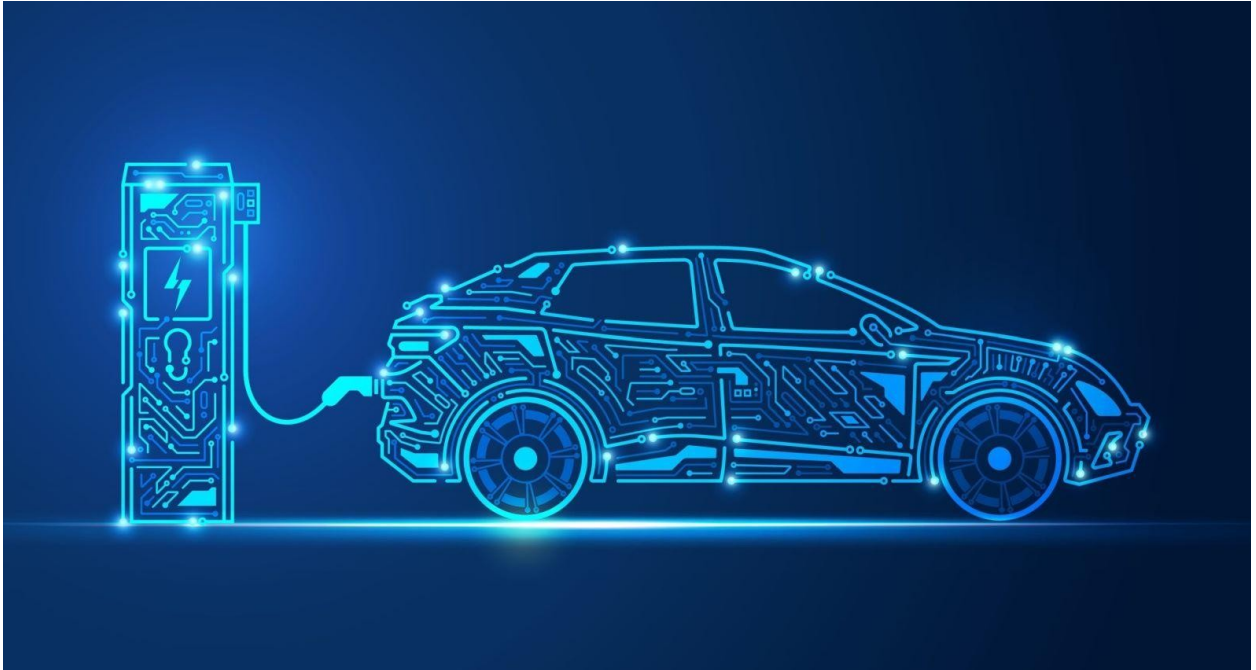


## Electric Cars EDA with Feature Engineering



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## 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

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

### Loading Dataset

```
df =
pd.read_csv("C:/Users/DELL/Downloads/Electric_Vehicle_Population_Data.
csv")
df
```

Year \	VIN (1-10)	County	City	State	Postal Code	Model
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)

Tract	Electric Utility	2020 Census
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

Type \	Make	Model	Electric Vehicle
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)
```

Year \	VIN (1-10)	County	City	State	Postal Code	Model
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						

Type \	Make	Model	Electric Vehicle
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			

```
df.duplicated().sum()
0
```

## Checking Null and Blank Values

```
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

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()]
```

Make \	VIN (1-10)	County	City	State	Postal Code	Model Year
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

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

Checking null values in Model Code column

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

Year \	VIN (1-10)	County	City	State	Postal Code	Model
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

```
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

```
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	Vehicle Location	Electric Utility	2020 Census
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()]
```

Year	VIN (1-10)	County	City	State	Postal Code	Model
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	5YJYGAE5M	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 (BEV)	NISSAN	LEAF	Battery Electric Vehicle		
7262 (BEV)	NISSAN	LEAF	Battery Electric Vehicle		
12989 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
14103 (BEV)	NISSAN	LEAF	Battery Electric Vehicle		
15353 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
20062 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
21361 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
24896 (BEV)	NISSAN	LEAF	Battery Electric Vehicle		
25185 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
30143 (PHEV)	FORD	FUSION	Plug-in	Hybrid Electric Vehicle	
31053 (BEV)	CHEVROLET	BOLT EV	Battery Electric Vehicle		
31790 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
32618 (BEV)	FORD	MUSTANG MACH-E	Battery Electric Vehicle		
33798 (BEV)	TESLA	MODEL 3	Battery Electric Vehicle		
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)				

Range	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric
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	

Location \	Base MSRP	Legislative District	DOL Vehicle ID	Vehicle
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

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

Checking Null values in Electric Utility column

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

Code \	VIN (1-10)	County	City	State	Postal
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

Tract	Vehicle Location	Electric Utility	2020 Census
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()]
```

Make \	VIN (1-10)	County	City	State	Postal Code	Model Year
104754 TESLA	5YJRE11B48	King	Seattle	BC	98052.0	2008
106559 TESLA	5YJ3E1EA5K	King	Seattle	BC	98052.0	2019
Model	Electric Vehicle Type \					
104754	ROADSTER	Battery	Electric Vehicle (BEV)			
106559	MODEL 3	Battery	Electric Vehicle (BEV)			
Range \	Clean Alternative Fuel Vehicle (CAFV) Eligibility					Electric
104754 220	Clean Alternative Fuel Vehicle Eligible					
106559 220	Clean Alternative Fuel Vehicle Eligible					
Base MSRP	Legislative District	DOL Vehicle ID Vehicle				
Location \						
104754 Unknown	98950		10.0		143609049	
106559 Unknown	0		23.0		475254825	
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

Year \	VIN (1-10)	County	City	State	Postal Code	Model
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]

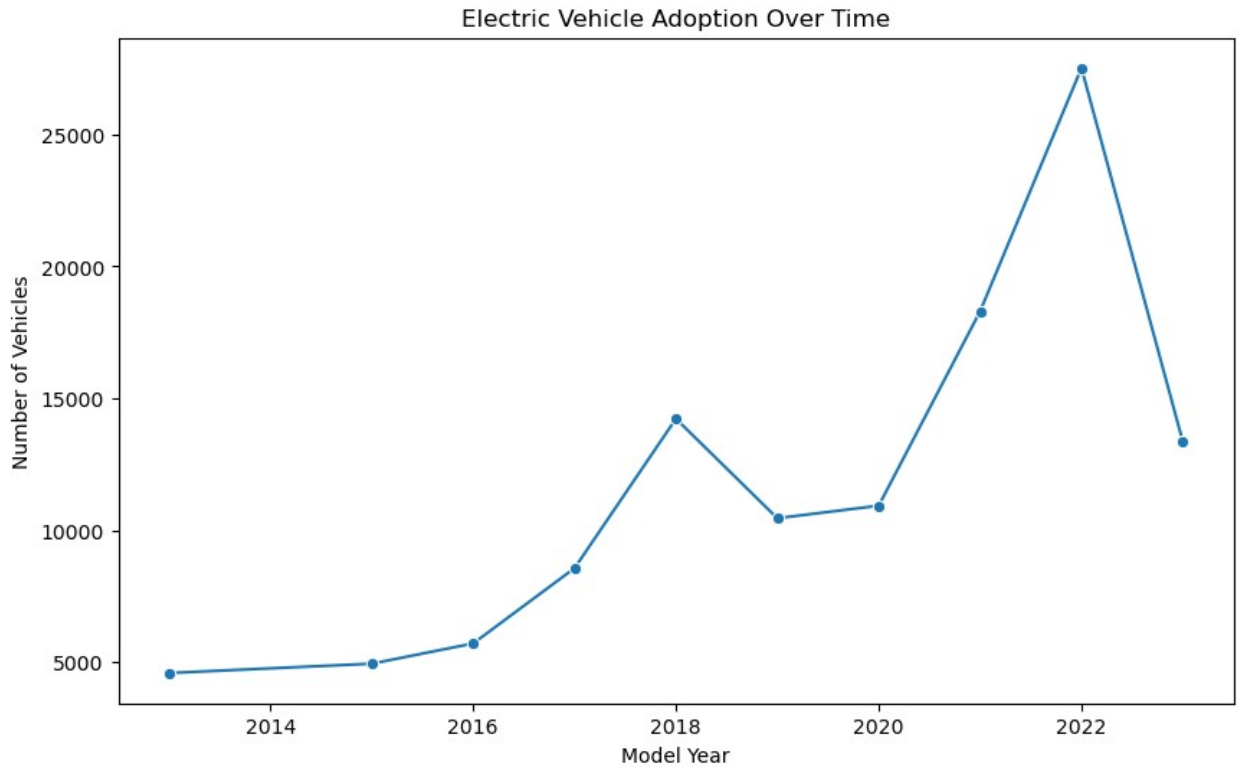
## Electric Vehicle Adoption Over Time (Model Year Trend)

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

