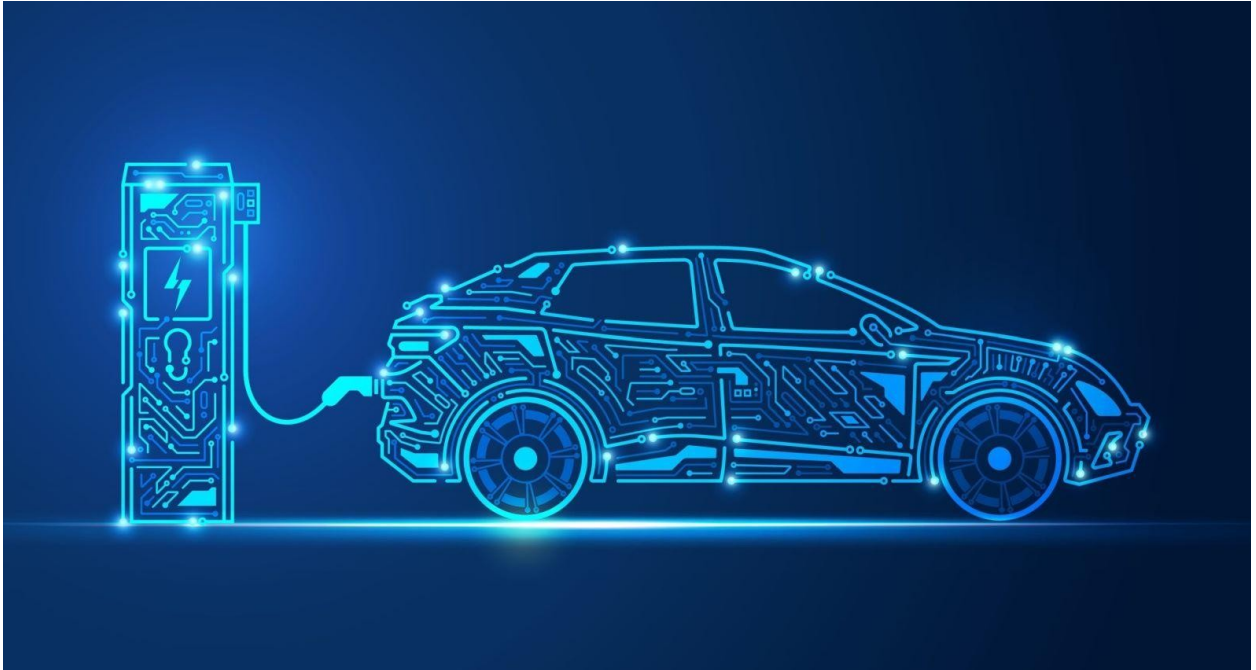# Electric Cars EDA with Feature Engineering

Submitted by: Rohan Negi

Submitted to: Neeraj Sharma

Objective

Problem

Electric cars are a promising solution to reduce carbon emissions and promote sustainability. However, their adoption faces challenges such as high costs, limited range, and insufficient charging infrastructure. Understanding the current market is crucial to addressing these issues and boosting electric car adoption.

Agitation

This analysis dives into the electric car market, examining factors like location, make, and model distributions, eligibility for clean fuel incentives, and the role of utility companies. It also explores price ranges and identifies gaps in charging infrastructure that limit widespread adoption.

Benefits

By addressing these barriers, the study provides actionable recommendations for increasing electric car adoption. These changes can reduce carbon emissions, promote sustainable transportation, and pave the way for a greener future with a positive environmental impact.

Import Necessary Libraries

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
```

Loading Dataset

```python
df = pd.read_csv("D:/SC
projects/Electric_Vehicle_Population_Data.csv")
df
```

	VIN (1-10)	County	City	State	Postal Code	Model Year
0	5YJ3E1EB4L	Yakima	Yakima	WA	98908.0	2020
1	5YJ3E1EA7K	San Diego	San Diego	CA	92101.0	2019
2	7JRBR0FL9M	Lane	Eugene	OR	97404.0	

```
2021
3         5YJXCBE21K       Yakima        Yakima     WA       98908.0
2019
4         5UXKT0C5XH     Snohomish       Bothell     WA       98021.0
2017
...              ...           ...           ...     ...          ...
...
124711  5YJ3E1EB6N     Snohomish        Monroe     WA       98272.0
2022
124712  KNDCM3LD2L       Pierce        Tacoma     WA       98406.0
2020
124713  7SAYGDEE0P      Whatcom     Bellingham     WA       98226.0
2023
124714  1G1FW6S03J       Pierce        Tacoma     WA       98444.0
2018
124715  1G1RC6E47F       Benton    Benton City     WA       99320.0
2015

             Make     Model                     Electric Vehicle Type  \
0            TESLA   MODEL 3          Battery Electric Vehicle (BEV)
1            TESLA   MODEL 3          Battery Electric Vehicle (BEV)
2            VOLVO       S60  Plug-in Hybrid Electric Vehicle (PHEV)
3            TESLA   MODEL X          Battery Electric Vehicle (BEV)
4              BMW        X5  Plug-in Hybrid Electric Vehicle (PHEV)
...            ...       ...                                     ...
124711       TESLA   MODEL 3          Battery Electric Vehicle (BEV)
124712         KIA      NIRO  Plug-in Hybrid Electric Vehicle (PHEV)
124713       TESLA   MODEL Y          Battery Electric Vehicle (BEV)
124714  CHEVROLET   BOLT EV          Battery Electric Vehicle (BEV)
124715  CHEVROLET      VOLT  Plug-in Hybrid Electric Vehicle (PHEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
0                 Clean Alternative Fuel Vehicle Eligible
322
1                 Clean Alternative Fuel Vehicle Eligible
220
2                       Not eligible due to low battery range
22
3                 Clean Alternative Fuel Vehicle Eligible
289
4                       Not eligible due to low battery range
14
...                                                     ...
...
124711  Eligibility unknown as battery range has not b...
0
124712                  Not eligible due to low battery range
26
```

```
124713  Eligibility unknown as battery range has not b...
0
124714           Clean Alternative Fuel Vehicle Eligible
238
124715           Clean Alternative Fuel Vehicle Eligible
38

        Base MSRP  Legislative District  DOL Vehicle ID  \
0               0                  14.0       127175366
1               0                   NaN       266614659
2               0                   NaN       144502018
3               0                  14.0       477039944
4               0                   1.0       106314946
...           ...                   ...             ...
124711          0                  39.0       192999061
124712          0                  27.0       113346250
124713          0                  42.0       232751305
124714          0                  29.0       102589007
124715          0                  16.0       476974718

               Vehicle Location  \
0       POINT (-120.56916 46.58514)
1       POINT (-117.16171 32.71568)
2       POINT (-123.12802 44.09573)
3       POINT (-120.56916 46.58514)
4        POINT (-122.18384 47.8031)
...                          ...
124711   POINT (-121.98087 47.8526)
124712  POINT (-122.52054 47.26887)
124713   POINT (-122.49756 48.7999)
124714  POINT (-122.46495 47.16778)
124715  POINT (-119.48756 46.26543)

                                  Electric Utility  2020 Census
Tract
0                                       PACIFICORP
5.307700e+10
1                                              NaN
6.073005e+09
2                                              NaN
4.103900e+10
3                                       PACIFICORP
5.307700e+10
4                             PUGET SOUND ENERGY INC
5.306105e+10
...                                            ...
...
124711                        PUGET SOUND ENERGY INC
5.306105e+10
124712  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
```

```
                                                          5.305306e+10
124713  PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM CO...
                                                          5.307300e+10
124714  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
                                                          5.305307e+10
124715  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF B...
                                                          5.300501e+10

[124716 rows x 17 columns]
```

df.head(15)

```
     VIN (1-10)     County         City State   Postal Code   Model Year
\
0    5YJ3E1EB4L     Yakima        Yakima    WA       98908.0         2020

1    5YJ3E1EA7K  San Diego     San Diego    CA       92101.0         2019

2    7JRBR0FL9M       Lane        Eugene    OR       97404.0         2021

3    5YJXCBE21K     Yakima        Yakima    WA       98908.0         2019

4    5UXKT0C5XH  Snohomish       Bothell    WA       98021.0         2017

5    1N4AZ0CP4F  Snohomish       Everett    WA       98201.0         2015

6    5YJ3E1EBXJ     Kitsap       Poulsbo    WA       98370.0         2018

7    WDC0G5EB0K     Yakima        Naches    WA       98937.0         2019

8    1N4AZ0CP3D     Kitsap   Port Orchard   WA       98366.0         2013

9    KNDCC3LD9K     Kitsap        Olalla    WA       98359.0         2019

10   KNDJX3AE8G  Snohomish       Bothell    WA       98012.0         2016

11   KNDC3DLCXN   Thurston       Olympia    WA       98502.0         2022

12   1G1RB6S59J  Snohomish     Marysville   WA       98270.0         2018

13   5YJSA1CG3D  Riverside         Indio    CA       92201.0         2013

14   1FADP3R48H       Kern      Rosamond    CA       93560.0         2017


           Make        Model                   Electric Vehicle
Type   \
0          TESLA     MODEL 3          Battery Electric Vehicle (BEV)

1          TESLA     MODEL 3          Battery Electric Vehicle (BEV)
```

2	VOLVO	S60	Plug-in Hybrid Electric Vehicle (PHEV)
3	TESLA	MODEL X	Battery Electric Vehicle (BEV)
4	BMW	X5	Plug-in Hybrid Electric Vehicle (PHEV)
5	NISSAN	LEAF	Battery Electric Vehicle (BEV)
6	TESLA	MODEL 3	Battery Electric Vehicle (BEV)
7	MERCEDES-BENZ	GLC-CLASS	Plug-in Hybrid Electric Vehicle (PHEV)
8	NISSAN	LEAF	Battery Electric Vehicle (BEV)
9	KIA	NIRO	Plug-in Hybrid Electric Vehicle (PHEV)
10	KIA	SOUL	Battery Electric Vehicle (BEV)
11	KIA	EV6	Battery Electric Vehicle (BEV)
12	CHEVROLET	VOLT	Plug-in Hybrid Electric Vehicle (PHEV)
13	TESLA	MODEL S	Battery Electric Vehicle (BEV)
14	FORD	FOCUS	Battery Electric Vehicle (BEV)

	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric Range \
0	Clean Alternative Fuel Vehicle Eligible	322
1	Clean Alternative Fuel Vehicle Eligible	220
2	Not eligible due to low battery range	22
3	Clean Alternative Fuel Vehicle Eligible	289
4	Not eligible due to low battery range	14
5	Clean Alternative Fuel Vehicle Eligible	84
6	Clean Alternative Fuel Vehicle Eligible	215
7	Not eligible due to low battery range	10
8	Clean Alternative Fuel Vehicle Eligible	75
9	Not eligible due to low battery range	26
10	Clean Alternative Fuel Vehicle Eligible	93
11	Eligibility unknown as battery range has not b...	0

```
12             Clean Alternative Fuel Vehicle Eligible                53

13             Clean Alternative Fuel Vehicle Eligible               208

14             Clean Alternative Fuel Vehicle Eligible               100


    Base MSRP  Legislative District  DOL Vehicle ID  \
0           0                  14.0       127175366
1           0                   NaN       266614659
2           0                   NaN       144502018
3           0                  14.0       477039944
4           0                   1.0       106314946
5           0                  38.0       107901699
6           0                  23.0       475036313
7           0                  14.0       338148968
8           0                  26.0       249239623
9           0                  26.0       475609368
10      31950                  21.0       442691672
11          0                  22.0       202289321
12          0                  44.0       207571087
13      69900                   NaN       239204752
14          0                   NaN       218307183

               Vehicle Location        Electric Utility  2020 Census
Tract
0    POINT (-120.56916 46.58514)             PACIFICORP
5.307700e+10
1    POINT (-117.16171 32.71568)                    NaN
6.073005e+09
2    POINT (-123.12802 44.09573)                    NaN
4.103900e+10
3    POINT (-120.56916 46.58514)             PACIFICORP
5.307700e+10
4     POINT (-122.18384 47.8031)  PUGET SOUND ENERGY INC
5.306105e+10
5    POINT (-122.20596 47.97659)  PUGET SOUND ENERGY INC
5.306104e+10
6    POINT (-122.64681 47.73689)  PUGET SOUND ENERGY INC
5.303594e+10
7     POINT (-120.69972 46.7309)             PACIFICORP
5.307700e+10
8    POINT (-122.63847 47.54103)  PUGET SOUND ENERGY INC
5.303509e+10
9    POINT (-122.54729 47.42602)  PUGET SOUND ENERGY INC
5.303509e+10
10   POINT (-122.21061 47.83448)  PUGET SOUND ENERGY INC
5.306105e+10
11   POINT (-122.92333 47.03779)  PUGET SOUND ENERGY INC
```

```
5.306701e+10
12   POINT (-122.1769 48.06114)   PUGET SOUND ENERGY INC
5.306105e+10
13  POINT (-116.21942 33.72213)                           NaN
6.065046e+09
14  POINT (-118.16344 34.86438)                           NaN
6.029006e+09

df.tail(15)

        VIN (1-10)      County       City State   Postal Code   Model
Year  \
124701   JTMEB3FV7N    Snohomish    Lynnwood    WA      98036.0
2022
124702   KL8CL6S06E     Clallam      Sequim     WA      98382.0
2014
124703   5YJ3E1EB6J      Lewis      Chehalis    WA      98532.0
2018
124704   1N4AZ0CP0F     Chelan       Chelan     WA      98816.0
2015
124705   5YJ3E1EA6L    Snohomish    Bothell     WA      98012.0
2020
124706   YV4ED3GB7N     Pierce       Tacoma     WA      98422.0
2022
124707   1C4RJYC61N      Grant      Ephrata     WA      98823.0
2022
124708   WBY1Z4C54G      King       Seattle     WA      98144.0
2016
124709   WA1VAAGE9M     Whatcom    Bellingham   WA      98229.0
2021
124710   5YJ3E1EAXM    Snohomish    Lynnwood    WA      98037.0
2021
124711   5YJ3E1EB6N    Snohomish    Monroe      WA      98272.0
2022
124712   KNDCM3LD2L     Pierce       Tacoma     WA      98406.0
2020
124713   7SAYGDEE0P     Whatcom    Bellingham   WA      98226.0
2023
124714   1G1FW6S03J     Pierce       Tacoma     WA      98444.0
2018
124715   1G1RC6E47F     Benton    Benton City   WA      99320.0
2015

              Make          Model                  Electric Vehicle
Type  \
124701      TOYOTA       RAV4 PRIME   Plug-in Hybrid Electric Vehicle
(PHEV)
124702   CHEVROLET         SPARK          Battery Electric Vehicle
(BEV)
124703       TESLA        MODEL 3          Battery Electric Vehicle
```

