Electric Vehicle Analysis:

This project focuses on analyzing the registration data of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) in Washington State, aiming to uncover trends, patterns, and adoption dynamics to gain insights into the growth and development of sustainable transportation.

Problem Statement:

Conduct a Data Analysis on Electric Vehicles using the provided dataset to uncover insights.

Task 1:

> Perform Exploratory Data Analysis (EDA), including both Univariate and Bivariate analyses, to explore patterns and trends within the dataset.

Task 2:

> Create a Choropleth map using Plotly Express to visualize the distribution of electric vehicles based on location.

Task 3:

> Develop a Racing Bar Plot to animate the changes in the number of electric vehicle makes over the years.

```
# importing the required libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import warnings

warnings.filterwarnings('ignore')

# load the dataset
PATH = r'/content/drive/MyDrive/Colab Notebooks/data/ev_dataset.csv'
ev_df = pd.read_csv(PATH)

# Overview of the dataset
ev_df.head()
```

```
{"type":"dataframe","variable_name":"ev_df"}
```

```
ev_df.shape
```

```
(112634, 17)
```

```
ev_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 112634 entries, 0 to 112633
Data columns (total 17 columns):
 #   Column                                             Non-Null Count  
Dtype
---  ------                                             --------------  
-----
 0   VIN (1-10)                                         112634 non-
null  object
 1   County                                             112634 non-
null  object
 2   City                                               112634 non-
null  object
 3   State                                              112634 non-
null  object
 4   Postal Code                                        112634 non-
null  int64
 5   Model Year                                         112634 non-
null  int64
 6   Make                                               112634 non-
null  object
 7   Model                                              112614 non-
null  object
 8   Electric Vehicle Type                              112634 non-
null  object
 9   Clean Alternative Fuel Vehicle (CAFV) Eligibility  112634 non-
null  object
 10  Electric Range                                     112634 non-
null  int64
 11  Base MSRP                                          112634 non-
null  int64
 12  Legislative District                               112348 non-
null  float64
 13  DOL Vehicle ID                                     112634 non-
null  int64
 14  Vehicle Location                                   112610 non-
null  object
 15  Electric Utility                                   112191 non-
null  object
 16  2020 Census Tract                                  112634 non-
null  int64
dtypes: float64(1), int64(6), object(10)
memory usage: 14.6+ MB
```

```
ev_df.describe().T
```

```
{"summary":"{\n  \"name\": \"ev_df\",\n  \"rows\": 7,\n  \"fields\":
[\n    {\n      \"column\": \"count\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 108.09783928063898,\n
\"min\": 112348.0,\n        \"max\": 112634.0,\n
\"num_unique_values\": 2,\n        \"samples\": [\n
112348.0,\n          112634.0\n        ],\n        \"semantic_type\":
\"\",\n        \"description\": \"\"\n      }\n    },\n    {\n
\"column\": \"mean\",\n      \"properties\": {\n        \"dtype\":
\"number\",\n        \"std\": 20007020693.25397,\n        \"min\":
29.805604016092854,\n        \"max\": 52966495754.096825,\n
\"num_unique_values\": 7,\n        \"samples\": [\n
98156.22684979669,\n          2019.0033648809417\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"std\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 637243096.1203485,\n
\"min\": 2.8923640117558467,\n        \"max\": 1699104499.621227,\n
\"num_unique_values\": 7,\n        \"samples\": [\n
2648.733064096689,\n          2.8923640117558467\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"min\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 416138878.1723344,\n
\"min\": 0.0,\n        \"max\": 1101001400.0,\n
\"num_unique_values\": 6,\n        \"samples\": [\n          1730.0,\n
1997.0\n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    },\n    {\n      \"column\":
\"25%\",\n      \"properties\": {\n        \"dtype\": \"number\",\n
\"std\": 20035313918.826183,\n        \"min\": 0.0,\n        \"max\":
53033008500.0,\n        \"num_unique_values\": 6,\n
\"samples\": [\n          98052.0,\n          2017.0\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"50%\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 20032603538.483376,\n
\"min\": 0.0,\n        \"max\": 53033029305.0,\n
\"num_unique_values\": 7,\n        \"samples\": [\n          98119.0,\
n          2020.0\n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    },\n    {\n      \"column\":
\"75%\",\n      \"properties\": {\n        \"dtype\": \"number\",\n
\"std\": 20038529056.330368,\n        \"min\": 0.0,\n        \"max\":
53053072506.0,\n        \"num_unique_values\": 7,\n
\"samples\": [\n          98370.0,\n          2022.0\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"max\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 21148987088.325718,\n
\"min\": 49.0,\n        \"max\": 56033000100.0,\n
\"num_unique_values\": 7,\n        \"samples\": [\n          99701.0,\
n          2023.0\n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    }\n  ]\n}","type":"dataframe"}
```

```python
ev_df.isna().sum().sort_values(ascending=False)
```

```
Electric Utility                                         443
Legislative District                                     286
Vehicle Location                                          24
Model                                                     20
```

```
VIN (1-10)                                             0
Clean Alternative Fuel Vehicle (CAFV) Eligibility      0
DOL Vehicle ID                                         0
Base MSRP                                              0
Electric Range                                         0
Electric Vehicle Type                                  0
County                                                 0
Make                                                   0
Model Year                                             0
Postal Code                                            0
State                                                  0
City                                                   0
2020 Census Tract                                      0
dtype: int64
```

Data Cleaning

```
## Copy the dataset
df = ev_df.copy()

df.isna().sum().sort_values(ascending=False)
```

```
Electric Utility                                     443
Legislative District                                 286
Vehicle Location                                      24
Model                                                 20
VIN (1-10)                                             0
Clean Alternative Fuel Vehicle (CAFV) Eligibility      0
DOL Vehicle ID                                         0
Base MSRP                                              0
Electric Range                                         0
Electric Vehicle Type                                  0
County                                                 0
Make                                                   0
Model Year                                             0
Postal Code                                            0
State                                                  0
City                                                   0
2020 Census Tract                                      0
dtype: int64
```

```
df.dropna(inplace=True)
df.reset_index(drop=True, inplace=True)

df.isna().sum().sort_values(ascending=False)
```

```
VIN (1-10)                                           0
Clean Alternative Fuel Vehicle (CAFV) Eligibility    0
Electric Utility                                     0
Vehicle Location                                     0
```

```
DOL Vehicle ID                                       0
Legislative District                                 0
Base MSRP                                            0
Electric Range                                       0
Electric Vehicle Type                                0
County                                               0
Model                                                0
Make                                                 0
Model Year                                           0
Postal Code                                          0
State                                                0
City                                                 0
2020 Census Tract                                    0
dtype: int64
```

```
df.shape
```

```
(112152, 17)
```

```
total_rows = ev_df.shape[0]
rows_after_removal = df.shape[0]
removed_rows = total_rows - rows_after_removal

removed_rows_percentage = (removed_rows / total_rows) * 100

print(f"Total rows              :: {total_rows}")
print(f"Rows after removal      :: {rows_after_removal}")
print(f"Removed rows            :: {removed_rows}")
print(f"Removed rows percentage :: {removed_rows_percentage:.3f} %")
```

```
Total rows              :: 112634
Rows after removal      :: 112152
Removed rows            :: 482
Removed rows percentage :: 0.428 %
```

```
# Checking for duplicates in the dataset
df.duplicated().sum()
```

```
0
```

```
# Convert columns like 'Model Year' to numerical and 'Postal Code' to
strings if necessary
df['Model Year'] = pd.to_numeric(df['Model Year'], errors='coerce')
df['Postal Code'] = df['Postal Code'].astype(str)

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 112152 entries, 0 to 112151
Data columns (total 17 columns):
 #   Column                                             Non-Null Count
```

```
Dtype
---  ------                                             --------------
-----
 0   VIN (1-10)                                         112152 non-
null  object
 1   County                                             112152 non-
null  object
 2   City                                               112152 non-
null  object
 3   State                                              112152 non-
null  object
 4   Postal Code                                        112152 non-
null  object
 5   Model Year                                         112152 non-
null  int64
 6   Make                                               112152 non-
null  object
 7   Model                                              112152 non-
null  object
 8   Electric Vehicle Type                              112152 non-
null  object
 9   Clean Alternative Fuel Vehicle (CAFV) Eligibility  112152 non-
null  object
 10  Electric Range                                     112152 non-
null  int64
 11  Base MSRP                                          112152 non-
null  int64
 12  Legislative District                               112152 non-
null  float64
 13  DOL Vehicle ID                                     112152 non-
null  int64
 14  Vehicle Location                                   112152 non-
null  object
 15  Electric Utility                                   112152 non-
null  object
 16  2020 Census Tract                                  112152 non-
null  int64
dtypes: float64(1), int64(5), object(11)
memory usage: 14.5+ MB
```

```
# Drop irrelevant columns for analysis (e.g., VIN, DOL Vehicle ID)
df.drop(columns=['VIN (1-10)', 'DOL Vehicle ID'], inplace=True)

# Inspect the cleaned data
print(df.info())
print(df.describe().T)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 112152 entries, 0 to 112151
Data columns (total 15 columns):
 #   Column                                             Non-Null Count
Dtype
---  ------                                             --------------
-----
 0   County                                             112152 non-
null  object
 1   City                                               112152 non-
null  object
 2   State                                              112152 non-
null  object
 3   Postal Code                                        112152 non-
null  object
 4   Model Year                                         112152 non-
null  int64
 5   Make                                               112152 non-
null  object
 6   Model                                              112152 non-
null  object
 7   Electric Vehicle Type                              112152 non-
null  object
 8   Clean Alternative Fuel Vehicle (CAFV) Eligibility  112152 non-
null  object
 9   Electric Range                                     112152 non-
null  int64
 10  Base MSRP                                          112152 non-
null  int64
 11  Legislative District                               112152 non-
null  float64
 12  Vehicle Location                                   112152 non-
null  object
 13  Electric Utility                                   112152 non-
null  object
 14  2020 Census Tract                                  112152 non-
null  int64
dtypes: float64(1), int64(4), object(10)
memory usage: 12.8+ MB
None
                         count          mean           std
min  \
Model Year            112152.0  2.019004e+03  2.891859e+00
1.997000e+03
Electric Range        112152.0  8.782965e+01  1.023366e+02
0.000000e+00
Base MSRP             112152.0  1.793882e+03  1.078526e+04
0.000000e+00
Legislative District  112152.0  2.981770e+01  1.469873e+01
1.000000e+00
2020 Census Tract     112152.0  5.303958e+10  1.617788e+07
5.300195e+10
```

```
                               25%           50%           75%
max
Model Year              2.017000e+03  2.020000e+03  2.022000e+03
2.023000e+03
Electric Range          0.000000e+00  3.200000e+01  2.080000e+02
3.370000e+02
Base MSRP               0.000000e+00  0.000000e+00  0.000000e+00
8.450000e+05
Legislative District    1.800000e+01  3.400000e+01  4.300000e+01
4.900000e+01
2020 Census Tract       5.303301e+10  5.303303e+10  5.305307e+10
5.307794e+10
```

Univariate Analysis

Analyzing the Numerical Columns

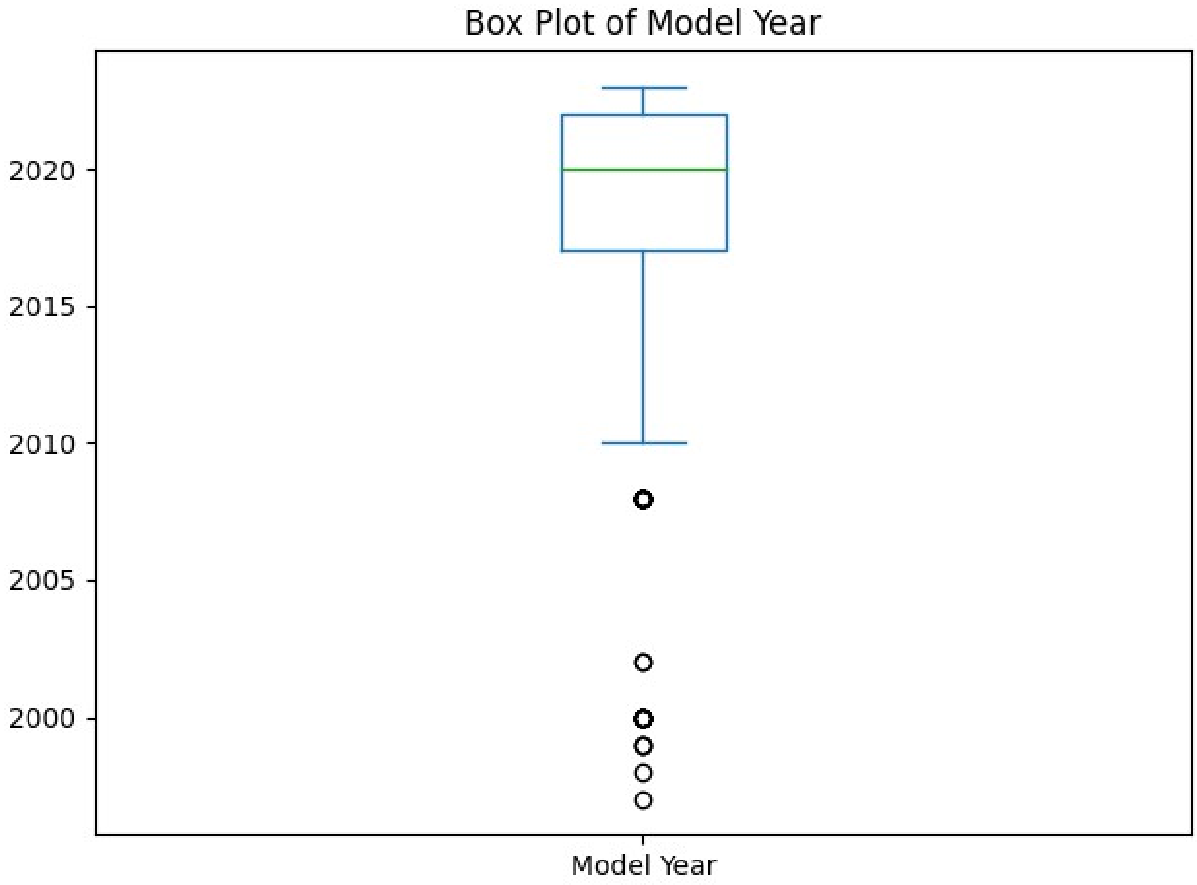
```
# Analysing the numerical columns
numerical_df = df.select_dtypes(include=['int64', 'float64'])

def univariate_analysis_numeric(df:pd.DataFrame) -> None:
  for col_name in df:
    print("*"*10, col_name, "*"*10)
    print(df[col_name].agg(['min', 'max', 'mean', 'median', 'std']))
    print()

univariate_analysis_numeric(numerical_df)

********** Model Year **********
min       1997.000000
max       2023.000000
mean      2019.004494
median    2020.000000
std          2.891859
Name: Model Year, dtype: float64

********** Electric Range **********
min         0.000000
max       337.000000
mean       87.829651
median     32.000000
std       102.336645
Name: Electric Range, dtype: float64

********** Base MSRP **********
min            0.000000
max       845000.000000
mean        1793.882320
```