```
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

```
# 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()
```



## 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
```

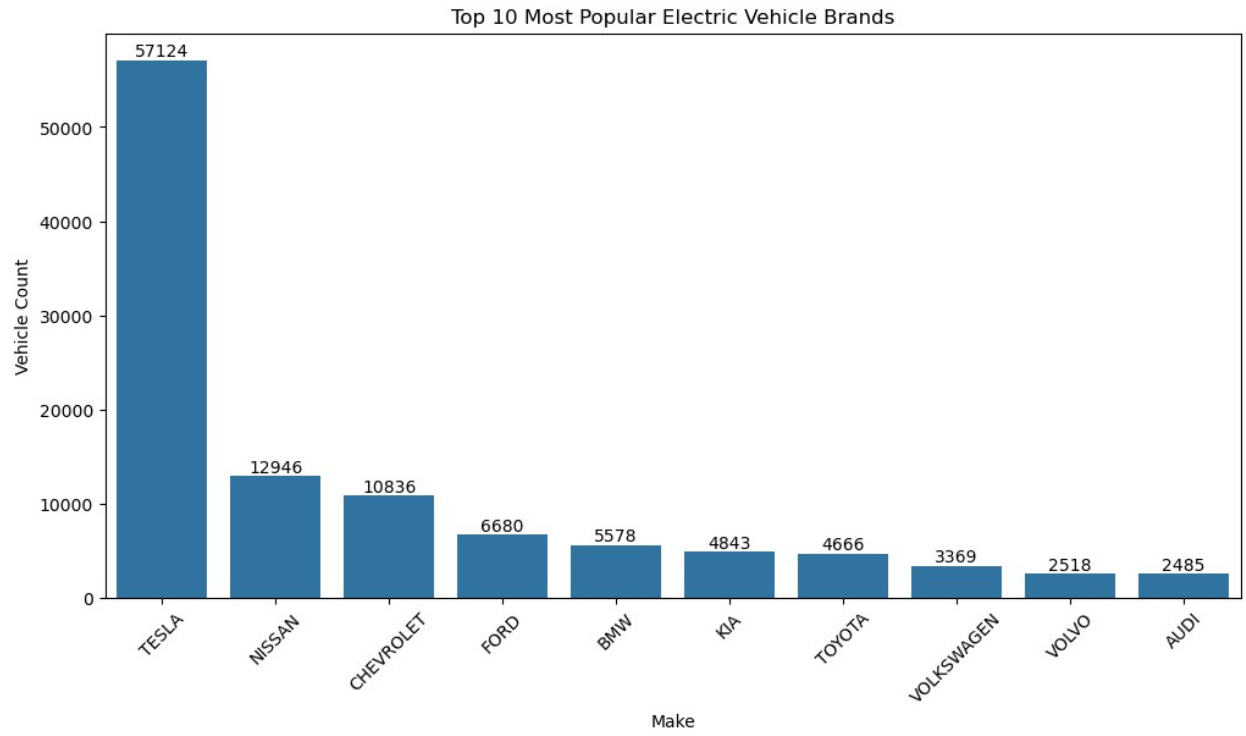
	Make	Vehicle Count
0	TESLA	57124
1	NISSAN	12946
2	CHEVROLET	10836
3	FORD	6680
4	BMW	5578
5	KIA	4843
6	TOYOTA	4666
7	VOLKSWAGEN	3369
8	VOLVO	2518
9	AUDI	2485
10	HYUNDAI	2002
11	JEEP	1936
12	CHRYSLER	1906
13	RIVIAN	1429
14	PORSCHE	898
15	FIAT	810
16	HONDA	800

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

```

# 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()

```



## 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.

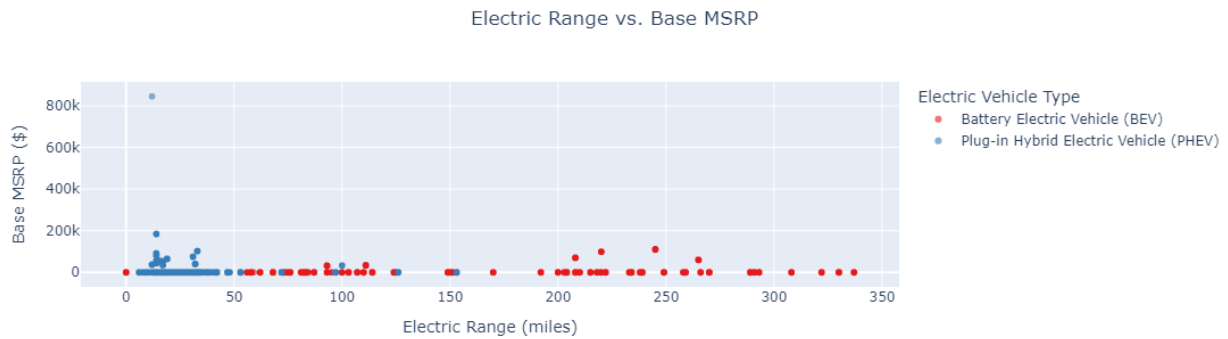
**Increase Production Capacity:** Other manufacturers should increase their production capacity to meet growing demand and compete with Tesla.

**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

```
# 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()
```



## 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.

