mini EV   NaN          2020-07
3          Nissan               Nissan Leaf   NaN          2010-12
4             BYD    BYD Yuan Plus / Atto 3   NaN          2022-02

  Lifetime_global_sales Total_sales_through Annual_global_sales         Status
0         ~2.49 million             2023-12    1,211,601 (2023)  In production
1         ~2.06 million             2023-06      529,287 (2023)  In production
2               1218640             2023-12      118,834 (2023)  In production
3              ~650,000             2023-07       64,201 (2021)  In production
4                614260             2023-12      412,202 (2023)  In production
```

[89]:
```
# check number of missing values in each column.
vehicle_df.isna().sum()
```

[89]:
```
Company                  0
Model                    0
Image                   18
Market_launch_dt         0
Lifetime_global_sales    0
Total_sales_through      0
Annual_global_sales      0
Status                   0
dtype: int64
```

[90]:
```
# Image column has majority missing values. So, dropping this column from the␣
↪dataframe
vehicle_df = vehicle_df.drop(['Image'], axis=1)
```

[91]:
```
vehicle_df.head()
```

[91]:

	Company	Model	Market_launch_dt	\
0	Tesla, Inc.	Tesla Model Y	2020-03	
1	Tesla, Inc.	Tesla Model 3	2017-07	
2	SAIC-GM-Wuling	Wuling Hongguang Mini EV	2020-07	
3	Nissan	Nissan Leaf	2010-12	
4	BYD	BYD Yuan Plus / Atto 3	2022-02	

	Lifetime_global_sales	Total_sales_through	Annual_global_sales	Status
0	~2.49 million	2023-12	1,211,601 (2023)	In production
1	~2.06 million	2023-06	529,287 (2023)	In production
2	1218640	2023-12	118,834 (2023)	In production
3	~650,000	2023-07	64,201 (2021)	In production
4	614260	2023-12	412,202 (2023)	In production

[92]:
```
# Model and Company are useful columns. So, need to fix the casing to all␣
↪uppercase
vehicle_df['Company'] = vehicle_df['Company'].str.upper()
vehicle_df['Model'] = vehicle_df['Model'].str.upper()
```

[93]:
```
vehicle_df.head()
```

[93]:

	Company	Model	Market_launch_dt	\
0	TESLA, INC.	TESLA MODEL Y	2020-03	
1	TESLA, INC.	TESLA MODEL 3	2017-07	
2	SAIC-GM-WULING	WULING HONGGUANG MINI EV	2020-07	
3	NISSAN	NISSAN LEAF	2010-12	
4	BYD	BYD YUAN PLUS / ATTO 3	2022-02	

	Lifetime_global_sales	Total_sales_through	Annual_global_sales	Status
0	~2.49 million	2023-12	1,211,601 (2023)	In production
1	~2.06 million	2023-06	529,287 (2023)	In production
2	1218640	2023-12	118,834 (2023)	In production
3	~650,000	2023-07	64,201 (2021)	In production
4	614260	2023-12	412,202 (2023)	In production

0.0.6 Dataset 1

[99]:
```
# Model and Manufacturer are useful columns. So, need to fix the casing to all␣
↪uppercase
df1['Manufacturer'] = df1['Manufacturer'].str.upper()
df1['Model'] = df1['Model'].str.upper()
```

[100]:
```
df1.head()
```

[100]:

	Vehicle_ID	Fuel_ID	Manufacturer_ID	Category ID	Model	Model_yr	Alt_fuel_Eco_Combd	Conv_Fuel_Eco_Combd	Transmission_typ	Engine_Size	Manufacturer	Category	Fuel_code	Fuel	Electric_Range	PHEV_range	Drivetrain	Cluster
0	13044	45	365	27	NSX	2022	NaN	21.0	auto	3.5L	ACURA	Sedan/Wagon	HYBR	Hybrid Electric	NaN	NaN	AWD	1
1	12854	45	377	27	A3	2022	NaN	32.0	auto	2.0L	AUDI	Sedan/Wagon	HYBR	Hybrid Electric	NaN	NaN	FWD	1
2	12842	45	377	27	A3 QUATTRO	2022	NaN	31.0	auto	2.0L	AUDI	Sedan/Wagon	HYBR	Hybrid Electric	NaN	NaN	AWD	1
3	12783	45	377	27	A4 ALLROAD QUATTRO	2022	NaN	26.0	auto	2.0L	AUDI	Sedan/Wagon	HYBR	Hybrid Electric	NaN	NaN	AWD	1
4	12782	45	377	27	A4 QUATTRO	2022	NaN	29.0	auto	2.0L	AUDI	Sedan/Wagon	HYBR	Hybrid Electric	NaN	NaN	AWD	1

[106]:
```
# Get distinct Manufacturer names from the "Manufacturer" column
distinct_manuf = df1['Manufacturer'].unique()