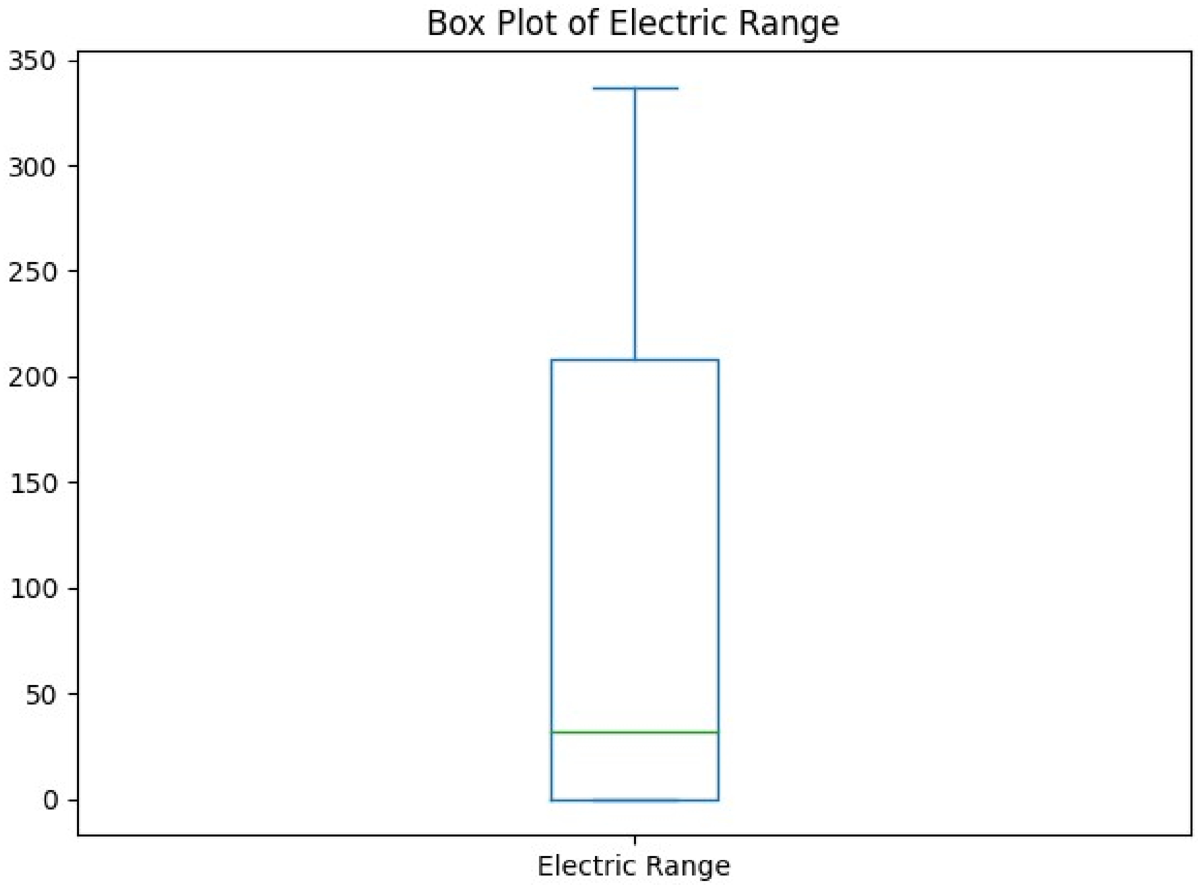
```
median          0.000000
std         10785.259118
Name: Base MSRP, dtype: float64

********** Legislative District **********
min        1.000000
max       49.000000
mean      29.817703
median    34.000000
std       14.698726
Name: Legislative District, dtype: float64

********** 2020 Census Tract **********
min       5.300195e+10
max       5.307794e+10
mean      5.303958e+10
median    5.303303e+10
std       1.617788e+07
Name: 2020 Census Tract, dtype: float64
```

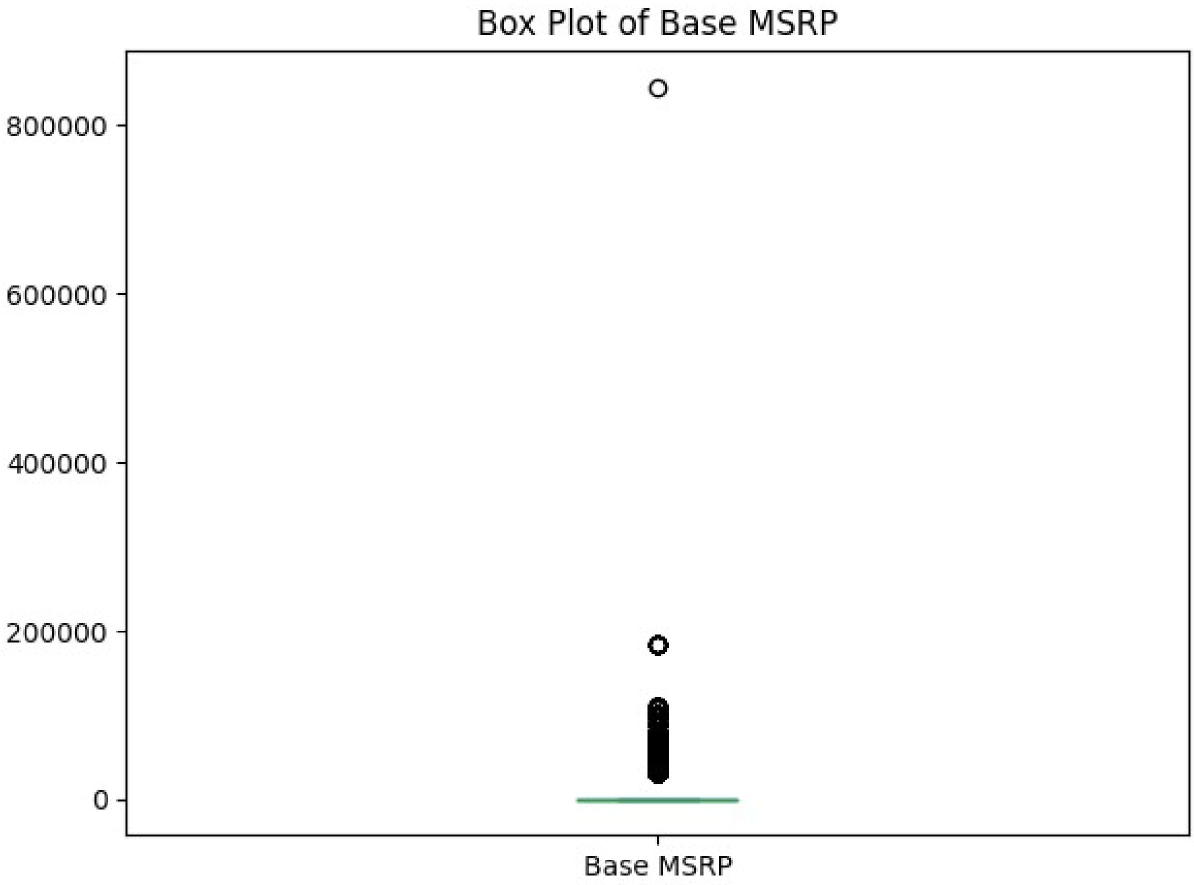
Visualization of numeric columns -

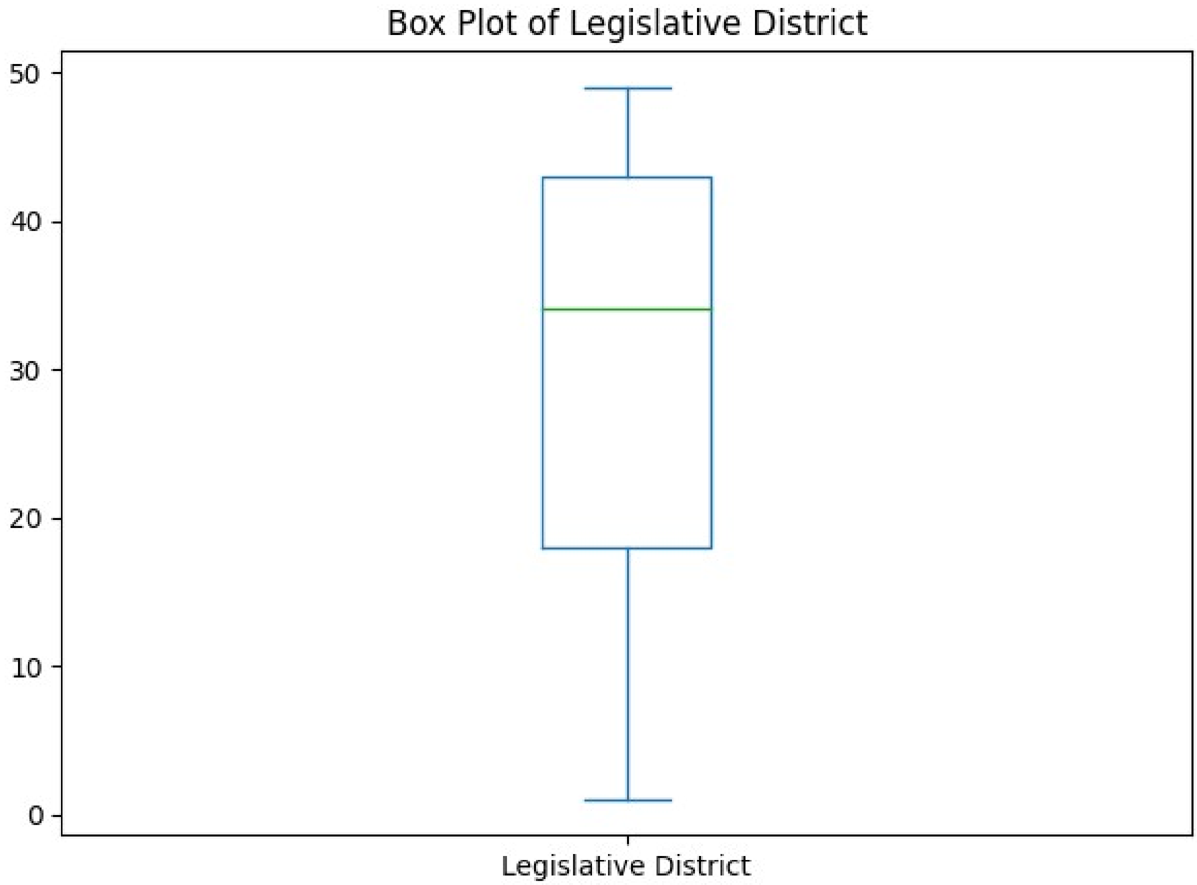
- To understand how the data is distributed can be effectively visualized using a box plot.
- It displays the spread of data, highlighting the median, quartiles, and potential outliers, making it a great choice for summarizing distributions in a single plot.