```
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



### 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')
```

```
# 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

```
# 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')
```

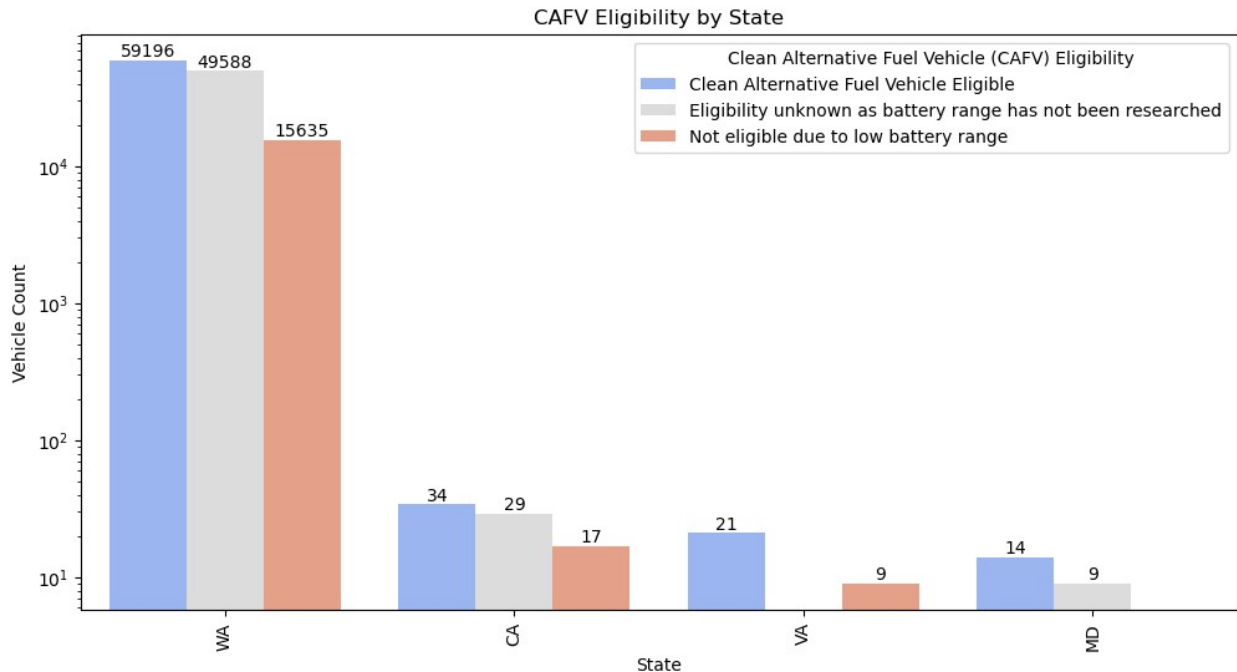
```
plt.yscale("log")
```

```
plt.xticks(rotation=90)
```

```
# Adding labels on the bars
```

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

```
plt.show()
```



### 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

```
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)
```

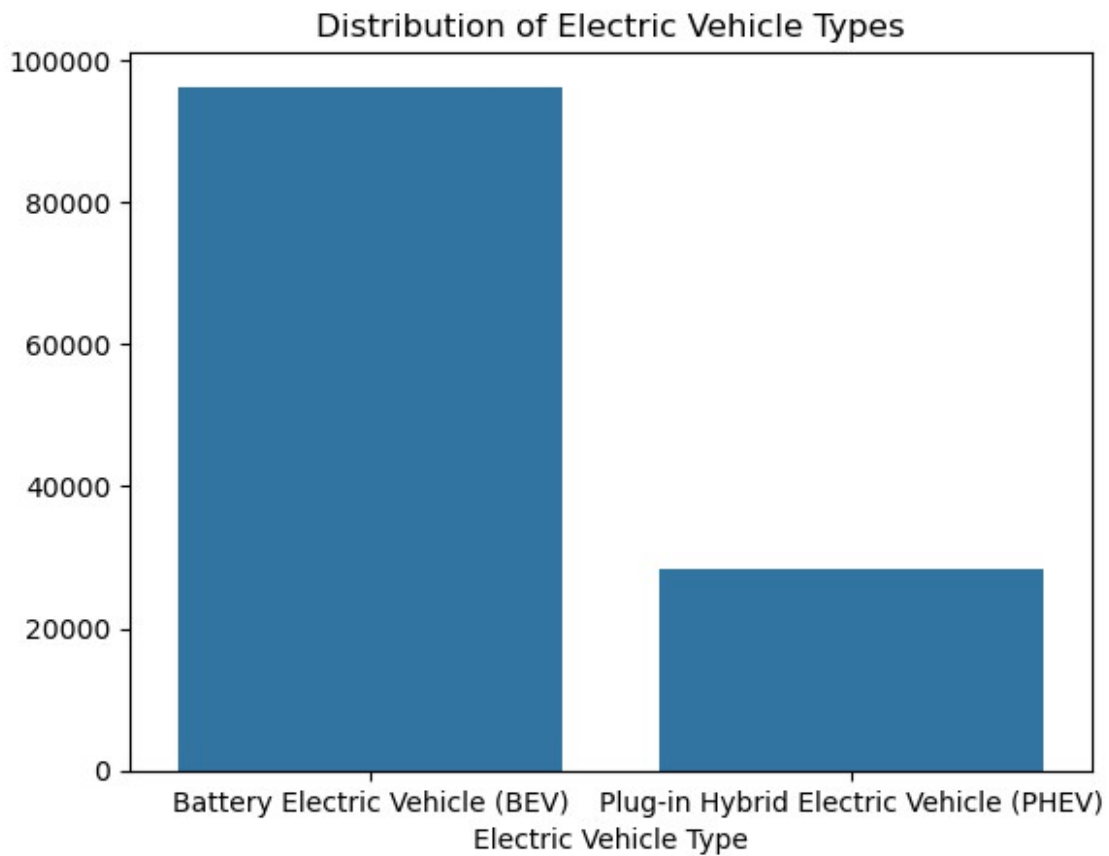
Electric Vehicle Type

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:

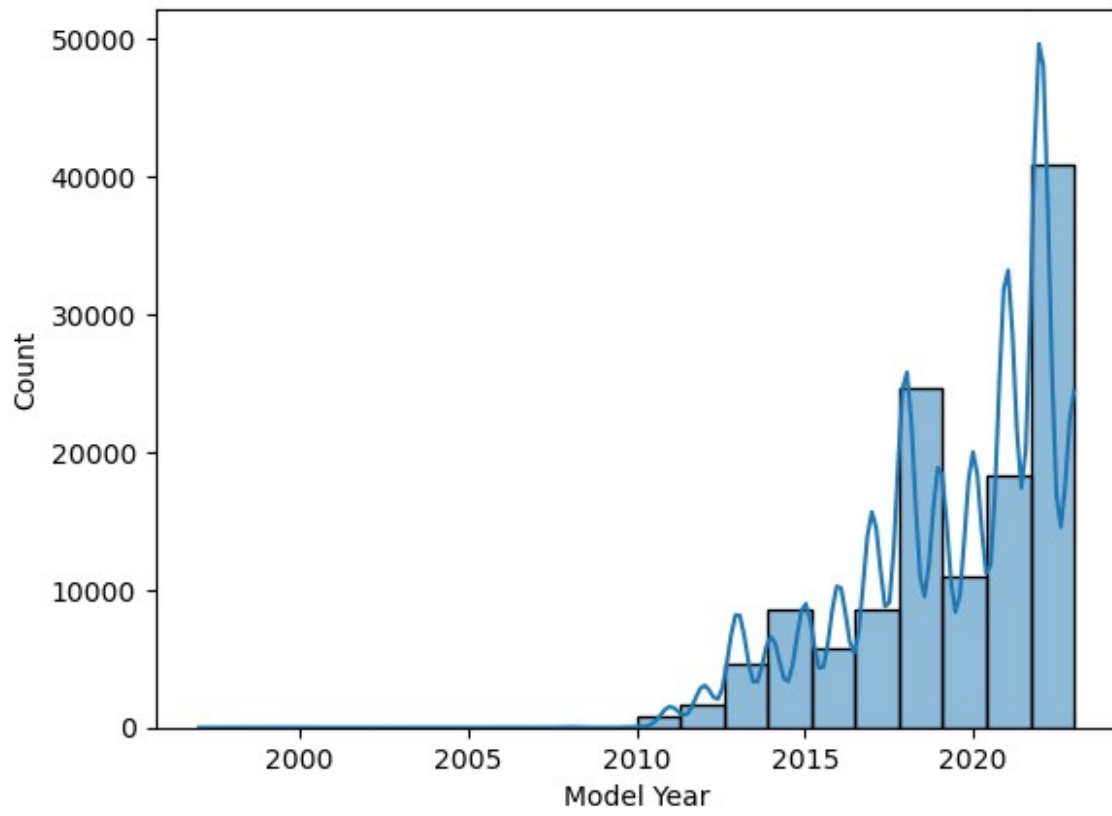
**Focus on BEV Development:** Manufacturers should prioritize the development and production of BEVs to capitalize on the growing demand for fully electric vehicles.

**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.

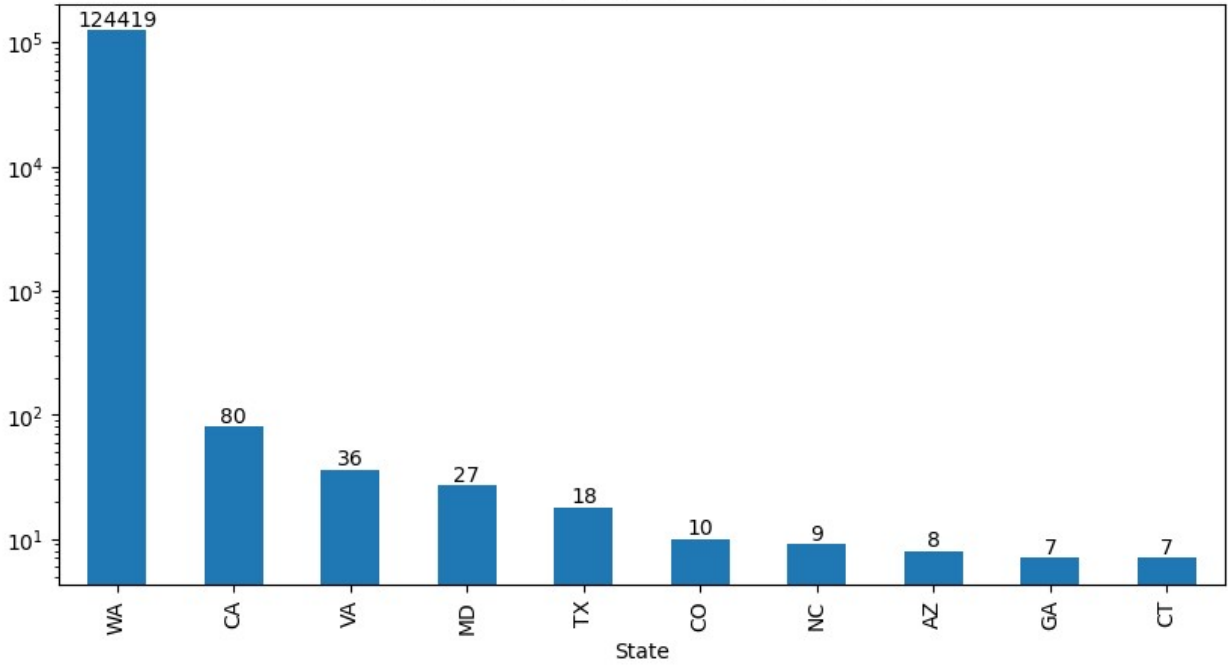
## State-Wise Distribution of EVs

```
# 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.

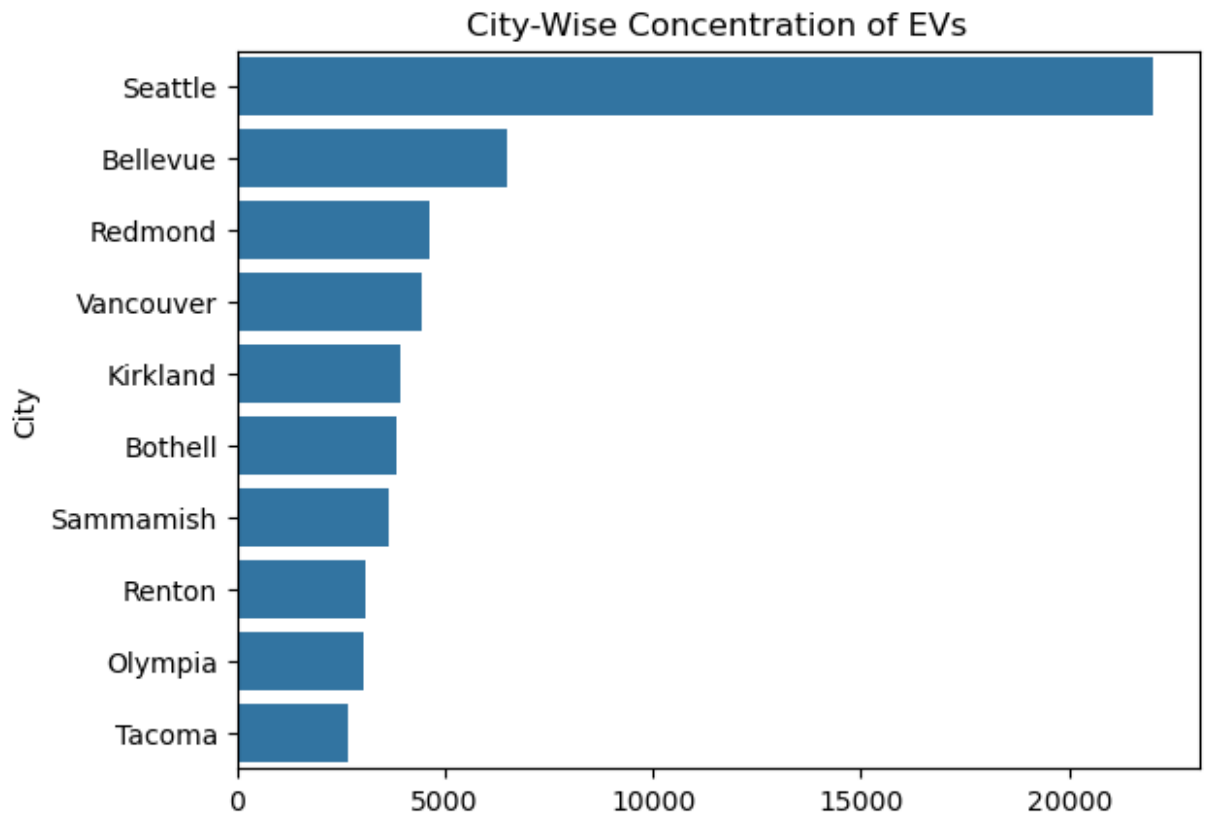
**Regional Analysis:** Conduct a detailed analysis of factors influencing electric vehicle adoption in different states to identify opportunities for growth.

## 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')
```