```
               (BEV)
124704      NISSAN                LEAF        Battery Electric Vehicle
               (BEV)
124705       TESLA             MODEL 3        Battery Electric Vehicle
               (BEV)
124706       VOLVO                 C40        Battery Electric Vehicle
               (BEV)
124707        JEEP   GRAND CHEROKEE  Plug-in Hybrid Electric Vehicle
               (PHEV)
124708         BMW                  I3  Plug-in Hybrid Electric Vehicle
               (PHEV)
124709        AUDI              E-TRON        Battery Electric Vehicle
               (BEV)
124710       TESLA             MODEL 3        Battery Electric Vehicle
               (BEV)
124711       TESLA             MODEL 3        Battery Electric Vehicle
               (BEV)
124712         KIA                NIRO  Plug-in Hybrid Electric Vehicle
               (PHEV)
124713       TESLA             MODEL Y        Battery Electric Vehicle
               (BEV)
124714   CHEVROLET             BOLT EV        Battery Electric Vehicle
               (BEV)
124715   CHEVROLET                VOLT  Plug-in Hybrid Electric Vehicle
               (PHEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range   \
124701              Clean Alternative Fuel Vehicle Eligible
42
124702              Clean Alternative Fuel Vehicle Eligible
82
124703              Clean Alternative Fuel Vehicle Eligible
215
124704              Clean Alternative Fuel Vehicle Eligible
84
124705              Clean Alternative Fuel Vehicle Eligible
266
124706  Eligibility unknown as battery range has not b...
0
124707              Not eligible due to low battery range
25
124708              Clean Alternative Fuel Vehicle Eligible
72
124709  Eligibility unknown as battery range has not b...
0
124710  Eligibility unknown as battery range has not b...
0
124711  Eligibility unknown as battery range has not b...
```

```
0
124712              Not eligible due to low battery range
26
124713  Eligibility unknown as battery range has not b...
0
124714              Clean Alternative Fuel Vehicle Eligible
238
124715              Clean Alternative Fuel Vehicle Eligible
38

        Base MSRP  Legislative District  DOL Vehicle ID  \
124701          0                  32.0       192604814
124702          0                  24.0       115801689
124703          0                  20.0       473639225
124704          0                  12.0       134852315
124705          0                  44.0       110108841
124706          0                  27.0       204890073
124707          0                  13.0       224079530
124708          0                  37.0       148555137
124709          0                  40.0       152586290
124710          0                  32.0       233874014
124711          0                  39.0       192999061
124712          0                  27.0       113346250
124713          0                  42.0       232751305
124714          0                  29.0       102589007
124715          0                  16.0       476974718

                   Vehicle Location  \
124701  POINT (-122.29245 47.82557)
124702  POINT (-123.10367 48.07965)
124703   POINT (-122.96462 46.6621)
124704  POINT (-120.01454 47.83985)
124705  POINT (-122.21061 47.83448)
124706  POINT (-122.41666 47.30682)
124707  POINT (-119.55125 47.31867)
124708  POINT (-122.30866 47.57874)
124709  POINT (-122.45516 48.74487)
124710  POINT (-122.27734 47.83785)
124711   POINT (-121.98087 47.8526)
124712  POINT (-122.52054 47.26887)
124713   POINT (-122.49756 48.7999)
124714  POINT (-122.46495 47.16778)
124715  POINT (-119.48756 46.26543)

                                    Electric Utility  2020 Census
Tract
124701                     PUGET SOUND ENERGY INC
5.306105e+10
124702  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF C...
5.300900e+10
```

```
124703        PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.304197e+10
124704                          PUD NO 1 OF CHELAN COUNTY
5.300796e+10
124705                             PUGET SOUND ENERGY INC
5.306105e+10
124706  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305394e+10
124707                          PUD NO 2 OF GRANT COUNTY
5.302501e+10
124708        CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
124709  PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM CO...
5.307300e+10
124710                             PUGET SOUND ENERGY INC
5.306105e+10
124711                             PUGET SOUND ENERGY INC
5.306105e+10
124712  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305306e+10
124713  PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM CO...
5.307300e+10
124714  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305307e+10
124715  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF B...
5.300501e+10
```

Performing basic operations

```
df.size

2120172

df.shape

(124716, 17)

df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 124716 entries, 0 to 124715
Data columns (total 17 columns):
 #   Column                                       Non-Null Count
Dtype
---  ------                                       --------------
-----
 0   VIN (1-10)                                   124716 non-
null  object
 1   County                                       124714 non-
null  object
```

```
 2   City                                              124714 non-
null  object
 3   State                                             124716 non-
null  object
 4   Postal Code                                       124714 non-
null  float64
 5   Model Year                                        124716 non-
null  int64
 6   Make                                              124716 non-
null  object
 7   Model                                             124535 non-
null  object
 8   Electric Vehicle Type                             124716 non-
null  object
 9   Clean Alternative Fuel Vehicle (CAFV) Eligibility 124716 non-
null  object
 10  Electric Range                                    124716 non-
null  int64
 11  Base MSRP                                         124716 non-
null  int64
 12  Legislative District                              124419 non-
null  float64
 13  DOL Vehicle ID                                    124716 non-
null  int64
 14  Vehicle Location                                  124687 non-
null  object
 15  Electric Utility                                  124243 non-
null  object
 16  2020 Census Tract                                 124714 non-
null  float64
dtypes: float64(3), int64(4), object(10)
memory usage: 16.2+ MB

df.describe().T

                             count          mean           std
min  \
Postal Code             124714.0   9.816383e+04   2.550123e+03
1.730000e+03
Model Year              124716.0   2.019406e+03   2.976174e+00
1.997000e+03
Electric Range          124716.0   7.947194e+01   1.003320e+02
0.000000e+00
Base MSRP               124716.0   1.556069e+03   1.005329e+04
0.000000e+00
Legislative District    124419.0   2.966448e+01   1.474952e+01
1.000000e+00
DOL Vehicle ID          124716.0   2.040790e+08   8.882569e+07
4.385000e+03
2020 Census Tract       124714.0   5.297079e+10   1.652363e+09
```

```
1.081042e+09
```

	25%	50%	75%
max			
Postal Code	9.805200e+04	9.812100e+04	9.837000e+04
9.970100e+04			
Model Year	2.018000e+03	2.020000e+03	2.022000e+03
2.023000e+03			
Electric Range	0.000000e+00	2.500000e+01	2.000000e+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			
DOL Vehicle ID	1.541015e+08	1.995558e+08	2.275165e+08
4.792548e+08			
2020 Census Tract	5.303301e+10	5.303303e+10	5.305307e+10
5.603300e+10			

```python
df.duplicated().sum()
```

```
0
```

Checking Null and Blank Values

```python
df.isna().sum()
```

```
VIN (1-10)                                           0
County                                               2
City                                                 2
State                                                0
Postal Code                                          2
Model Year                                           0
Make                                                 0
Model                                              181
Electric Vehicle Type                                0
Clean Alternative Fuel Vehicle (CAFV) Eligibility    0
Electric Range                                       0
Base MSRP                                            0
Legislative District                               297
DOL Vehicle ID                                       0
Vehicle Location                                    29
Electric Utility                                   473
2020 Census Tract                                    2
dtype: int64
```

```python
blank_values = (df==" ").sum()
print('Blank Values count:\n',blank_values)
```

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

Handling Null values

Checking null values in County column

```
df[df['County'].isnull()]

        VIN (1-10) County City State  Postal Code  Model Year
Make  \
104754   5YJRE11B48    NaN  NaN    BC          NaN        2008   TESLA

106559   5YJ3E1EA5K    NaN  NaN    BC          NaN        2019   TESLA


           Model          Electric Vehicle Type  \
104754  ROADSTER   Battery Electric Vehicle (BEV)
106559   MODEL 3   Battery Electric Vehicle (BEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility   Electric
Range  \
104754            Clean Alternative Fuel Vehicle Eligible
220
106559            Clean Alternative Fuel Vehicle Eligible
220


          Base MSRP  Legislative District  DOL Vehicle ID Vehicle
Location  \
104754        98950                   NaN       143609049
NaN
106559            0                   NaN       475254825
NaN
```

```
        Electric Utility  2020 Census Tract
104754             NaN                   NaN
106559             NaN                   NaN
```

Handling NaN values with Mode

```
df['County'] = df['County'].fillna(df['County'].mode()[0])
```

Checking null values in City column

```
df[df['City'].isnull()]
```

```
        VIN (1-10) County City State  Postal Code  Model Year
Make  \
104754   5YJRE11B48   King  NaN    BC         NaN         2008   TESLA

106559   5YJ3E1EA5K   King  NaN    BC         NaN         2019   TESLA


          Model               Electric Vehicle Type  \
104754   ROADSTER  Battery Electric Vehicle (BEV)
106559    MODEL 3  Battery Electric Vehicle (BEV)

     Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
104754           Clean Alternative Fuel Vehicle Eligible
220
106559           Clean Alternative Fuel Vehicle Eligible
220

        Base MSRP  Legislative District  DOL Vehicle ID Vehicle
Location  \
104754       98950                   NaN       143609049
NaN
106559           0                   NaN       475254825
NaN

        Electric Utility  2020 Census Tract
104754             NaN                   NaN
106559             NaN                   NaN
```

Handling NaN values with Mode

```
df['City'] = df['City'].fillna(df['City'].mode()[0])
```

Checking null values in Postal Code column

```
df[df['Postal Code'].isnull()]
```

```
        VIN (1-10) County     City State  Postal Code  Model Year
Make  \
104754  5YJRE11B48   King  Seattle    BC          NaN         2008
TESLA
106559  5YJ3E1EA5K   King  Seattle    BC          NaN         2019
TESLA

           Model             Electric Vehicle Type  \
104754   ROADSTER  Battery Electric Vehicle (BEV)
106559    MODEL 3  Battery Electric Vehicle (BEV)

       Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
104754          Clean Alternative Fuel Vehicle Eligible
220
106559          Clean Alternative Fuel Vehicle Eligible
220

        Base MSRP  Legislative District  DOL Vehicle ID Vehicle
Location  \
104754      98950                   NaN       143609049
NaN
106559          0                   NaN       475254825
NaN

        Electric Utility  2020 Census Tract
104754               NaN                NaN
106559               NaN                NaN
```

Handling NaN values with Mode

```python
df['Postal Code'] = df['Postal Code'].fillna(df['Postal Code'].mode()[0])
```

Checking null values in Model Code column

```python
df[df['Model'].isnull()]
```

```
       VIN (1-10)     County        City State  Postal Code  Model
Year  \
926     YV4ED3UM8P       King    Bellevue    WA     98006.0
2023
2362    YV4ED3UM2P       King    Issaquah    WA     98029.0
2023
2735    YV4ED3UW4P  Snohomish     Bothell    WA     98021.0
2023
2866    YV4ED3UM9P       King     Redmond    WA     98052.0
2023
4461    YV4ED3UW1P       King     Seattle    WA     98146.0
2023
```

```
...            ...         ...        ...   ...         ...
...
120078   YV4ED3UM6P       King     Seattle    WA     98125.0
2023
121595   YV4ED3UM6P       King  Woodinville   WA     98072.0
2023
121654   YV4ED3UM8P  Snohomish     Edmonds    WA     98026.0
2023
122264   YV4ED3UM5P       King     Seattle    WA     98106.0
2023
123855   YV4ED3UL1P       King     Seattle    WA     98109.0
2023

         Make Model        Electric Vehicle Type  \
926      VOLVO   NaN  Battery Electric Vehicle (BEV)
2362     VOLVO   NaN  Battery Electric Vehicle (BEV)
2735     VOLVO   NaN  Battery Electric Vehicle (BEV)
2866     VOLVO   NaN  Battery Electric Vehicle (BEV)
4461     VOLVO   NaN  Battery Electric Vehicle (BEV)
...        ...   ...                            ...
120078   VOLVO   NaN  Battery Electric Vehicle (BEV)
121595   VOLVO   NaN  Battery Electric Vehicle (BEV)
121654   VOLVO   NaN  Battery Electric Vehicle (BEV)
122264   VOLVO   NaN  Battery Electric Vehicle (BEV)
123855   VOLVO   NaN  Battery Electric Vehicle (BEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
926      Eligibility unknown as battery range has not b...
0
2362     Eligibility unknown as battery range has not b...
0
2735     Eligibility unknown as battery range has not b...
0
2866     Eligibility unknown as battery range has not b...
0
4461     Eligibility unknown as battery range has not b...
0
...                                                    ...
...
120078   Eligibility unknown as battery range has not b...
0
121595   Eligibility unknown as battery range has not b...
0
121654   Eligibility unknown as battery range has not b...
0
122264   Eligibility unknown as battery range has not b...
0
123855   Eligibility unknown as battery range has not b...
```

```
0

        Base MSRP  Legislative District  DOL Vehicle ID  \
926             0                  41.0      233716570
2362            0                   5.0      224739035
2735            0                   1.0      226044115
2866            0                  45.0      234908943
4461            0                  34.0      227240163
...           ...                   ...            ...
120078          0                  46.0      228469741
121595          0                  45.0      228880550
121654          0                  21.0      233842416
122264          0                  34.0      233676355
123855          0                  36.0      225775693

                 Vehicle Location  \
926      POINT (-122.12096 47.55584)
2362     POINT (-122.00292 47.54748)
2735      POINT (-122.18384 47.8031)
2866     POINT (-122.13158 47.67858)
4461     POINT (-122.36178 47.49408)
...                            ...
120078    POINT (-122.3026 47.72656)
121595   POINT (-122.15545 47.75448)
121654   POINT (-122.31768 47.87166)
122264   POINT (-122.35163 47.54287)
123855   POINT (-122.35022 47.63824)

                                      Electric Utility  2020 Census
Tract
926      PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.303302e+10
2362     PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.303303e+10
2735                           PUGET SOUND ENERGY INC
5.306105e+10
2866     PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.303303e+10
4461       CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
...                                           ...                .
..
120078    CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303300e+10
121595   PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.303303e+10
121654                         PUGET SOUND ENERGY INC
5.306105e+10
122264    CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
```

```
123855    CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10

[181 rows x 17 columns]
```

Handling NaN values with unknown name

```python
df.loc[df['Model'].isna(),'Model'] = 'Unknown'

df.isna().sum()
```

```
VIN (1-10)                                              0
County                                                 0
City                                                   0
State                                                  0
Postal Code                                            0
Model Year                                             0
Make                                                   0
Model                                                  0
Electric Vehicle Type                                  0
Clean Alternative Fuel Vehicle (CAFV) Eligibility      0
Electric Range                                         0
Base MSRP                                              0
Legislative District                                 297
DOL Vehicle ID                                         0
Vehicle Location                                      29
Electric Utility                                     473
2020 Census Tract                                      2
dtype: int64
```

Checking Null values in Legislative District column

```python
df[df['Legislative District'].isnull()]
```

```
        VIN (1-10)       County             City State  Postal
Code  \
1       5YJ3E1EA7K    San Diego        San Diego    CA
92101.0
2       7JRBR0FL9M         Lane           Eugene    OR
97404.0
13      5YJSA1CG3D    Riverside            Indio    CA
92201.0
14      1FADP3R48H         Kern         Rosamond    CA
93560.0
106     3FA6P0SU9E    San Diego         Coronado    CA
92118.0
...            ...          ...              ...   ...      ..
.
124264  7JRBR0FL1N   Montgomery    Silver Spring    MD
20906.0
124319  5YJ3E1EBXM   Washington      Keedysville    MD
```

```
               21756.0
124382  5YJ3E1EB2L      Laramie        Cheyenne   WY
82001.0
124603  KNDCC3LGXN  San Bernardino  Twentynine Palms   CA
92277.0
124647  KM8K33AGXN      Montgomery     Silver Spring   MD
20906.0