# Display the distinct Manufacturer names
print(distinct_manuf)
```

```
['ACURA' 'AUDI' 'BENTLEY' 'BMW' 'CHEVROLET' 'CHRYSLER' 'FERRARI' 'FORD'
 'HONDA' 'HYUNDAI' 'JAGUAR' 'JEEP' 'KIA' 'LAND ROVER' 'LEXUS' 'LINCOLN'
 'LUCID' 'MAZDA' 'MERCEDES-BENZ' 'MINI' 'MITSUBISHI' 'NISSAN' 'POLESTAR'
 'PORSCHE' 'RAM' 'RIVIAN ' 'TESLA' 'TOYOTA' 'VOLKSWAGEN' 'VOLVO' 'KANDI'
 'KARMA' 'SUBARU' 'BUICK' 'BYD' 'FIAT' 'SMART' 'CADILLAC' 'GMC' 'INFINITI'
 'MCLAREN' 'SCION' 'CODA AUTOMOTIVE' 'FISKER' 'WHEEGO ELECTRIC CARS, INC.'
 'MERCURY' 'DODGE' 'SATURN' 'SOLECTRIA' 'GENERAL MOTORS EV']
```

[104]:
```
# Replace values in the "Company" column
df1['Manufacturer'] = df1['Manufacturer'].replace('BYD MOTORS', 'BYD')
df1['Manufacturer'] = df1['Manufacturer'].replace('BENTLEY MOTORS', 'BENTLEY')
df1['Manufacturer'] = df1['Manufacturer'].replace('LUCID USA, INC.', 'LUCID')
```

```
df1['Manufacturer'] = df1['Manufacturer'].replace('POLESTAR AUTOMOTIVE USA',␣
↪'POLESTAR')
df1['Manufacturer'] = df1['Manufacturer'].replace('FISKER AUTOMOTIVE', 'FISKER')
```

0.0.7 Dataset 2

[105]:
```
# Get distinct Company names from the "Company" column
distinct_comp = vehicle_df['Company'].unique()

# Display the distinct model names
print(distinct_comp)
```

```
['TESLA' 'SAIC-GM-WULING' 'NISSAN' 'BYD' 'GAC GROUP' 'RENAULT'
 'VOLKSWAGEN' 'CHERY' 'HYUNDAI'
 'NOTES: (1) VEHICLES ARE CONSIDERED HIGHWAY-CAPABLE IF ABLE TO ACHIEVE AT LEAST
A TOP SPEED OF 100\xa0KM/H (62\xa0MPH).']
```

[102]:
```
# Replace values in the "Company" column
vehicle_df['Company'] = vehicle_df['Company'].replace('TESLA, INC.', 'TESLA')
```

0.0.8 Joining Dataset 1 and Dataset 2

[110]:
```
# Merge the two DataFrames on the "Manufacturer" and "Company" columns
combined_df = pd.merge(df1, vehicle_df, left_on='Manufacturer',␣
↪right_on='Company', how='inner')

# Display the combined DataFrame
combined_df.head()
```

[110]:

	Vehicle_ID	Fuel_ID	Manufacturer_ID	Category ID	Model_x	\
0	12808	45	351	27	ELANTRA HYBRID	
1	12808	45	351	27	ELANTRA HYBRID	
2	12809	45	351	27	ELANTRA HYBRID BLUE	
3	12809	45	351	27	ELANTRA HYBRID BLUE	
4	12810	45	351	27	IONIQ	

	Model_yr	Alt_fuel_Eco_Combd	Conv_Fuel_Eco_Combd	Transmission_typ	\
0	2022	NaN	50.0	auto	
1	2022	NaN	50.0	auto	
2	2022	NaN	54.0	auto	
3	2022	NaN	54.0	auto	
4	2022	NaN	55.0	auto	

	Engine_Size	…	PHEV_range	Drivetrain	Cluster	Company	\
0	1.6L	…	NaN	FWD	1	HYUNDAI	
1	1.6L	…	NaN	FWD	1	HYUNDAI	