## 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.

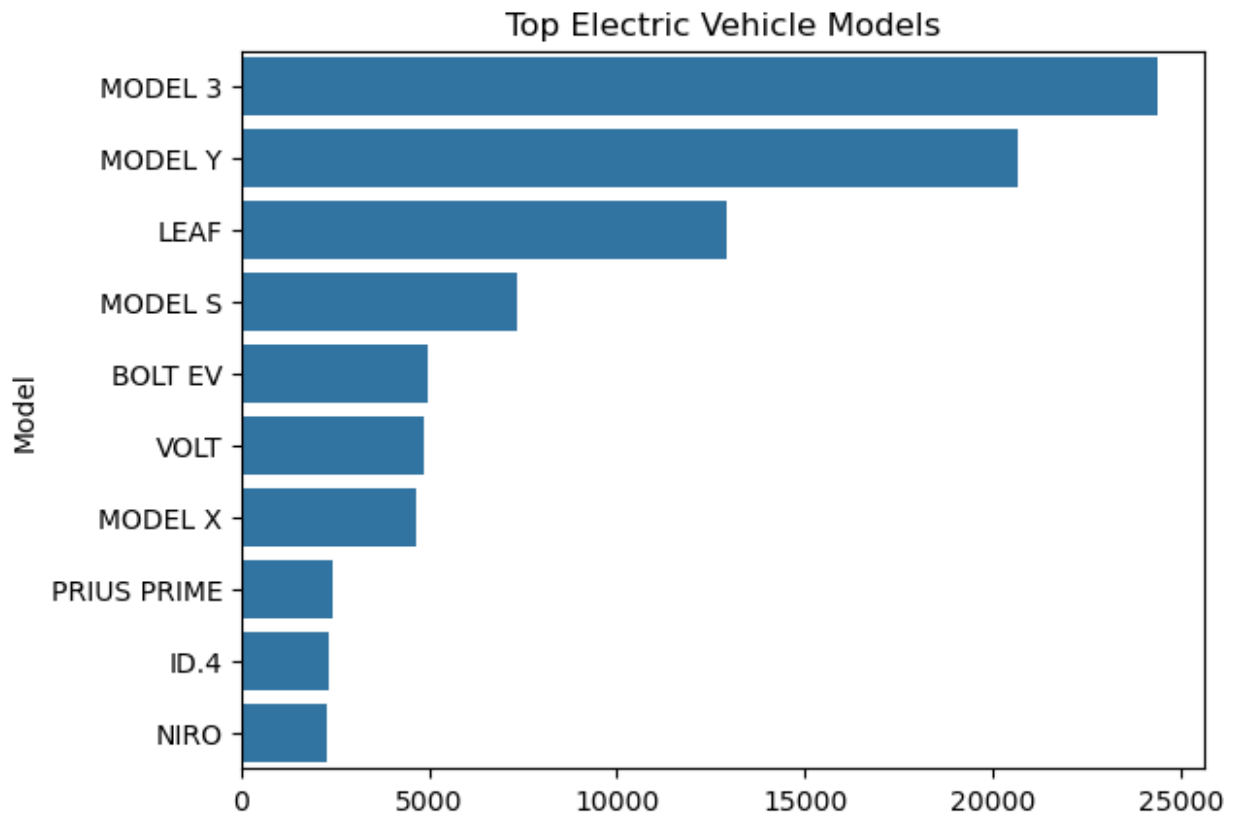
**Study Suburban Adoption:** Analyze the factors driving EV adoption in suburban areas to identify strategies for promoting EVs in other regions.