        Model Year    Make            Model   \
1            2019    TESLA         MODEL 3
2            2021    VOLVO             S60
13           2013    TESLA         MODEL S
14           2017     FORD          FOCUS
106          2014     FORD          FUSION
...          ...      ...             ...
124264       2022    VOLVO             S60
124319       2021    TESLA         MODEL 3
124382       2020    TESLA         MODEL 3
124603       2022      KIA            NIRO
124647       2022  HYUNDAI  KONA ELECTRIC


                        Electric Vehicle Type  \
1              Battery Electric Vehicle (BEV)
2       Plug-in Hybrid Electric Vehicle (PHEV)
13             Battery Electric Vehicle (BEV)
14             Battery Electric Vehicle (BEV)
106     Plug-in Hybrid Electric Vehicle (PHEV)
...                                        ...
124264  Plug-in Hybrid Electric Vehicle (PHEV)
124319         Battery Electric Vehicle (BEV)
124382         Battery Electric Vehicle (BEV)
124603         Battery Electric Vehicle (BEV)
124647         Battery Electric Vehicle (BEV)

       Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
1               Clean Alternative Fuel Vehicle Eligible
220
2                  Not eligible due to low battery range
22
13              Clean Alternative Fuel Vehicle Eligible
208
14              Clean Alternative Fuel Vehicle Eligible
100
106                Not eligible due to low battery range
19
...                                                   ...
...
124264             Not eligible due to low battery range
22
```

```
124319  Eligibility unknown as battery range has not b...
0
124382             Clean Alternative Fuel Vehicle Eligible
322
124603  Eligibility unknown as battery range has not b...
0
124647  Eligibility unknown as battery range has not b...
0

        Base MSRP  Legislative District  DOL Vehicle ID  \
1               0                   NaN       266614659
2               0                   NaN       144502018
13          69900                   NaN       239204752
14              0                   NaN       218307183
106             0                   NaN       119899125
...           ...                   ...             ...
124264          0                   NaN       187436525
124319          0                   NaN       142037626
124382          0                   NaN       133911886
124603          0                   NaN       187545123
124647          0                   NaN       198535893

                 Vehicle Location Electric Utility  2020 Census
Tract
1        POINT (-117.16171 32.71568)            NaN
6.073005e+09
2        POINT (-123.12802 44.09573)            NaN
4.103900e+10
13       POINT (-116.21942 33.72213)            NaN
6.065046e+09
14       POINT (-118.16344 34.86438)            NaN
6.029006e+09
106      POINT (-117.17089 32.67619)            NaN
6.073022e+09
...                              ...            ...            ..
.
124264   POINT (-77.07354 39.09303)            NaN
2.403170e+10
124319   POINT (-77.69839 39.48824)            NaN
2.404301e+10
124382   POINT (-104.82154 41.13481)            NaN
5.602100e+10
124603   POINT (-116.05461 34.13561)            NaN
6.071010e+09
124647   POINT (-77.07354 39.09303)            NaN
2.403170e+10

[297 rows x 17 columns]
```

Handling NaN values with ffill method

```
df['Legislative District'] = df['Legislative District'].ffill()
```

Checking Null values in Vehicle Location column

```
df[df['Vehicle Location'].isnull()]
```

	VIN (1-10)	County	City	State	Postal Code	Model Year
5588	1N4BZ1CP7K	Pierce	Wilkeson	WA	98396.0	2019
7262	JN1AZ0CP1B	King	Seattle	WA	98124.0	2011
12989	3FMTK4SE6M	Pierce	Wilkeson	WA	98396.0	2021
14103	JN1AZ0CP0B	King	Seattle	WA	98124.0	2011
15353	3FMTK4SE4N	Thurston	Olympia	WA	98504.0	2022
20062	3FMTK2SU3N	Thurston	Olympia	WA	98504.0	2022
21361	3FMTK2SU4N	Thurston	Olympia	WA	98504.0	2022
24896	1N4AZ0CP4D	Pierce	Kapowsin	WA	98344.0	2013
25185	3FMTK2SU3N	Thurston	Olympia	WA	98504.0	2022
30143	3FA6P0PU2D	Pierce	Wilkeson	WA	98396.0	2013
31053	1G1FW6S05H	Thurston	Olympia	WA	98504.0	2017
31790	3FMTK2SUXN	Thurston	Olympia	WA	98504.0	2022
32618	3FMTK2SU1N	Thurston	Olympia	WA	98504.0	2022
33798	5YJ3E1EC4L	Rockingham	Portsmouth	NH	3804.0	2020
37582	3FMTK2SU8N	Thurston	Olympia	WA	98504.0	2022
43505	1G1RD6E41D	Pierce	Tacoma	WA	98401.0	2013
43514	3FA6P0PU8G	Pierce	Kapowsin	WA	98344.0	2016
54043	KM8K23AG6M	Pierce	Tacoma	WA	98401.0	2021
68909	JTDKN3DP5E	Whatcom	Bellingham	WA	98227.0	2014
83962	5YJXCBE2XG	Thurston	Lacey	WA	98509.0	2016
84269	1N4AZ0CP3D	Thurston	Bucoda	WA	98530.0	

```
        2013
104754  5YJRE11B48      King    Seattle    BC    98052.0
        2008
106559  5YJ3E1EA5K      King    Seattle    BC    98052.0
        2019
110296  5YJ3E1EA8J   San Diego  Oceanside  CA    92051.0
        2018
119161  1FADP5CU5G    Thurston   Olympia   WA    98507.0
        2016
119860  5YJYGAEE5M    Maricopa  Scottsdale AZ    85252.0
        2021
120672  JN1AZ0CP6C      King    Seattle    WA    98124.0
        2012
122845  1G1FW6S08N     Pacific Long Beach  WA    98634.0
        2022
124579  JN1AZ0CP6C      King    Seattle    WA    98124.0
        2012

              Make          Model                  Electric Vehicle
Type   \
5588       NISSAN           LEAF        Battery Electric Vehicle
(BEV)
7262       NISSAN           LEAF        Battery Electric Vehicle
(BEV)
12989       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
14103      NISSAN           LEAF        Battery Electric Vehicle
(BEV)
15353       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
20062       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
21361       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
24896      NISSAN           LEAF        Battery Electric Vehicle
(BEV)
25185       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
30143       FORD          FUSION  Plug-in Hybrid Electric Vehicle
(PHEV)
31053   CHEVROLET       BOLT EV        Battery Electric Vehicle
(BEV)
31790       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
32618       FORD   MUSTANG MACH-E       Battery Electric Vehicle
(BEV)
33798      TESLA         MODEL 3        Battery Electric Vehicle
(BEV)
37582       FORD   MUSTANG MACH-E       Battery Electric Vehicle
```

```
       (BEV)
43505     CHEVROLET              VOLT  Plug-in Hybrid Electric Vehicle
       (PHEV)
43514         FORD            FUSION  Plug-in Hybrid Electric Vehicle
       (PHEV)
54043      HYUNDAI   KONA ELECTRIC           Battery Electric Vehicle
       (BEV)
68909       TOYOTA   PRIUS PLUG-IN  Plug-in Hybrid Electric Vehicle
       (PHEV)
83962        TESLA         MODEL X           Battery Electric Vehicle
       (BEV)
84269       NISSAN            LEAF           Battery Electric Vehicle
       (BEV)
104754       TESLA        ROADSTER           Battery Electric Vehicle
       (BEV)
106559       TESLA         MODEL 3           Battery Electric Vehicle
       (BEV)
110296       TESLA         MODEL 3           Battery Electric Vehicle
       (BEV)
119161        FORD           C-MAX  Plug-in Hybrid Electric Vehicle
       (PHEV)
119860       TESLA         MODEL Y           Battery Electric Vehicle
       (BEV)
120672      NISSAN            LEAF           Battery Electric Vehicle
       (BEV)
122845   CHEVROLET         BOLT EV           Battery Electric Vehicle
       (BEV)
124579      NISSAN            LEAF           Battery Electric Vehicle
       (BEV)

       Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
5588            Clean Alternative Fuel Vehicle Eligible
150
7262            Clean Alternative Fuel Vehicle Eligible
73
12989  Eligibility unknown as battery range has not b...
0
14103           Clean Alternative Fuel Vehicle Eligible
73
15353  Eligibility unknown as battery range has not b...
0
20062  Eligibility unknown as battery range has not b...
0
21361  Eligibility unknown as battery range has not b...
0
24896           Clean Alternative Fuel Vehicle Eligible
75
25185  Eligibility unknown as battery range has not b...
```

```
0
30143                  Not eligible due to low battery range
19
31053            Clean Alternative Fuel Vehicle Eligible
238
31790    Eligibility unknown as battery range has not b...
0
32618    Eligibility unknown as battery range has not b...
0
33798            Clean Alternative Fuel Vehicle Eligible
308
37582    Eligibility unknown as battery range has not b...
0
43505            Clean Alternative Fuel Vehicle Eligible
38
43514                  Not eligible due to low battery range
19
54043    Eligibility unknown as battery range has not b...
0
68909                  Not eligible due to low battery range
6
83962            Clean Alternative Fuel Vehicle Eligible
200
84269            Clean Alternative Fuel Vehicle Eligible
75
104754           Clean Alternative Fuel Vehicle Eligible
220
106559           Clean Alternative Fuel Vehicle Eligible
220
110296           Clean Alternative Fuel Vehicle Eligible
215
119161                 Not eligible due to low battery range
19
119860   Eligibility unknown as battery range has not b...
0
120672           Clean Alternative Fuel Vehicle Eligible
73
122845   Eligibility unknown as battery range has not b...
0
124579           Clean Alternative Fuel Vehicle Eligible
73

        Base MSRP   Legislative District   DOL Vehicle ID  Vehicle
Location  \
5588            0                   31.0        476833899
NaN
7262            0                   11.0        101502166
NaN
12989           0                   31.0        181410736
```

			NaN
14103	0	11.0	165560762
			NaN
15353	0	22.0	213445004
			NaN
20062	0	22.0	219271216
			NaN
21361	0	22.0	216554257
			NaN
24896	0	2.0	237061968
			NaN
25185	0	22.0	216702503
			NaN
30143	0	31.0	226631765
			NaN
31053	0	22.0	168485502
			NaN
31790	0	22.0	225712350
			NaN
32618	0	22.0	219275304
			NaN
33798	0	47.0	8798226
			NaN
37582	0	22.0	212089510
			NaN
43505	0	27.0	177221138
			NaN
43514	0	2.0	192402612
			NaN
54043	0	27.0	157122437
			NaN
68909	0	42.0	136857493
			NaN
83962	0	22.0	174187562
			NaN
84269	0	20.0	106785206
			NaN
104754	98950	10.0	143609049
			NaN
106559	0	23.0	475254825
			NaN
110296	0	24.0	153998050
			NaN
119161	0	22.0	339958097
			NaN
119860	0	32.0	166089591
			NaN
120672	0	11.0	90772
			NaN

```
122845          0                      19.0        218102209
NaN
124579          0                      11.0        250994733
NaN

                                           Electric Utility   2020 Census
Tract
5588        PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.305307e+10
7262         CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
12989       PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.305307e+10
14103        CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
15353                              PUGET SOUND ENERGY INC
5.306701e+10
20062                              PUGET SOUND ENERGY INC
5.306701e+10
21361                              PUGET SOUND ENERGY INC
5.306701e+10
24896       PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.305307e+10
25185                              PUGET SOUND ENERGY INC
5.306701e+10
30143       PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.305307e+10
31053                              PUGET SOUND ENERGY INC
5.306701e+10
31790                              PUGET SOUND ENERGY INC
5.306701e+10
32618                              PUGET SOUND ENERGY INC
5.306701e+10
33798                                                 NaN
3.301507e+10
37582                              PUGET SOUND ENERGY INC
5.306701e+10
43505   BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305306e+10
43514       PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
5.305307e+10
54043   BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305306e+10
68909   PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM CO...
5.307300e+10
83962                              PUGET SOUND ENERGY INC
5.306701e+10
84269                              PUGET SOUND ENERGY INC
5.306701e+10
```

```
104754                                                    NaN
NaN
106559                                                    NaN
NaN
110296                                                    NaN
6.073019e+09
119161                               PUGET SOUND ENERGY INC
5.306701e+10
119860                                                    NaN
4.013218e+09
120672       CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
122845  BONNEVILLE POWER ADMINISTRATION||PUD NO 2 OF P...
5.304995e+10
124579       CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
5.303301e+10
```

Handling NaN values with unknown name

```python
df.loc[df['Vehicle Location'].isna(),'Vehicle Location'] = 'Unknown'
```

Checking Null values in Electric Utility column

```python
df[df['Electric Utility'].isnull()]
```

```
        VIN (1-10)          County              City State  Postal
Code  \
1       5YJ3E1EA7K       San Diego         San Diego    CA
92101.0
2       7JRBR0FL9M            Lane            Eugene    OR
97404.0
13      5YJSA1CG3D       Riverside             Indio    CA
92201.0
14      1FADP3R48H            Kern          Rosamond    CA
93560.0
53      5YJSA1H13E        Thurston           Olympia    WA
98502.0
...            ...             ...               ...   ...        ..
.
124536  1G1RD6E4XE          Island         Greenbank    WA
98253.0
124571  5YJ3E1EA1L          Skagit         Anacortes    WA
98221.0
124603  KNDCC3LGXN  San Bernardino  Twentynine Palms    CA
92277.0
124647  KM8K33AGXN      Montgomery      Silver Spring    MD
20906.0
124675  1G1FX6S07H          Island           Clinton    WA
98236.0
```

```
        Model Year      Make           Model  \
1              2019     TESLA          MODEL 3
2              2021     VOLVO              S60
13             2013     TESLA          MODEL S
14             2017      FORD            FOCUS
53             2014     TESLA          MODEL S
...             ...       ...              ...
124536         2014  CHEVROLET           VOLT
124571         2020     TESLA          MODEL 3
124603         2022       KIA             NIRO
124647         2022   HYUNDAI  KONA ELECTRIC
124675         2017  CHEVROLET        BOLT EV

                        Electric Vehicle Type  \
1              Battery Electric Vehicle (BEV)
2       Plug-in Hybrid Electric Vehicle (PHEV)
13             Battery Electric Vehicle (BEV)
14             Battery Electric Vehicle (BEV)
53             Battery Electric Vehicle (BEV)
...                                        ...
124536  Plug-in Hybrid Electric Vehicle (PHEV)
124571         Battery Electric Vehicle (BEV)
124603         Battery Electric Vehicle (BEV)
124647         Battery Electric Vehicle (BEV)
124675         Battery Electric Vehicle (BEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
1               Clean Alternative Fuel Vehicle Eligible
220
2                 Not eligible due to low battery range
22
13              Clean Alternative Fuel Vehicle Eligible
208
14              Clean Alternative Fuel Vehicle Eligible
100
53              Clean Alternative Fuel Vehicle Eligible
208
...                                                   ...
...
124536          Clean Alternative Fuel Vehicle Eligible
38
124571          Clean Alternative Fuel Vehicle Eligible
266
124603  Eligibility unknown as battery range has not b...
0
124647  Eligibility unknown as battery range has not b...
0
124675          Clean Alternative Fuel Vehicle Eligible
```

```
238

        Base MSRP  Legislative District  DOL Vehicle ID  \
1                0                  14.0       266614659
2                0                  14.0       144502018
13           69900                  44.0       239204752
14               0                  44.0       218307183
53           69900                  35.0       241793912
...            ...                   ...             ...
124536           0                  10.0       214314726
124571           0                  40.0         2536285
124603           0                  45.0       187545123
124647           0                  36.0       198535893
124675           0                  10.0       349641456