```
2        1.6L  …         NaN        FWD       1  HYUNDAI
3        1.6L  …         NaN        FWD       1  HYUNDAI
4        1.6L  …         NaN        FWD       1  HYUNDAI

                Model_y  Market_launch_dt Lifetime_global_sales  \
0  HYUNDAI KONA ELECTRIC           2018-05                329643
1        HYUNDAI IONIQ 5           2021-03                280430
2  HYUNDAI KONA ELECTRIC           2018-05                329643
3        HYUNDAI IONIQ 5           2021-03                280430
4  HYUNDAI KONA ELECTRIC           2018-05                329643

   Total_sales_through Annual_global_sales         Status
0              2023-12       70,871 (2023)  In production
1              2023-12      114,988 (2023)  In production
2              2023-12       70,871 (2023)  In production
3              2023-12      114,988 (2023)  In production
4              2023-12       70,871 (2023)  In production

[5 rows x 25 columns]
```

[116]:
```
#dropping this column from the dataframe
combined_df = combined_df.
 ↪drop(['Vehicle_ID','Fuel_ID','Manufacturer_ID','Category␣
 ↪ID','Model_x','Company'], axis=1)
```

[117]:
```
# Display the combined DataFrame
combined_df.head()
```

[117]:
```
   Model_yr  Alt_fuel_Eco_Combd  Conv_Fuel_Eco_Combd Transmission_typ  \
0      2022                 NaN                 50.0             auto
1      2022                 NaN                 50.0             auto
2      2022                 NaN                 54.0             auto
3      2022                 NaN                 54.0             auto
4      2022                 NaN                 55.0             auto

  Engine_Size Manufacturer     Category Fuel_code             Fuel  \
0        1.6L      HYUNDAI  Sedan/Wagon      HYBR  Hybrid Electric
1        1.6L      HYUNDAI  Sedan/Wagon      HYBR  Hybrid Electric
2        1.6L      HYUNDAI  Sedan/Wagon      HYBR  Hybrid Electric
3        1.6L      HYUNDAI  Sedan/Wagon      HYBR  Hybrid Electric
4        1.6L      HYUNDAI  Sedan/Wagon      HYBR  Hybrid Electric

   Electric_Range  PHEV_range Drivetrain  Cluster                Model_y  \
0             NaN         NaN        FWD        1  HYUNDAI KONA ELECTRIC
1             NaN         NaN        FWD        1        HYUNDAI IONIQ 5
2             NaN         NaN        FWD        1  HYUNDAI KONA ELECTRIC
3             NaN         NaN        FWD        1        HYUNDAI IONIQ 5
```