## Most Popular EV Models

```
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')
```



## 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.

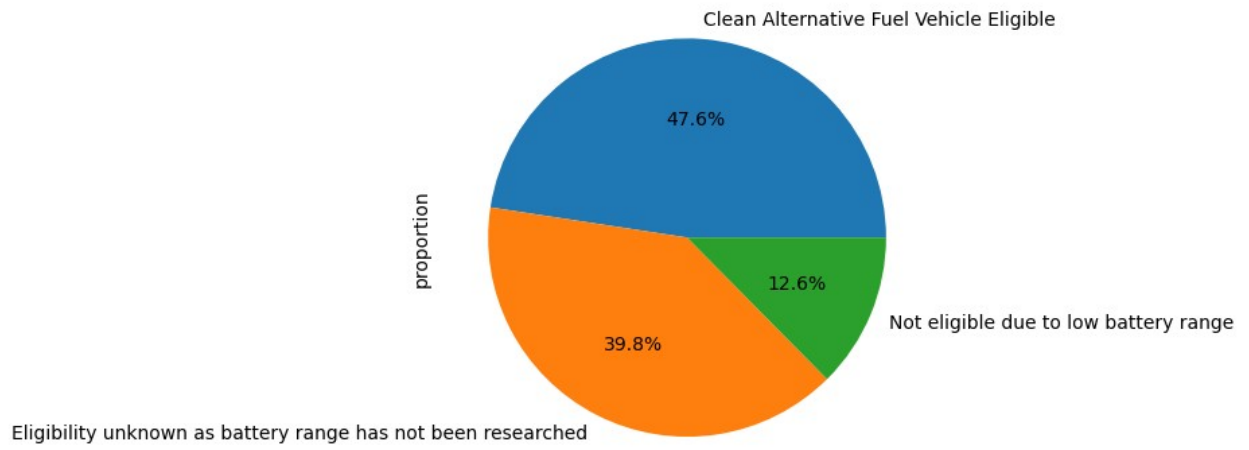
## Eligibility for Clean Fuel Incentives

```
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



## 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.

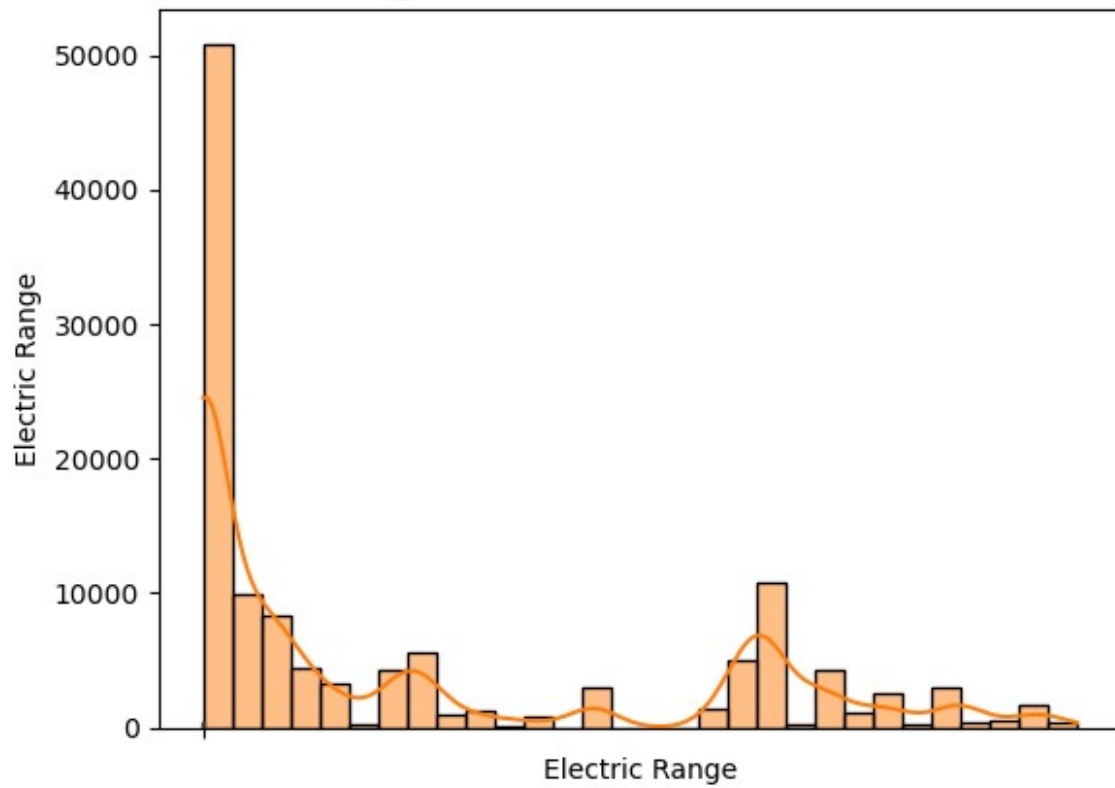
**Promote CAFV Incentives:** Implement policies and incentives to encourage the adoption of CAFV vehicles, particularly in states with high adoption potential.

**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

```
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.

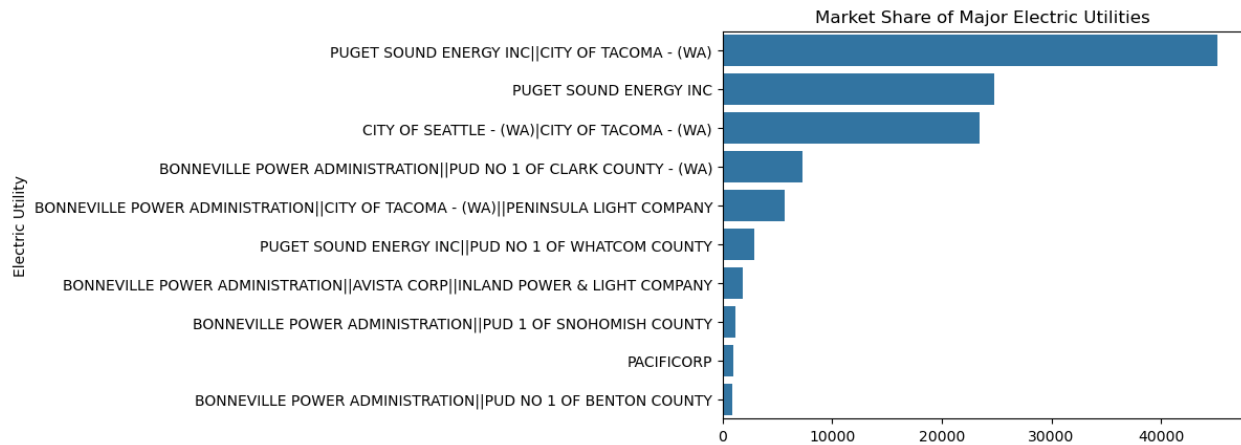
## Top Electric Utilities

```
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	count
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')
```



## 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.

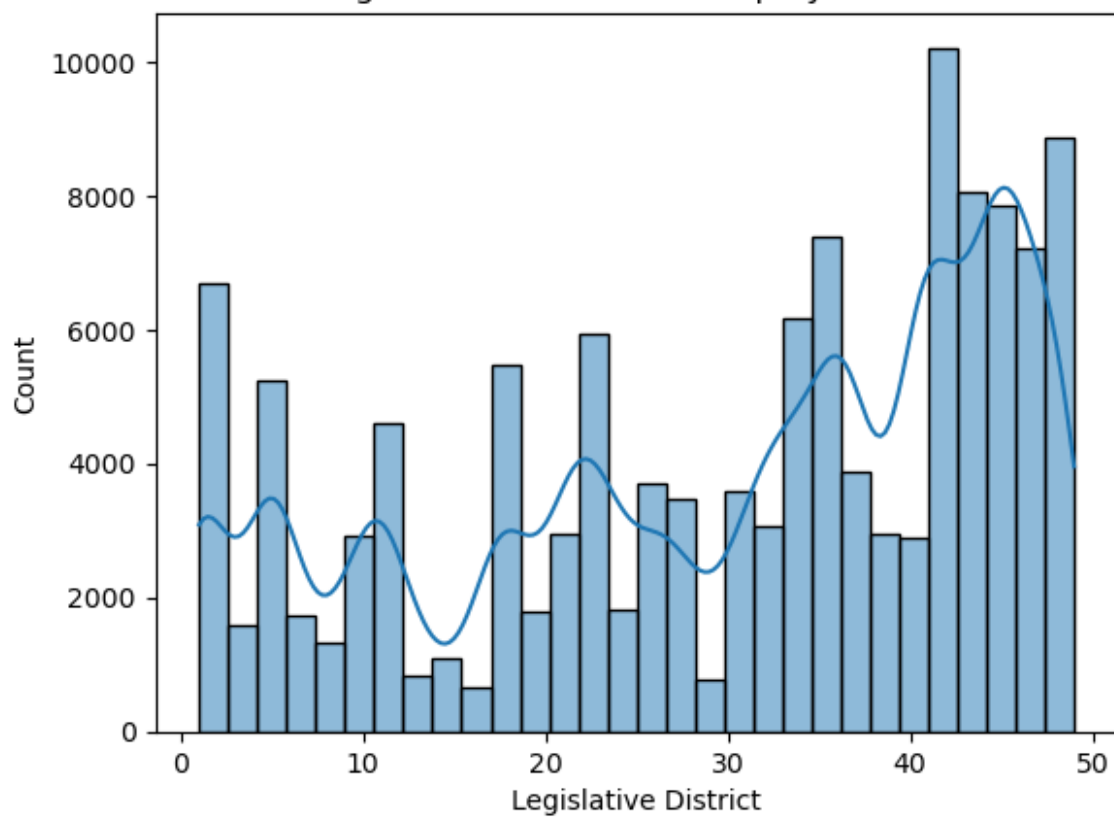
**Leverage Technology:** Utilize technology to improve operational efficiency, enhance customer experience, and explore new business opportunities.