                   Vehicle Location Electric Utility  2020 Census
Tract
1        POINT (-117.16171 32.71568)              NaN
6.073005e+09
2        POINT (-123.12802 44.09573)              NaN
4.103900e+10
13       POINT (-116.21942 33.72213)              NaN
6.065046e+09
14       POINT (-118.16344 34.86438)              NaN
6.029006e+09
53       POINT (-122.92333 47.03779)              NaN
5.306701e+10
...                          ...              ...            ..
.
124536  POINT (-122.56821 48.08844)              NaN
5.302997e+10
124571  POINT (-122.61214 48.51748)              NaN
5.305795e+10
124603  POINT (-116.05461 34.13561)              NaN
6.071010e+09
124647    POINT (-77.07354 39.09303)              NaN
2.403170e+10
124675    POINT (-122.35803 47.9796)              NaN
5.302997e+10

[473 rows x 17 columns]
```

Handling NaN values with bfill method

```
df['Electric Utility'] = df['Electric Utility'].bfill()
```

Checking Null values in Electric Utility column

```
df[df['2020 Census Tract'].isnull()]
```

```
        VIN (1-10) County       City State  Postal Code  Model Year
Make  \
104754  5YJRE11B48   King  Seattle     BC      98052.0         2008
TESLA
106559  5YJ3E1EA5K   King  Seattle     BC      98052.0         2019
TESLA

             Model            Electric Vehicle Type  \
104754   ROADSTER  Battery Electric Vehicle (BEV)
106559    MODEL 3  Battery Electric Vehicle (BEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
104754           Clean Alternative Fuel Vehicle Eligible
220
106559           Clean Alternative Fuel Vehicle Eligible
220

        Base MSRP  Legislative District  DOL Vehicle ID Vehicle
Location  \
104754      98950                  10.0       143609049
Unknown
106559          0                  23.0       475254825
Unknown

              Electric Utility  2020 Census Tract
104754  PUGET SOUND ENERGY INC                 NaN
106559  PUGET SOUND ENERGY INC                 NaN
```

Handling NaN values with median method

```
df['2020 Census Tract']=df['2020 Census Tract'].fillna(df['2020 Census
Tract'].median())

df

        VIN (1-10)     County        City State  Postal Code  Model
Year  \
0       5YJ3E1EB4L     Yakima      Yakima    WA      98908.0
2020
1       5YJ3E1EA7K  San Diego   San Diego    CA      92101.0
2019
2       7JRBR0FL9M       Lane      Eugene    OR      97404.0
2021
3       5YJXCBE21K     Yakima      Yakima    WA      98908.0
2019
4       5UXKT0C5XH  Snohomish     Bothell    WA      98021.0
2017
...            ...        ...         ...   ...          ...
...
```

```
124711  5YJ3E1EB6N   Snohomish       Monroe   WA      98272.0
2022
124712  KNDCM3LD2L     Pierce        Tacoma   WA      98406.0
2020
124713  7SAYGDEE0P    Whatcom    Bellingham   WA      98226.0
2023
124714  1G1FW6S03J     Pierce        Tacoma   WA      98444.0
2018
124715  1G1RC6E47F     Benton   Benton City   WA      99320.0
2015

              Make    Model                      Electric Vehicle Type  \
0            TESLA  MODEL 3         Battery Electric Vehicle (BEV)
1            TESLA  MODEL 3         Battery Electric Vehicle (BEV)
2            VOLVO      S60  Plug-in Hybrid Electric Vehicle (PHEV)
3            TESLA  MODEL X         Battery Electric Vehicle (BEV)
4              BMW       X5  Plug-in Hybrid Electric Vehicle (PHEV)
...            ...      ...                                    ...
124711       TESLA  MODEL 3         Battery Electric Vehicle (BEV)
124712         KIA     NIRO  Plug-in Hybrid Electric Vehicle (PHEV)
124713       TESLA  MODEL Y         Battery Electric Vehicle (BEV)
124714   CHEVROLET  BOLT EV         Battery Electric Vehicle (BEV)
124715   CHEVROLET     VOLT  Plug-in Hybrid Electric Vehicle (PHEV)

        Clean Alternative Fuel Vehicle (CAFV) Eligibility  Electric
Range  \
0                 Clean Alternative Fuel Vehicle Eligible
322
1                 Clean Alternative Fuel Vehicle Eligible
220
2                     Not eligible due to low battery range
22
3                 Clean Alternative Fuel Vehicle Eligible
289
4                     Not eligible due to low battery range
14
...                                                    ...
...
124711  Eligibility unknown as battery range has not b...
0
124712                  Not eligible due to low battery range
26
124713  Eligibility unknown as battery range has not b...
0
124714              Clean Alternative Fuel Vehicle Eligible
238
124715              Clean Alternative Fuel Vehicle Eligible
38

        Base MSRP  Legislative District  DOL Vehicle ID  \
```

```
0                  0              14.0       127175366
1                  0              14.0       266614659
2                  0              14.0       144502018
3                  0              14.0       477039944
4                  0               1.0       106314946
...              ...               ...             ...
124711             0              39.0       192999061
124712             0              27.0       113346250
124713             0              42.0       232751305
124714             0              29.0       102589007
124715             0              16.0       476974718

               Vehicle Location  \
0        POINT (-120.56916 46.58514)
1        POINT (-117.16171 32.71568)
2        POINT (-123.12802 44.09573)
3        POINT (-120.56916 46.58514)
4         POINT (-122.18384 47.8031)
...                              ...
124711   POINT (-121.98087 47.8526)
124712  POINT (-122.52054 47.26887)
124713   POINT (-122.49756 48.7999)
124714  POINT (-122.46495 47.16778)
124715  POINT (-119.48756 46.26543)

                                         Electric Utility  2020 Census
Tract
0                                              PACIFICORP
5.307700e+10
1                                              PACIFICORP
6.073005e+09
2                                              PACIFICORP
4.103900e+10
3                                              PACIFICORP
5.307700e+10
4                                      PUGET SOUND ENERGY INC
5.306105e+10
...                                                     ...
...
124711                                 PUGET SOUND ENERGY INC
5.306105e+10
124712  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305306e+10
124713  PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM CO...
5.307300e+10
124714  BONNEVILLE POWER ADMINISTRATION||CITY OF TACOM...
5.305307e+10
124715  BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF B...
5.300501e+10
```

```
[124716 rows x 17 columns]
```

Electric Vehicle Adoption Over Time (Model Year Trend

Track the adoption of electric vehicles over the years by examining the Model Year
column

```python
ev_by_year = df.groupby('Model Year').size().reset_index(name='Vehicle
Count')
ev_by_year = ev_by_year.sort_values(by='Vehicle Count',
ascending=True).tail(10)
ev_by_year
```

```
    Model Year  Vehicle Count
10        2013           4581
12        2015           4935
13        2016           5702
14        2017           8558
16        2019          10450
17        2020          10926
20        2023          13353
15        2018          14224
18        2021          18296
19        2022          27522
```

```python
# Plot the trend
plt.figure(figsize=(10, 6))
sns.lineplot(data=ev_by_year, x='Model Year', y='Vehicle Count',
marker='o')
plt.title('Electric Vehicle Adoption Over Time')
plt.xlabel('Model Year')
plt.ylabel('Number of Vehicles')
plt.show()
```

Electric Vehicle Adoption Over Time
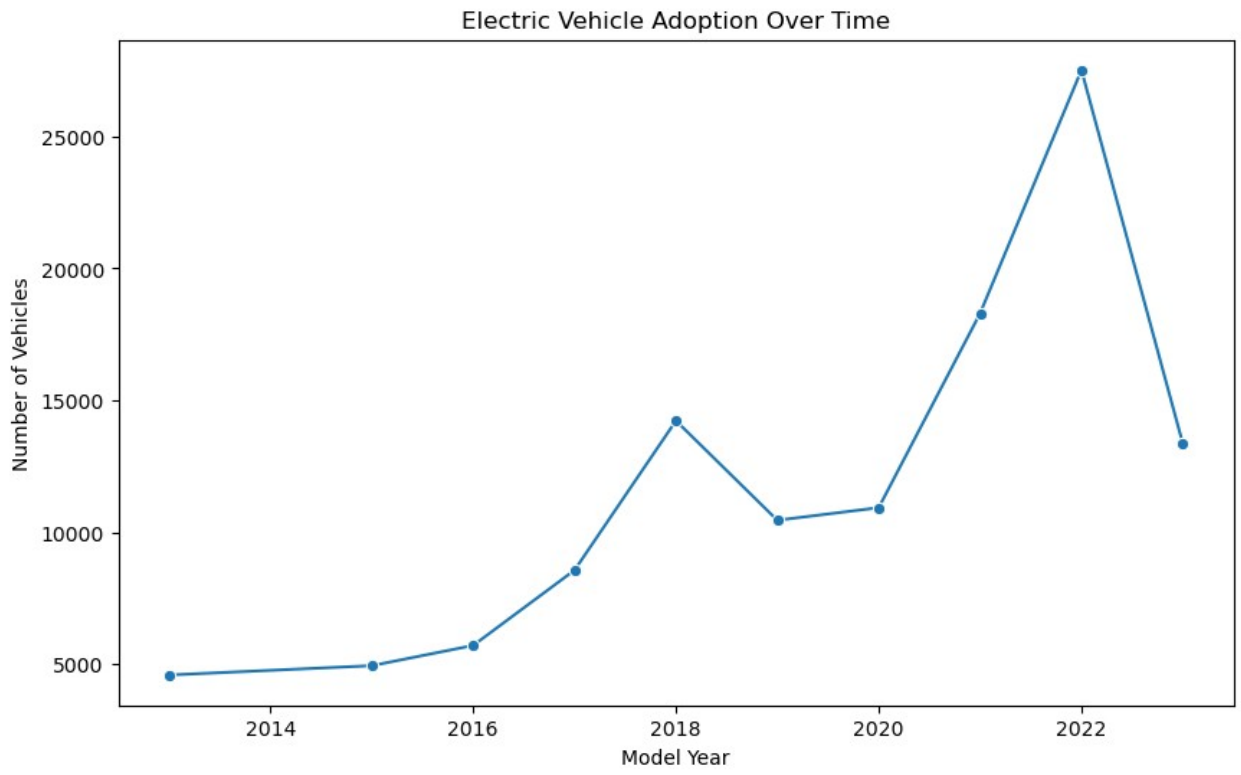
Observations:

Electric vehicle adoption has been increasing steadily over the years, with a significant surge in 2021 and 2022.

There is a slight dip in 2019, followed by a sharp increase in 2020.

Recommendations:

Incentivize Adoption: Continue to offer incentives like tax breaks and subsidies to encourage consumers to adopt electric vehicles.

Expand Charging Infrastructure: Invest in expanding the charging infrastructure to address range anxiety and make electric vehicles more convenient.

Promote Environmental Benefits: Emphasize the environmental benefits of electric vehicles to attract eco-conscious consumers.

Most Popular Electric Vehicle Brands (Make)

Find the top electric vehicle brands in the dataset by the number of vehicles, focusing on the Make column

```
# Group by Make and count the number of vehicles
ev_by_make = df['Make'].value_counts().reset_index(name='Vehicle
Count').rename(columns={'index': 'Make'})
ev_by_make

          Make  Vehicle Count
0        TESLA          57124
1       NISSAN          12946
2    CHEVROLET          10836
3         FORD           6680
4          BMW           5578
5          KIA           4843
6       TOYOTA           4666
7   VOLKSWAGEN           3369
8        VOLVO           2518
9         AUDI           2485
10     HYUNDAI           2002
11        JEEP           1936
12    CHRYSLER           1906
13      RIVIAN           1429
14     PORSCHE            898
15        FIAT            810
16       HONDA            800
```

```
17                MINI       711
18       MERCEDES-BENZ       653
19            POLESTAR       635
20          MITSUBISHI       619
21               SMART       274
22              JAGUAR       219
23             LINCOLN       199
24              SUBARU       184
25        LUCID MOTORS       118
26            CADILLAC       112
27               LEXUS        54
28             GENESIS        44
29          LAND ROVER        37
30              FISKER        15
31      AZURE DYNAMICS         7
32  WHEEGO ELECTRIC CARS       3
33               TH!NK         3
34             BENTLEY         3
```

```python
# Plot the top 10 most popular EV brands
plt.figure(figsize=(12, 6))
ax=sns.barplot(data=ev_by_make.head(10), x='Make', y='Vehicle Count')
plt.title('Top 10 Most Popular Electric Vehicle Brands')
plt.xlabel('Make')
plt.ylabel('Vehicle Count')
plt.xticks(rotation=45)
# Adding labels on the bars
for container in ax.containers:
    ax.bar_label(container)
plt.show()
```

Top 10 Most Popular Electric Vehicle Brands
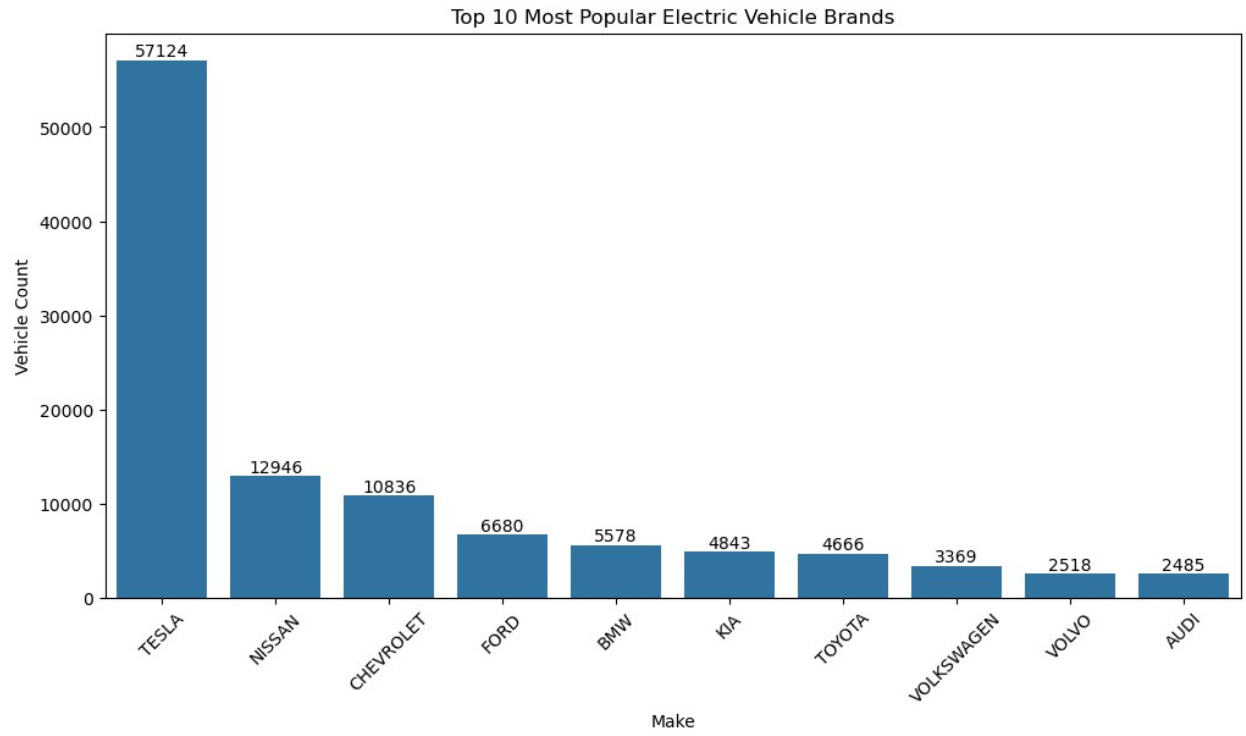
Observations:

Tesla is the clear leader in the electric vehicle market with a significant lead over other brands.

Nissan, Chevrolet, and Ford follow behind, but with a noticeable gap from Tesla.

Recommendations:

Focus on Market Leadership: Tesla should continue to innovate and expand its product line to maintain its market dominance.

Increase Production Capacity: Other manufacturers should increase their production capacity to meet growing demand and compete with Tesla.

Improve Battery Technology: Advancements in battery technology can improve vehicle range and reduce charging time, further driving adoption.

Electric Range vs. Base MSRP (Price)

Analyze the relationship between Electric Range and Base MSRP to understand whether higher range vehicles are more expensive