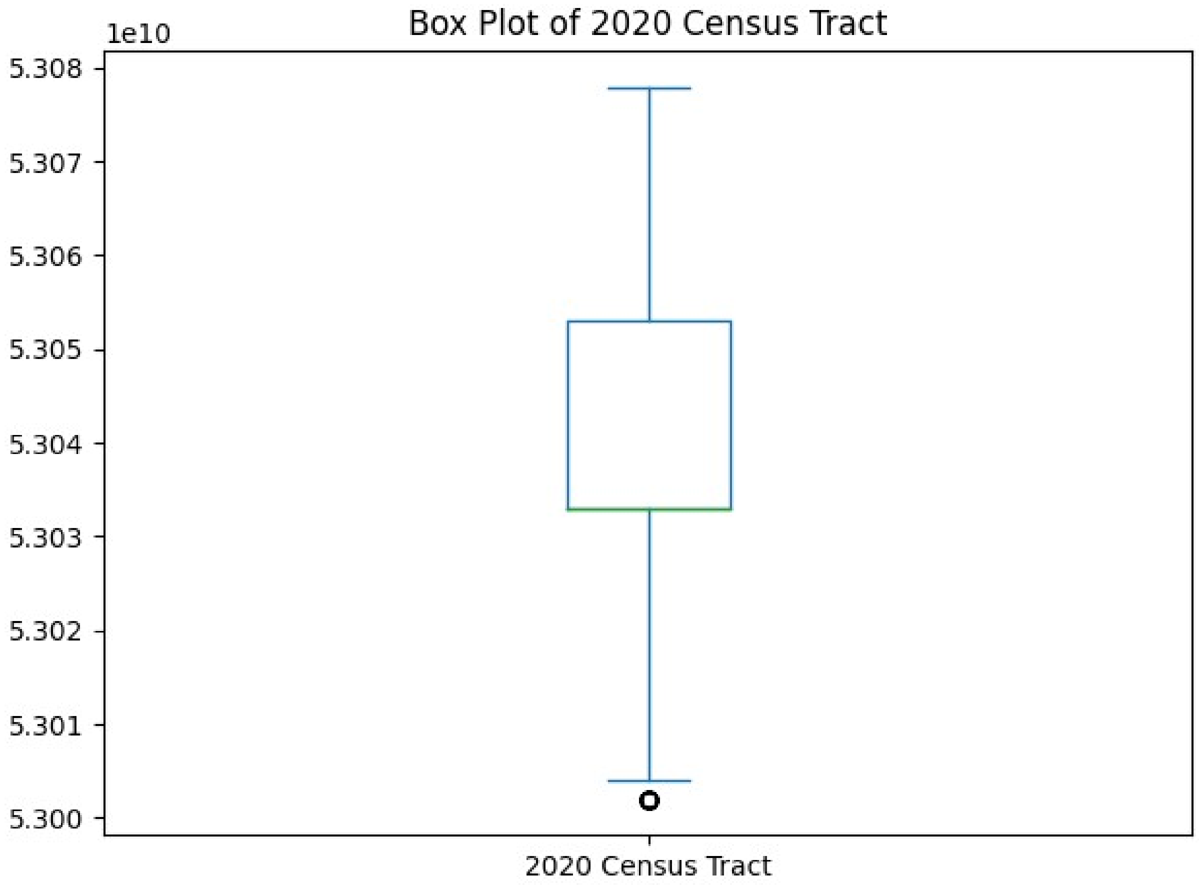
```
def numerical_df_visualization(numeric_data):
    for col in numeric_data.columns:
        numeric_data[col].plot(kind="box")
        plt.title(f"Box Plot of {col}")
        plt.tight_layout()
        plt.show()


numerical_df_visualization(numerical_df)
```


Box Plot of Model Year
2020
2015
2010
2005
2000
Model Year

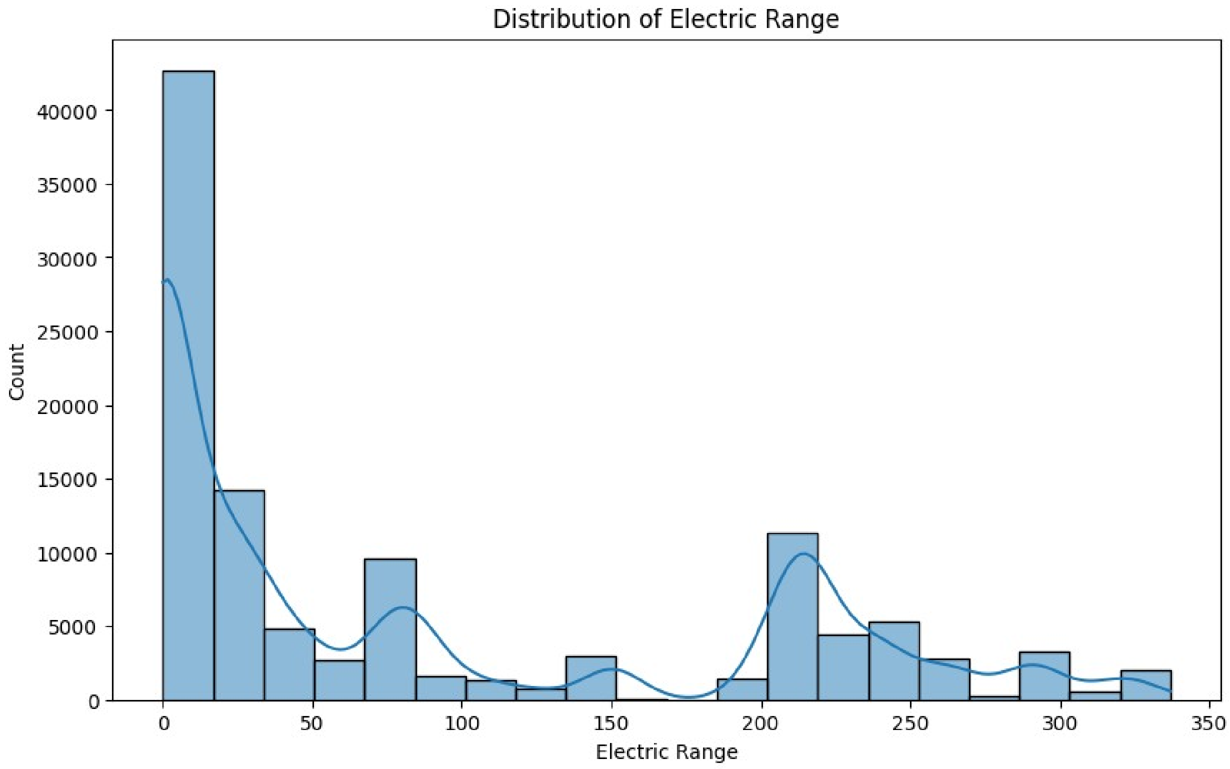

Box Plot of Electric Range
350
300
250
200
150
100
50
0
Electric Range


Box Plot of Base MSRP
800000
600000
400000
200000
0
Base MSRP


Box Plot of Legislative District
50
40
30
20
10
0
Legislative District



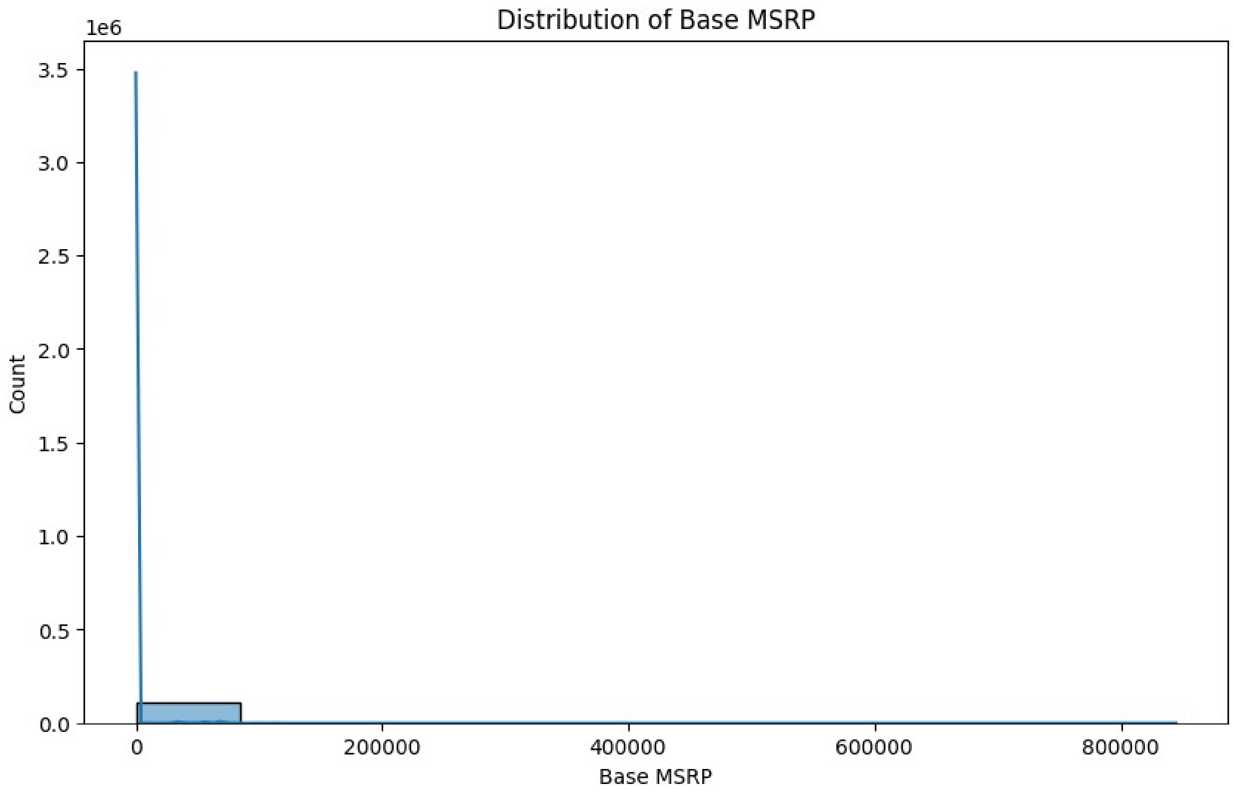
```
# Univariate Analysis of Numerical Columns
plt.figure(figsize=(10, 6))
sns.histplot(df['Electric Range'], bins=20, kde=True)
plt.title('Distribution of Electric Range')
plt.show()
```



Insight:

- Most vehicles have a range of 0-50 miles, indicating limited electric-only driving capability.
- Popular electric ranges are around 50, 100, and 200 miles, reflecting different vehicle tiers.
- A smaller number of vehicles exceed 200 miles on a single charge.
- The distribution is right-skewed, with most vehicles concentrated in the lower range.

```
plt.figure(figsize=(10, 6))
sns.histplot(df['Base MSRP'], bins=10, kde=True)
plt.title('Distribution of Base MSRP')
plt.show()
```

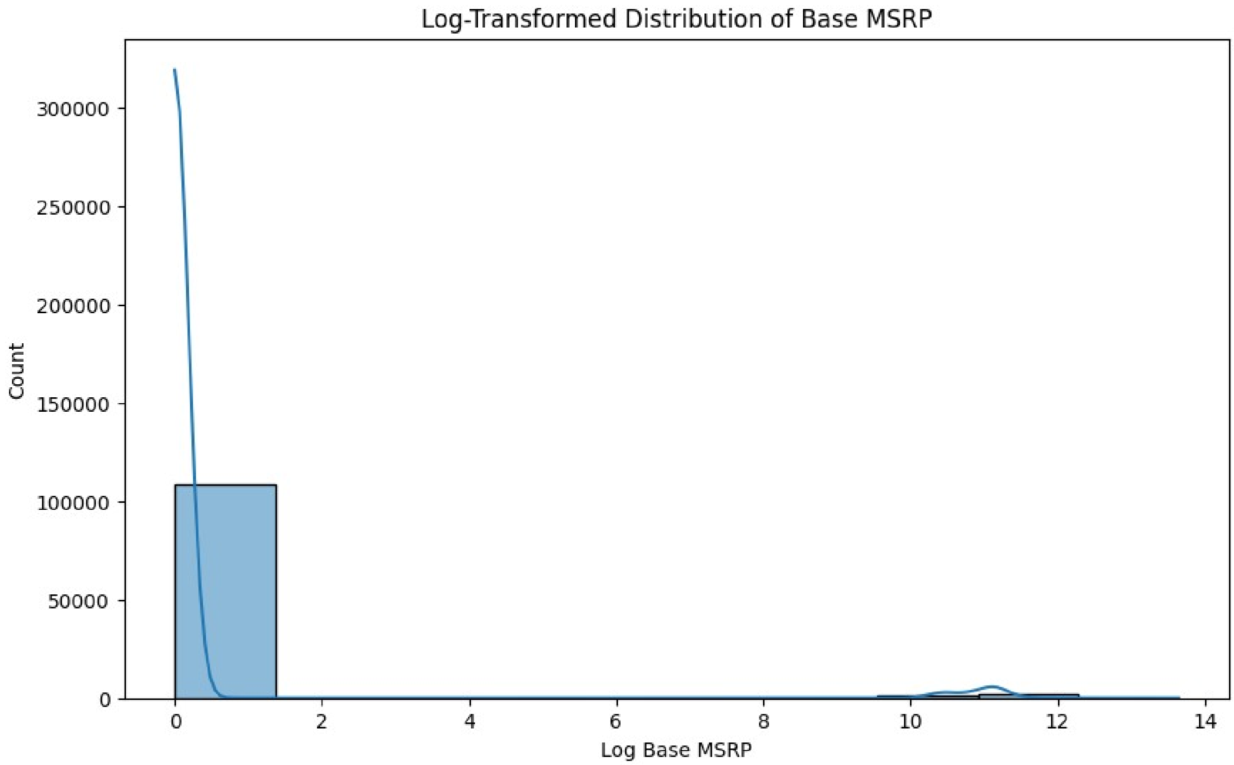


Insight :

- The graph shows the distribution of Base MSRP, which is heavily right-skewed with most values concentrated at lower prices.
- There are extreme outliers extending beyond $800,000.
- But, the majority of vehicles are likely priced below $50,000, though exact details are hard to see due to the wide scale.

Therefore, we have to transform the data (e.g., log transformation) to better visualize the distribution.

```
# Apply log transformation (use np.log1p to handle zeros)
df['Log Base MSRP'] = np.log1p(df['Base MSRP'])

# Plot the log-transformed data
plt.figure(figsize=(10, 6))
sns.histplot(df['Log Base MSRP'], bins=10, kde=True)
plt.title('Log-Transformed Distribution of Base MSRP')
plt.show()
```



Insights :

- Most values remain concentrated in the lower MSRP range, as indicated by the sharp decline in count at the lower end of the log scale.