```
4             NaN         NaN        FWD        1  HYUNDAI KONA ELECTRIC

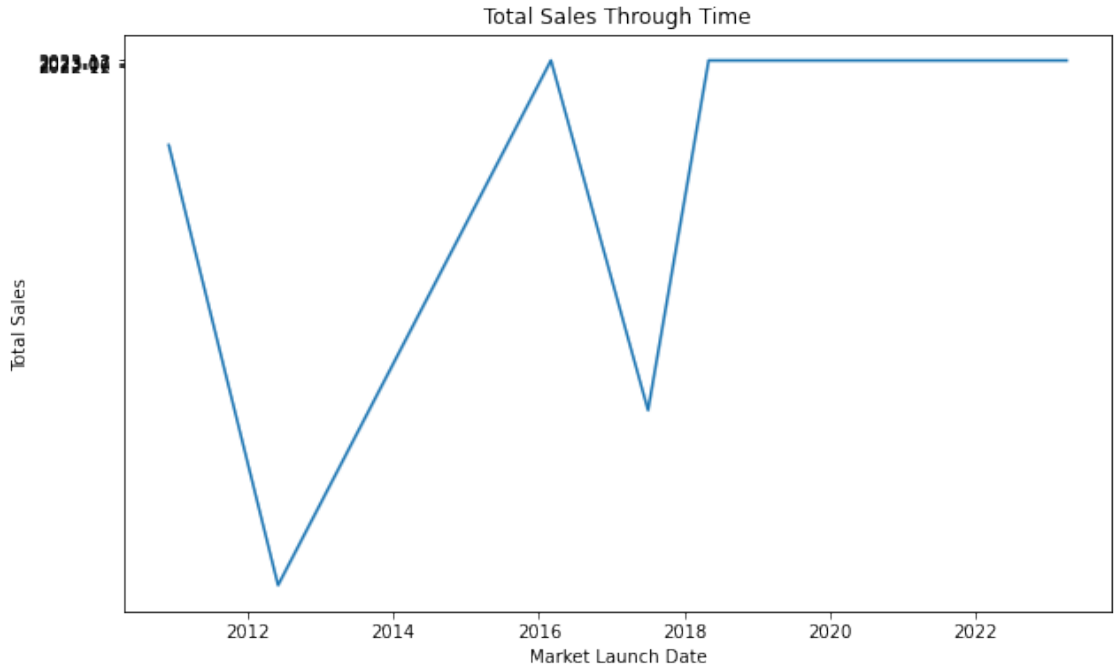
  Market_launch_dt Lifetime_global_sales Total_sales_through  \
0          2018-05                329643             2023-12
1          2021-03                280430             2023-12
2          2018-05                329643             2023-12
3          2021-03                280430             2023-12
4          2018-05                329643             2023-12

  Annual_global_sales         Status
0       70,871 (2023)  In production
1      114,988 (2023)  In production
2       70,871 (2023)  In production
3      114,988 (2023)  In production
4       70,871 (2023)  In production
```

0.0.9 Time Series Analysis

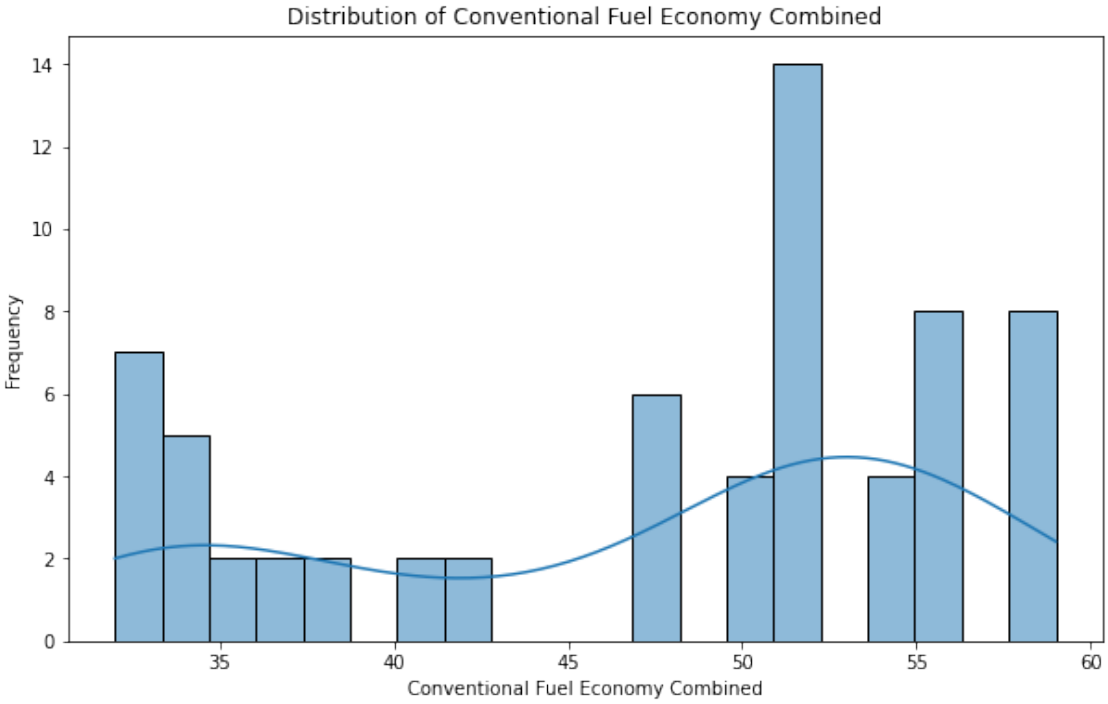
[125]:
```
# Convert 'Market_launch_dt' column to datetime
combined_df['Market_launch_dt'] = pd.
 ↪to_datetime(combined_df['Market_launch_dt'])