```python
# Plot Electric Range vs. Base MSRP to analyze the relationship
fig = px.scatter(df, x='Electric Range', y='Base MSRP',
color='Electric Vehicle Type', opacity=0.6, title='Electric Range vs.
Base MSRP', color_discrete_sequence=px.colors.qualitative.Set1)
fig.update_layout(
    xaxis_title='Electric Range (miles)',
    yaxis_title='Base MSRP ($)',
    title_x=0.5
)
fig.show()
```

Electric Range vs. Base MSRP
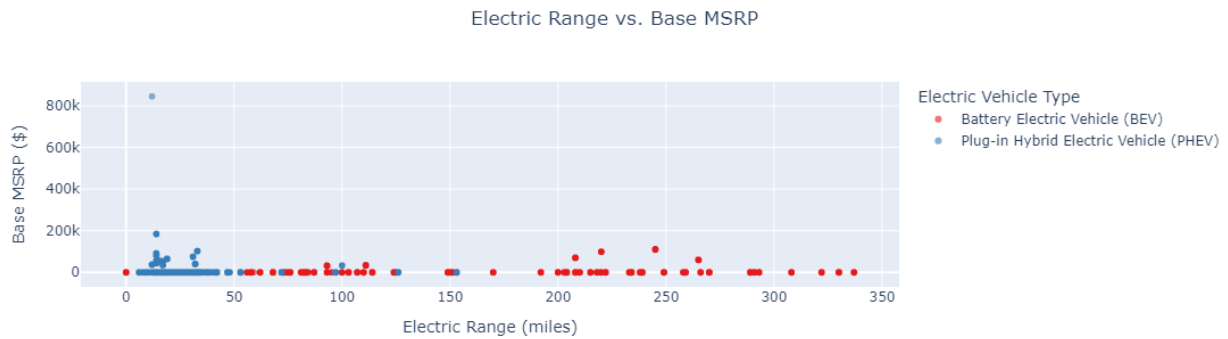
Observations:

Positive Correlation: There's a positive correlation between electric range and base MSRP. Vehicles with higher electric ranges tend to have higher prices.

Two Distinct Clusters: The plot reveals two distinct clusters corresponding to Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). BEVs generally have higher electric ranges and MSRPs compared to PHEVs.

Recommendations:

Target Market Segmentation: Identify specific target segments based on price sensitivity and range requirements.

Product Positioning: Position BEVs as premium, high-range vehicles and PHEVs as more affordable, shorter-range options.

Battery Technology: Continue to invest in battery technology to improve range and reduce costs, making electric vehicles more accessible to a wider range of consumers.

```python
fig = px.pie(df, names='Electric Vehicle Type', values='Base MSRP',
title='Base MSRP Distribution by Electric Vehicle Type')
fig.update_layout(
    title_x=0.5  # Center the title
)
fig.show()
```

Base MSRP Distribution by Electric Vehicle Type

Legend:
- Battery Electric Vehicle (BEV)
- Plug-in Hybrid Electric Vehicle (PHEV)

Observations:

BEVs Dominate the Market: Battery Electric Vehicles (BEVs) account for a significantly larger share (68.9%) of the market compared to Plug-in Hybrid Electric Vehicles (PHEVs).

PHEVs are a Smaller Segment: PHEVs represent a smaller segment of the market, accounting for 31.1% of the total.

Recommendations:

Focus on BEV Development: Manufacturers should prioritize the development and production of BEVs to capitalize on the growing demand for fully electric vehicles.

Diversify PHEV Offerings: While BEVs are the primary focus, manufacturers should continue to offer a range of PHEV options to cater to specific consumer needs and regulations.

Improve Battery Technology: Advancements in battery technology can help reduce the cost and increase the range of both BEVs and PHEVs, driving further adoption.

Clean Alternative Fuel Vehicle (CAFV) Eligibility

Identify how the CAFV Eligibility varies by state, to understand where EVs are most likely to receive government incentives.

```
# Group by State and CAFV Eligibility to get the count of eligible vs
non-eligible EVs
ev_by_state_eligibility = df.groupby(['State', 'Clean Alternative Fuel
Vehicle (CAFV) Eligibility']).size().reset_index(name='Vehicle Count')
```

```python
# Sort the data to get the top 10
ev_by_state_eligibility_sorted =
ev_by_state_eligibility.sort_values(by='Vehicle Count',
ascending=False).head(10)
ev_by_state_eligibility_sorted
```

	State	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Vehicle Count
80	WA	Clean Alternative Fuel Vehicle Eligible	59196
81	WA	Eligibility unknown as battery range has not b...	49588
82	WA	Not eligible due to low battery range	15635
8	CA	Clean Alternative Fuel Vehicle Eligible	34
9	CA	Eligibility unknown as battery range has not b...	29
77	VA	Clean Alternative Fuel Vehicle Eligible	21
10	CA	Not eligible due to low battery range	17
38	MD	Clean Alternative Fuel Vehicle Eligible	14
39	MD	Eligibility unknown as battery range has not b...	9
79	VA	Not eligible due to low battery range	9

```python
# Assuming ev_by_state_eligibility_sorted is the DataFrame you created
earlier
plt.figure(figsize=(12, 6))
ax = sns.barplot(data=ev_by_state_eligibility_sorted, x='State',
y='Vehicle Count', hue='Clean Alternative Fuel Vehicle (CAFV)
Eligibility', palette='coolwarm')
plt.title('CAFV Eligibility by State')
plt.xlabel('State')
plt.ylabel('Vehicle Count')
plt.yscale("log")
plt.xticks(rotation=90)

# Adding labels on the bars
for container in ax.containers:
    ax.bar_label(container)

plt.show()
```

CAFV Eligibility by State
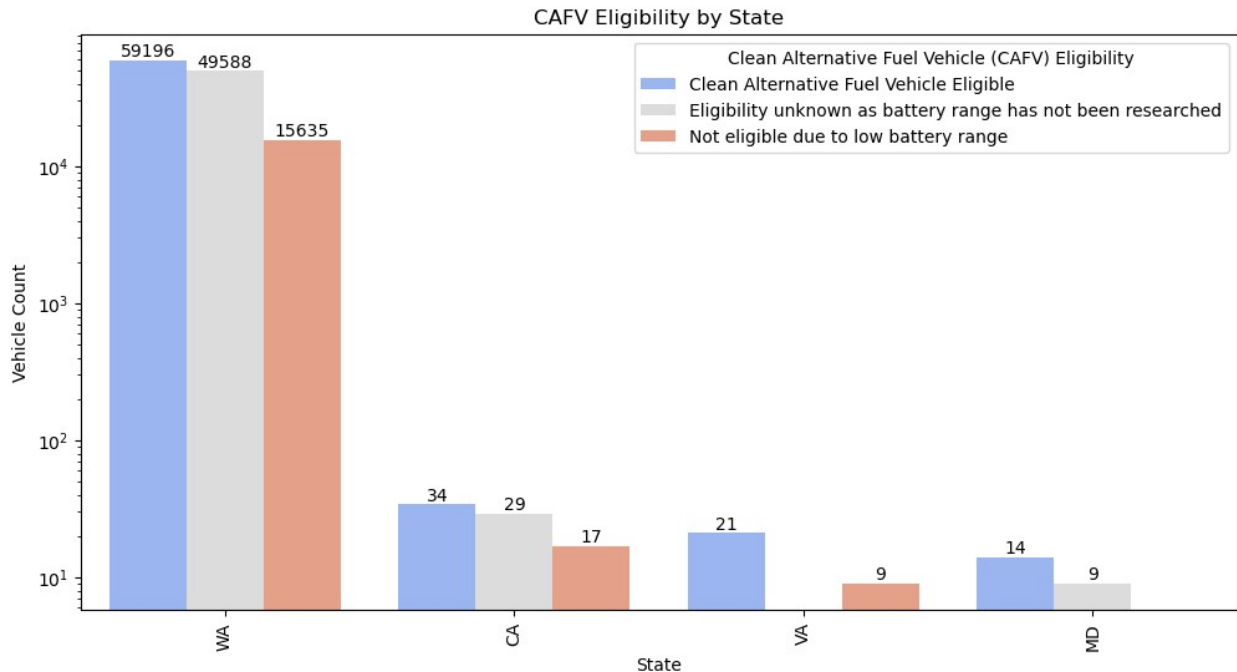
 Observations:

Washington (WA) and California (CA) have the highest number of vehicles eligible for Clean Alternative Fuel Vehicle (CAFV) incentives.

Eligibility uncertainty and low battery range are significant factors limiting eligibility in other states.

 Recommendations:

Expand Research: Conduct research to determine battery range for vehicles with unknown eligibility to identify potential CAFV candidates.

Relax Eligibility Criteria: Consider relaxing eligibility criteria, especially for states with a high number of vehicles with unknown eligibility.

Promote CAFV Adoption: Implement policies and incentives to encourage the adoption of CAFV vehicles in states with lower eligibility rates.

 Most Common Electric Vehicle Type

```python
ev_type_count = df['Electric Vehicle Type'].value_counts()
print(ev_type_count)
```

```
plt.title('Distribution of Electric Vehicle Types')
sns.barplot(x=ev_type_count.index, y=ev_type_count.values)

Electric Vehicle Type
Battery Electric Vehicle (BEV)            96266
Plug-in Hybrid Electric Vehicle (PHEV)    28450
Name: count, dtype: int64

<Axes: title={'center': 'Distribution of Electric Vehicle Types'},
xlabel='Electric Vehicle Type'>
```
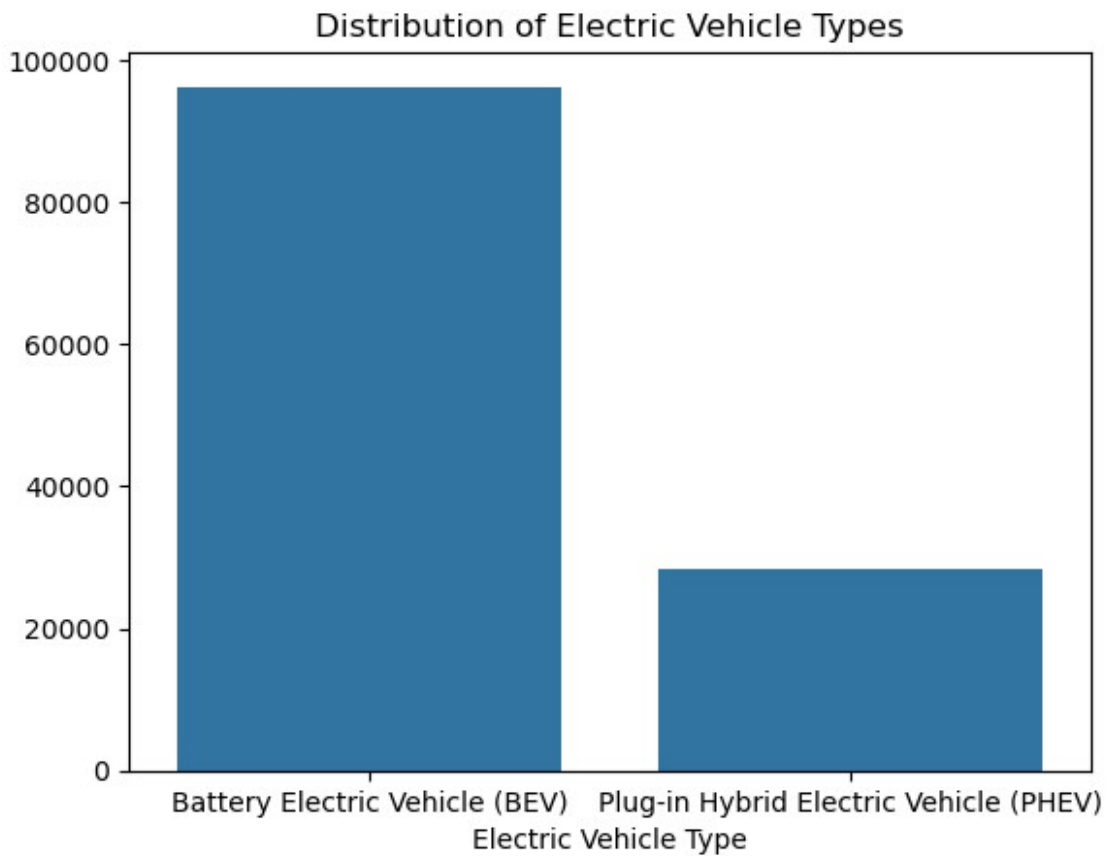
Observations:

BEVs Dominate: Battery Electric Vehicles (BEVs) significantly outnumber Plug-in Hybrid Electric Vehicles (PHEVs).

PHEVs are a Smaller Segment: PHEVs represent a smaller segment of the market.

Recommendations:

Focus on BEV Development: Manufacturers should prioritize the development and production of BEVs to capitalize on the growing demand for fully electric vehicles.

Diversify PHEV Offerings: While BEVs are the primary focus, manufacturers should continue to offer a range of PHEV options to cater to specific consumer needs and regulations.

Distribution of Model Years

```
sns.histplot(df['Model Year'], bins=20, kde=True)
plt.title('The Evolution of Electric Vehicle Model Over Years')