Analyzing the Categorical columns

```
categorical_df = ev_df.select_dtypes(include='object')

categorical_df.head()

{"type":"dataframe","variable_name":"categorical_df"}

def categorical_univariate_analysis(cat_data):
    for i in cat_data:
        print("*"*10, i ,"*"*10)
        print("Unique values:",cat_data[i].unique())
        print("Nunique values:",cat_data[i].nunique())

print("--------------------------------------------------------")

categorical_univariate_analysis(categorical_df)

********** VIN (1-10) **********
Unique values: ['JTMEB3FV6N' '1G1RD6E45D' 'JN1AZ0CP8B' ...
'KMHE14L25K' 'WA1LAAGE5M'
 'YV4ED3GM0P']
Nunique values: 7548
```

```
--------------------------------------------------------
********** County **********
Unique values: ['Monroe' 'Clark' 'Yakima' 'Skagit' 'Snohomish'
'Island' 'Thurston'
 'Grant' 'St. Clair' 'Pierce' 'Saratoga' 'Stevens' 'King' 'Kitsap'
 'Newport News' 'Jackson' 'Whitman' 'Lake' 'Spokane' 'Clallam'
'Cowlitz'
 'Kittitas' 'Grays Harbor' 'Chelan' 'Whatcom' 'Benton' 'Walla Walla'
 'Mason' 'San Juan' 'Lewis' 'Jefferson' 'Douglas' 'Klickitat' 'Geary'
 'Skamania' 'Fairfax' 'Adams' 'Franklin' 'Okanogan' 'Sonoma' 'Asotin'
 'Ferry' 'Pacific' 'Riverside' 'Orange' 'Columbia' 'Wahkiakum'
 'Leavenworth' 'Contra Costa' 'Howard' 'Larimer' 'District of
Columbia'
 'Washington' 'Tipton' 'San Diego' 'Sumter' "Prince George's" 'New
Haven'
 'Lincoln' 'Las Animas' 'Frederick' 'Hidalgo' 'Pend Oreille' 'Bexar'
 'Garfield' 'Pennington' 'Honolulu' 'Anne Arundel' 'Montgomery'
'Houston'
 'Charleston' 'Monterey' 'Kern' 'Napa' 'Loudoun' 'Harrison' 'Pulaski'
 'Cumberland' 'Los Angeles' 'Ray' 'Salt Lake' 'Solano' 'Allegheny'
 'Carroll' 'Clackamas' 'Kent' 'Harris' 'Ventura' 'Hamilton' 'Polk'
 'Placer' 'Calvert' 'Sheridan' 'Kings' 'El Paso' 'Portsmouth' 'Elmore'
 'Santa Clara' 'Pinal' 'Wayne' 'Alameda' 'Maricopa' 'Stafford'
 'Santa Barbara' 'Fairbanks North Star' 'Plaquemines' 'Rock Island'
 'Chaves' 'Palm Beach' 'Danville' 'Galveston' 'Virginia Beach'
'Suffolk'
 'Louisa' 'Hillsborough' 'Denton' 'Bell' 'Norfolk' 'Okaloosa'
'Rockdale'
 'Cook' 'Chesapeake' 'Alexandria' 'Charles' 'Boulder' 'Beaufort'
 'St. Louis' "St. Mary's" 'Marin' 'Arapahoe' 'Laramie' 'Multnomah'
'Hoke'
 'Sarasota' 'Santa Cruz' 'Queens' 'Wichita' 'San Bernardino' 'Oldham'
 'Onslow' 'Arlington' 'Sarpy' 'Moore' 'Sevier' 'Bartow' 'Sacramento'
 'Camden' 'Hennepin' 'Middlesex' 'New London' 'Platte' 'Penobscot'
 'Nassau' 'Richmond' 'Newport' 'Rockingham' 'San Mateo' 'DeKalb'
'Kauai'
 'Burlington' 'St. Tammany' 'Bryan' 'Dorchester' 'Williams'
'Kootenai']
Nunique values: 165
--------------------------------------------------------
********** City **********
Unique values: ['Key West' 'Laughlin' 'Yakima' 'Concrete' 'Everett'
'Bothell' 'Mukilteo'
 'Clinton' 'Anacortes' 'Lacey' 'Moses Lake' 'Mascoutah' 'Rochester'
 'Burlington' 'Kapowsin' 'Marysville' 'Lynnwood' 'Greenfield Center'
 'Edmonds' 'Nine Mile Falls' 'Olympia' 'Seattle' 'Auburn' 'Langley'
 'Snohomish' 'Bremerton' 'Newport News' 'Altus' 'Pullman' 'Highland
Park'
 'Spokane' 'Suquamish' 'Monroe' 'Sequim' 'Keyport' 'Gurnee' 'Maple
```

```
Valley'
 'Kent' 'Lake Forest Park' 'Poulsbo' 'Redmond' 'Issaquah' 'Longview'
 'Tacoma' 'Ellensburg' 'Burien' 'Gig Harbor' 'South Hill' 'Sammamish'
 'Westport' 'Vancouver' 'Airway Heights' 'Mercer Island' 'Stanwood'
 'Tumwater' 'Bainbridge Island' 'Entiat' 'Lakewood' 'Lake Tapps'
 'Bellevue' 'Kirkland' 'Newcastle' 'Port Orchard' 'Bellingham'
'Richland'
 'Camano Island' 'Wenatchee' 'Lake Stevens' 'Roy' 'Des Moines'
'Renton'
 'Camas' 'Kennewick' 'Battle Ground' 'Bonney Lake' 'Walla Walla'
 'North Bend' 'Mount Vernon' 'Woodland' 'Woodinville' 'Allyn' 'Brier'
 'Snoqualmie' 'Fall City' 'Puyallup' 'Friday Harbor' 'Point Roberts'
 'Dupont' 'Castle Rock' 'Blaine' 'Morton' 'Port Townsend' 'Roslyn'
 'Kenmore' 'Covington' 'Federal Way' 'Silverdale' 'Medina' 'Shoreline'
 'Enumclaw' 'Orondo' 'Grandview' 'Mill Creek' 'Zillah' 'Edgewood'
'Vashon'
 'White Salmon' 'Normandy Park' 'Fircrest' 'East Wenatchee'
'Peshastin'
 'Grapeview' 'Steilacoom' 'Sumner' 'Junction City' 'Greenacres'
'Shelton'
 'Chehalis' 'Pacific Beach' 'Everson' 'Black Diamond' 'North
Bonneville'
 'Coupeville' 'Seabeck' 'Arlington' 'Alexandria' 'Palouse' 'Bow'
'Lakebay'
 'University Place' 'Clyde Hill' 'Cle Elum' 'Yacolt' 'Oak Harbor'
 'Goldendale' 'Port Hadlock' 'Acme' 'Ritzville' 'Union' 'Orting'
'Tahuya'
 'Fox Island' 'Moxee' 'Port Angeles' 'Spanaway' 'Lopez Island'
 'Hunts Point' 'Leavenworth' 'Seatac' 'Stevenson' 'Pasco' 'Yelm'
 'Tonasket' 'Liberty Lake' 'Hansville' 'Eastsound' 'Nordland'
'Touchet'
 'Spokane Valley' 'Tukwila' 'Selah' 'Fife' 'Lynden' 'Aberdeen'
 'Anderson Island' 'Orcas Is' 'Kingston' 'Randle' 'Sedro-Woolley'
 'Carnation' 'Belfair' 'Cheney' 'Elma' 'Olalla' 'Granite Falls'
'Ephrata'
 'Preston' 'Ridgefield' 'Mccleary' 'Ferndale' 'Mountlake Terrace'
 'Freeland' 'Sonoma' 'Yarrow Point' 'Rainier' 'Sunnyside' 'Salkum'
 'Colville' 'Duvall' 'Otis Orchards' 'Twisp' 'Eatonville' 'Chattaroy'
 'Ocean Shores' 'Washougal' 'Port Ludlow' 'Benton City' 'Clarkston'
 'Ravensdale' 'Kelso' 'Curlew' 'Deming' 'Prosser' 'Milton' 'Artondale'
 'Hoodsport' 'West Richland' 'Parkland' 'Chelan' 'Graham' 'Raymond'
 'Brush Prairie' 'Rock Island' 'La Conner' 'St John' 'Mead' 'Hoquiam'
 'Deer Park' 'Electric City' 'Chimacum' 'Burbank' 'Quincy' 'Omaha'
 'La Center' 'Ronald' 'Long Beach' 'Valley' 'Beaux Arts' 'Kalama'
 'Indianola' 'Winthrop' 'Wildomar' 'Aliso Viejo' 'Woodway' 'Buckley'
 'Montesano' 'Las Vegas' 'Dayton' 'Vaughn' 'Onalaska' 'Medical Lake'
 'Nooksack' 'Centralia' 'Sultan' 'Trout Lake' 'Seaview' 'Carson'
'Colbert'
 'Lummi Island' 'Newman Lake' 'Cathlamet' 'Veradale' 'Valleyford'
 'Cashmere' 'Ariel' 'Cosmopolis' 'Bz Corner' 'Ilwaco' 'Oakville'
'Algona'
 'Silverlake' 'Lopez Is' 'Winlock' 'Greenbank' 'Tenino' 'Royal City'
 'Tulalip' 'Fort Leavenworth' 'Custer' 'Moraga' 'College Place'
 'Underwood' 'Amboy' 'Bingen' 'Ryderwood' 'Clearlake' 'Naches'
'Surfside'
 'Olga' 'Ocean Park' 'Othello' 'Rosalia' 'Snoqualmie Pass' 'Timnath'
 'Republic' 'Washington' 'Keedysville' 'Atoka' 'San Diego' 'Sumter'
 'Upper Marlboro' 'Madison' 'Lincoln City' 'Grand Coulee' 'Trinidad'
 'Chewelah' 'Packwood' 'Thorp' 'Frederick' 'Malaga' 'Lind'
 'Joint Base Lewis Mcchord' 'Granger' 'Wilbur' 'Toledo' 'Pacific'
 'Toppenish' 'Eltopia' 'Sekiu' 'Sedro Woolley' 'Garfield' 'Lincoln'
 'Mcallen' 'Newport' 'Harrington' 'San Antonio' 'Ethel' 'Pomeroy'
 'Longbranch' 'Connell' 'Brinnon' 'Skykomish' 'Reardan' 'Maple Falls'
 'Rapid City' 'Coulee City' 'Dallesport' 'Vantage' 'Oroville' 'Manson'
 'Honolulu' 'Omak' 'Bridgeport Bar' 'Mesa' 'Odenton' 'Waterville'
 'Chinook' 'Gold Bar' 'Soap Lake' 'Nahcotta' 'Tieton' 'Silver Spring'
 'Warner Robins' 'Mattawa' 'Addy' 'Ruston' 'Loon Lake' 'Charleston
Afb'
 'Forks' 'Wapato' 'Naselle' 'Quilcene' 'Asotin' 'Monterey' 'Easton'
 'Fairchild Air Force Base' 'Ridgecrest' 'Skamokawa' 'Lilliwaup'
'Napa'
 'Aldie' 'Marlin' 'Warden' 'Biloxi' 'Seven Bays' 'Chula Vista'
 'Little Rock' 'Fayetteville' 'Kettle Falls' 'South Bend' 'Rayville'
 'Okanogan' 'Mansfield' 'Pateros' 'Sumas' 'Salt Lake City' 'McCleary'
 'North Las Vegas' 'Cusick' 'Vacaville' 'Fort Campbell' 'Wexford'
 'Ashford' 'Elk' 'Carbonado' 'Rockford' 'Lyle' 'Latah' 'Westminster'
 'Carlton' 'Darrington' 'West Linn' 'Mossyrock' 'Dover' 'Tumtum'
'Arnold'
 'Tavares' 'Houston' 'Ventura' 'Riverside' 'North Cove' 'Bay Center'
 'Brewster' 'Springdale' 'Cougar' 'Endicott' 'Inchelium' 'Wilkeson'
 'Cincinnati' 'Salem' 'Roseville' 'Chesapeake Beach' 'Frances'
'Colfax'
 'White Swan' 'Grayland' 'Rice' 'Sheridan' 'Neah Bay' 'Lemoore'
 'Montgomery' 'Colorado Springs' 'Davenport' 'Portsmouth' 'Lancaster'
 'Coulee Dam' 'Union Gap' 'Menifee' 'Shaw Island' 'Mountain Home Afb'
 'Marblemount' 'Santa Clara' 'Baring' 'Spangle' 'Glacier' 'Maricopa'
 'Carmel By The Sea' 'Deer Meadows' 'Silver Creek' 'Goldsboro' 'Menlo'
 'Tokeland' 'Berkeley' 'Phoenix' 'Stafford' 'Roosevelt' 'Chandler'
 'Wahkiacus' 'Lompoc' 'Alhambra' 'Buena Park' 'Snowden' 'Walla Walla
Co'
 'Outlook' 'Vader' 'Fairbanks' 'Cupertino' 'Kittitas' 'Mica'
 'Indian Wells' 'Mazama' 'Hunters' 'Camarillo' 'Belle Chasse' 'Evans'
 'Beaver' 'Grays River' 'West Valley City' 'Oceanside' 'Odessa' 'Usk'
 'Roswell' 'Gambrills' 'Oysterville' 'Potomac' 'Mineral' 'Amanda Park'
 'Toutle' 'Curtis' 'Cinebar' 'Hartline' 'Waitsburg' 'Gaithersburg'
'Husum'
 'El Paso' 'Klickitat' 'Elkton' 'Edwall' 'Sprague' 'West Palm Beach'
 'Tekoa' 'Coronado' 'Pe Ell' 'Methow' 'Danville' 'Annapolis' 'Murdock'
 'Mechanicsburg' 'Ford' 'Dickinson' 'Virginia Beach' 'Benicia'
'Moclips'
 'Suffolk' 'Holden Village' 'Bumpass' 'Lithia' 'Felts Mills' 'Little
Elm'
 'Andrews Air Force Base' 'Lyman' 'Harker Heights' 'Pittsburg'
 'Norristown' 'Mcchord Afb' 'Norfolk' 'Valparaiso' 'Conyers' 'Skokie'
 'Glenwood' 'Chesapeake' 'Fpo' 'Hughesville' 'Belleville' 'Colton'
 'South Prairie' 'Clallam Bay' 'Longmont' 'Malott' 'Okatie' 'Saint
Louis'
 'Lexington Park' 'Rockport' 'San Rafael' 'Bucoda' 'Germantown'
 'Smith Creek' 'Englewood' 'Lebam' 'South Range' 'Tempe' 'Fort Bragg'
 'Ewa Beach' 'Glenoma' 'Cheyenne' 'Portland' 'Burke' 'Hawthorne'
 'Copalis Beach' 'Satsop' 'Palisades' 'Goodyear' 'Gardena'
'Southworth'
 'Raeford' 'Rosamond' 'Clayton' 'Quinault' 'Sarasota' 'Santa Cruz'
 'Jamaica' 'Wichita Falls' 'Maryhill' 'Yermo' 'Vienna' 'Waldron'
 'Clarksville' 'Goshen' 'Herndon' 'Fruitland' 'Mccutcheon Field'
