DSAIML Bootcamp 2024 Piyush

June 24, 2024

0.0.1 Bootcamp DSAIML Project 2024 - Piyush(C4) System id : 2022434137

1 List of Table

2 List of Figure

3 # Problem statement/Objective

Market Size Analysis is the process of estimating the potential sales for a product or service within a particular market segment. In the context of electric vehicles (EVs), it involves assessing the total volume of EV registrations to understand the growth of the market, forecast future trends, and help stakeholders make informed decisions regarding production, infrastructure development, and policy-making.

The provided dataset contains the following columns, each representing different aspects of the electric vehicle (EV) population in the United States:

- VIN (1-10): Partial Vehicle Identification Number.
- County: The county in which the vehicle is registered.
- City: The city in which the vehicle is registered.
- State: The state in which the vehicle is registered. It appears that this dataset may be focused on Washington (WA) state.
- Postal Code: The postal code where the vehicle is registered.
- Model Year: The year of the vehicle model
- Make: The manufacturer of the vehicle.
- Model: The model of the vehicle.
- Electric Vehicle Type: The type of electric vehicle, e.g., Battery Electric Vehicle (BEV).
- Clean Alternative Fuel Vehicle (CAFV) Eligibility: Eligibility status for clean alternative fuel vehicle programs.
- Electric Range: The maximum range of the vehicle on a single charge (in miles).
- Base MSRP: The Manufacturer's Suggested Retail Price.
- Legislative District: The legislative district where the vehicle is registered.
- DOL Vehicle ID: Department of Licensing Vehicle Identification.
- Vehicle Location: Geographic coordinates of the vehicle location.
- Electric Utility: The electric utility service provider for the vehicle's location.
- 2020 Census Tract: The census tract for the vehicle's location.

3.1 Basic Steps

```
[1]: import os
     os.getcwd()
```

```
[1]: 'C:\\Users\\anupi'
```

```
[11]: import pandas as pd
      import numpy as np
      import matplotlib.pyplot as plt
      import seaborn as sns
```

```
[12]: dtype_specification = {
          10: str,
          12: str
      }
      data = pd.read_csv('6-Electric_Vehicle_Population_Data New.csv',␣
       ↪dtype=dtype_specification)
```

3.2 1) Display the top 5 rows

```
[13]: data.head()
```

```
[13]:    VIN (1-10)     County       City State  Postal Code  Model Year    Make  \
      0  5YJYGDEE1L       King    Seattle    WA      98122.0        2020   TESLA
      1  7SAYGDEE9P  Snohomish    Bothell    WA      98021.0        2023   TESLA
      2  5YJSA1E4XK       King    Seattle    WA      98109.0        2019   TESLA
      3  5YJSA1E27G       King   Issaquah    WA      98027.0        2016   TESLA
      4  5YJYGDEE5M     Kitsap  Suquamish    WA      98392.0        2021     NaN

           Model               Electric Vehicle Type  \
      0  MODEL Y  Battery Electric Vehicle (BEV)
      1  MODEL Y  Battery Electric Vehicle (BEV)
      2  MODEL S  Battery Electric Vehicle (BEV)
      3  MODEL S  Battery Electric Vehicle (BEV)
      4  MODEL Y  Battery Electric Vehicle (BEV)

         Clean Alternative Fuel Vehicle (CAFV) Eligibility Electric Range  \
      0           Clean Alternative Fuel Vehicle Eligible            291
      1  Eligibility unknown as battery range has not b…              0
      2                                              NaN            270
      3           Clean Alternative Fuel Vehicle Eligible            210
      4  Eligibility unknown as battery range has not b…              0

         Base MSRP Legislative District  DOL Vehicle ID  \
      0          0                    37       125701579
      1          0                     1       244285107
      2          0                    36       156773144
```

```
3          0                   5        165103011
4          0                  23        205138552


                 Vehicle Location  \
0   POINT (-122.30839 47.610365)
1  POINT (-122.179458 47.802589)
2   POINT (-122.34848 47.632405)
3   POINT (-122.03646 47.534065)
4   POINT (-122.55717 47.733415)


                                     Electric Utility  2020 Census Tract
0   CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)        5.303301e+10
1                         PUGET SOUND ENERGY INC        5.306105e+10
2   CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)        5.303301e+10
3  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        5.303303e+10
4                         PUGET SOUND ENERGY INC        5.303594e+10
```

3.3 2) Display the last 5 rows

```
[ ]: data.tail()
```

```
[ ]:        VIN (1-10)    County        City State  Postal Code  Model Year  \
     4350   KMHM34AC5P      King    Kirkland    WA        98034        2023
     4351   5YJSA1E2XK      King    Bellevue    WA        98006        2019
     4352   5YJ3E1EB9M    Island  Oak Harbor    WA        98277        2021
     4353   1G1FZ6S08N  Thurston   Rochester    WA        98579        2022
     4354   1N4BZ0CP4G      King   Covington    WA        98042        2016


                Make    Model          Electric Vehicle Type  \
     4350    HYUNDAI  IONIQ 6  Battery Electric Vehicle (BEV)
     4351      TESLA  MODEL S  Battery Electric Vehicle (BEV)
     4352      TESLA  MODEL 3  Battery Electric Vehicle (BEV)
     4353  CHEVROLET  BOLT EV  Battery Electric Vehicle (BEV)
     4354     NISSAN     LEAF  Battery Electric Vehicle (BEV)


           Clean Alternative Fuel Vehicle (CAFV) Eligibility Electric Range  \
     4350  Eligibility unknown as battery range has not b…                0
     4351           Clean Alternative Fuel Vehicle Eligible              270
     4352  Eligibility unknown as battery range has not b…                0
     4353  Eligibility unknown as battery range has not b…                0
     4354           Clean Alternative Fuel Vehicle Eligible               84


           Base MSRP Legislative District  DOL Vehicle ID  \
     4350          0                   45       260328554
     4351          0                   41       202143378
     4352          0                   10       181200813
     4353          0                   20       211177039
```

```
4354              0                   47       176683636

                        Vehicle Location  \
4350     POINT (-122.209285 47.71124)
4351     POINT (-122.16937 47.571015)
4352  POINT (-122.6788673 48.2897314)
4353      POINT (-123.09575 46.82114)
4354     POINT (-122.111625 47.36078)


                                    Electric Utility  2020 Census Tract
4350  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        53033021903
4351  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        53033023902
4352                         PUGET SOUND ENERGY INC        53029970402
4353                         PUGET SOUND ENERGY INC        53067012730
4354  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)         5303303200
```

3.4 3) Check the shape of dataset

```
[ ]: data.shape
```

```
[ ]: (13029, 17)
```

3.5 4) Check the datatypes of each feature.

```
[7]: data.dtypes
```

```
[7]: VIN (1-10)                                          object
     County                                             object
     City                                               object
     State                                              object
     Postal Code                                        float64
     Model Year                                          int64
     Make                                               object
     Model                                              object
     Electric Vehicle Type                              object
     Clean Alternative Fuel Vehicle (CAFV) Eligibility  object
     Electric Range                                     object
     Base MSRP                                           int64
     Legislative District                               object
     DOL Vehicle ID                                      int64
     Vehicle Location                                   object
     Electric Utility                                   object
     2020 Census Tract                                  float64
     dtype: object
```

3.6 5) Check the Statistical summary

```
[ ]: data.describe()
```

```
[ ]:          Postal Code    Model Year     Base MSRP  DOL Vehicle ID  \
     count   13029.000000  13029.000000  13029.000000    1.302900e+04
     mean    98179.398879   2020.496585   1119.917876    2.209412e+08
     std       224.795648      2.960427   8595.903627    7.720531e+07
     min     98001.000000   2000.000000      0.000000    1.861330e+05
     25%     98033.000000   2019.000000      0.000000    1.823020e+08
     50%     98103.000000   2022.000000      0.000000    2.276053e+08
     75%     98178.000000   2023.000000      0.000000    2.549045e+08
     max     99362.000000   2024.000000 184400.000000    4.789259e+08

             2020 Census Tract
     count        1.302800e+04
     mean         5.303352e+10
     std          1.206012e+07
     min          5.300796e+10
     25%          5.303301e+10
     50%          5.303302e+10
     75%          5.303303e+10
     max          5.307794e+10
```

3.7 6) Check the null values

```
[8]: data.isnull().sum()
```

```
[8]: VIN (1-10)                                           0
     County                                               5
     City                                                 5
     State                                                0
     Postal Code                                          5
     Model Year                                           0
     Make                                                 7
     Model                                                4
     Electric Vehicle Type                                6
     Clean Alternative Fuel Vehicle (CAFV) Eligibility    2
     Electric Range                                       3
     Base MSRP                                            0
     Legislative District                               389
     DOL Vehicle ID                                       0
     Vehicle Location                                     9
     Electric Utility                                     5
     2020 Census Tract                                    5
     dtype: int64
```

3.8 7- Check the duplicate values

```
[ ]: data.duplicated().sum()
```

```
[ ]: 0
```