Text(0.5, 1.0, 'The Evolution of Electric Vehicle Model Over Years')
```

The Evolution of Electric Vehicle Model Over Years
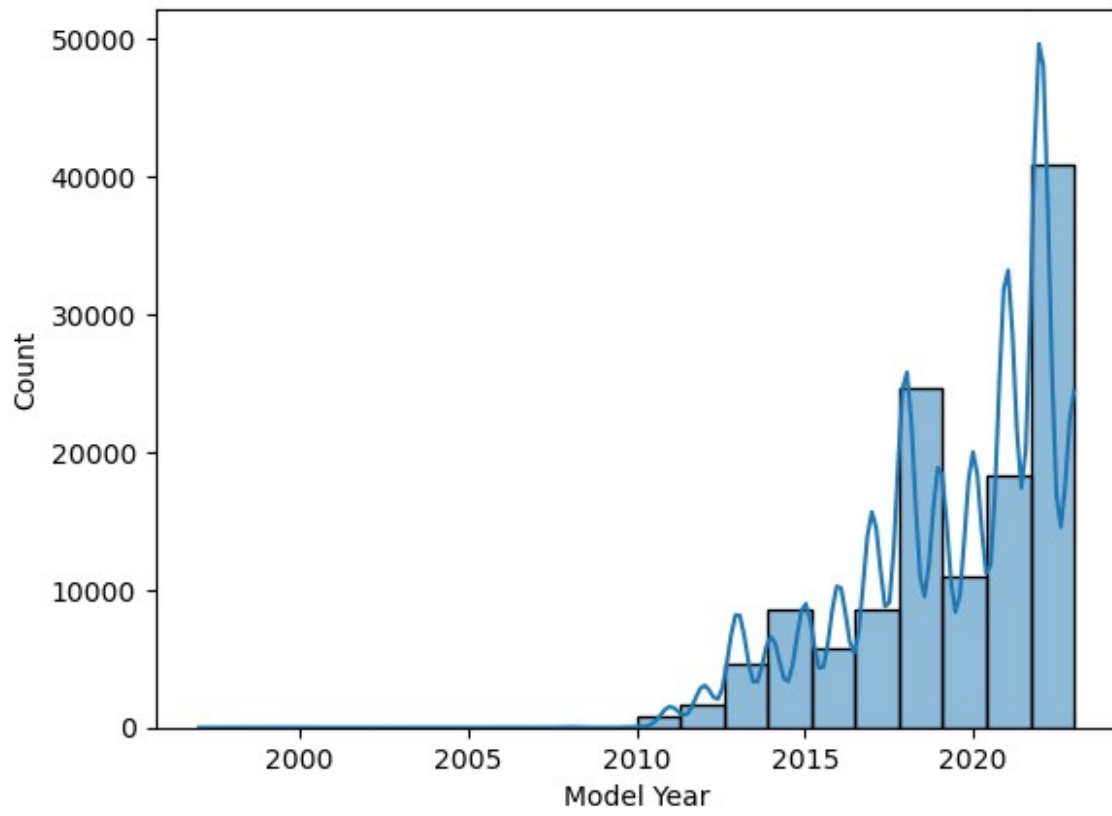
Observations:

The distribution of model years is right-skewed, indicating a larger number of newer electric vehicles.

There are peaks in the distribution around certain model years, suggesting popular model introductions or changes in consumer preferences.

Recommendations:

Focus on Newer Models: Prioritize the analysis and modeling of newer electric vehicles, as they represent a larger portion of the dataset and may have different characteristics compared to older models.

Consider Model Year as a Feature: Model year could be a valuable feature in machine learning models to predict factors like vehicle price, range, or performance.

Segment Data by Model Year: Segment the data by model year ranges to identify trends and patterns within specific time periods.

State-Wise Distribution of EVs

```python
# Assuming state_count is the series you created earlier
state_count = df['State'].value_counts()

# Plot the data
fig, ax = plt.subplots(figsize=(10, 5))
state_count.head(10).plot(kind='bar', ax=ax)
ax.set_yscale('log')
ax.set_title('Electric Vehicle Count by State', fontsize=15)


for container in ax.containers:
    ax.bar_label(container)
plt.show()
```

Electric Vehicle Count by State
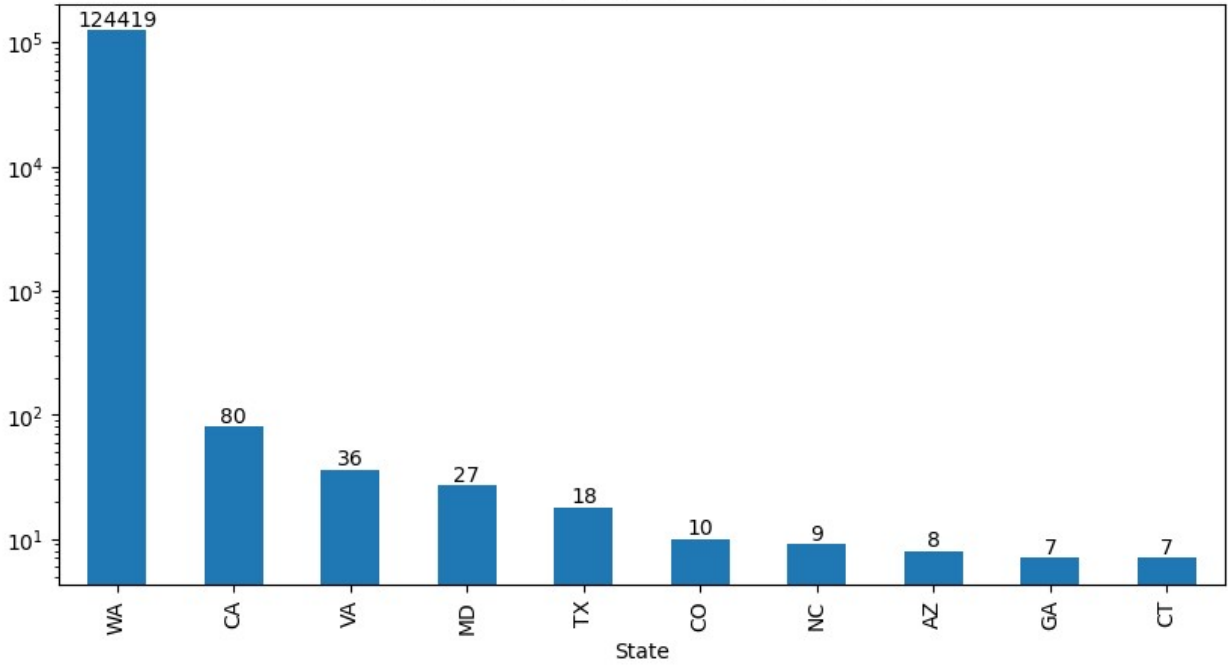
Observations:

Uneven Distribution: The distribution of electric vehicles across states is highly uneven.

California Dominance: California has a significantly higher number of electric vehicles compared to other states.

Recommendations:

Targeted Incentives: Implement targeted incentives and policies to promote electric vehicle adoption in states with lower adoption rates.

Expand Charging Infrastructure: Invest in expanding the charging infrastructure in states with high electric vehicle concentrations to support growing demand.

Regional Analysis: Conduct a detailed analysis of factors influencing electric vehicle adoption in different states to identify opportunities for growth.

City-Wise Concentration of EVs

```
city_count = df['City'].value_counts().head(10)
print(city_count)
sns.barplot(x=city_count.values, y=city_count.index)
plt.title('City-Wise Concentration of EVs')

City
Seattle      22011
Bellevue      6489
Redmond       4646
Vancouver     4464
Kirkland      3923
Bothell       3852
Sammamish     3653
Renton        3115
Olympia       3041
Tacoma        2655
Name: count, dtype: int64

Text(0.5, 1.0, 'City-Wise Concentration of EVs')
```

City-Wise Concentration of EVs
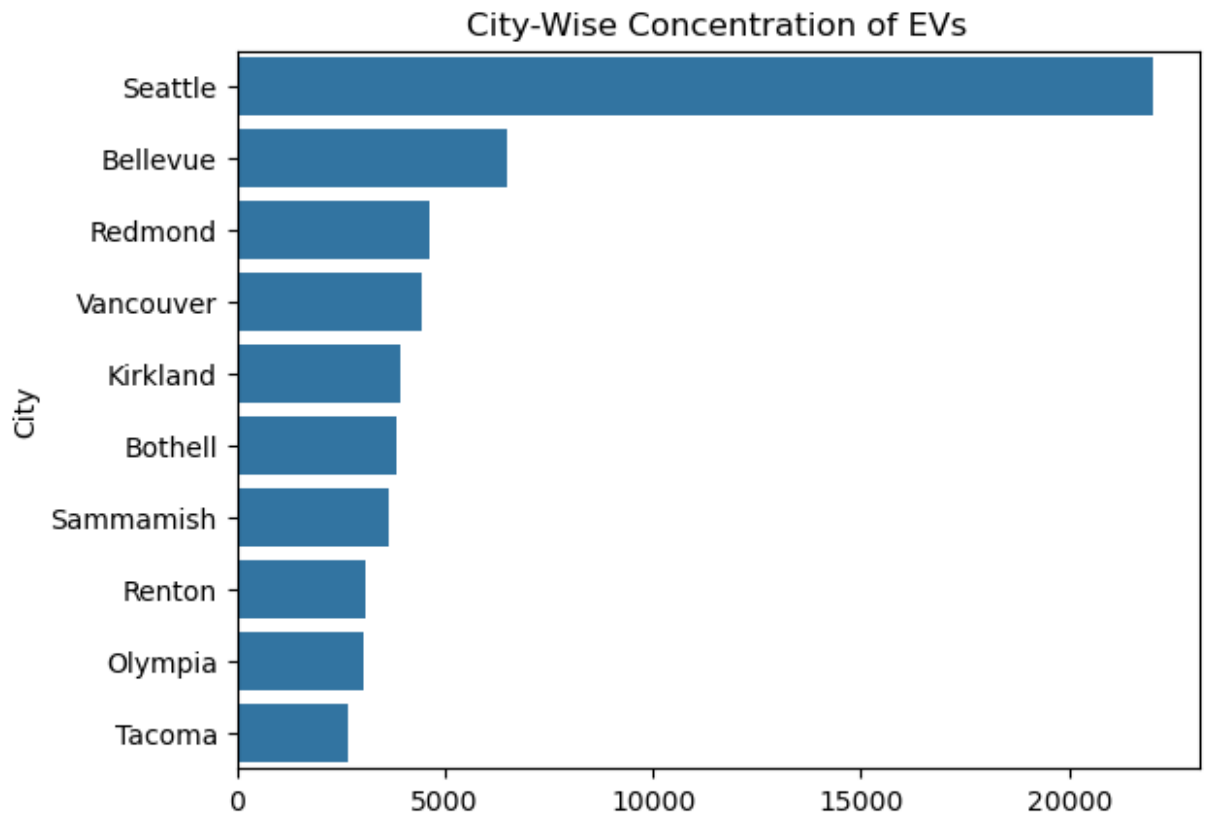
Observations:

Seattle Dominates: Seattle has the highest concentration of electric vehicles among the listed cities.

Suburban Areas: Bellevue, Redmond, and Kirkland have a significant presence of electric vehicles, suggesting suburban areas are adopting EVs.

Recommendations:

Targeted Infrastructure: Invest in expanding charging infrastructure in cities like Seattle and its surrounding suburbs to support the growing number of EVs.

Incentivize Adoption: Offer additional incentives and benefits to encourage EV adoption in cities with high concentrations, such as preferential parking or toll discounts.

Study Suburban Adoption: Analyze the factors driving EV adoption in suburban areas to identify strategies for promoting EVs in other regions.

Most Popular EV Models

```python
popular_models = df['Model'].value_counts().head(10)
print(popular_models)
sns.barplot(x=popular_models.values, y=popular_models.index)
plt.title('Top Electric Vehicle Models')

Model
MODEL 3        24409
MODEL Y        20673
LEAF           12924
MODEL S         7345
BOLT EV         4988
VOLT            4888
MODEL X         4647
PRIUS PRIME     2435
ID.4            2329
NIRO            2295
Name: count, dtype: int64

Text(0.5, 1.0, 'Top Electric Vehicle Models')
```

Top Electric Vehicle Models
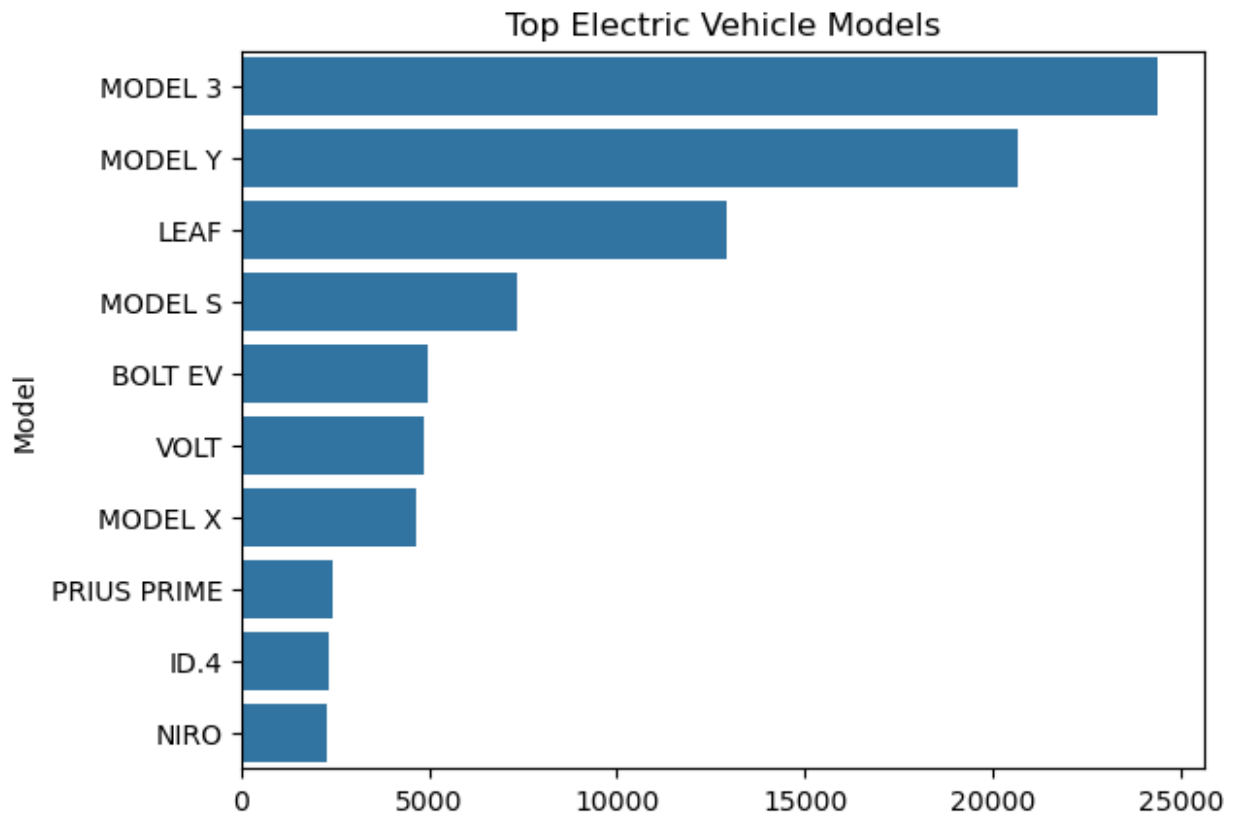
Observations:

Tesla Dominance: Tesla's Model 3 and Model Y are the most popular electric vehicle models, significantly outpacing other brands.

Nissan Leaf and Chevrolet Bolt: These models have a significant market share, but are behind Tesla's offerings.

Recommendations:

Focus on Innovation: Tesla should continue to innovate and introduce new features to maintain its market leadership.

Increase Production Capacity: Other manufacturers should increase production capacity to meet growing demand and compete with Tesla.

Target Specific Segments: Manufacturers should identify specific target segments and tailor their product offerings accordingly. For example, compact EVs like the Nissan Leaf and Chevrolet Bolt can target budget-conscious consumers.

Eligibility for Clean Fuel Incentives