 'South Cle Elum' 'Irvine' 'Centerville' 'Fairfield' 'Lamont' 'Santa
Rosa'
 'Southern Pines' 'Copalis Crossing' 'De Queen' 'Taholah' 'Mountain
View'
 'Adairsville' 'Sacramento' 'Port Gamble' 'Apple Valley' 'Rosburg'
 'Stratford' 'Haddonfield' 'Minneapolis' 'Chelmsford' 'Old Lyme'
 'Platte City' 'Hanscom Afb' 'Fort George G Meade' 'Bangor' 'Matlock'
 'Canoga Park' 'Jericho' 'Gifford' 'Santa Ana' 'Augusta' 'San
Clemente'
 'Middletown' 'Prescott' 'San Mateo' 'Aurora' 'Bedford' 'Carrolls'
 'Fredericksburg' 'Waterford' 'Decatur' 'Mililani' 'Kekaha' 'Medford'
 'Edgewater' 'Slidell' 'Pawcatuck' 'Groton' 'Richmond Hill' 'Mabton'
 'Joint Base Mdl' 'Uniontown' 'Palo Alto' 'North Conway' 'Summerville'
 'Lansing' 'Williston' 'Worley']
Nunique values: 629
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********** State **********
Unique values: ['FL' 'NV' 'WA' 'IL' 'NY' 'VA' 'OK' 'KS' 'CA' 'NE' 'MD'
'CO' 'DC' 'TN'
 'SC' 'CT' 'OR' 'TX' 'SD' 'HI' 'GA' 'MS' 'AR' 'NC' 'MO' 'UT' 'PA' 'DE'
 'OH' 'WY' 'AL' 'ID' 'AZ' 'AK' 'LA' 'NM' 'WI' 'KY' 'NJ' 'MN' 'MA' 'ME'
 'RI' 'NH' 'ND']
Nunique values: 45
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********** Make **********
Unique values: ['TOYOTA' 'CHEVROLET' 'NISSAN' 'FORD' 'TESLA' 'KIA'
'AUDI' 'FIAT' 'BMW'
 'PORSCHE' 'CADILLAC' 'HONDA' 'MITSUBISHI' 'CHRYSLER' 'RIVIAN'
'HYUNDAI'
 'VOLVO' 'VOLKSWAGEN' 'MERCEDES-BENZ' 'JEEP' 'MINI' 'SMART' 'SUBARU'
 'POLESTAR' 'LUCID MOTORS' 'LINCOLN' 'JAGUAR' 'FISKER' 'LAND ROVER'
 'LEXUS' 'TH!NK' 'GENESIS' 'BENTLEY' 'AZURE DYNAMICS']
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Nunique values: 34
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********** Model **********
Unique values: ['RAV4 PRIME' 'VOLT' 'LEAF' 'BOLT EV' 'FUSION' 'MODEL
3' 'SOUL' 'Q5 E'
 'MODEL X' '500' 'X5' '530E' 'TAYCAN' 'X3' 'A3' 'SOUL EV' 'C-MAX'
 'MODEL S' 'F-150' 'CT6' 'I3' 'CLARITY' 'MODEL Y' 'NIRO' 'OUTLANDER'
 'PACIFICA' 'R1T' 'KONA ELECTRIC' 'XC40' 'ID.4' 'PRIUS PLUG-IN'
 'MUSTANG MACH-E' 'EQB-CLASS' 'E-GOLF' 'PRIUS PRIME' 'C40' 'SORENTO'
 'XC60' 'CAYENNE' 'WRANGLER' 'COUNTRYMAN' 'S60' 'EV6'
 'FORTWO ELECTRIC DRIVE' 'GRAND CHEROKEE' '330E' 'CROSSTREK' 'IONIQ 5'
 'IONIQ' 'E-TRON' 'ROADSTER' 'KONA' 'XC90' 'SPARK' 'PS2' 'A7'
'HARDTOP'
 'ESCAPE' 'LUCID AIR' 'E-TRON SPORTBACK' 'Q5' 'RAV4' 'AVIATOR' 'E-TRON
GT'
 'EDV' 'IX' 'FORTWO' 'I-PACE' 'SANTA FE' 'B-CLASS' 'KARMA' 'I4'
'OPTIMA'
 'GLC-CLASS' 'Q4' 'SONATA' 'EQ FORTWO' 'FOCUS' 'RANGE ROVER SPORT'
 'TRANSIT' 'PANAMERA' 'I8' 'BOLT EUV' 'CORSAIR' 'ELR' 'GLE-CLASS'
'V60'
 'EQS-CLASS SEDAN' 'R1S' 'I-MIEV' 'NX' '740E' 'SPORTAGE' 'C-CLASS'
 'S-CLASS' 'CITY' 'S90' 'TUCSON' 'GV60' 'EQS-CLASS SUV' 'A8 E'
 'RANGE ROVER' nan 'RS E-TRON GT' 'RANGER' 'BENTAYGA' '745E'
 'TRANSIT CONNECT ELECTRIC' 'ACCORD' 'S-10 PICKUP' 'SOLTERRA' 'G80'
'918'
 'FLYING SPUR' '745LE']
Nunique values: 114
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********** Electric Vehicle Type **********
Unique values: ['Plug-in Hybrid Electric Vehicle (PHEV)' 'Battery
Electric Vehicle (BEV)']
Nunique values: 2
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********** Clean Alternative Fuel Vehicle (CAFV) Eligibility
**********
Unique values: ['Clean Alternative Fuel Vehicle Eligible'
 'Not eligible due to low battery range'
 'Eligibility unknown as battery range has not been researched']
Nunique values: 3
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********** Vehicle Location **********
Unique values: ['POINT (-81.80023 24.5545)' 'POINT (-114.57245
35.16815)'
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Nunique values: 758
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********** Electric Utility **********
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 'PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)'
 'CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)' 'AVISTA CORP'
 'MODERN ELECTRIC WATER COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF COWLITZ COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PENINSULA
LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF ELLENSBURG - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF GRAYS HARBOR COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLARK COUNTY - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||AVISTA CORP||INLAND POWER & LIGHT
COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||PUD 1 OF SNOHOMISH COUNTY'
 'PUD NO 1 OF CHELAN COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||VERA IRRIGATION DISTRICT #15'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||ELMHURST
MUTUAL POWER & LIGHT CO|PENINSULA LIGHT COMPANY'
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 'PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF RICHLAND - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF BENTON COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PUD NO 3 OF
MASON COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||ORCAS POWER & LIGHT COOP'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PUD NO 1 OF
LEWIS COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUGET SOUND ENERGY INC||PUD NO 1 OF
JEFFERSON COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLALLAM COUNTY'
 'PUD NO 1 OF DOUGLAS COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF KLICKITAT COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||TOWN OF STEILACOOM|CITY OF TACOMA -
(WA)||PENINSULA LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||INLAND POWER & LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF SKAMANIA CO'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||LAKEVIEW
LIGHT & POWER|PENINSULA LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||AVISTA CORP||BIG BEND ELECTRIC
COOP, INC'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PUD NO 1 OF
MASON COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF FRANKLIN COUNTY'
 'PUD NO 1 OF OKANOGAN COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF MCCLEARY - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||PACIFICORP||BENTON RURAL ELECTRIC
ASSN'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF PORT ANGELES - (WA)'
 'OKANOGAN COUNTY ELEC COOP, INC'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||OHOP MUTUAL
LIGHT COMPANY, INC|PENINSULA LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||AVISTA CORP||PUD NO 1 OF ASOTIN
COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF FERRY COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF MILTON - (WA)|CITY OF
TACOMA - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PARKLAND
LIGHT & WATER COMPANY|PENINSULA LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 2 OF PACIFIC COUNTY'
 'CITY OF TACOMA - (WA)||TANNER ELECTRIC COOP'
 'CITY OF BLAINE - (WA)||PUD NO 1 OF WHATCOM COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PACIFICORP||PUD NO 1 OF CLARK
COUNTY - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||COLUMBIA RURAL ELEC ASSN, INC'
 'BONNEVILLE POWER ADMINISTRATION||PACIFICORP||COLUMBIA RURAL ELEC
ASSN, INC'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF CENTRALIA - (WA)|CITY OF
TACOMA - (WA)'
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 'PUD NO 1 OF WHATCOM COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF WAHKIAKUM COUNTY'
 'CITY OF CHENEY - (WA)' 'CITY OF CHEWELAH'
 'BONNEVILLE POWER ADMINISTRATION||BENTON RURAL ELECTRIC ASSN'
 'PUD NO 1 OF PEND OREILLE COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||BIG BEND ELECTRIC COOP, INC'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF MASON COUNTY|PUD NO 1
OF JEFFERSON COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF KITTITAS COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||TOWN OF EATONVILLE - (WA)|CITY OF
TACOMA - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||TOWN OF RUSTON - (WA)|CITY OF
TACOMA - (WA)||PENINSULA LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||BENTON RURAL
ELECTRIC ASSN|PENINSULA LIGHT COMPANY'
 'CITY OF SEATTLE - (WA)'
 'CITY OF SUMAS - (WA)||PUD NO 1 OF WHATCOM COUNTY'
 'BONNEVILLE POWER ADMINISTRATION||CITY OF COULEE DAM - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||PENINSULA LIGHT COMPANY'
 'CITY OF TACOMA - (WA)'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF ASOTIN COUNTY'
 'PORTLAND GENERAL ELECTRIC CO'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF ASOTIN COUNTY||INLAND
POWER & LIGHT COMPANY'
 'BONNEVILLE POWER ADMINISTRATION||NESPELEM VALLEY ELEC COOP, INC'
 'BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLALLAM COUNTY|PUD NO 1
OF JEFFERSON COUNTY']
Nunique values: 73
--------------------------------------------------------
```
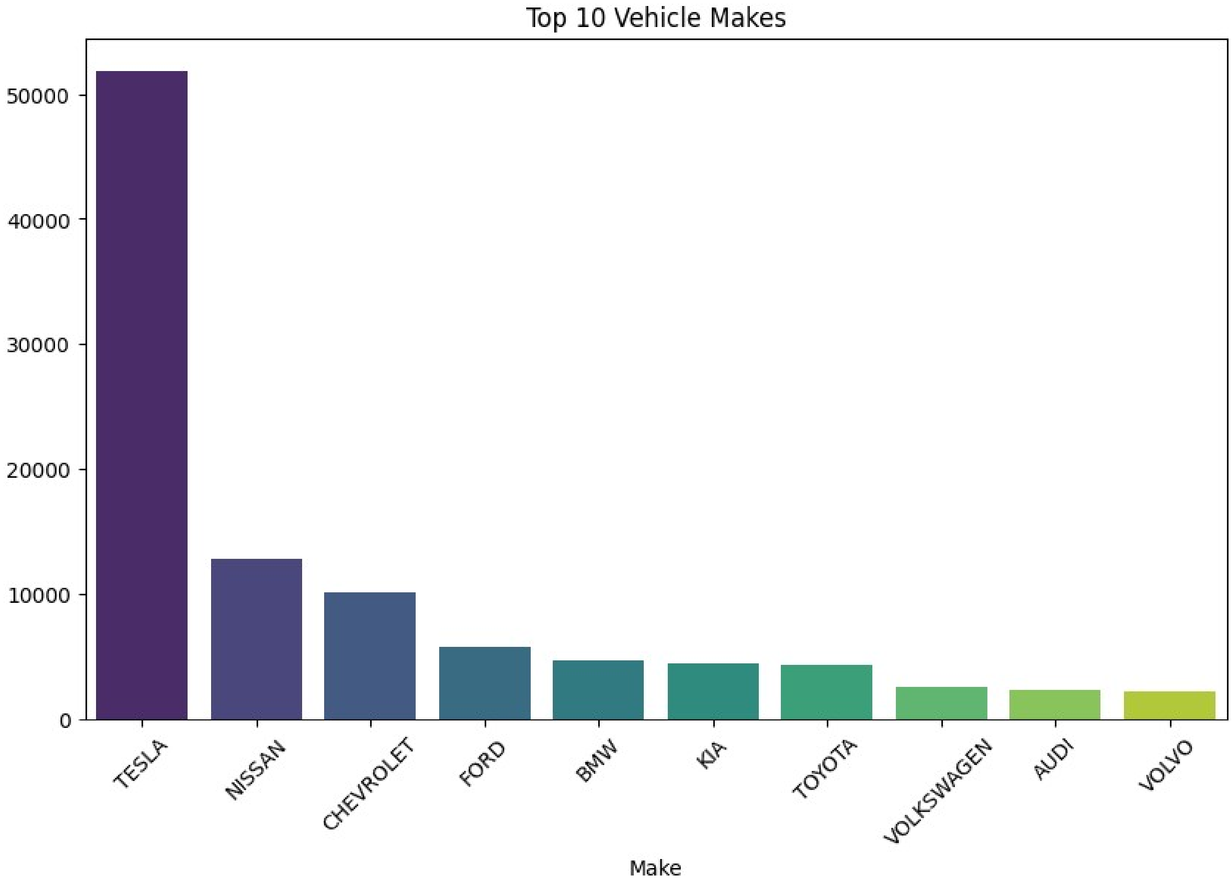

```python
# All of the categorical data columns
print(categorical_df.columns)
```

```
Index(['VIN (1-10)', 'County', 'City', 'State', 'Make', 'Model',
       'Electric Vehicle Type',
       'Clean Alternative Fuel Vehicle (CAFV) Eligibility', 'Vehicle
Location',
       'Electric Utility'],
      dtype='object')
```

```python
# Analyze unique counts for categorical columns
print("Unique Makes  :", df['Make'].nunique())
print("Unique Models :", df['Model'].nunique())

# Top 10 most common vehicle makes
top_makes = df['Make'].value_counts().nlargest(10)
plt.figure(figsize=(10, 6))
sns.barplot(x=top_makes.index, y=top_makes.values,palette='viridis')
plt.title('Top 10 Vehicle Makes')
plt.xticks(rotation=45)
plt.show()

Unique Makes  : 34
Unique Models : 114
```