3.8.1 8) Check the anomalies or wrong entries.

```
[14]: plt.figure(figsize=(12, 8))

      # Create a boxplot
      sns.boxplot(x='Model Year', data=data, palette="Set2")
      # Add a title and labels
      plt.title('Distribution of Model Years of Electric Vehicles', fontsize=16)
      plt.xlabel('Model Year', fontsize=14)
      plt.ylabel('')

      # Improve layout and show the plot
      plt.tight_layout()
      plt.show()
```
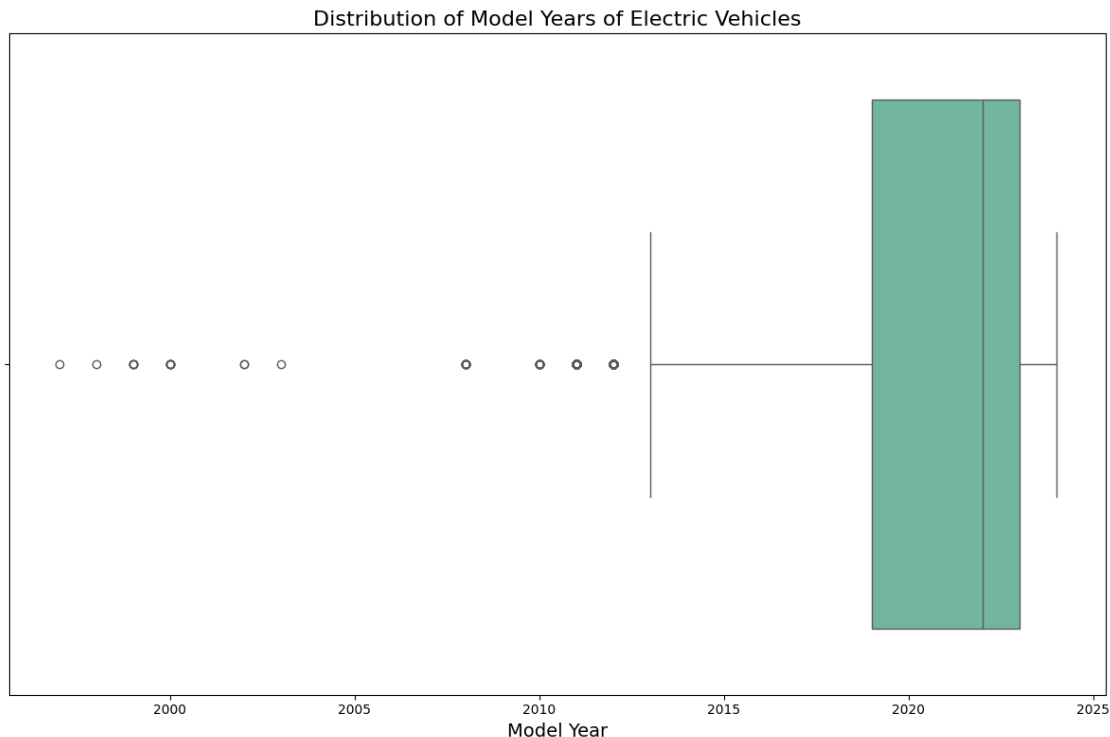
C:\Users\anupi\AppData\Local\Temp\ipykernel_9408\53870542.py:4: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  sns.boxplot(x='Model Year', data=data, palette="Set2")

Distribution of Model Years of Electric Vehicles

plt.figure(figsize=(10,10)) sns.boxplot(data=data[''],orient='h')

3.8.2 9- Check the outliers and their authenticity.

```
[15]: data[data['2020 Census Tract']=='?']
```

```
[15]: Empty DataFrame
      Columns: [VIN (1-10), County, City, State, Postal Code, Model Year, Make, Model,
      Electric Vehicle Type, Clean Alternative Fuel Vehicle (CAFV) Eligibility,
      Electric Range, Base MSRP, Legislative District, DOL Vehicle ID, Vehicle
      Location, Electric Utility, 2020 Census Tract]
      Index: []
```

3.8.3 10- Do the necessary data cleaning steps like dropping duplicates, unnecessary columns, null value imputation, outliers treatment etc.

```
[ ]: data = data.drop_duplicates()
```

```
[ ]: data['2020 Census Tract']=data['2020 Census Tract'].replace('?',np.nan)
```

```
[ ]: data[data['2020 Census Tract']=='?']
```

```
[ ]: Empty DataFrame
     Columns: [VIN (1-10), County, City, State, Postal Code, Model Year, Make, Model,
     Electric Vehicle Type, Clean Alternative Fuel Vehicle (CAFV) Eligibility,
     Electric Range, Base MSRP, Legislative District, DOL Vehicle ID, Vehicle
     Location, Electric Utility, 2020 Census Tract]
     Index: []
```

```
[ ]: data.sample(5)
```

```
[ ]:        VIN (1-10)    County          City  State  Postal Code   Model Year  \
     9278    1G1RA6S5XH    Kitsap   Port Orchard    WA        98367         2017
     11875   5YJ3E1EA7P      King       Kirkland    WA        98034         2023
     4205    WBY43AW05P      King       Bellevue    WA        98004         2023
     7850    1FTVW1EV4P      King           Kent    WA        98031         2023
     6808    1C4JJXP65N  Thurston           Yelm    WA        98597         2022

                  Make      Model                      Electric Vehicle Type  \
     9278    CHEVROLET       VOLT  Plug-in Hybrid Electric Vehicle (PHEV)
     11875       TESLA    MODEL 3           Battery Electric Vehicle (BEV)
     4205          BMW         I4           Battery Electric Vehicle (BEV)
     7850         FORD      F-150           Battery Electric Vehicle (BEV)
     6808         JEEP   WRANGLER  Plug-in Hybrid Electric Vehicle (PHEV)

            Clean Alternative Fuel Vehicle (CAFV) Eligibility Electric Range  \
     9278             Clean Alternative Fuel Vehicle Eligible              53
     11875  Eligibility unknown as battery range has not b…               0
     4205   Eligibility unknown as battery range has not b…               0
     7850   Eligibility unknown as battery range has not b…               0
     6808              Not eligible due to low battery range              21

            Base MSRP  Legislative District  DOL Vehicle ID  \
     9278           0                    26       198140960
     11875          0                     1       240897989
     4205           0                    41       244394363
     7850           0                    11       258067407
     6808           0                     2       207670669

                          Vehicle Location  \
     9278      POINT (-122.6847073 47.50524)
     11875      POINT (-122.209285 47.71124)
     4205       POINT (-122.201905 47.61385)
     7850    POINT (-122.2012521 47.3931814)
     6808        POINT (-122.61023 46.94126)

                                       Electric Utility  2020 Census Tract
     9278                        PUGET SOUND ENERGY INC        5.303509e+10
     11875  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        5.303302e+10
```

```
4205    PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)      5.303302e+10
7850    PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)      5.303303e+10
6808                        PUGET SOUND ENERGY INC         5.306701e+10
```

[ ]: data[data['Base MSRP']==data['Base MSRP'].min()]