```python
eligibility_distribution = df['Clean Alternative Fuel Vehicle (CAFV)
Eligibility'].value_counts(normalize=True)
print(eligibility_distribution)
eligibility_distribution.plot(kind='pie', autopct='%1.1f%%')
plt.title('CAFV Eligibility by Battery Range')
```

```
Clean Alternative Fuel Vehicle (CAFV) Eligibility
Clean Alternative Fuel Vehicle Eligible
0.475753
Eligibility unknown as battery range has not been researched
0.398385
Not eligible due to low battery range
0.125862
Name: proportion, dtype: float64

Text(0.5, 1.0, 'CAFV Eligibility by Battery Range')
```

CAFV Eligibility by Battery Range

Clean Alternative Fuel Vehicle Eligible

proportion

47.6%

12.6%

Not eligible due to low battery range

39.8%

Eligibility unknown as battery range has not been researched
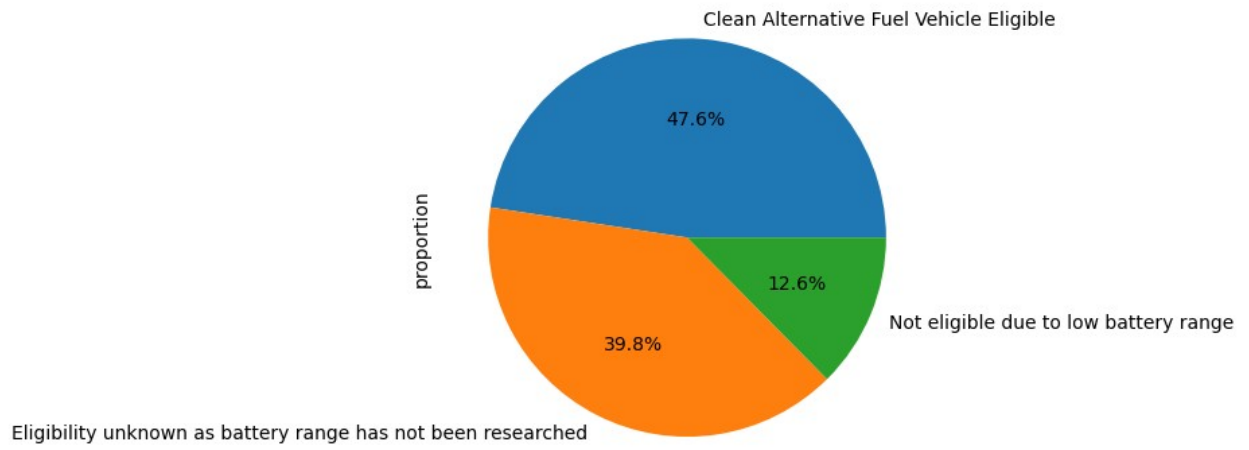
Observations:

Significant Proportion Eligible: Nearly half of the vehicles are eligible for Clean Alternative Fuel Vehicle (CAFV) incentives.

Battery Range as a Limiting Factor: A significant portion of vehicles are ineligible due to low battery range.

Data Gap: A substantial portion of vehicles have unknown eligibility due to missing battery range data.

Recommendations:

Expand Research: Conduct thorough research to determine the battery range of vehicles with unknown eligibility to identify potential CAFV candidates.

Relax Eligibility Criteria: Consider relaxing eligibility criteria, especially for vehicles with slightly lower battery ranges, to encourage wider adoption of clean fuel vehicles.

Promote CAFV Incentives: Implement policies and incentives to encourage the adoption of CAFV vehicles, particularly in states with high adoption potential.

Invest in Charging Infrastructure: Develop a robust charging infrastructure to support the growing number of CAFV vehicles, especially in areas with high adoption rates.

Electric Range Distribution

```python
sns.boxplot(df['Electric Range'])
sns.histplot(df['Electric Range'], bins=30, kde=True)
plt.title('Range Distribution of Electric Vehicles')

Text(0.5, 1.0, 'Range Distribution of Electric Vehicles')
```

Range Distribution of Electric Vehicles
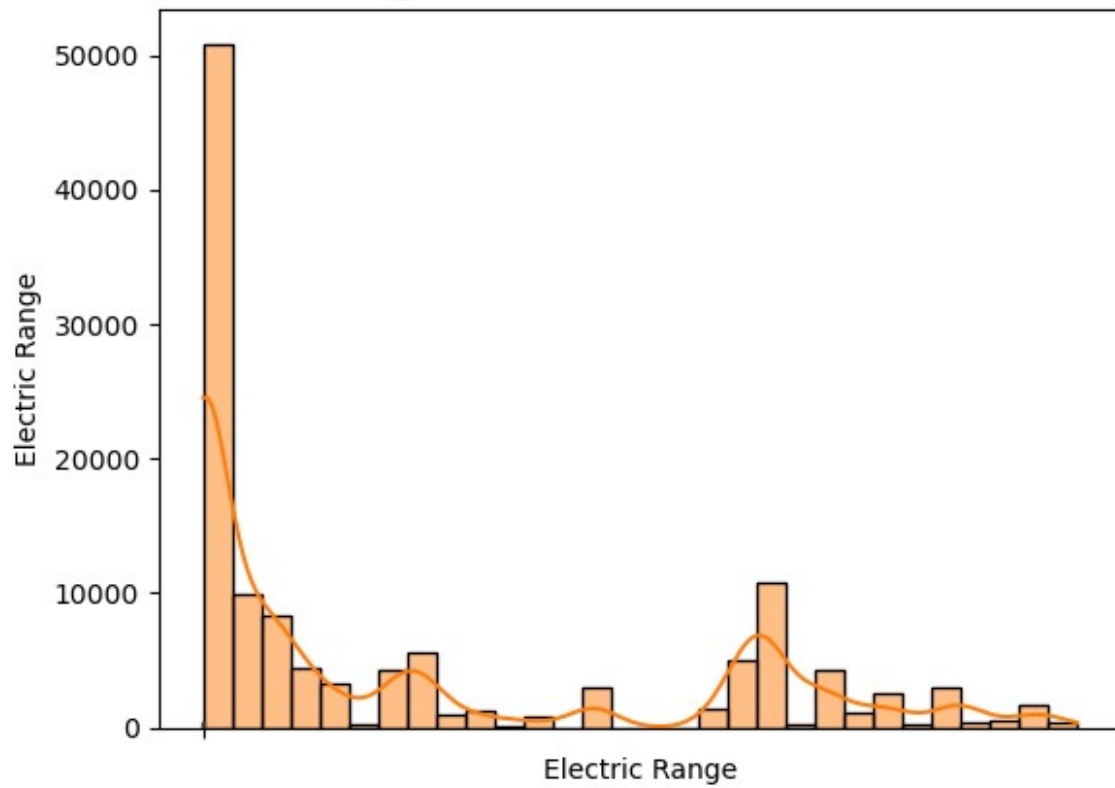
Observations:

The distribution of electric vehicle ranges is right-skewed, with a majority of vehicles having shorter ranges.

There are a few peaks in the distribution, indicating specific range points that are more common.

Recommendations:

Focus on Range Improvement: Manufacturers should prioritize improving battery technology to increase vehicle range and attract a wider range of consumers.

Target Specific Segments: Identify specific market segments that prioritize range, such as long-distance commuters or rural residents, and develop targeted products to meet their needs.

Top Electric Utilities

```
utility_count = df['Electric Utility'].value_counts().head(10)
print(utility_count)
sns.barplot(x=utility_count.values, y=utility_count.index)
plt.title('Market Share of Major Electric Utilities')

Electric Utility
PUGET SOUND ENERGY INC||CITY OF TACOMA - (WA)
45156
PUGET SOUND ENERGY INC
24779
CITY OF SEATTLE - (WA)|CITY OF TACOMA - (WA)
23405
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF CLARK COUNTY - (WA)
7249
BONNEVILLE POWER ADMINISTRATION||CITY OF TACOMA - (WA)||PENINSULA
LIGHT COMPANY       5628
PUGET SOUND ENERGY INC||PUD NO 1 OF WHATCOM COUNTY
2933
BONNEVILLE POWER ADMINISTRATION||AVISTA CORP||INLAND POWER & LIGHT
COMPANY             1853
BONNEVILLE POWER ADMINISTRATION||PUD 1 OF SNOHOMISH COUNTY
1128
PACIFICORP
945
BONNEVILLE POWER ADMINISTRATION||PUD NO 1 OF BENTON COUNTY
911
Name: count, dtype: int64
```

```
Text(0.5, 1.0, 'Market Share of Major Electric Utilities')
```

Market Share of Major Electric Utilities
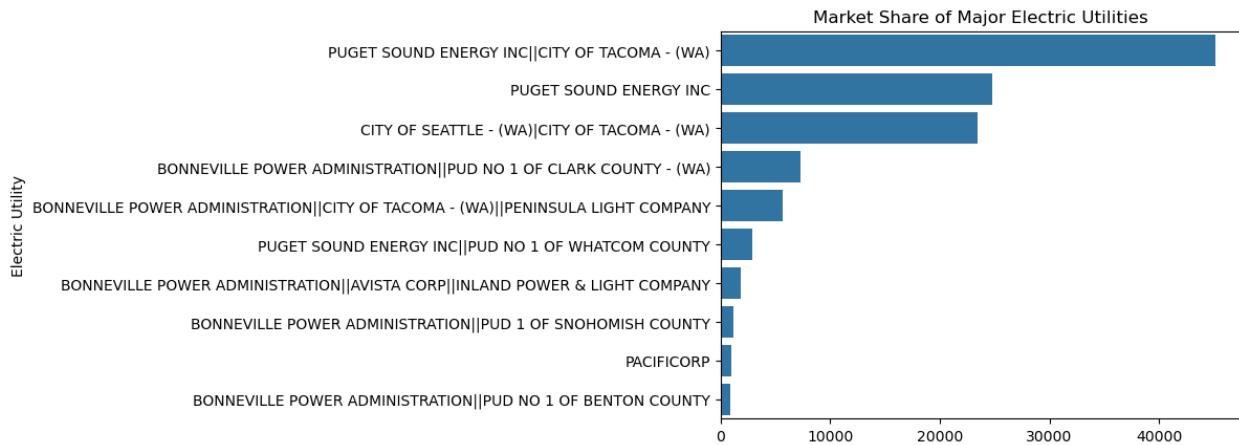
Observations:

Puget Sound Energy dominates the market share, followed by Puget Sound Energy Inc (City of Tacoma).

There is a significant drop in market share after the top two utilities.

Recommendations:

Focus on Market Leaders: Analyze the strategies and customer satisfaction of top utilities like Puget Sound Energy to identify potential areas for improvement and growth.

Targeted Marketing: Implement targeted marketing campaigns to attract and retain customers in regions served by smaller utilities.

Leverage Technology: Utilize technology to improve operational efficiency, enhance customer experience, and explore new business opportunities.

Legislative District Distribution

```python
sns.histplot(df['Legislative District'], bins=30, kde=True)
plt.title('Legislative District-wise Inquiry Volume')
```

```
Text(0.5, 1.0, 'Legislative District-wise Inquiry Volume')
```

Legislative District-wise Inquiry Volume
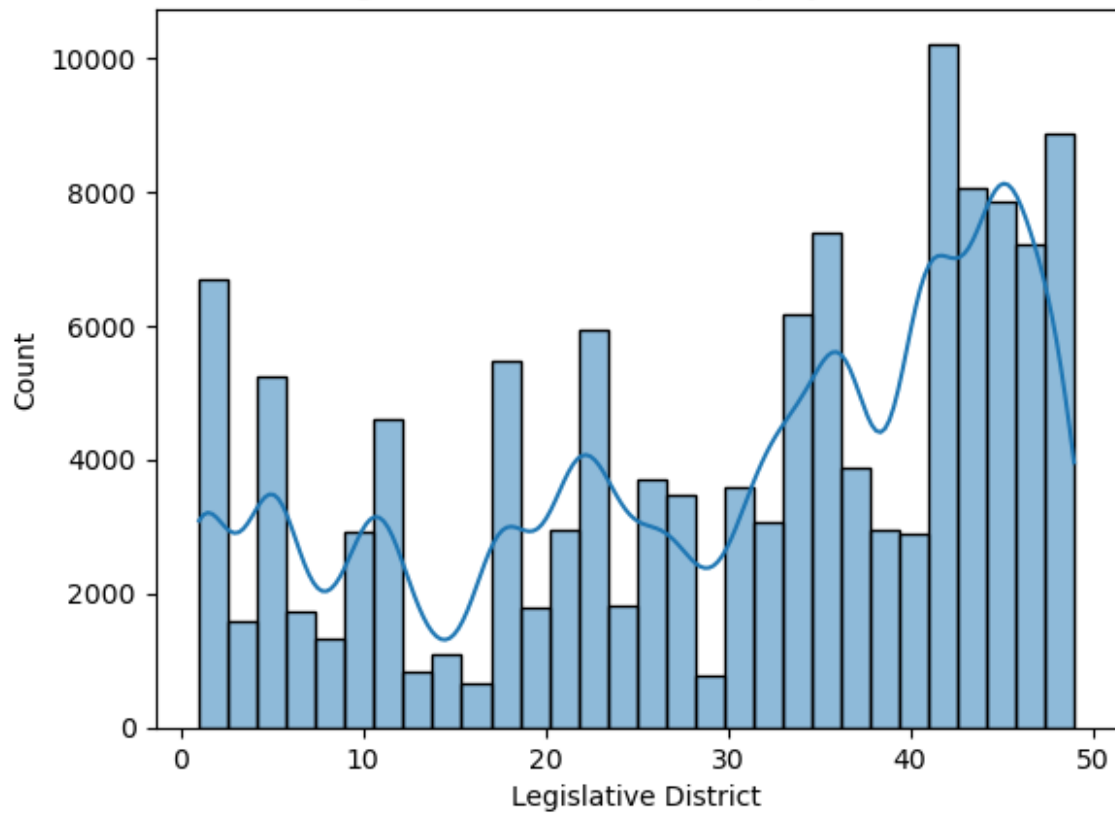
Observations:

The distribution of inquiries across legislative districts is uneven, with some districts receiving a significantly higher number of inquiries than others.

There are peaks in the distribution, indicating districts with higher inquiry volumes.

Recommendations:

Targeted Resource Allocation: Allocate resources and personnel to districts with higher inquiry volumes to ensure timely and efficient response.

Identify High-Inquiry Areas: Analyze the factors contributing to high inquiry volumes in specific districts to implement targeted strategies for improvement.

Electric Range by Vehicle Type

```
sns.boxplot(x='Electric Vehicle Type', y='Electric Range', data=df)
plt.title('Comparing Electric Ranges: BEVs vs PHEVs')