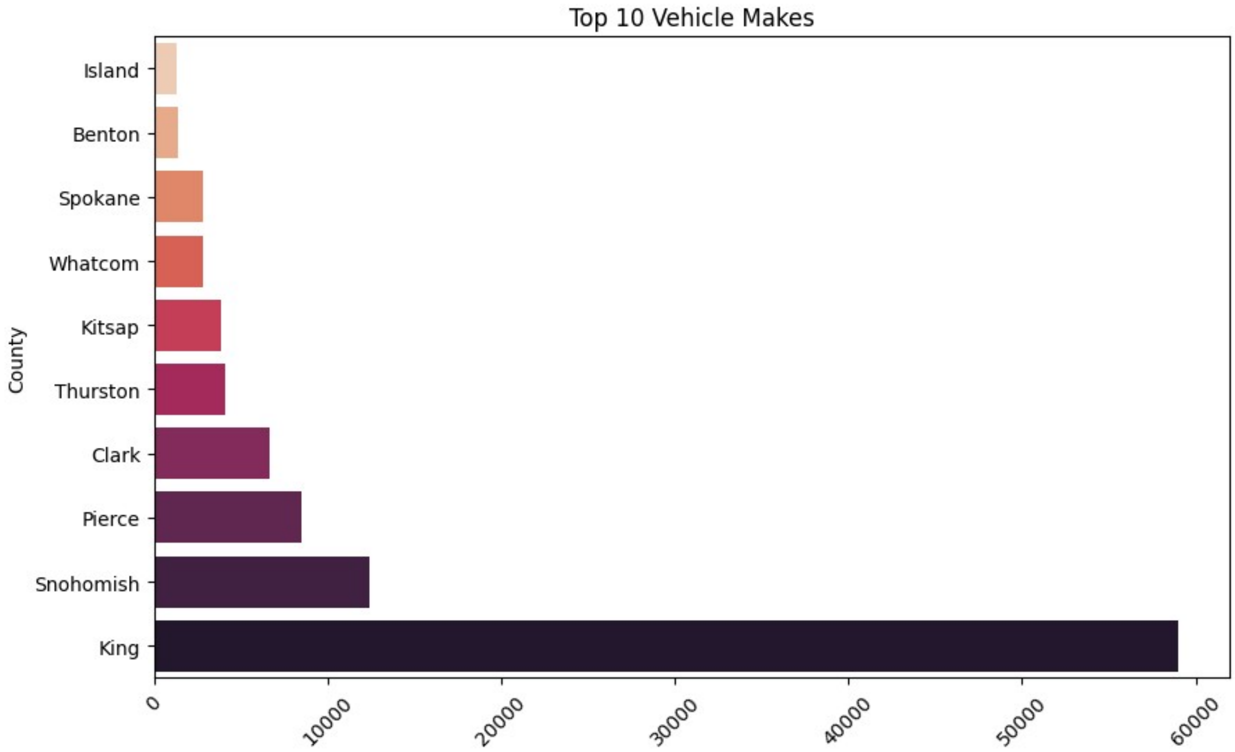


Question : Which county has the highest population?

```
top_10_counties =
df["County"].value_counts().sort_values(ascending=False).head(10)

print("*"*5, "Top 10 Counties", "*"*5)
for county, count in top_10_counties.items():
  print("{0} : {1}".format(county, count))

***** Top 10 Counties *****
King : 58980
Snohomish : 12412
Pierce : 8525
Clark : 6681
Thurston : 4109
Kitsap : 3828
Whatcom : 2839
```

```
Spokane : 2785
Benton : 1376
Island : 1298
```

```
top_10_counties_sorted = top_10_counties.sort_values(ascending=True)

plt.figure(figsize=(10, 6))
ax = sns.barplot(y=top_10_counties_sorted.index,
x=top_10_counties_sorted.values, palette='rocket_r')
plt.title('Top 10 Vehicle Makes')
plt.xticks(rotation=45)
plt.show()
```



```
df["City"].value_counts().sort_values(ascending=False).head(10)
# df["Model"].value_counts()
# df["Electric Vehicle Type"].value_counts().plot(kind = "barh")
# df["Clean Alternative Fuel Vehicle (CAFV)
Eligibility"].value_counts().plot(kind = "barh")
```

```
City
Seattle      20295
Bellevue      5919
Redmond       4199
Vancouver     4013
Kirkland      3598
Bothell       3334
```

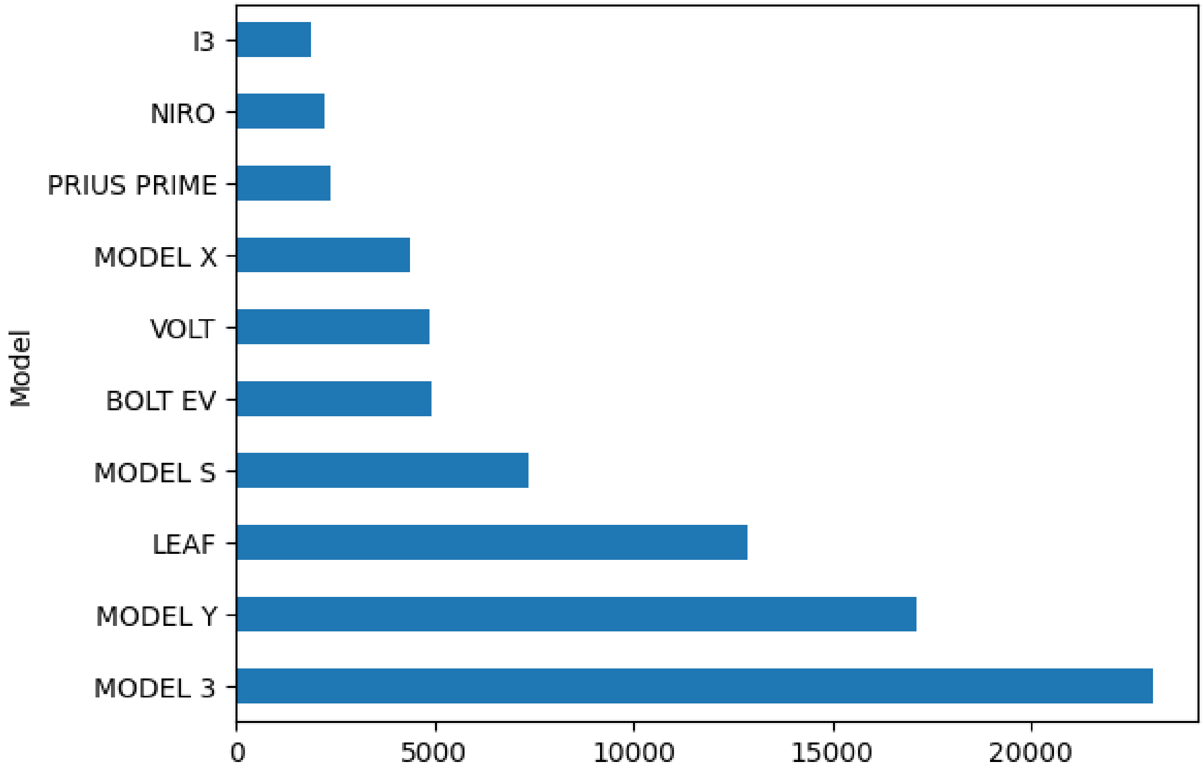
```
Sammamish      3291
Renton         2777
Olympia        2729
Tacoma         2375
Name: count, dtype: int64
```

Question:

How does the popularity of electric car models compare, and what trends can be observed from the high sales of the Model 3 and Model Y versus the lower sales of models like the i3 and Niro?

```
df["Model"].value_counts().head(10).plot(kind = "barh")
```

```
<Axes: ylabel='Model'>
```



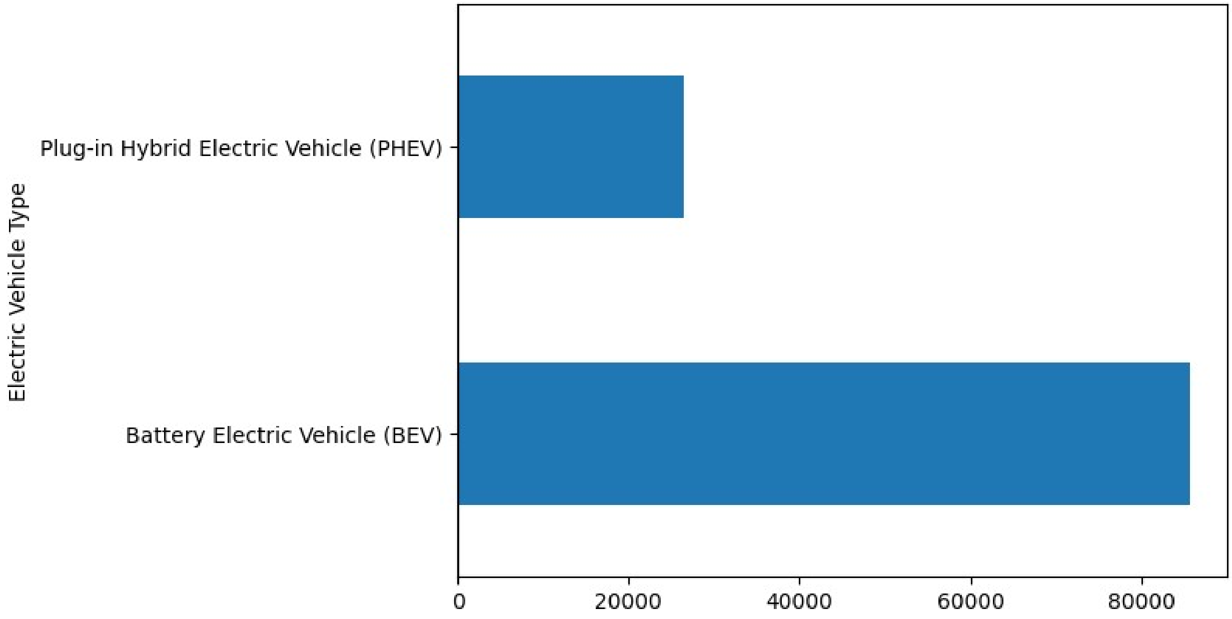
Insight:

- The popularity of different electric car models.
- The most popular model is the Model 3, followed by the Model Y.
- The least popular models are the i3 and Niro.
- The overall popularity of electric cars seems to be increasing, as evidenced by the relatively high sales of the Model 3 and Model Y.