## Legislative District Distribution

```
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:

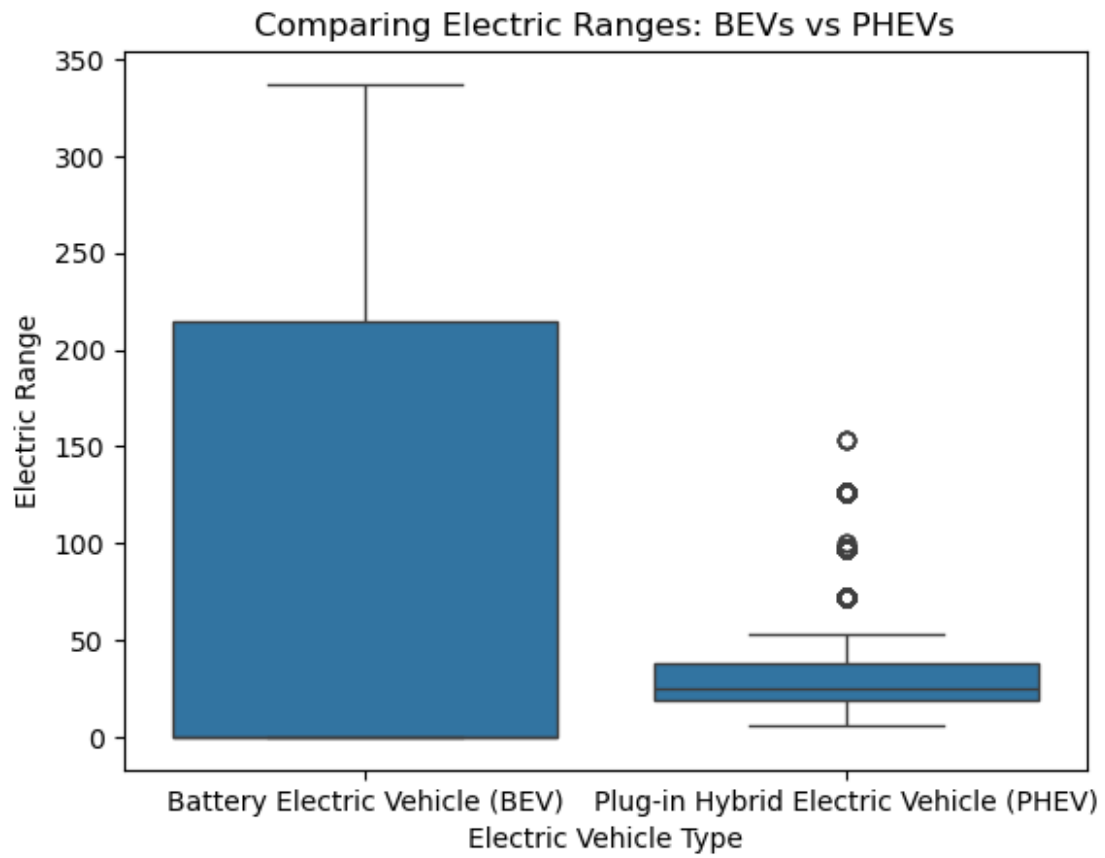
**Targeted Resource Allocation:** Allocate resources and personnel to districts with higher inquiry volumes to ensure timely and efficient response.

**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')
```



## 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.

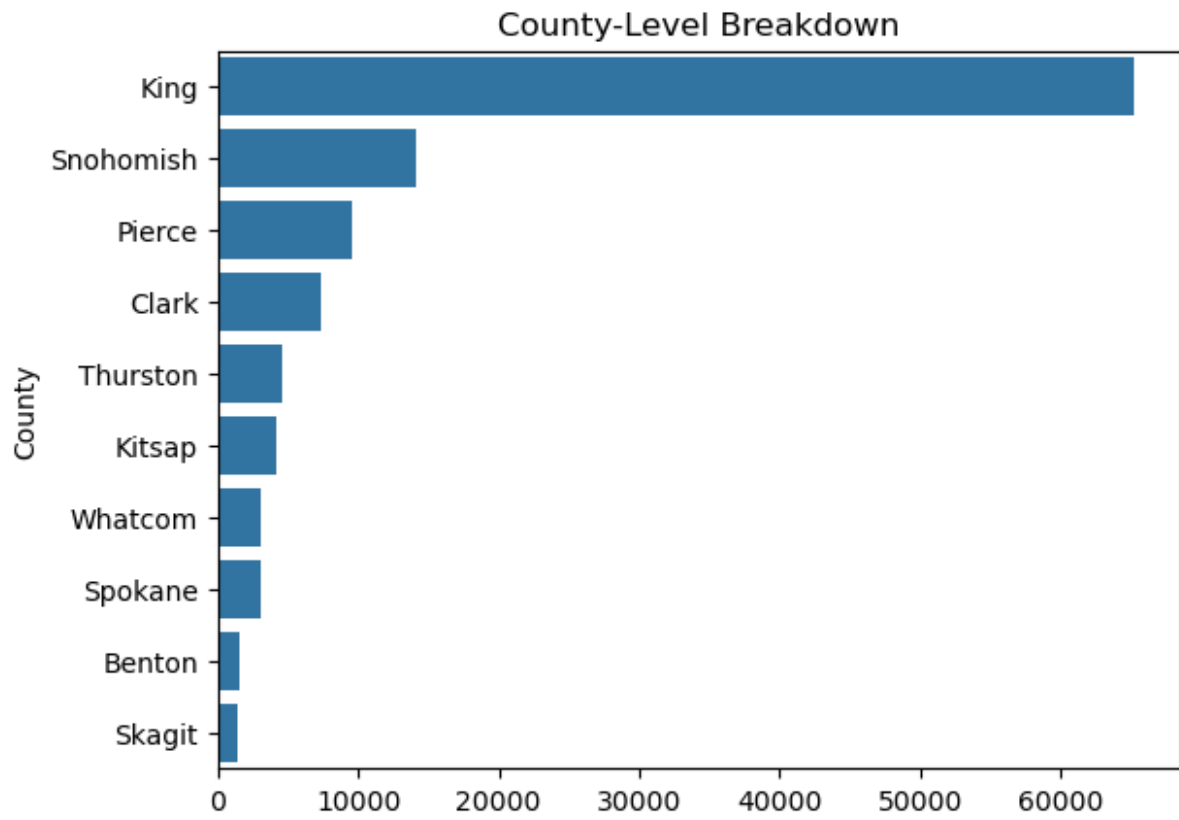
**Consider Consumer Preferences:** Conduct market research to understand consumer preferences for electric range and vehicle type, and tailor product offerings accordingly.