# Time Series Analysis
plt.figure(figsize=(10, 6))
sns.lineplot(x='Market_launch_dt', y='Total_sales_through', data=combined_df,␣
 ↪estimator='sum')
plt.title('Total Sales Through Time')
plt.xlabel('Market Launch Date')
plt.ylabel('Total Sales')
plt.show()
```



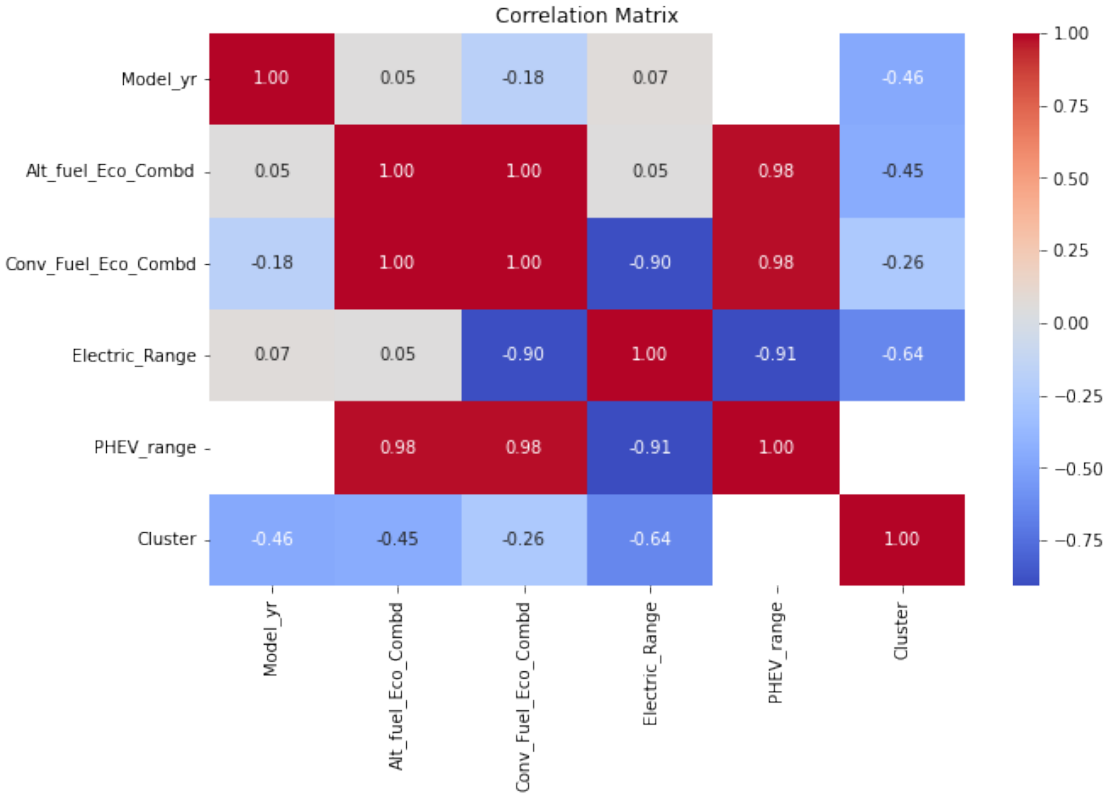
0.0.10 Distribution Analysis

[126]:
```
plt.figure(figsize=(10, 6))
sns.histplot(combined_df['Conv_Fuel_Eco_Combd'].dropna(), bins=20, kde=True)
plt.title('Distribution of Conventional Fuel Economy Combined')
plt.xlabel('Conventional Fuel Economy Combined')