[ ]:
```
          VIN (1-10)     County        City State  Postal Code  Model Year    Make  \
0          5YJYGDEE1L       King     Seattle    WA        98122        2020   TESLA
1          7SAYGDEE9P  Snohomish     Bothell    WA        98021        2023   TESLA
2          5YJSA1E4XK       King     Seattle    WA        98109        2019   TESLA
3          5YJSA1E27G       King    Issaquah    WA        98027        2016   TESLA
4          5YJYGDEE5M     Kitsap   Suquamish    WA        98392        2021     NaN
...               ...        ...         ...   ...          ...         ...     ...
13024      5YJ3E1EB0N      Clark   Vancouver    WA        98685        2022   TESLA
13025      5YJYGDEE9M       King   Newcastle    WA        98056        2021   TESLA
13026      5YJYGDEE1M       King    Bellevue    WA        98007        2021   TESLA
13027      7SAYGDEE4N      Clark   Vancouver    WA        98661        2022   TESLA
13028      WA1L2BFZXN       King     Seattle    WA        98177        2022    AUDI

         Model           Electric Vehicle Type  \
0       MODEL Y  Battery Electric Vehicle (BEV)
1       MODEL Y  Battery Electric Vehicle (BEV)
2       MODEL S  Battery Electric Vehicle (BEV)
3       MODEL S  Battery Electric Vehicle (BEV)
4       MODEL Y  Battery Electric Vehicle (BEV)
...         ...                             ...
13024   MODEL 3  Battery Electric Vehicle (BEV)
13025   MODEL Y  Battery Electric Vehicle (BEV)
13026   MODEL Y  Battery Electric Vehicle (BEV)
13027   MODEL Y  Battery Electric Vehicle (BEV)
13028        Q4  Battery Electric Vehicle (BEV)

       Clean Alternative Fuel Vehicle (CAFV) Eligibility Electric Range  \
0                Clean Alternative Fuel Vehicle Eligible            291
1      Eligibility unknown as battery range has not b…              0
2                                                   NaN            270
3                Clean Alternative Fuel Vehicle Eligible            210
4      Eligibility unknown as battery range has not b…              0
...                                                ...            ...
13024  Eligibility unknown as battery range has not b…              0
13025  Eligibility unknown as battery range has not b…              0
13026  Eligibility unknown as battery range has not b…              0
13027  Eligibility unknown as battery range has not b…              0
13028  Eligibility unknown as battery range has not b…              0

       Base MSRP Legislative District  DOL Vehicle ID  \
0              0                   37       125701579
```

```
1                0                    1       244285107
2                0                   36       156773144
3                0                    5       165103011
4                0                   23       205138552
…               …                    …            …
13024            0                   18       220742007
13025            0                   41       171497959
13026            0                   48       138322005
13027            0                   49       227325850
13028            0                   32       219952008

                  Vehicle Location  \
0        POINT (-122.30839 47.610365)
1        POINT (-122.179458 47.802589)
2         POINT (-122.34848 47.632405)
3         POINT (-122.03646 47.534065)
4         POINT (-122.55717 47.733415)
…                         …
13024   POINT (-122.70302 45.703706)
13025   POINT (-122.180505 47.500055)
13026   POINT (-122.147385 47.599975)
13027   POINT (-122.641835 45.638545)
13028    POINT (-122.382425 47.77279)

                                        Electric Utility  2020 Census Tract
0          CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)       5.303301e+10
1                               PUGET SOUND ENERGY INC       5.306105e+10
2          CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)       5.303301e+10
3         PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)       5.303303e+10
4                               PUGET SOUND ENERGY INC       5.303594e+10
…                                        …                        …
13024  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF C…       5.301104e+10
13025      PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)      5.303302e+10
13026      PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)      5.303302e+10
13027  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF C…       5.301104e+10
13028             CITY OF SEATTLE - (WA)|CITY OF TACOM              NaN

[12782 rows x 17 columns]
```
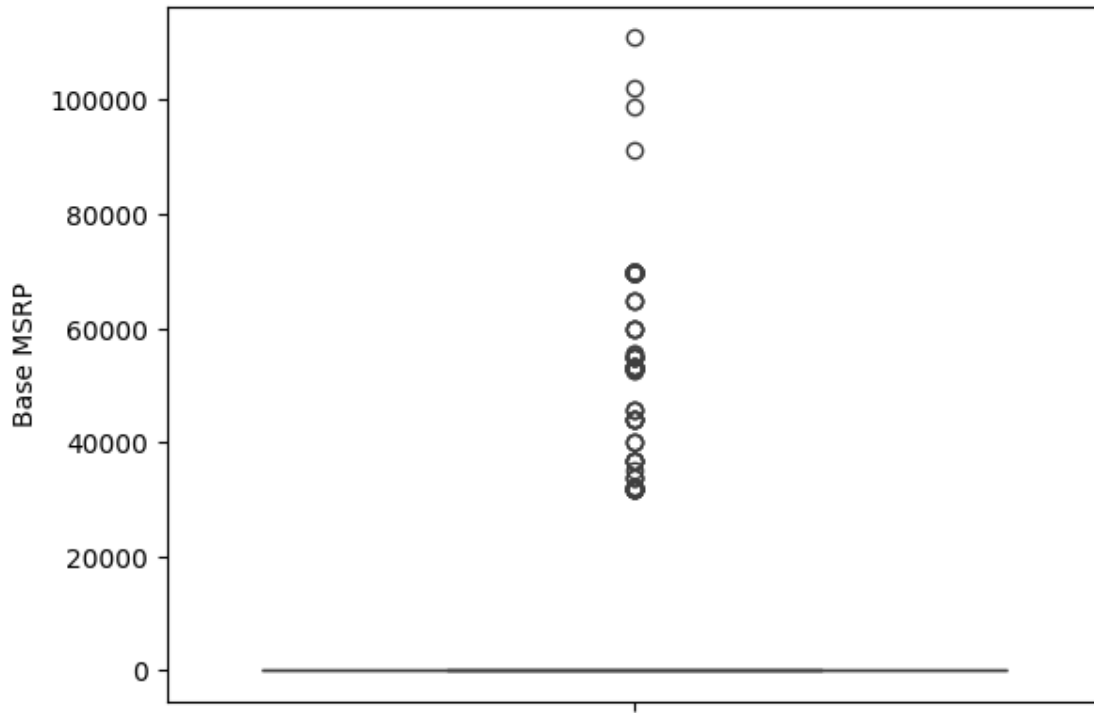
```
[ ]: sns.boxplot(data['Base MSRP'])
```

```
[ ]: <Axes: ylabel='Base MSRP'>
```

```
data['Base MSRP'].min()
```

```
0
```

```
data['Base MSRP'].max()
```

```
102000
```

```
data[data['Base MSRP']==data['Base MSRP'].min()]
```

```
        VIN (1-10)     County        City State  Postal Code  Model Year  \
0        5YJYGDEE1L       King     Seattle    WA        98122        2020
1        7SAYGDEE9P  Snohomish      Bothell    WA        98021        2023
2        5YJSA1E4XK       King     Seattle    WA        98109        2019
3        5YJSA1E27G       King    Issaquah    WA        98027        2016
4        5YJYGDEE5M     Kitsap   Suquamish    WA        98392        2021
...             ...        ...         ...   ...          ...         ...
4350     KMHM34AC5P       King    Kirkland    WA        98034        2023
4351     5YJSA1E2XK       King    Bellevue    WA        98006        2019
4352     5YJ3E1EB9M     Island  Oak Harbor    WA        98277        2021
4353     1G1FZ6S08N   Thurston   Rochester    WA        98579        2022
4354     1N4BZ0CP4G       King   Covington    WA        98042        2016

          Make     Model        Electric Vehicle Type  \
```

```
0          TESLA    MODEL Y   Battery Electric Vehicle (BEV)
1          TESLA    MODEL Y   Battery Electric Vehicle (BEV)
2          TESLA    MODEL S   Battery Electric Vehicle (BEV)
3          TESLA    MODEL S   Battery Electric Vehicle (BEV)
4            NaN    MODEL Y   Battery Electric Vehicle (BEV)
…            …        …                      …
4350    HYUNDAI    IONIQ 6   Battery Electric Vehicle (BEV)
4351      TESLA    MODEL S   Battery Electric Vehicle (BEV)
4352      TESLA    MODEL 3   Battery Electric Vehicle (BEV)
4353  CHEVROLET    BOLT EV   Battery Electric Vehicle (BEV)
4354     NISSAN       LEAF   Battery Electric Vehicle (BEV)

      Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric Range  \
0              Clean Alternative Fuel Vehicle Eligible              291
1      Eligibility unknown as battery range has not b…                0
2                                                   NaN              270
3              Clean Alternative Fuel Vehicle Eligible              210
4      Eligibility unknown as battery range has not b…                0
…                                                     …                …
4350   Eligibility unknown as battery range has not b…                0
4351           Clean Alternative Fuel Vehicle Eligible              270
4352   Eligibility unknown as battery range has not b…                0
4353   Eligibility unknown as battery range has not b…                0
4354           Clean Alternative Fuel Vehicle Eligible               84

      Base MSRP  Legislative District  DOL Vehicle ID  \
0             0                    37       125701579
1             0                     1       244285107
2             0                    36       156773144
3             0                     5       165103011
4             0                    23       205138552
…             …                     …               …
4350          0                    45       260328554
4351          0                    41       202143378
4352          0                    10       181200813
4353          0                    20       211177039
4354          0                    47       176683636

                   Vehicle Location  \
0        POINT (-122.30839 47.610365)
1        POINT (-122.179458 47.802589)
2        POINT (-122.34848 47.632405)
3        POINT (-122.03646 47.534065)
4        POINT (-122.55717 47.733415)
…                         …
4350     POINT (-122.209285 47.71124)
4351     POINT (-122.16937 47.571015)
```

```
4352  POINT (-122.6788673 48.2897314)
4353     POINT (-123.09575 46.82114)
4354    POINT (-122.111625 47.36078)


                                    Electric Utility  2020 Census Tract
0       CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)        53033007800
1                            PUGET SOUND ENERGY INC        53061051938
2       CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)        53033006800
3       PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)       53033032104
4                            PUGET SOUND ENERGY INC        53035940100
...                                            ...                  ...
4350  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        53033021903
4351  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)        53033023902
4352                         PUGET SOUND ENERGY INC        53029970402
4353                         PUGET SOUND ENERGY INC        53067012730
4354  PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)         5303303200

[4280 rows x 17 columns]
```

3.9 1. Descriptive Statistics:

3.9.1 What are the mean, median, and standard deviation of the base MSRP for the vehicles in the dataset?

3.10 mean

```
[ ]: data['Base MSRP'].mean()
```

```
[ ]: 1119.917875508481
```

3.10.1 Median

```
[ ]: data['Base MSRP'].median()
```

```
[ ]: 0.0
```

Standard Deviation

```
[ ]: data['Base MSRP'].std()
```

```
[ ]: 8595.903627066002
```

3.11 2. Data Distribution:

3.12 What is the distribution of vehicle makes in the dataset? Represent it using a bar chart.

```
[ ]: data['Make'].value_counts()
```

```
[ ]: Make
     TESLA             6047
     NISSAN            1071
     CHEVROLET          935
     BMW                624
     FORD               556
     KIA                539
     TOYOTA             460
     HYUNDAI            359
     VOLKSWAGEN         346
     RIVIAN             307
     JEEP               306
     VOLVO              302
     AUDI               271
     CHRYSLER           137
     MERCEDES-BENZ      119
     PORSCHE            104
     MINI                69
     FIAT                63
     POLESTAR            56
     HONDA               50
     SUBARU              43
     MITSUBISHI          42
     DODGE               42
     LEXUS               29
     SMART               26
     CADILLAC            26
     MAZDA               25
     LINCOLN             15
     JAGUAR              13
     GENESIS             13
     LUCID               12
     LAND ROVER           5
     ALFA ROMEO           3
     FISKER               3
     GMC                  2
     TH!NK                1
     BENTLEY              1
     Name: count, dtype: int64
```

```
[ ]: data['Make'].value_counts().plot(kind='bar')
```

```
[ ]: <Axes: xlabel='Make'>
```
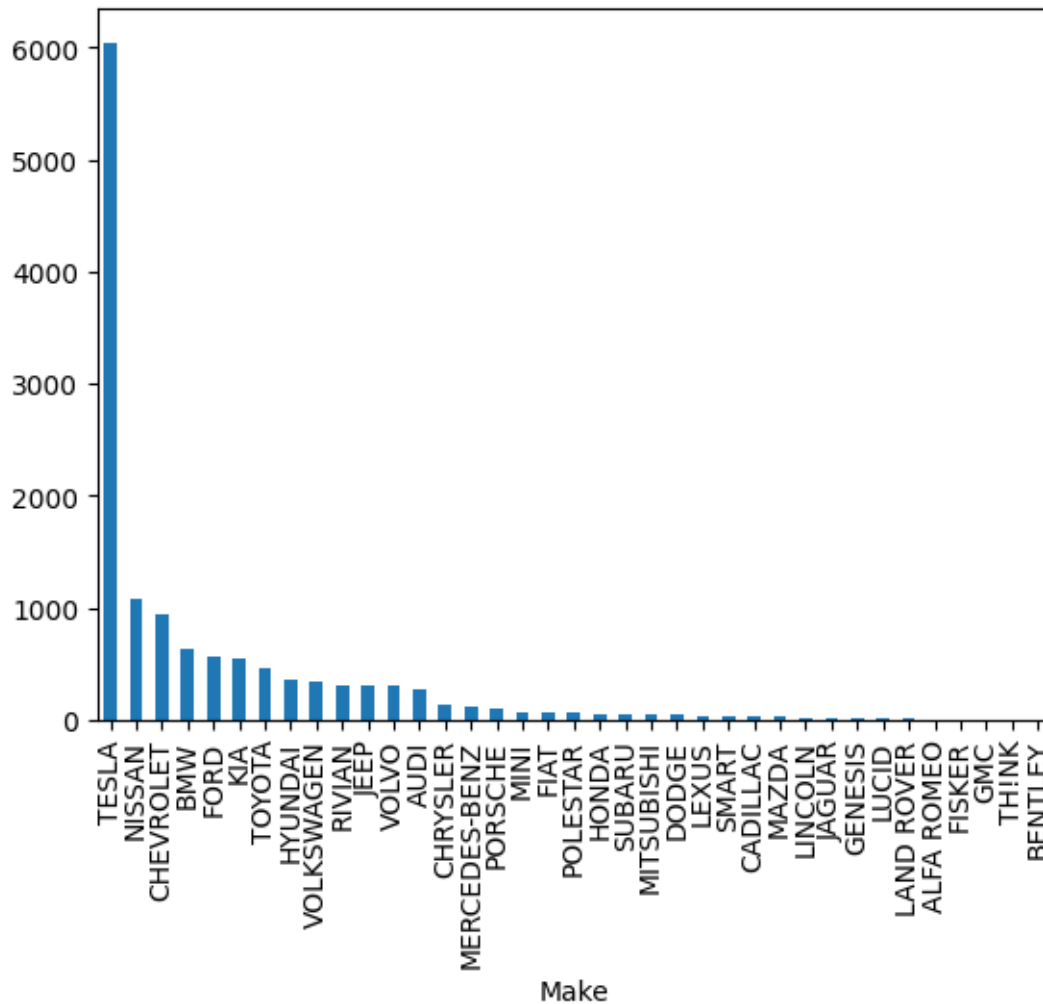
3.13 3. Model Year Analysis:

3.13.1 What are the most common model years in the dataset? Provide a frequency table and histogram.

```
[ ]: data['Model Year'].value_counts()
```

```
[ ]: Model Year
     2023    4169
     2022    2026
     2021    1388
     2018    1093
     2020     863
     2019     852
     2017     636
     2024     496
```

```
2016     431
2015     362
2013     321
2014     236
2012     103
2011      48
2010       3
2000       1
2008       1
Name: count, dtype: int64
```

[ ]: `data['Model Year'].value_counts().plot(kind='bar')`

[ ]: `<Axes: xlabel='Model Year'>`
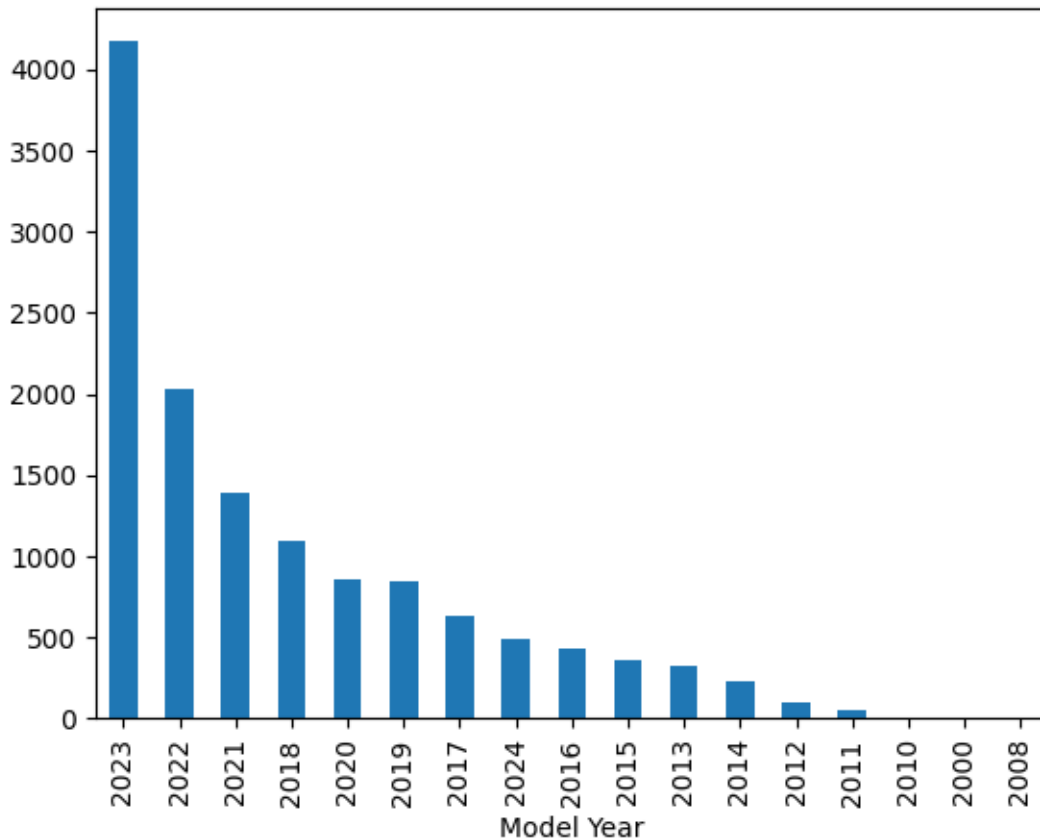
3.14 4. Electric Vehicle Type:

3.14.1 What is the proportion of Battery Electric Vehicles (BEV) versus other types of electric vehicles?

```
[ ]: data['Electric Vehicle Type'].value_counts()
```

```
[ ]: Electric Vehicle Type
     Battery Electric Vehicle (BEV)            10408
     Plug-in Hybrid Electric Vehicle (PHEV)     2615
     Name: count, dtype: int64
```

```
[ ]: data['Electric Vehicle Type'].value_counts().plot(kind='pie')
```

```
[ ]: <Axes: ylabel='count'>
```
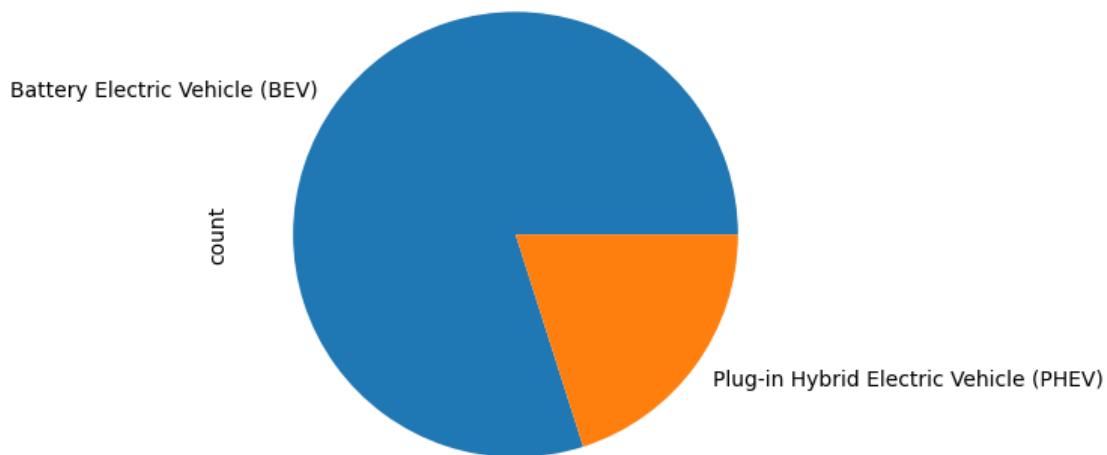

3.15 6. County Distribution:

3.15.1 How are vehicles distributed across different counties in Washington state? Represent the distribution using a pie chart.

```
[ ]: data['County'].value_counts()
```

```
[ ]: County
     King         92740
     Snohomish    21001
     Pierce       13782
     Clark        10416
     Thurston      6428
```

```
          ...
Sarpy            1
Suffolk          1
Beaufort         1
Meade            1
Hardin           1
Name: count, Length: 196, dtype: int64
```

```
[ ]: data['County'].value_counts().plot(kind='pie')
```

```
[ ]: <Axes: ylabel='count'>
```
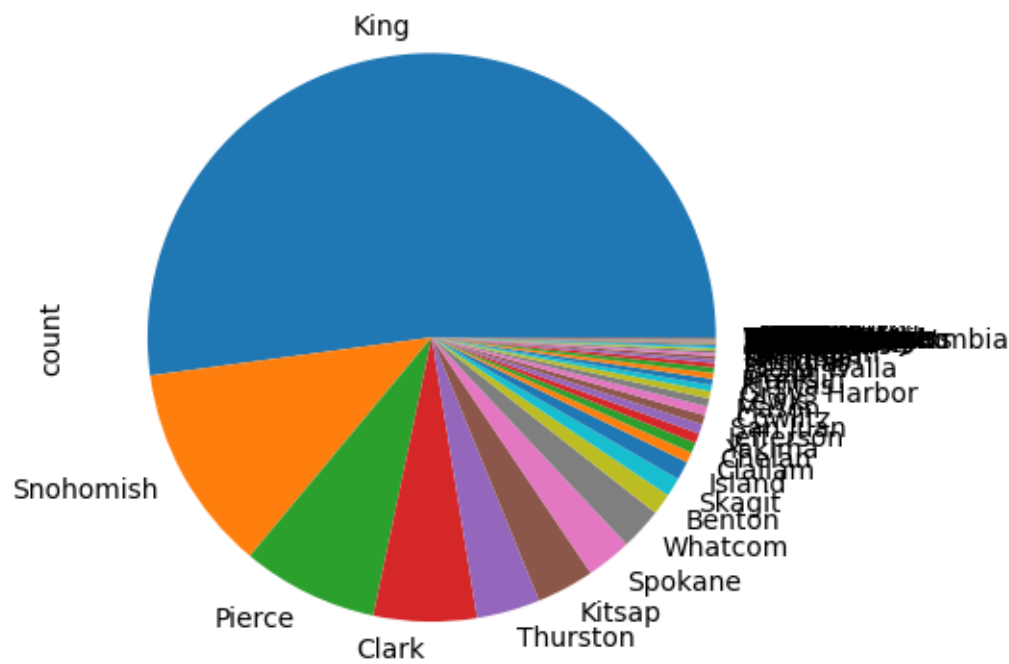

3.16 7. Price Analysis:

3.16.1 Compare the average base MSRP of vehicles eligible for the Clean Alternative Fuel Vehicle (CAFV) program versus those that are not.

```
[ ]: data.groupby('Clean Alternative Fuel Vehicle (CAFV) Eligibility')['Base MSRP'].
     ↪mean()
```

```
[ ]: Clean Alternative Fuel Vehicle (CAFV) Eligibility
     Clean Alternative Fuel Vehicle Eligible                     2028.133575
     Eligibility unknown as battery range has not been researched    0.000000
     Not eligible due to low battery range                       2877.020527
```

```
Name: Base MSRP, dtype: float64
```

```
[ ]: data.groupby('Clean Alternative Fuel Vehicle (CAFV) Eligibility')['Base MSRP'].
      ↪mean().plot(kind='bar')
```

```
[ ]: <Axes: xlabel='Clean Alternative Fuel Vehicle (CAFV) Eligibility'>
```

Clean Alternative Fuel Vehicle (CAFV) Eligibility
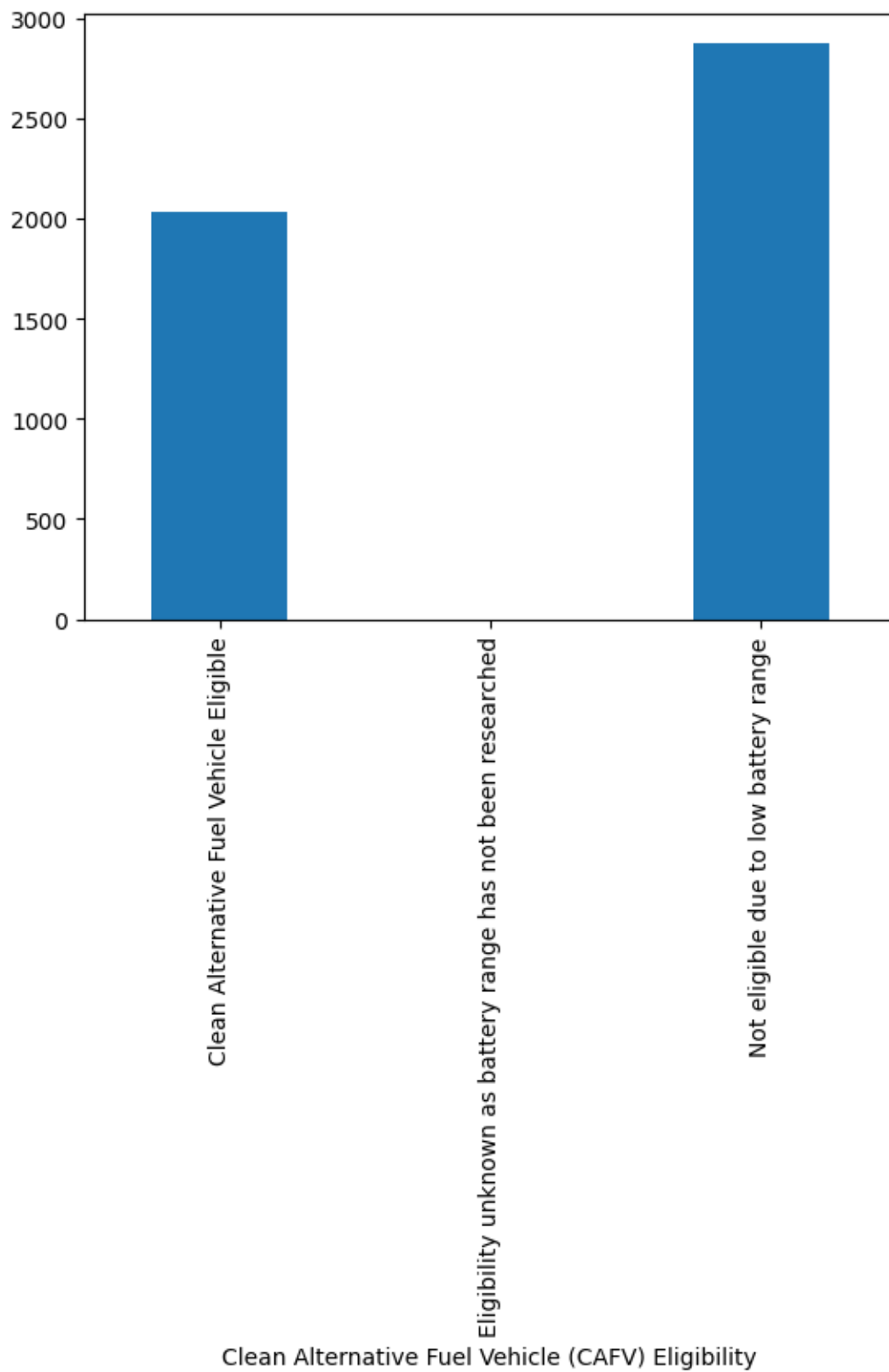
3.17   8. Geographical Analysis:

3.17.1   How does the base MSRP vary across different cities in Washington state

```python
data.groupby('City')['Base MSRP'].mean()
```

```
City
Algona            0.00000
Anacortes         0.00000
Ariel             0.00000
Arlington         0.00000
Auburn            0.00000
                   ...
Woodway           0.00000
Yacolt            0.00000
Yakima         2254.83871
Yelm              0.00000
Zillah            0.00000
Name: Base MSRP, Length: 122, dtype: float64
```

```python
data.groupby('City')['Base MSRP'].mean().plot(kind='bar')
```

```
<Axes: xlabel='City'>
```

3.18   9. Legislative Districts:

###Which legislative districts have the highest number of registered electric vehicles? Provide a ranked list.

```
[ ]: data['Legislative District'].value_counts()
```

```
[ ]: Legislative District
     45     538
     48     463
     41     447
     46     274
     1      204
     32     198
     11     189
```

```
43    188
17    181
18    173
23    159
47    156
36    148
37    102
34     95
33     85
22     82
21     72
49     70
44     60
5      57
35     43
26     43
20     41
24     37
30     37
2      34
10     28
14     26
39     26
19     23
15     20
7      11
31     11
13      9
38      6
12      5
9       4
16      4
3       2
40      2
?       1
6       1
Name: count, dtype: int64
```

[ ]: `data['Legislative District'].value_counts().plot(kind='bar')`

[ ]: `<Axes: xlabel='Legislative District'>`
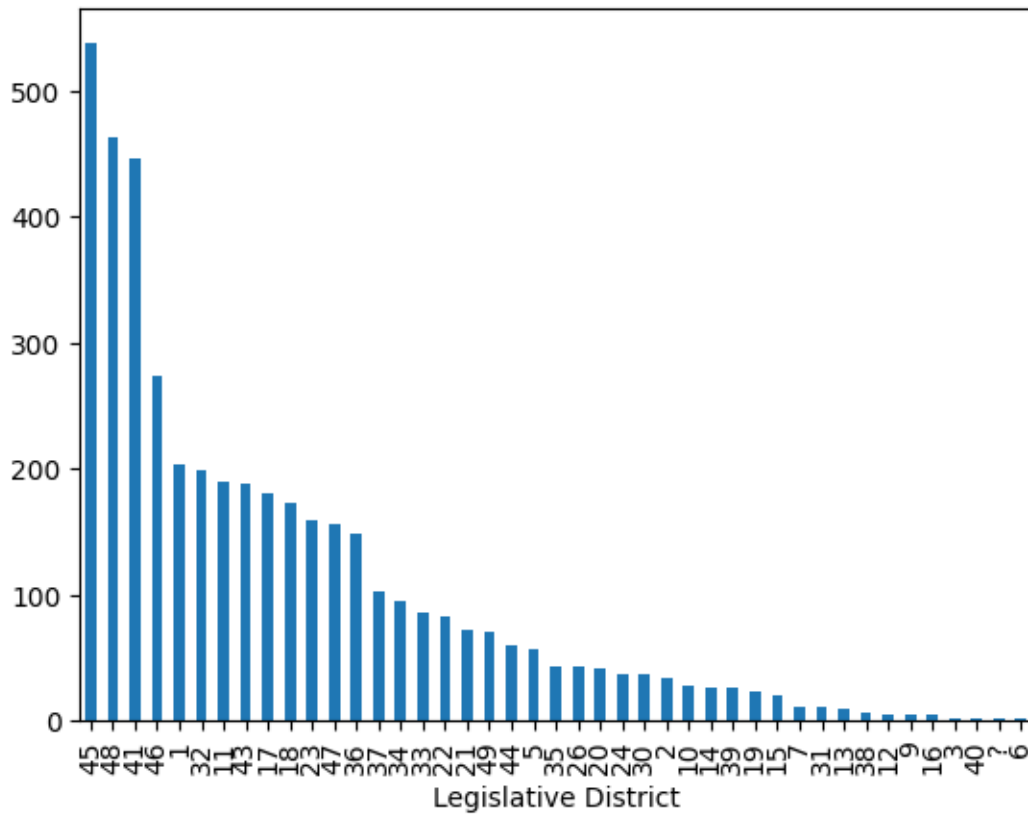
3.19 10. Electric Utility Providers:

3.19.1 What is the distribution of electric utility service providers for the vehicles in the dataset?

```python
data['Electric Utility'].value_counts()
```

```
Electric Utility
PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
2129
CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
1002
PUGET SOUND ENERGY INC
619
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLARK COUNTY - (WA)
418
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF COWLITZ COUNTY
47
PACIFICORP
46
BONNEVILLE POWER ADMINISTRATION||PUGET SOUND ENERGY INC||PUD NO 1 OF JEFFERSON
```

```
COUNTY          34
NO KNOWN ELECTRIC UTILITY SERVICE
11
BONNEVILLE POWER ADMINISTRATION||PUD 1 OF SNOHOMISH COUNTY
10
AVISTA CORP
8
BONNEVILLE POWER ADMINISTRATION||PACIFICORP||PUD NO 1 OF CLARK COUNTY - (WA)
8
PUD NO 2 OF GRANT COUNTY
6
PUD NO 1 OF CHELAN COUNTY
5
BONNEVILLE POWER ADMINISTRATION||PACIFICORP||BENTON RURAL ELECTRIC ASSN
4
MODERN ELECTRIC WATER COMPANY
3
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLALLAM COUNTY
2
PUD NO 1 OF PEND OREILLE COUNTY
1
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF MASON COUNTY|PUD NO 1 OF JEFFERSON
COUNTY          1
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF KLICKITAT COUNTY
1
Name: count, dtype: int64
```

```python
data['Electric Utility'].value_counts().plot(kind='bar')
```

```
<Axes: xlabel='Electric Utility'>
```

Electric Utility
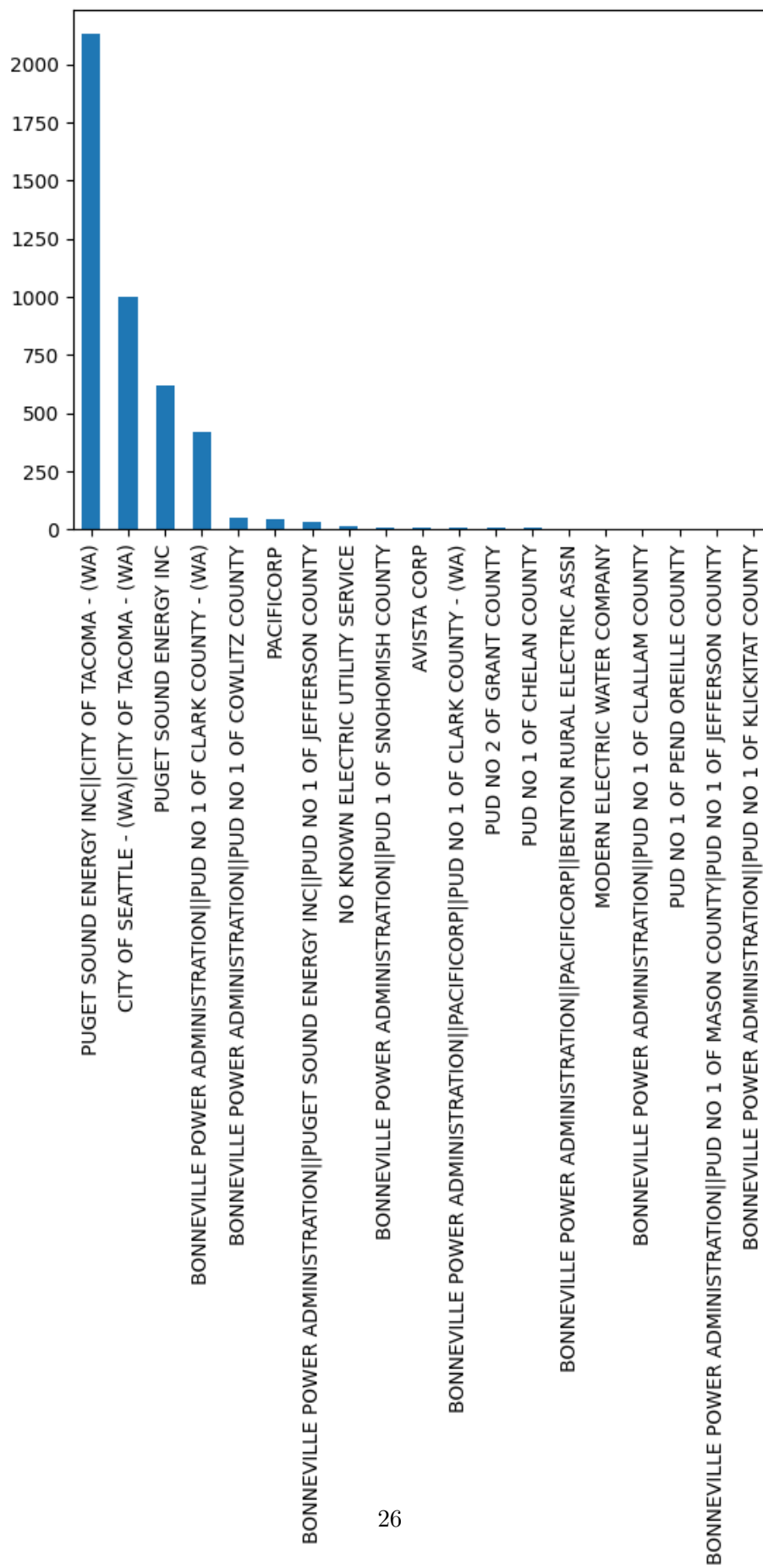
3.20 11. Census Tract Analysis:

3.20.1 How are vehicles distributed across different 2020 Census Tracts? Provide insights based on vehicle counts per tract.

```
[ ]: data['2020 Census Tract'].value_counts()
```

```
[ ]: 2020 Census Tract
     53033028200    74
     53033022603    63
     53033032321    62
     53033032323    53
     53033021904    50
                    ..
     53051970500     1
     53011040413     1
     53035091701     1
     53057940302     1
     5303303200      1
     Name: count, Length: 712, dtype: int64
```

```
[ ]: data['2020 Census Tract'].value_counts().plot(kind='bar')
```

```
[ ]: <Axes: xlabel='2020 Census Tract'>
```

2020 Census Tract
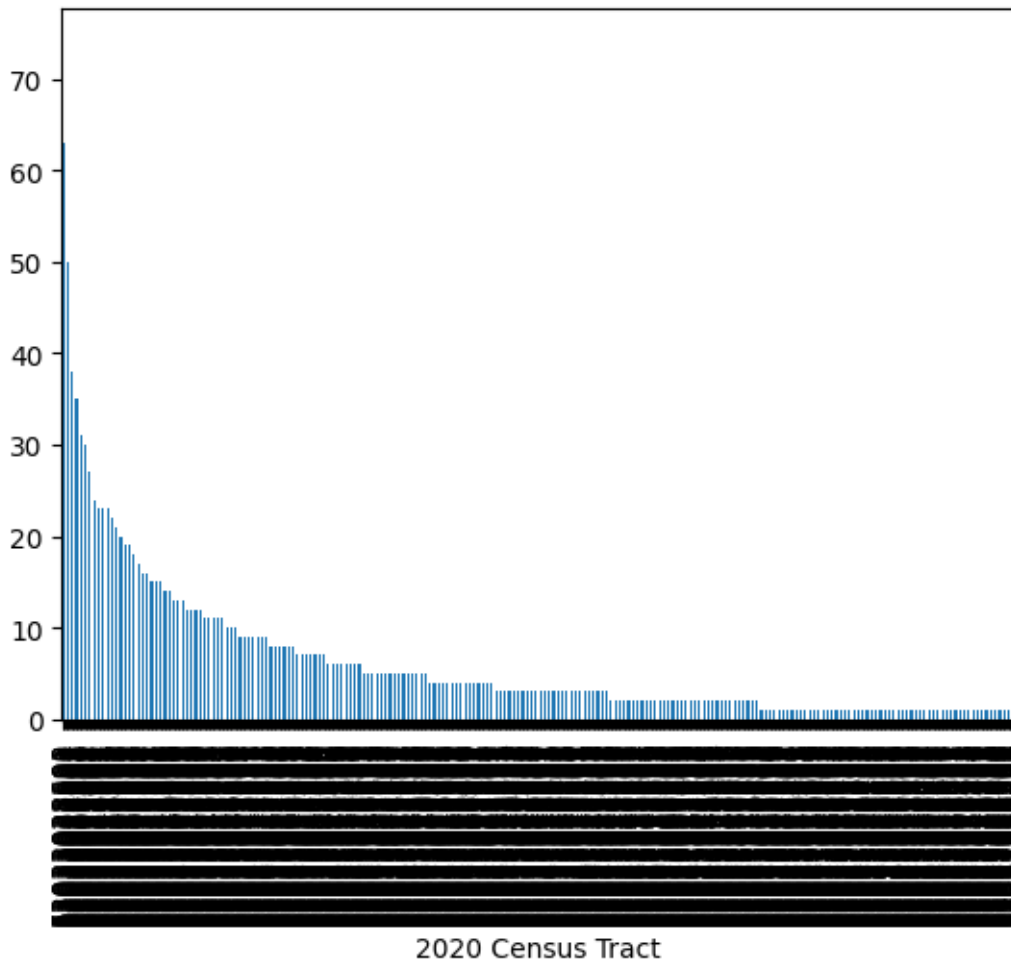
3.21 12. Electric Range Correlation:

3.21.1 Is there a correlation between the electric range and the base MSRP of the vehicles? Provide the correlation coefficient and interpret the result.

[ ]:

[ ]:

3.22 14. Eligibility Status:

3.22.1 What percentage of vehicles are eligible for the Clean Alternative Fuel Vehicle (CAFV) program?

```
[ ]:  data['Clean Alternative Fuel Vehicle (CAFV) Eligibility'].value_counts()
```

```
[ ]: Clean Alternative Fuel Vehicle (CAFV) Eligibility
     Eligibility unknown as battery range has not been researched    2229
     Clean Alternative Fuel Vehicle Eligible                         1690
     Not eligible due to low battery range                            434
     Name: count, dtype: int64
```

```
[ ]: data['Clean Alternative Fuel Vehicle (CAFV) Eligibility'].value_counts().
     ↪plot(kind='pie')
```

```
[ ]: <Axes: ylabel='count'>
```
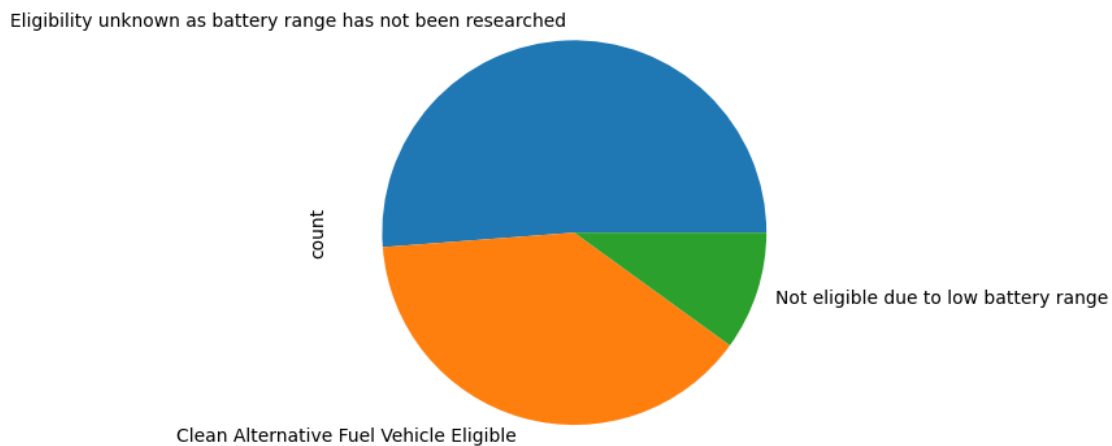

3.23   15. Model Popularity:

3.23.1   Which vehicle models are the most popular in the dataset? Provide a frequency table of the top 10 models.

```
[ ]: data['Model'].value_counts()
```

```
[ ]: Model
     MODEL Y      893
     MODEL 3      799
     LEAF         378
     MODEL S      190
     MODEL X      158
                  …
     CROSSTREK      1
     I-MIEV         1
     I5             1
     TONALE         1
     740E           1
```

```
Name: count, Length: 110, dtype: int64
```

```
[ ]: data['Model'].value_counts().head(10)
```

```
[ ]: Model
     MODEL Y      893
     MODEL 3      799
     LEAF         378
     MODEL S      190
     MODEL X      158
     BOLT EV      156
     VOLT          98
     X5            89
     WRANGLER      89
     ID.4          79
     Name: count, dtype: int64
```
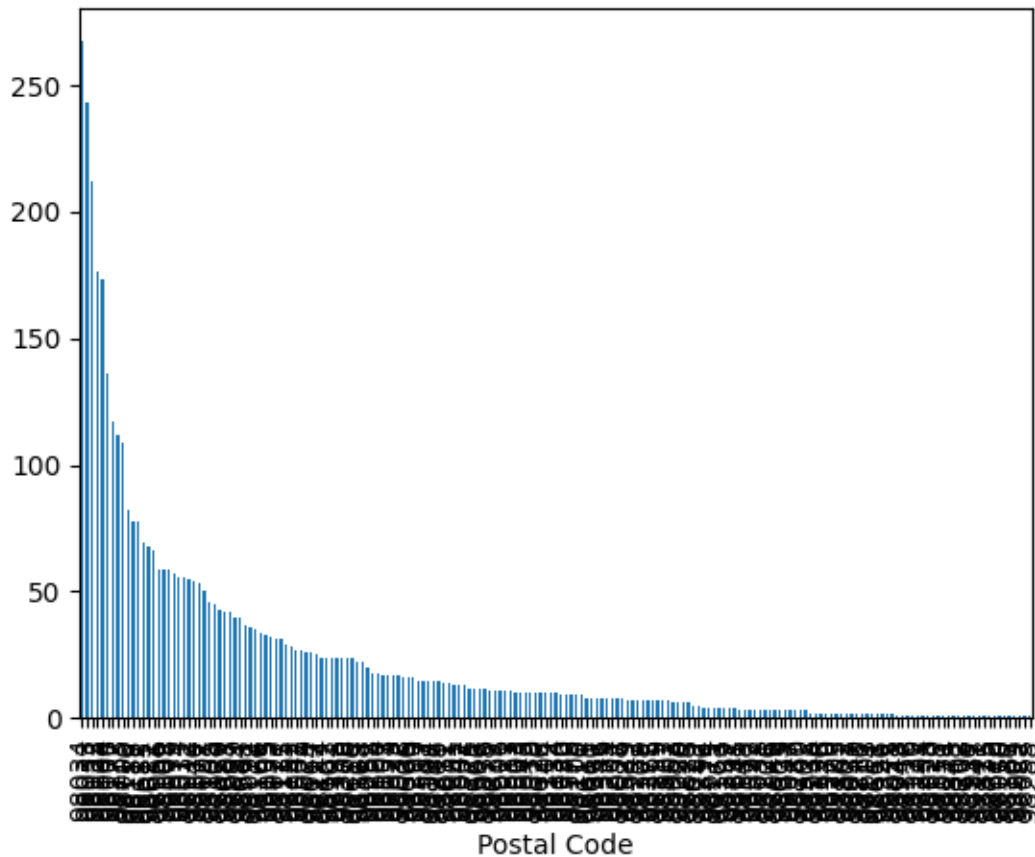
3.24   16. Postal Code Distribution:

3.24.1   How are vehicles distributed across different postal codes? Provide a heatmap or density plot.

```
[ ]: data['Postal Code'].value_counts()
```

```
[ ]: Postal Code
     98034     267
     98033     243
     98052     212
     98125     176
     98004     173
                ...
     98382       1
     99109       1
     98922       1
     98053       1
     98288       1
     Name: count, Length: 187, dtype: int64
```

```
[ ]: data['Postal Code'].value_counts().plot(kind='bar')
```

```
[ ]: <Axes: xlabel='Postal Code'>
```

3.25 17. Vehicle Location Analysis:

3.25.1 Analyze the geographic coordinates to determine any clusters of electric vehicles in certain areas of Washington state.

```
[ ]: data['Vehicle Location'].value_counts()
```

```
[ ]: Vehicle Location
     POINT (-122.209285 47.71124)        267
     POINT (-122.20264 47.6785)          243
     POINT (-122.12302 47.67668)         212
     POINT (-122.296385 47.71558)        176
     POINT (-122.201905 47.61385)        173
                                          …
     POINT (-123.105015 48.08125)          1
     POINT (-117.722145 48.27719)          1
     POINT (-120.938305 47.195355)         1
     POINT (-122.0222799 47.6958998)       1
     POINT (-121.360745 47.709505)         1
     Name: count, Length: 187, dtype: int64
```

```
data['Vehicle Location'].value_counts().plot(kind='bar')
```

```
<Axes: xlabel='Vehicle Location'>
```
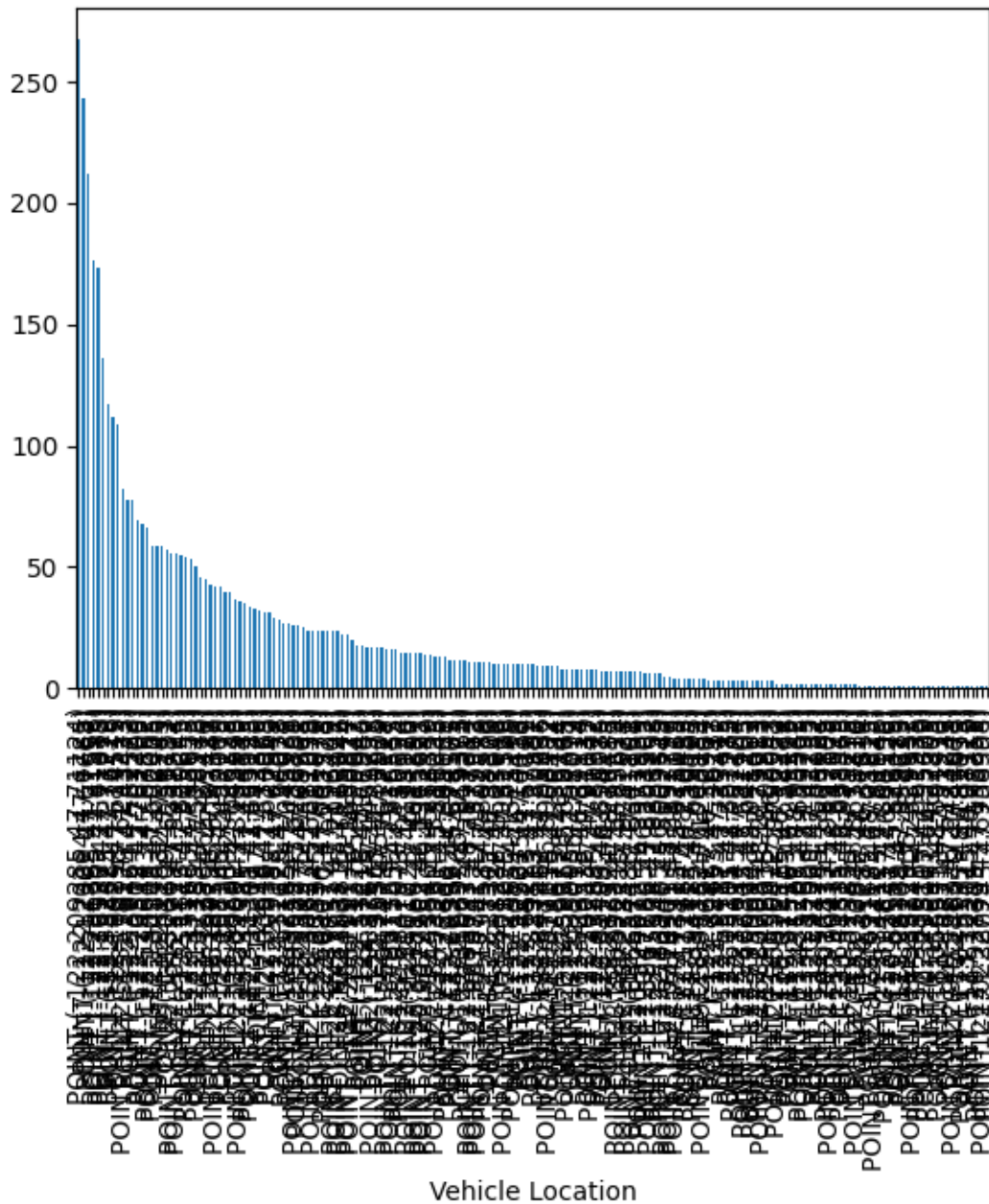
3.26 18. Model Year Trend:

3.26.1 Analyze the trend in the number of registered electric vehicles by model year. Provide a line chart to show any increase or decrease over the years.

```
[ ]: data['Model Year'].value_counts()
```

```
[ ]: Model Year
     2023    1389
     2022     662
     2021     469
     2018     390
     2019     308
     2020     285
     2017     193
     2024     156
     2016     144
     2015     125
     2013     114
     2014      71
     2012      34
     2011      15
     Name: count, dtype: int64
```

3.27 19. Range vs. Year:

3.27.1 Is there a trend between the model year and the electric range of the vehicles? Provide a scatter plot and analyze the trend.

```
[ ]: data['Model Year'].value_counts()
```

```
[ ]: Model Year
     2023    1389
     2022     662
     2021     469
     2018     390
     2019     308
     2020     285
     2017     193
     2024     156
     2016     144
     2015     125
     2013     114
     2014      71
     2012      34
     2011      15
     Name: count, dtype: int64
```

```
[ ]: data['Electric Range'].value_counts()
```

```
[ ]: Electric Range
     0        2228
     215       193
     220       110
     84         99
     21         88
             …
     110        1
     62         1
     ?          1
     68         1
     203        1
     Name: count, Length: 89, dtype: int64
```

3.28 20) Legislative District and MSRP:

3.28.1 How does the average base MSRP vary across different legislative districts?

```
[ ]: data['Legislative District'].value_counts()
```

```
[ ]: Legislative District
     45     538
     48     463
     41     447
     46     274
     1      204
     32     198
     11     189
     43     188
     17     181
     18     173
     23     159
     47     156
     36     148
     37     102
     34      95
     33      85
     22      82
     21      72
     49      70
     44      60
     5       57
     35      43
     26      43
     20      41
     24      37
     30      37
     2       34
```

```
10      28
14      26
39      26
19      23
15      20
7       11
31      11
13       9
38       6
12       5
9        4
16       4
3        2
40       2
?        1
6        1
Name: count, dtype: int64
```