## Top 10 counties with the most vehicles

```
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')
```



## 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.

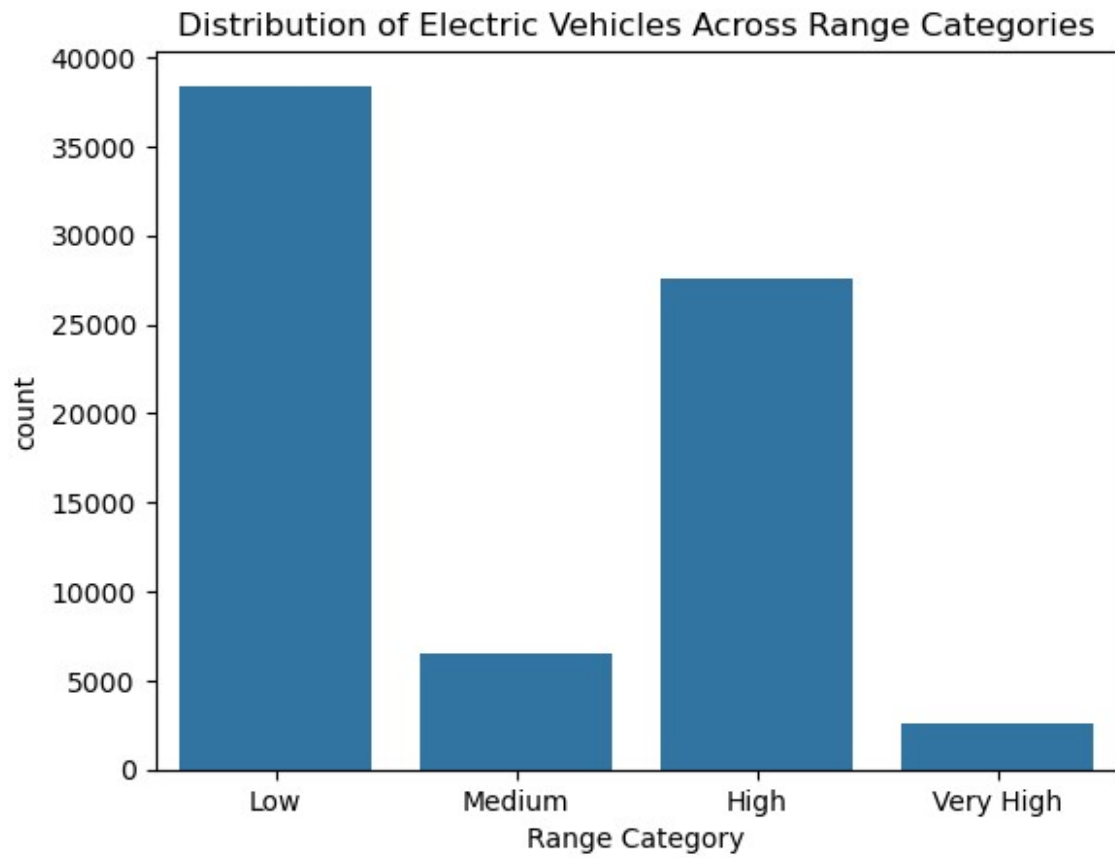
**Regional Analysis:** Conduct a detailed analysis of factors influencing electric vehicle adoption in different counties to identify opportunities for growth.

## Electric Range Binning

```
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')
```





## 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:

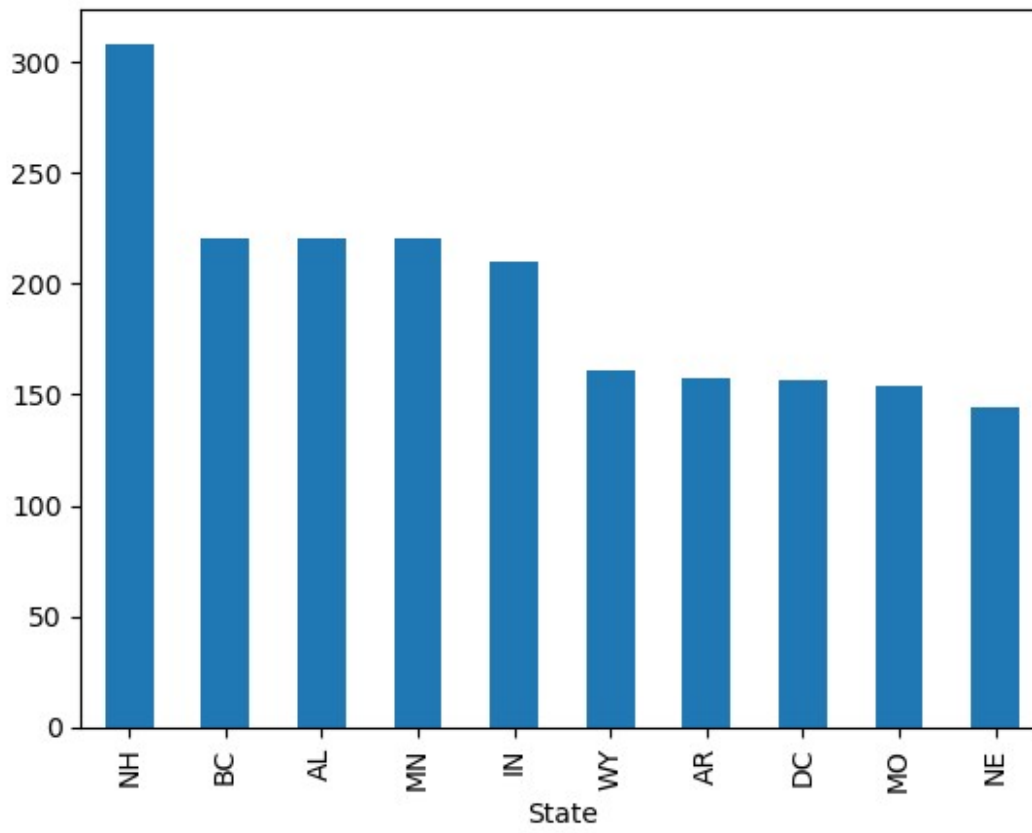
**Focus on Range Improvement:** Manufacturers should prioritize improving battery technology to increase vehicle range and attract a wider range of consumers.

**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.