plt.ylabel('Frequency')
plt.show()
```



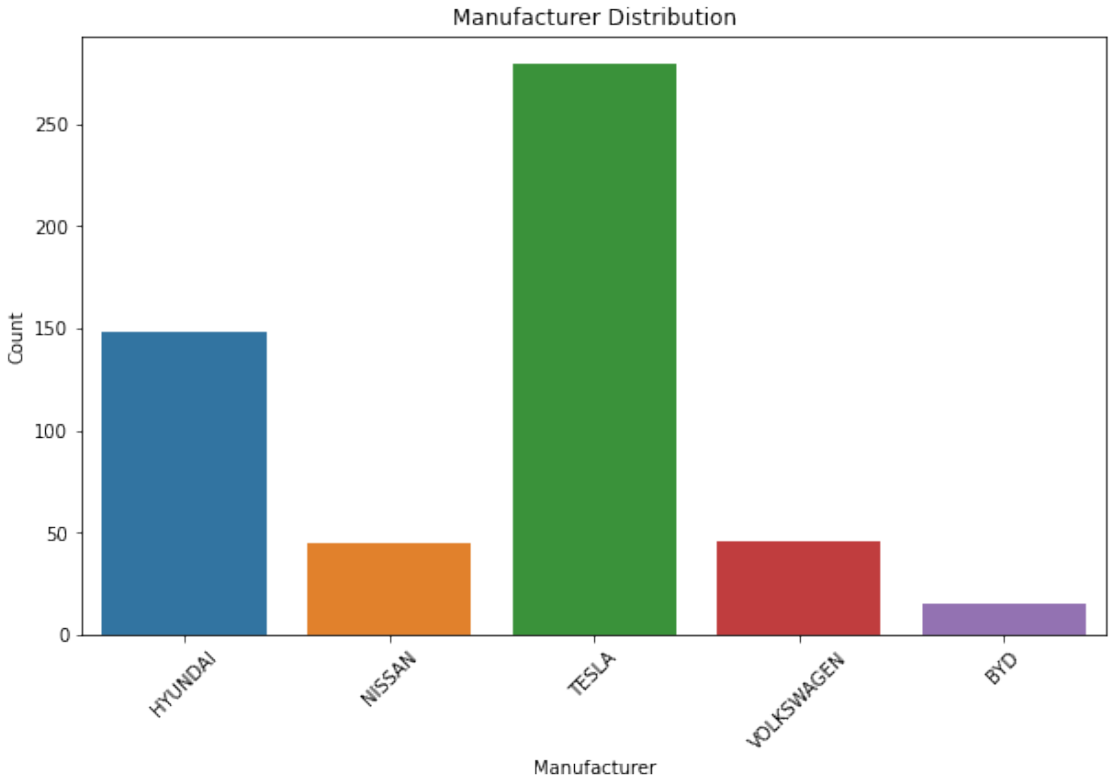
0.0.11 Correlation Analysis

[128]:
```
plt.figure(figsize=(10, 6))
sns.heatmap(combined_df.corr(), annot=True, cmap='coolwarm', fmt='.2f')
plt.title('Correlation Matrix')
plt.show()
```



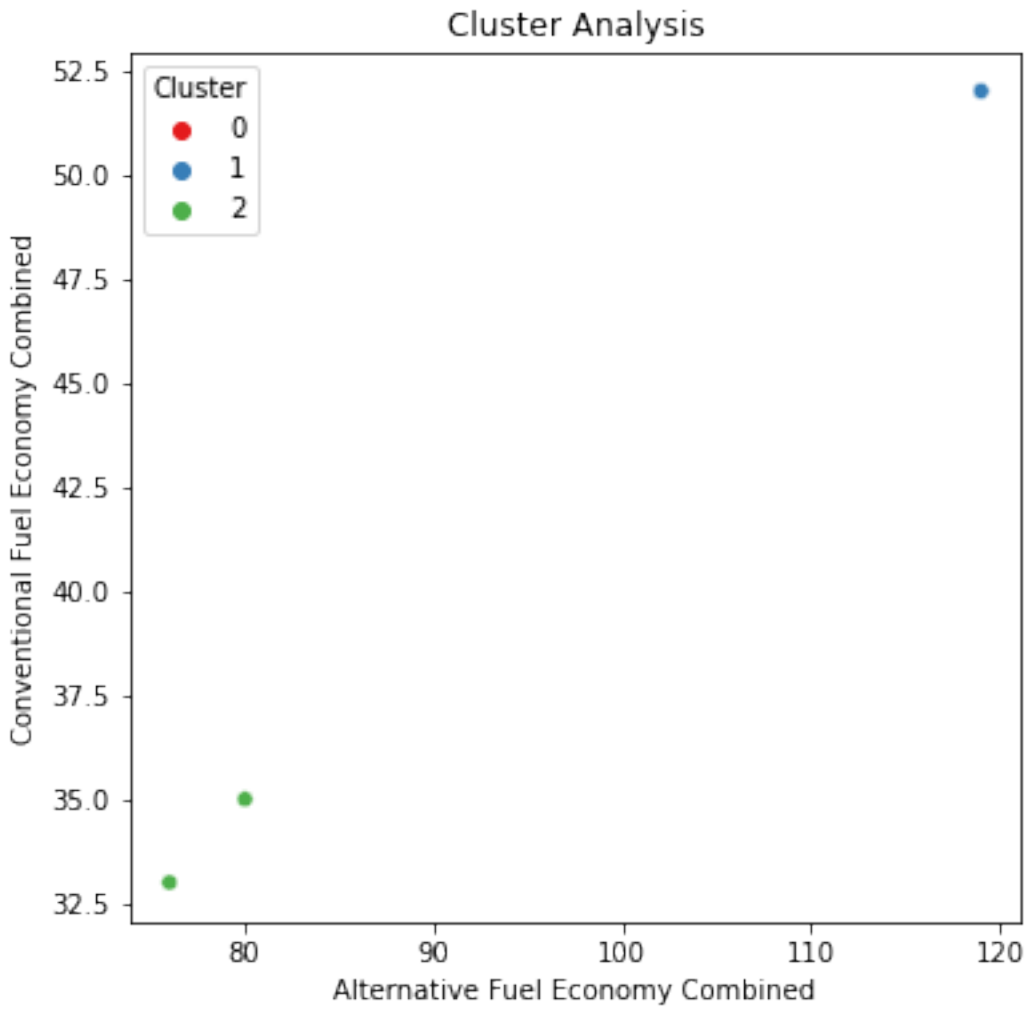
0.0.12 Categorical Analysis

[129]:
```
plt.figure(figsize=(10, 6))
sns.countplot(x='Manufacturer', data=combined_df)
plt.title('Manufacturer Distribution')
plt.xlabel('Manufacturer')
plt.ylabel('Count')
plt.xticks(rotation=45)
plt.show()
```



0.0.13 Cluster Analysis

[131]:
```
plt.figure(figsize=(6, 6))
sns.scatterplot(x='Alt_fuel_Eco_Combd', y='Conv_Fuel_Eco_Combd', hue='Cluster',␣
 ↪data=combined_df, palette='Set1')
plt.title('Cluster Analysis')
plt.xlabel('Alternative Fuel Economy Combined')
plt.ylabel('Conventional Fuel Economy Combined')
plt.show()
```



0.0.14 Regression analysis

[132]:
```
# Regression analysis on combined data
X = combined_df[['Electric_Range', 'PHEV_range', 'Conv_Fuel_Eco_Combd']]
y = combined_df['Alt_fuel_Eco_Combd']