Text(0.5, 1.0, 'Comparing Electric Ranges: BEVs vs PHEVs')
```

Comparing Electric Ranges: BEVs vs PHEVs
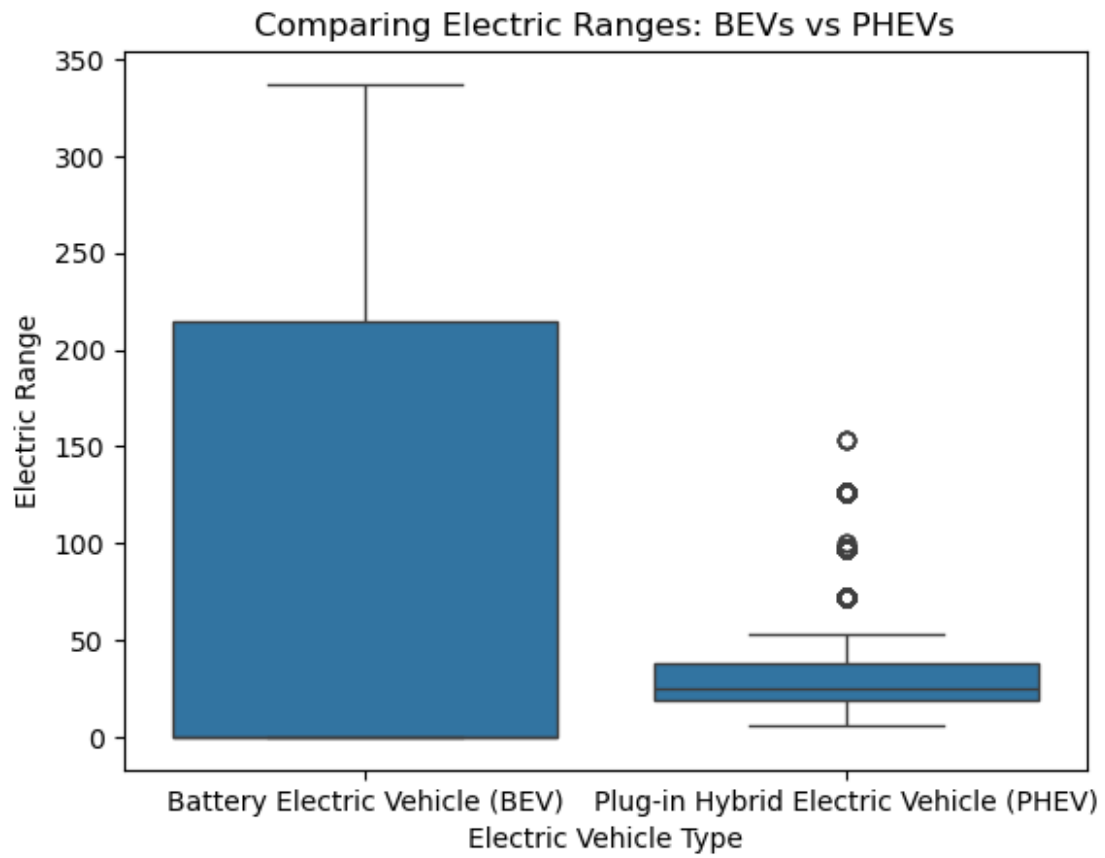
Observations:

BEVs have significantly higher electric ranges compared to PHEVs. This is evident from the median and the overall distribution of the box plots.

PHEVs exhibit more variability in their electric ranges. This is indicated by the larger spread of the box plot for PHEVs.

Recommendations:

Focus on BEV Technology: Manufacturers should continue to invest in battery technology to further increase the range of BEVs and make them more appealing to consumers.

Balance Range and Cost for PHEVs: For PHEVs, manufacturers should strike a balance between electric range and overall cost to attract a wider range of buyers.

Consider Consumer Preferences: Conduct market research to understand consumer preferences for electric range and vehicle type, and tailor product offerings accordingly.

Top 10 counties with the most vehicles

```python
county_counts = df['County'].value_counts().head(10)
print(county_counts)
sns.barplot(x=county_counts.values, y=county_counts.index)
plt.title('County-Level Breakdown')

County
King          65270
Snohomish     14061
Pierce         9538
Clark          7404
Thurston       4548
Kitsap         4148
Whatcom        3101
Spokane        3080
Benton         1568
Skagit         1406
Name: count, dtype: int64

Text(0.5, 1.0, 'County-Level Breakdown')
```

County-Level Breakdown
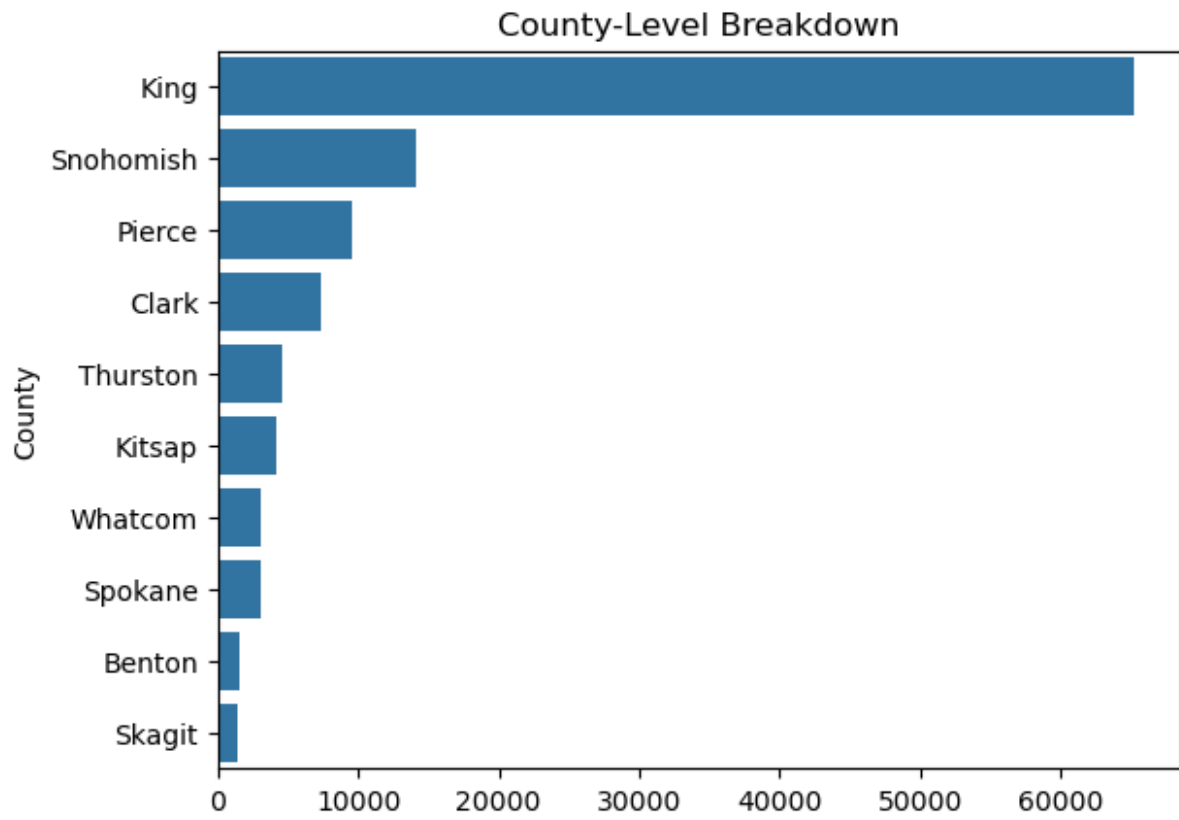
Observations:

King County Dominates: King County has the highest number of electric vehicles, significantly outpacing other counties.

Suburban Counties: Snohomish, Pierce, and Clark counties also have a significant number of electric vehicles, indicating strong adoption in suburban areas.

Recommendations:

Targeted Incentives: Implement targeted incentives and policies to encourage electric vehicle adoption in counties with lower adoption rates, such as Benton and Skagit.

Expand Charging Infrastructure: Invest in expanding the charging infrastructure in counties with high electric vehicle concentrations, particularly in King and Snohomish counties.

Regional Analysis: Conduct a detailed analysis of factors influencing electric vehicle adoption in different counties to identify opportunities for growth.

Electric Range Binning

```python
df['Range Category'] = pd.cut(df['Electric Range'], bins=[0, 100, 200, 300, 400], labels=['Low', 'Medium', 'High', 'Very High'])
sns.countplot(x='Range Category', data=df)
plt.title('Distribution of Electric Vehicles Across Range Categories')

Text(0.5, 1.0, 'Distribution of Electric Vehicles Across Range Categories')
```

Distribution of Electric Vehicles Across Range Categories
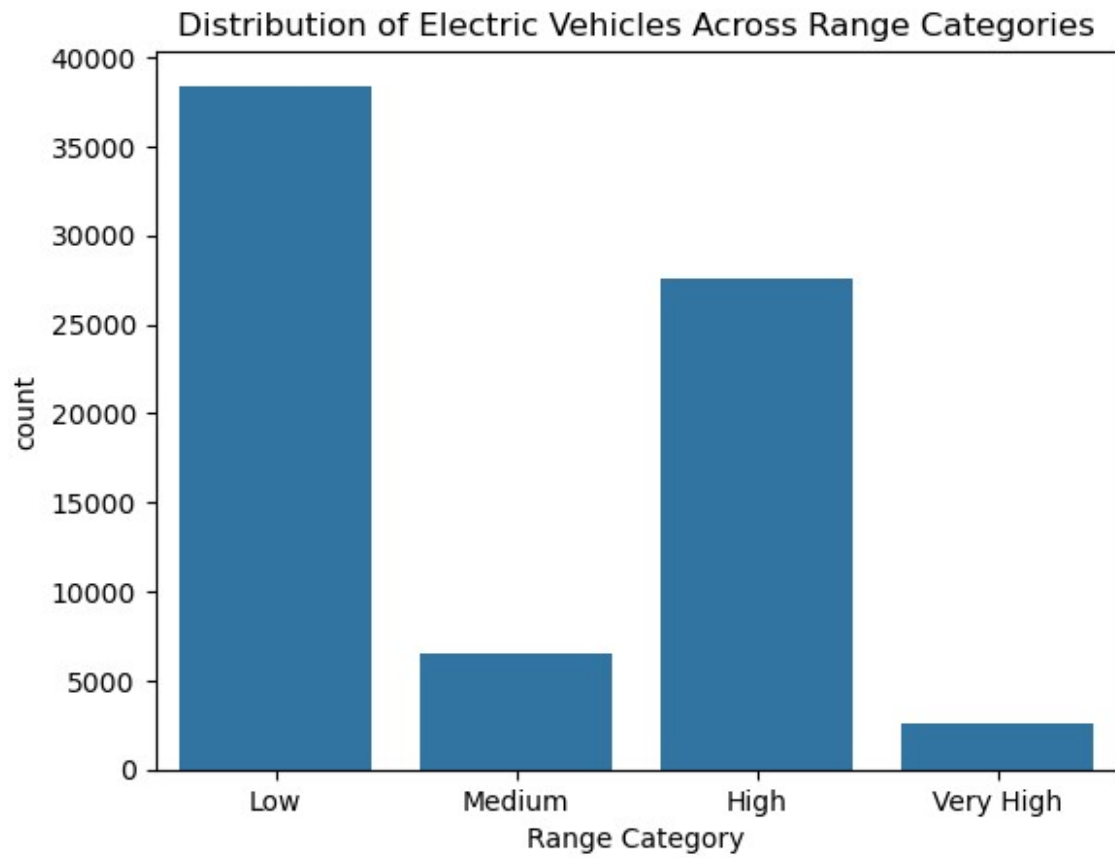
Observations:

Most vehicles fall into the "Low" range category. This suggests that a majority of electric vehicles currently available have relatively shorter ranges.

Fewer vehicles fall into the "Very High" range category. This indicates that high-range electric vehicles are still a niche market.

Recommendations:

Focus on Range Improvement: Manufacturers should prioritize improving battery technology to increase vehicle range and attract a wider range of consumers.

Target Specific Segments: Identify specific market segments that prioritize range, such as long-distance commuters or rural residents, and develop targeted products to meet their needs.

Average Range by State

```
avg_range_by_state = df.groupby('State')['Electric Range'].mean()
avg_range_by_state.sort_values(ascending=False).head(10).plot(kind='bar')
plt.title('State-wise Distribution')

Text(0.5, 1.0, 'State-wise Distribution')
```

State-wise Distribution
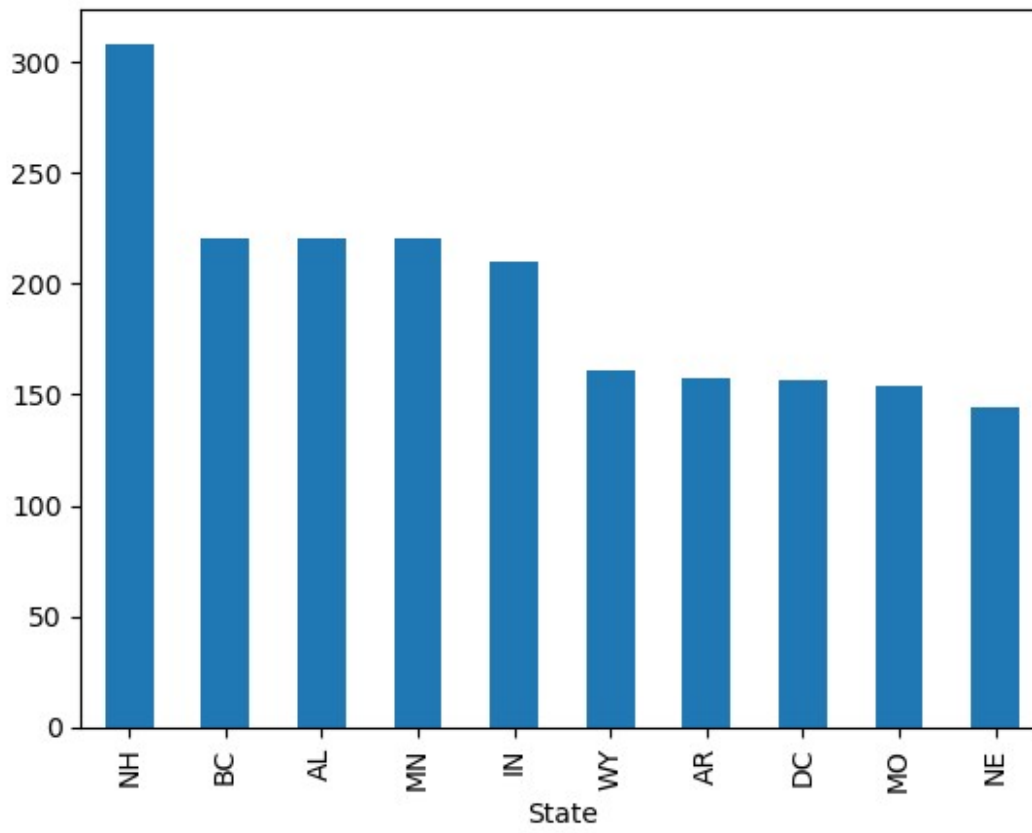
Observations:

Uneven Distribution: The distribution of data points across states is uneven, with some states having significantly higher counts than others.

Dominant States: NH and BC have the highest counts, indicating a higher concentration of data points in these regions.

Recommendations:

Targeted Analysis: Conduct a more detailed analysis of the dominant states (NH and BC) to identify specific trends and patterns within these regions.

Data Collection in Underrepresented States: Increase data collection efforts in states with lower counts to improve the overall data representation and analysis.

Consider Geographic Factors: Analyze the geographic factors influencing the distribution of data points, such as population density, infrastructure, or climate.

Conclusion

Electric vehicle adoption is rapidly increasing, with Battery Electric Vehicles (BEVs) dominating the market due to their higher range and eco-friendly appeal. Key focus areas include improving battery technology, expanding charging infrastructure, and offering targeted incentives to address regional disparities and attract diverse consumer segments.