Question:

What does the distribution of electric vehicle types reveal about consumer preferences, given the higher popularity of Battery Electric Vehicles (BEV) compared to Plug-in Hybrid Electric Vehicles (PHEV), and how might factors like range and operating costs influence this trend?

```
df["Electric Vehicle Type"].value_counts().plot(kind = "barh")

<Axes: ylabel='Electric Vehicle Type'>
```



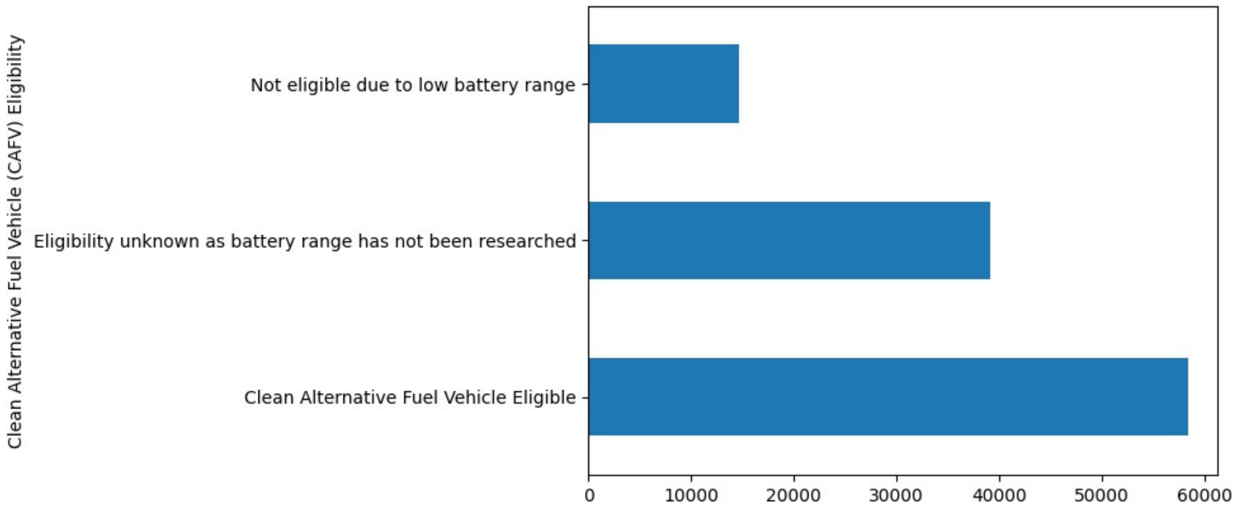
Insights:

- The distribution of electric vehicle types.
- The majority of electric vehicles are Battery Electric Vehicles (BEV), while a smaller portion are Plug-in Hybrid Electric Vehicles (PHEV).
- This suggests that BEVs are currently more popular among consumers, potentially due to factors such as longer range and lower operating costs.

Question:

How does the eligibility of electric vehicles for Clean Alternative Fuel Vehicle (CAFV) incentives vary, and what role does limited battery range and lack of research play in determining eligibility?

```
df["Clean Alternative Fuel Vehicle (CAFV)
Eligibility"].value_counts().plot(kind = "barh")

<Axes: ylabel='Clean Alternative Fuel Vehicle (CAFV) Eligibility'>
```

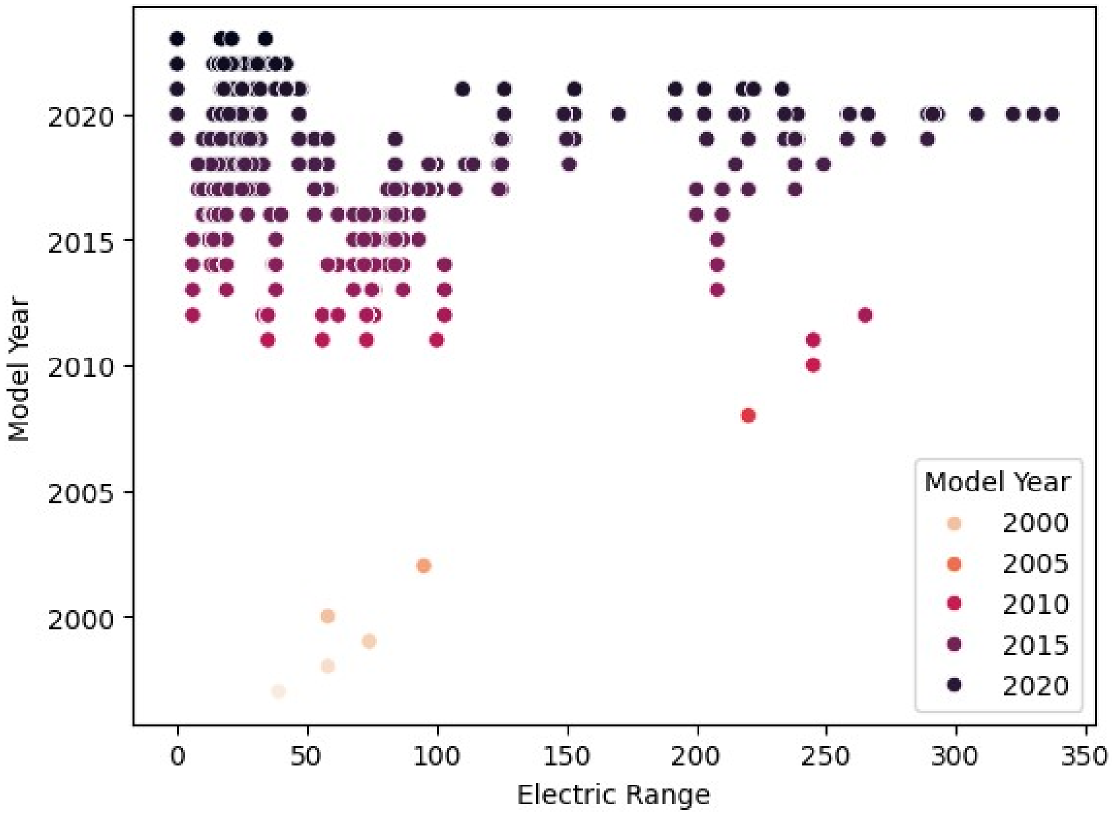


Insights:

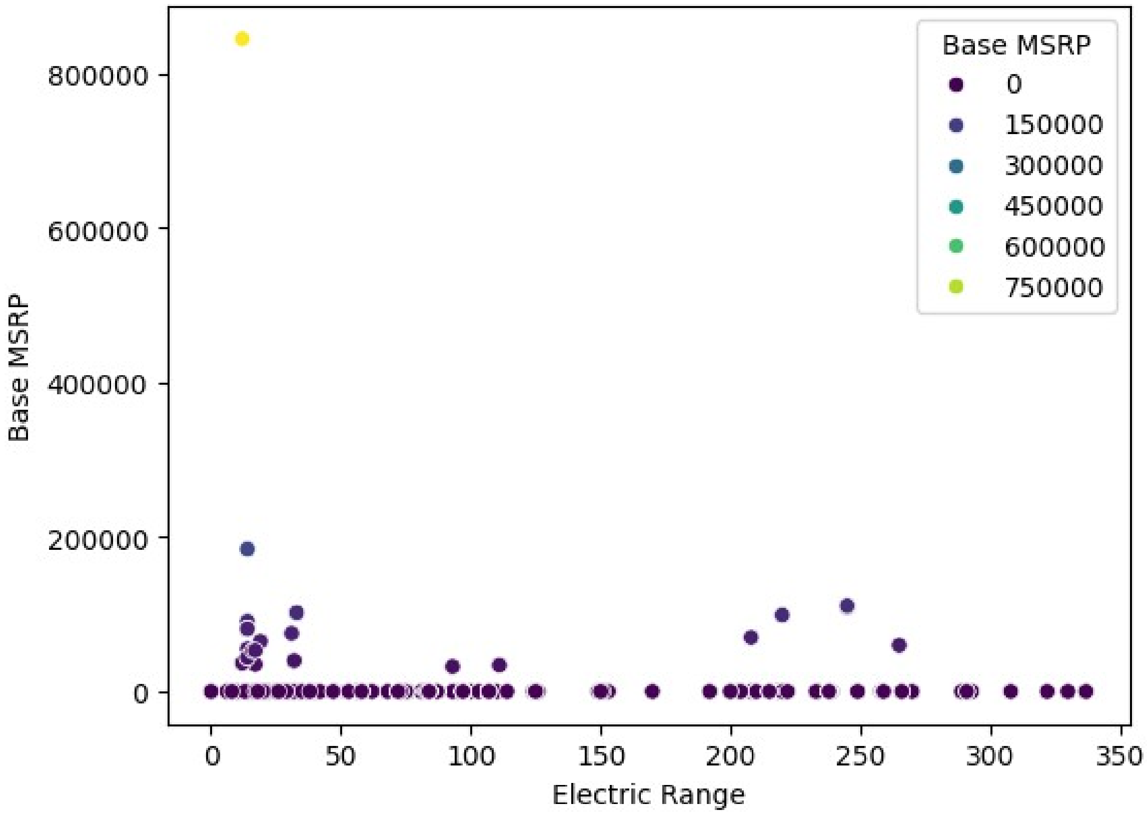
- The eligibility of different electric vehicles for Clean Alternative Fuel Vehicle (CAFV) incentives.
- The majority of vehicles are eligible, while some are ineligible due to low battery range.
- A significant number of vehicles have not been researched for battery range, and their eligibility is therefore unknown.
- This suggests that there is a need for more information on electric vehicle battery ranges to determine their eligibility for CAFV incentives.

Bivariate Analysis

```
# Categorical vs Categorical
correlation = ev_df['Electric Range'].corr(ev_df['Model Year'])
print("Pearson Correlation Coefficient between 'Electric Range' and
'Model Year':{:.2f}".format(correlation))

Pearson Correlation Coefficient between 'Electric Range' and 'Model
Year':-0.29

correlation = ev_df['Electric Range'].corr(ev_df['Base MSRP'])

print("Pearson Correlation Coefficient between 'Electric Range' and
'Model Year':{:.2f}".format(correlation))

Pearson Correlation Coefficient between 'Electric Range' and 'Model
Year':0.09

sns.scatterplot(df,x= df["Electric Range"],y=df["Model
Year"],hue=df["Model Year"], palette='rocket_r')
plt.show()
```



```
sns.scatterplot(df,x=df["Electric Range"],y = df["Base MSRP"],hue =
df["Base MSRP"], palette='viridis')
plt.show()
```



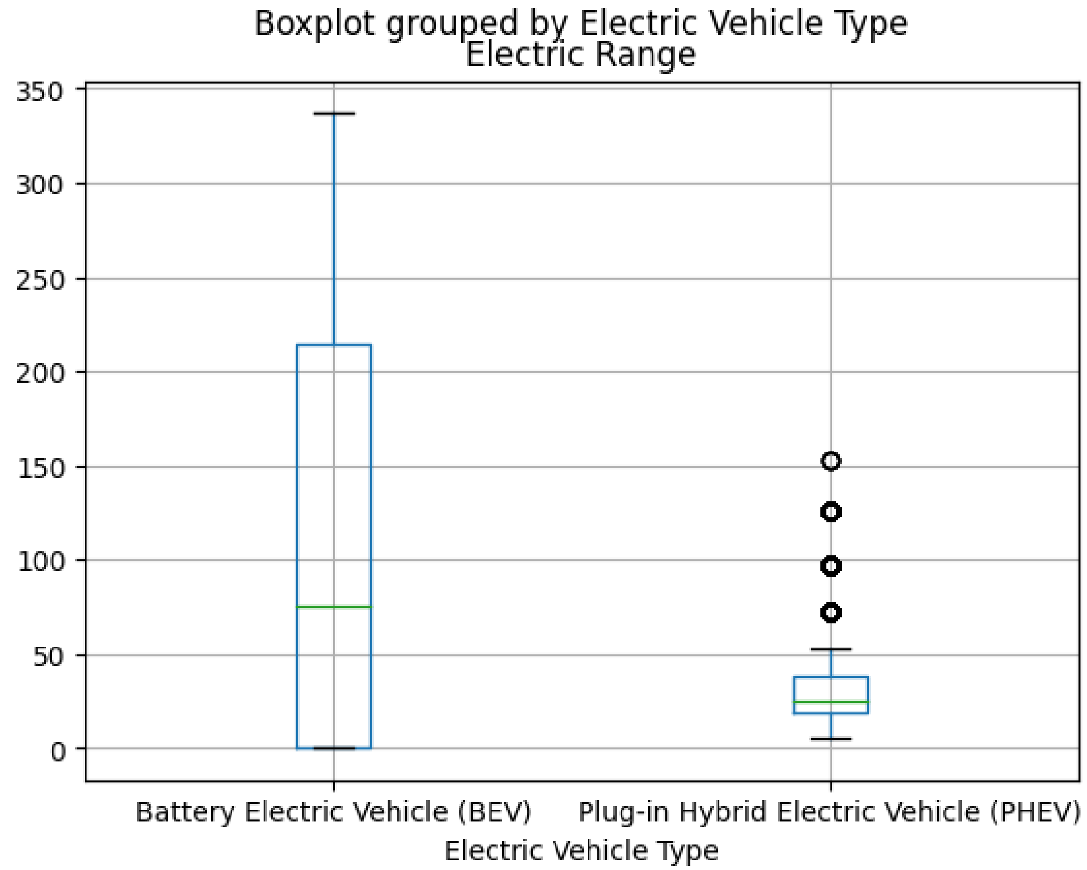
```
# Categorical Vs Numerical
df.groupby(by = "Make")["Model Year"].value_counts()

Make   Model Year
AUDI   2022          584
       2021          542
       2019          387
       2020          224
       2016          214
                    ...
VOLVO  2019          190
       2020          162
       2017          115
       2016          112
       2023            1
Name: count, Length: 209, dtype: int64

df.groupby(by = "Make")["Electric Range"].mean().head(10)

Make
AUDI                62.628448
AZURE DYNAMICS      56.000000
BENTLEY             18.666667
BMW                 46.681545
CADILLAC            35.537037
```

```
CHEVROLET         109.862032
CHRYSLER           32.360674
FIAT               85.628049
FISKER             33.000000
FORD               16.840484
Name: Electric Range, dtype: float64
```

```
df.groupby(by = ["Make","County"])["Model Year"].value_counts()
```

```
Make   County   Model Year
AUDI   Adams    2017          1
       Benton   2022         16
                2021          7
                2017          2
                2019          1
                             ..
VOLVO  Whitman  2022          1
       Yakima   2022          4
                2021          3
                2018          2
                2016          1
Name: count, Length: 3749, dtype: int64
```

```
df.boxplot(column="Electric Range", by = "Electric Vehicle
Type")#figsize = (8,6))
plt.show()
```



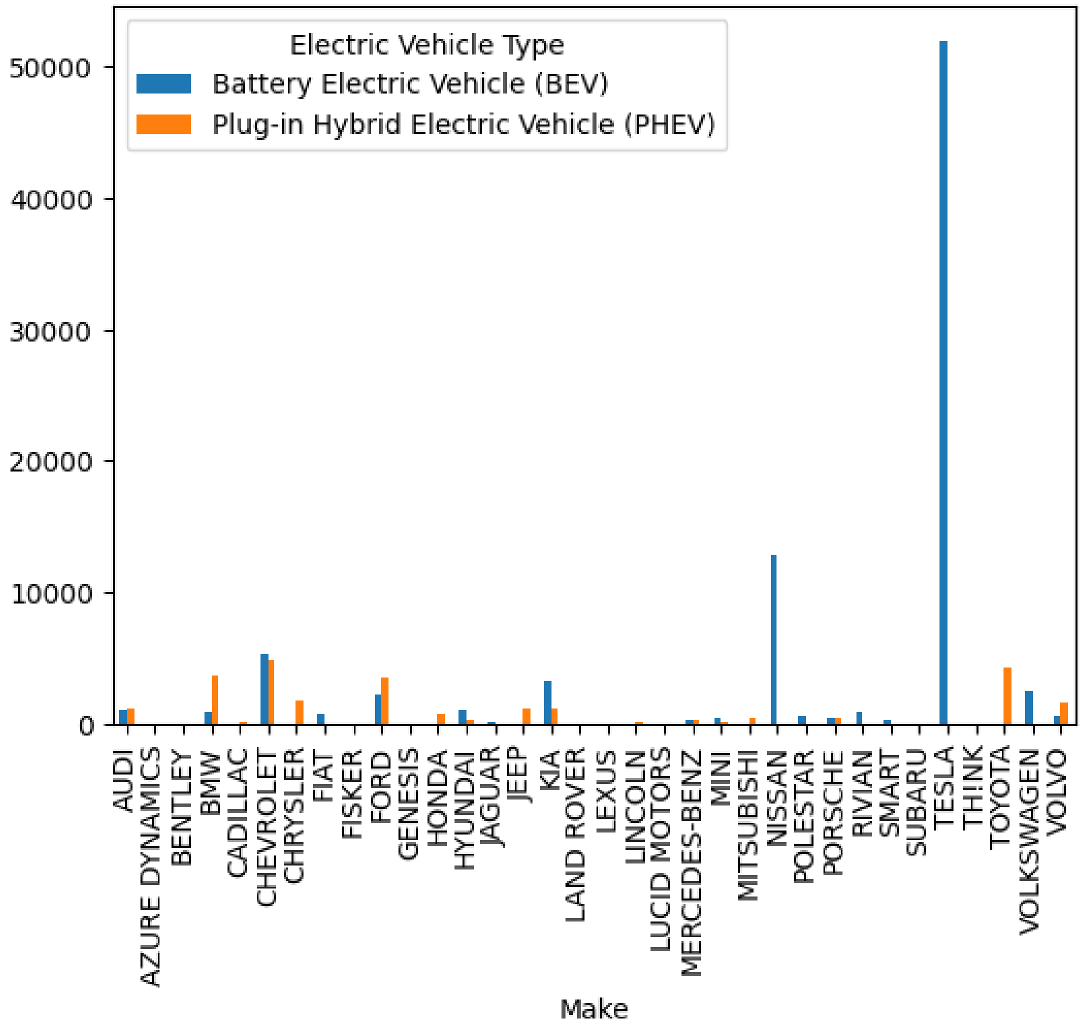
```
# Categorical Vs Categorical
df.head()

{"type":"dataframe","variable_name":"df"}

cross_tab = pd.crosstab(df["Make"],df["County"]).count()
cross_tab

County
Adams           34
Asotin          34
Benton          34
Chelan          34
Clallam         34
Clark           34
Columbia        34
Cowlitz         34
Douglas         34
Ferry           34
Franklin        34
Garfield        34
Grant           34
Grays Harbor    34
```

```
Island          34
Jefferson       34
King            34
Kitsap          34
Kittitas        34
Klickitat       34
Lewis           34
Lincoln         34
Mason           34
Okanogan        34
Pacific         34
Pend Oreille    34
Pierce          34
San Juan        34
Skagit          34
Skamania        34
Snohomish       34
Spokane         34
Stevens         34
Thurston        34
Wahkiakum       34
Walla Walla     34
Whatcom         34
Whitman         34
Yakima          34
dtype: int64
```

```
grouped_df = df.groupby(by=["Make", "Model"])


pd.crosstab(index=df["County"], columns=[df["Make"], df["Model"]])
```

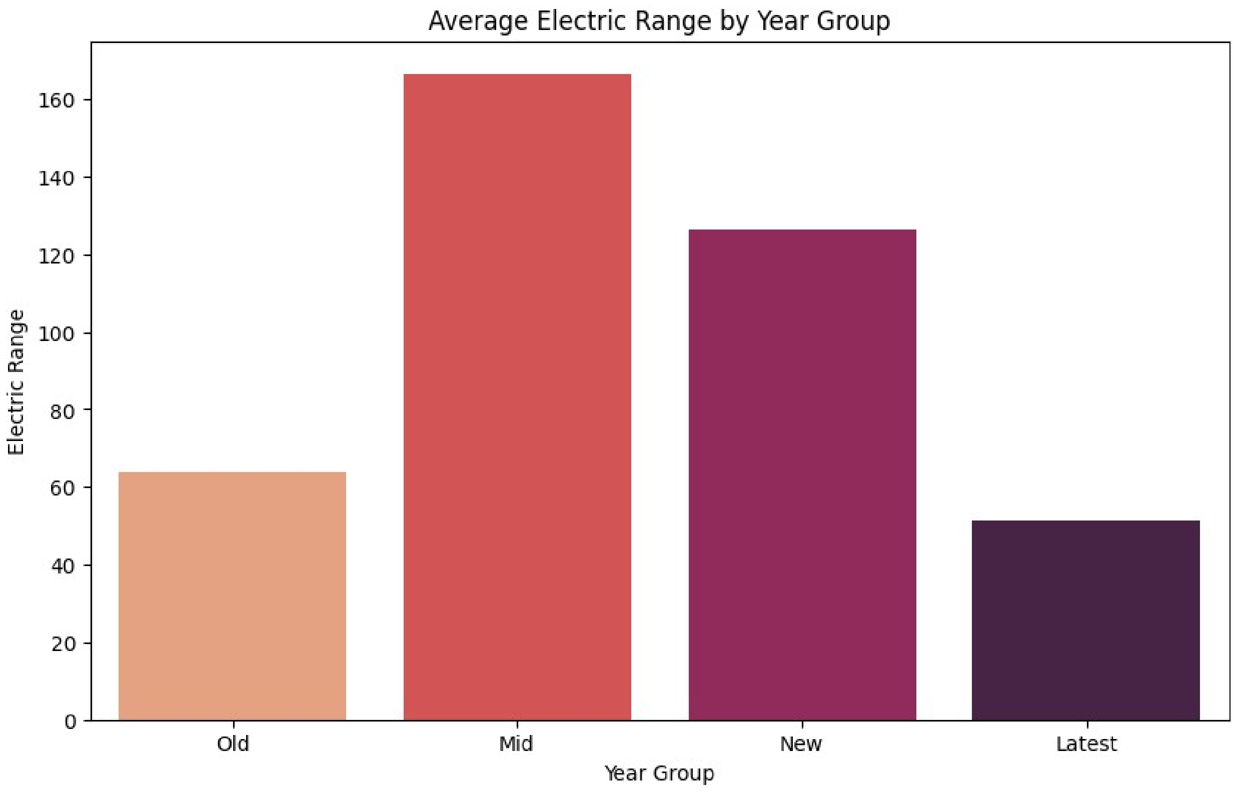
```
{"type":"dataframe"}
```

```
pd.crosstab(index=df["Make"],columns=df["Electric Vehicle
Type"]).plot(kind = "bar")
plt.show()
```



Optional Step : Feature Engineering

```
# Feature 1: Price per Electric Mile
df['Price per Mile'] = df['Base MSRP'] / df['Electric Range']

# Feature 2: Binning Model Year into categories
bins = [1980, 2000, 2010, 2020, 2025]
labels = ['Old', 'Mid', 'New', 'Latest']
df['Year Group'] = pd.cut(df['Model Year'], bins=bins, labels=labels,
right=False)

# Groupby Year Group and summarize MSRP and Electric Range
grouped_year = df.groupby('Year Group').agg({'Base MSRP': 'mean',
'Electric Range': 'mean'}).reset_index()
plt.figure(figsize=(10, 6))
sns.barplot(x='Year Group', y='Electric Range', data=grouped_year,
palette='rocket_r')
plt.title('Average Electric Range by Year Group')
plt.show()

# Feature 3: Create region feature from postal code (e.g., group by
first digit or state)
df['Region'] = df['Postal Code'].str[0]  # Example: use the first
digit of postal code as a proxy for region
```



Create a Choropleth using plotly.express to display the number of EV vehicles based on location.

```
!pip install plotly
```

```
Requirement already satisfied: plotly in
/usr/local/lib/python3.10/dist-packages (5.24.1)
Requirement already satisfied: tenacity>=6.2.0 in
/usr/local/lib/python3.10/dist-packages (from plotly) (9.0.0)
Requirement already satisfied: packaging in
/usr/local/lib/python3.10/dist-packages (from plotly) (24.1)
```

```
import plotly.express as px
```

```
ev_count_per_state =
ev_df.groupby('State').size().reset_index(name='ev_count')
ev_count_per_state.head(10)
```

```
{"summary":"{\n  \"name\": \"ev_count_per_state\",\n  \"rows\": 45,\n
\"fields\": [\n    {\n      \"column\": \"State\",\n
\"properties\": {\n        \"dtype\": \"string\",\n
\"num_unique_values\": 45,\n        \"samples\": [\n          \"TX\",\
n          \"NE\",\n          \"NH\"\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"ev_count\",\n      \"properties\":
{\n        \"dtype\": \"number\",\n        \"std\": 16746,\n
\"min\": 1,\n        \"max\": 112348,\n        \"num_unique_values\":
14,\n        \"samples\": [\n          5,\n          14,\n          1\
n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    }\n  ]\
n}","type":"dataframe","variable_name":"ev_count_per_state"}
```

```
fig = px.choropleth(ev_count_per_state,
                    locations='State',  # Column representing state
locations
                    locationmode="USA-states",  # Use USA state-level
mapping
                    color='ev_count',  # Column representing the count
of EVs
                    scope="usa",  # Focus the map on the USA
                    color_continuous_scale="Viridis",  # Color scale
                    title='Number of EV Vehicles by State')

fig.show()

try:
  fig.write_image("choropleth_map.png")
  print("File saved.")
except Exception as e:
  print(f"An error occurred: {e}")
```

```
An error occurred:
Image export using the "kaleido" engine requires the kaleido package,
which can be installed using pip:
    $ pip install -U kaleido
```

Create a Racing Bar Plot to display the animation of EV Make and its count each year.

```
!pip install bar_chart_race
```

```
Requirement already satisfied: bar_chart_race in
/usr/local/lib/python3.10/dist-packages (0.1.0)
```

```
Requirement already satisfied: pandas>=0.24 in
/usr/local/lib/python3.10/dist-packages (from bar_chart_race) (2.2.2)
Requirement already satisfied: matplotlib>=3.1 in
/usr/local/lib/python3.10/dist-packages (from bar_chart_race) (3.7.1)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (1.3.0)
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (4.54.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (1.4.7)
Requirement already satisfied: numpy>=1.20 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (1.26.4)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (24.1)
Requirement already satisfied: pillow>=6.2.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (3.1.4)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.1-
>bar_chart_race) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.10/dist-packages (from pandas>=0.24-
>bar_chart_race) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.10/dist-packages (from pandas>=0.24-
>bar_chart_race) (2024.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7-
>matplotlib>=3.1->bar_chart_race) (1.16.0)
```

```python
import bar_chart_race as bcr

make_counts_per_year = df.groupby(['Model Year',
'Make']).size().reset_index(name='Count')

pivot_df = make_counts_per_year.pivot(index='Model Year',
columns='Make', values='Count').fillna(0)

# bcr.bar_chart_race(df=pivot_df,
#                     title='Electric Vehicles Make Count Over Time',

#                      n_bars=10,

#                     period_length=1000,
# )

# Create the bar chart race with color effects
bcr.bar_chart_race(
    df=pivot_df,
    title='Electric Vehicles Make Count Over Time',
    n_bars=10,                    # Top 10 bars to display
    period_length=1000,            # Speed of the race (1000 ms = 1
second per frame)
    fixed_order=False,             # Let the order of bars change as
they race
    fixed_max=False,               # Allow the bar lengths to change
dynamically
    steps_per_period=30,           # Smoother transitions between
frames
    interpolate_period=False,      # No interpolation between frames
for cleaner transitions
    period_label={'x': .99, 'y': .25, 'ha': 'right', 'va': 'center'},
# Customize the period label
    bar_label_size=7,              # Label size for the bars
    tick_label_size=8,             # Size for the tick labels
    figsize=(6, 4),                # Size of the chart
    dpi=144,                       # DPI for higher resolution
    # cmap='viridis'                 # You can also add colormap for
gradient effect
)
```

```
<IPython.core.display.HTML object>
```