# Fill missing values with 0 for regression
X = X.fillna(0)
y = y.fillna(0)  # Fill NaN values in the target variable

model = LinearRegression()
model.fit(X, y)

print("Coefficient of determination (R-squared):", model.score(X, y))
print("Coefficients:", model.coef_)
```

```
Coefficient of determination (R-squared): 0.827892996525533
Coefficients: [0.34289337 0.14395417 0.07725874]
```

0.0.15 Cluster analysis

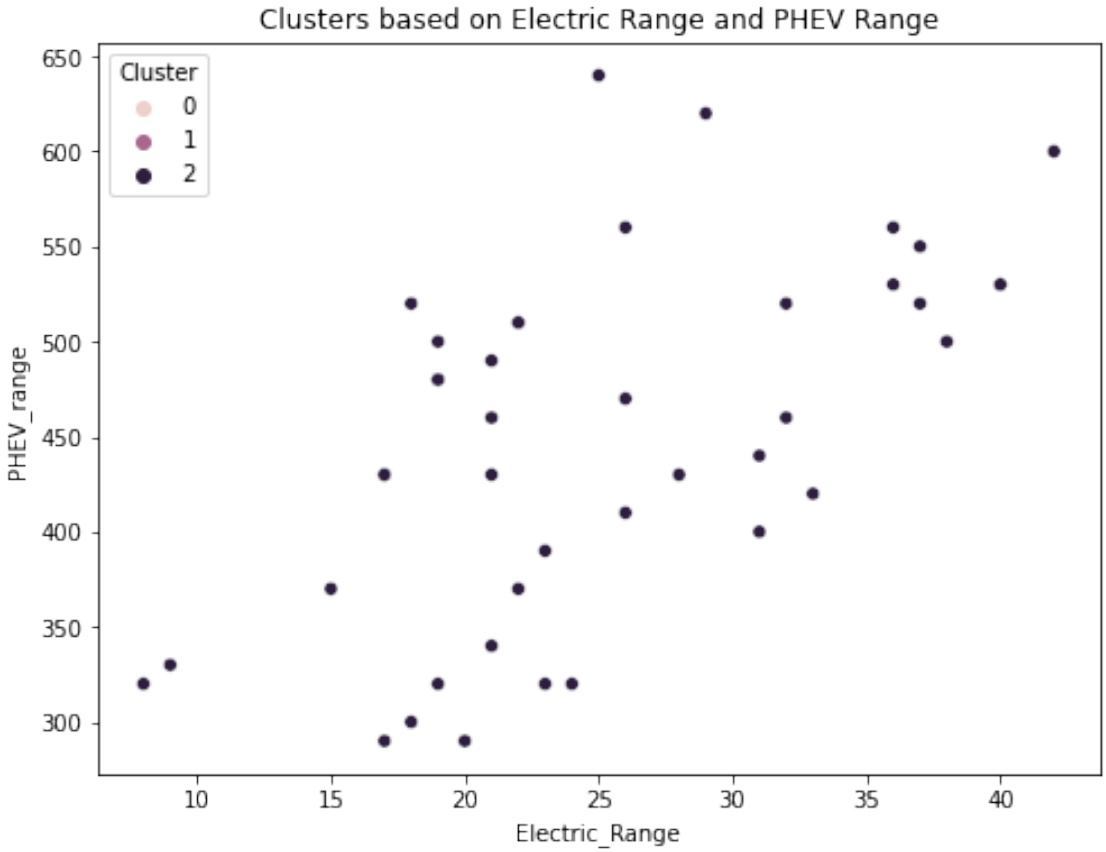
[133]:
```
# Cluster analysis on combined data
X = combined_df[['Electric_Range', 'PHEV_range', 'Conv_Fuel_Eco_Combd',␣
 ↪'Alt_fuel_Eco_Combd']]
X = X.fillna(0)  # Fill missing values with 0 for clustering

kmeans = KMeans(n_clusters=3, random_state=0)
labels = kmeans.fit_predict(X)

combined_df['Cluster'] = labels

plt.figure(figsize=(8, 6))
sns.scatterplot(x='Electric_Range', y='PHEV_range', hue='Cluster', data=df1)
plt.title('Clusters based on Electric Range and PHEV Range')
plt.show()

print(df1.groupby('Cluster').mean())
```



Cluster	Vehicle_ID	Fuel_ID	Manufacturer_ID	Category ID	Model_yr
0	12692.051813	41.497409	292.709845	27.683938	2020.927461
1	10469.418110	45.579528	275.151181	27.001575	2016.314173
2	12967.116279	57.000000	327.418605	27.372093	2022.000000

Cluster	Alt_fuel_Eco_Combd	Conv_Fuel_Eco_Combd	Electric_Range	PHEV_range
0	100.829016	31.000000	260.409326	NaN
1	71.664286	29.808905	29.768116	NaN
2	68.023256	28.232558	25.093023	450.465116

[ ]: