In [1]:
```
import pandas as pd
import numpy as np
import plotly.express as px
import warnings
warnings.filterwarnings("ignore")


df_makers=pd.read_csv('electric_vehicle_sales_by_makers.csv')
df_makers.head()
```

Out[1]:

	date	vehicle_category	maker	electric_vehicles_sold
0	01-Apr-21	2-Wheelers	OLA ELECTRIC	0
1	01-Apr-22	2-Wheelers	OKAYA EV	0
2	01-May-21	2-Wheelers	OLA ELECTRIC	0
3	01-Jun-21	2-Wheelers	OLA ELECTRIC	0
4	01-Jul-21	2-Wheelers	OLA ELECTRIC	0

In [2]:
```
df_makers.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 816 entries, 0 to 815
Data columns (total 4 columns):
 #   Column                 Non-Null Count  Dtype 
---  ------                 --------------  ----- 
 0   date                   816 non-null    object
 1   vehicle_category       816 non-null    object
 2   maker                  816 non-null    object
 3   electric_vehicles_sold  816 non-null    int64 
dtypes: int64(1), object(3)
memory usage: 25.6+ KB
```

In [3]:
```
#check for null values
df_makers.isnull().sum()
```

Out[3]:
```
date                   0
vehicle_category       0
maker                  0
electric_vehicles_sold    0
dtype: int64
```

In [4]:
```
#changing date object to date format
df_makers['date']=pd.to_datetime(df_makers['date'],format='%d-%b-%y')
```

In [5]:
```
df_makers.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 816 entries, 0 to 815
Data columns (total 4 columns):
 #   Column                 Non-Null Count  Dtype         
---  ------                 --------------  -----         
 0   date                   816 non-null    datetime64[ns]
 1   vehicle_category       816 non-null    object        
 2   maker                  816 non-null    object        
 3   electric_vehicles_sold  816 non-null    int64         
dtypes: datetime64[ns](1), int64(1), object(2)
memory usage: 25.6+ KB
```

In [6]:
```
df_state=pd.read_csv('electric_vehicle_sales_by_state.csv')
df_state.head()
```

Out[6]:

	date	state	vehicle_category	electric_vehicles_sold	total_vehicles_sold
0	01-Apr-21	Sikkim	2-Wheelers	0	398
1	01-Apr-21	Sikkim	4-Wheelers	0	361
2	01-May-21	Sikkim	2-Wheelers	0	113
3	01-May-21	Sikkim	4-Wheelers	0	98
4	01-Jun-21	Sikkim	2-Wheelers	0	229

In [7]:
```
#check for null values
df_state.isnull().sum()
```

Out[7]:
```
date                    0
state                   0
vehicle_category        0
electric_vehicles_sold  0
total_vehicles_sold     0
dtype: int64
```

In [8]:
```
df_state.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2445 entries, 0 to 2444
Data columns (total 5 columns):
 #   Column                  Non-Null Count  Dtype 
---  ------                  --------------  ----- 
 0   date                    2445 non-null   object
 1   state                   2445 non-null   object
 2   vehicle_category        2445 non-null   object
 3   electric_vehicles_sold  2445 non-null   int64 
 4   total_vehicles_sold     2445 non-null   int64 
dtypes: int64(2), object(3)
memory usage: 95.6+ KB
```

In [9]:
```
#changing date object to date format
df_state['date']=pd.to_datetime(df_state['date'],format='%d-%b-%y')
```

In [10]:
```
df_state.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2445 entries, 0 to 2444
Data columns (total 5 columns):
 #   Column                  Non-Null Count  Dtype         
---  ------                  --------------  -----         
 0   date                    2445 non-null   datetime64[ns]
 1   state                   2445 non-null   object        
 2   vehicle_category        2445 non-null   object        
 3   electric_vehicles_sold  2445 non-null   int64         
 4   total_vehicles_sold     2445 non-null   int64         
dtypes: datetime64[ns](1), int64(2), object(2)
memory usage: 95.6+ KB
```

In [11]:
```
df_date=pd.read_csv('dim_date.csv')
df_date.head()
```

Out[11]:

	date	fiscal_year	quarter
0	01-Apr-21	2022	Q1
1	01-May-21	2022	Q1
2	01-Jun-21	2022	Q1
3	01-Jul-21	2022	Q2
4	01-Aug-21	2022	Q2

In [12]:
```
df_date.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 36 entries, 0 to 35
Data columns (total 3 columns):
 #   Column       Non-Null Count  Dtype 
---  ------       --------------  ----- 
 0   date         36 non-null     object
 1   fiscal_year  36 non-null     int64 
 2   quarter      36 non-null     object
dtypes: int64(1), object(2)
memory usage: 996.0+ bytes
```

In [13]:
```
#changing date object to date format
df_date['date']=pd.to_datetime(df_date['date'],format='%d-%b-%y')
```

In [14]:
```
#merging dates data with makers data
new_m=pd.merge(df_date,df_makers,on='date',how='inner')
new_m
```

Out[14]:

	date	fiscal_year	quarter	vehicle_category	maker	electric_vehicles_sold
0	2021-04-01	2022	Q1	2-Wheelers	OLA ELECTRIC	0
1	2021-04-01	2022	Q1	4-Wheelers	BYD India	0
2	2021-04-01	2022	Q1	4-Wheelers	PCA Automobiles	0
3	2021-04-01	2022	Q1	4-Wheelers	BMW India	0
4	2021-04-01	2022	Q1	4-Wheelers	Volvo Auto India	0
...	...	...	...	...	...	...
811	2024-03-01	2024	Q4	2-Wheelers	BGAUSS	3070
812	2024-03-01	2024	Q4	2-Wheelers	BATTRE ELECTRIC	625
813	2024-03-01	2024	Q4	2-Wheelers	KINETIC GREEN	3915
814	2024-03-01	2024	Q4	2-Wheelers	REVOLT	585
815	2024-03-01	2024	Q4	2-Wheelers	OTHERS	10579

816 rows × 6 columns

In [15]:
```
#merging dates data with state data
new_s=pd.merge(df_date,df_state,on='date',how='inner')
new_s
```

Out[15]:

	date	fiscal_year	quarter	state	vehicle_category	electric_vehicles_sold	total_vehicles_sold
0	2021-04-01	2022	Q1	Sikkim	2-Wheelers	0	398
1	2021-04-01	2022	Q1	Sikkim	4-Wheelers	0	361
2	2021-04-01	2022	Q1	Andaman & Nicobar Island	2-Wheelers	0	515
3	2021-04-01	2022	Q1	Arunachal Pradesh	2-Wheelers	0	1256
4	2021-04-01	2022	Q1	Arunachal Pradesh	4-Wheelers	0	724
...	...	...	...	...	...	...	...
2440	2024-03-01	2024	Q4	Mizoram	2-Wheelers	58	1932
2441	2024-03-01	2024	Q4	DNH and DD	2-Wheelers	25	780
2442	2024-03-01	2024	Q4	Manipur	2-Wheelers	13	1394
2443	2024-03-01	2024	Q4	Andaman & Nicobar Island	2-Wheelers	2	447
2444	2024-03-01	2024	Q4	Nagaland	2-Wheelers	2	1180

2445 rows × 7 columns

In [16]:
```
#checking for duplicates
dup_rows=new_m[new_m.duplicated()]
dup_rows
```

Out[16]:

	date	fiscal_year	quarter	vehicle_category	maker	electric_vehicles_sold

In [17]:
```
#checking for duplicates
dup_rows=new_s[new_s.duplicated()]
dup_rows
```

Out[17]:

	date	fiscal_year	quarter	state	vehicle_category	electric_vehicles_sold	total_vehicles_sold

In [18]:
```
# Basic statistical Analysis
new_m.describe()
```

Out[18]:

	date	fiscal_year	electric_vehicles_sold
count	816	816.000000	816.000000
mean	2022-09-21 03:30:00	2023.014706	2531.998775
min	2021-04-01 00:00:00	2022.000000	0.000000
25%	2022-01-01 00:00:00	2022.000000	42.000000
50%	2022-10-01 00:00:00	2023.000000	662.000000
75%	2023-07-01 00:00:00	2024.000000	2636.500000
max	2024-03-01 00:00:00	2024.000000	44630.000000
std	NaN	0.813855	4771.077333

In [19]:
```
# Basic statistical Analysis
new_s.describe()
```

Out[19]:

	date	fiscal_year	electric_vehicles_sold	total_vehicles_sold
count	2445	2445.000000	2445.000000	2445.000000
mean	2022-09-15 12:50:56.687116800	2022.999591	845.035174	23402.966053
min	2021-04-01 00:00:00	2022.000000	0.000000	1.000000
25%	2022-01-01 00:00:00	2022.000000	2.000000	1158.000000
50%	2022-09-01 00:00:00	2023.000000	54.000000	6098.000000
75%	2023-06-01 00:00:00	2024.000000	534.000000	29396.000000
max	2024-03-01 00:00:00	2024.000000	26668.000000	387983.000000
std	NaN	0.816413	2185.167744	38353.266389

In [20]:
```
#KPI
Total_EV=sum(new_m['electric_vehicles_sold'])
Total_EV
```

Out[20]: 2066111

In [21]:
```
#KPI
Total_EV=sum(new_s['electric_vehicles_sold'])
Total_EV
```

Out[21]: 2066111

In [22]:
```
#KPI
Total_veh=sum(new_s['total_vehicles_sold'])
Total_veh
```

Out[22]: 57220252

List the top 3 and bottom 3 makers for the fiscal years 2023 and 2024 in terms of the number of 2-wheelers sold.

In [23]:
```
maker=new_m.groupby(['maker','vehicle_category','fiscal_year'])['electric_vehicles_sold'].sum().reset_index()
maker.head()
```

Out[23]:

	maker	vehicle_category	fiscal_year	electric_vehicles_sold
0	AMPERE	2-Wheelers	2022	25510
1	AMPERE	2-Wheelers	2023	87376
2	AMPERE	2-Wheelers	2024	54388
3	ATHER	2-Wheelers	2022	19976
4	ATHER	2-Wheelers	2023	76921

In [24]:
```
maker1 = maker[(maker['vehicle_category'] == '2-Wheelers') & (maker['fiscal_year'].isin([2023,2024]))]
maker1
```

Out[24]:

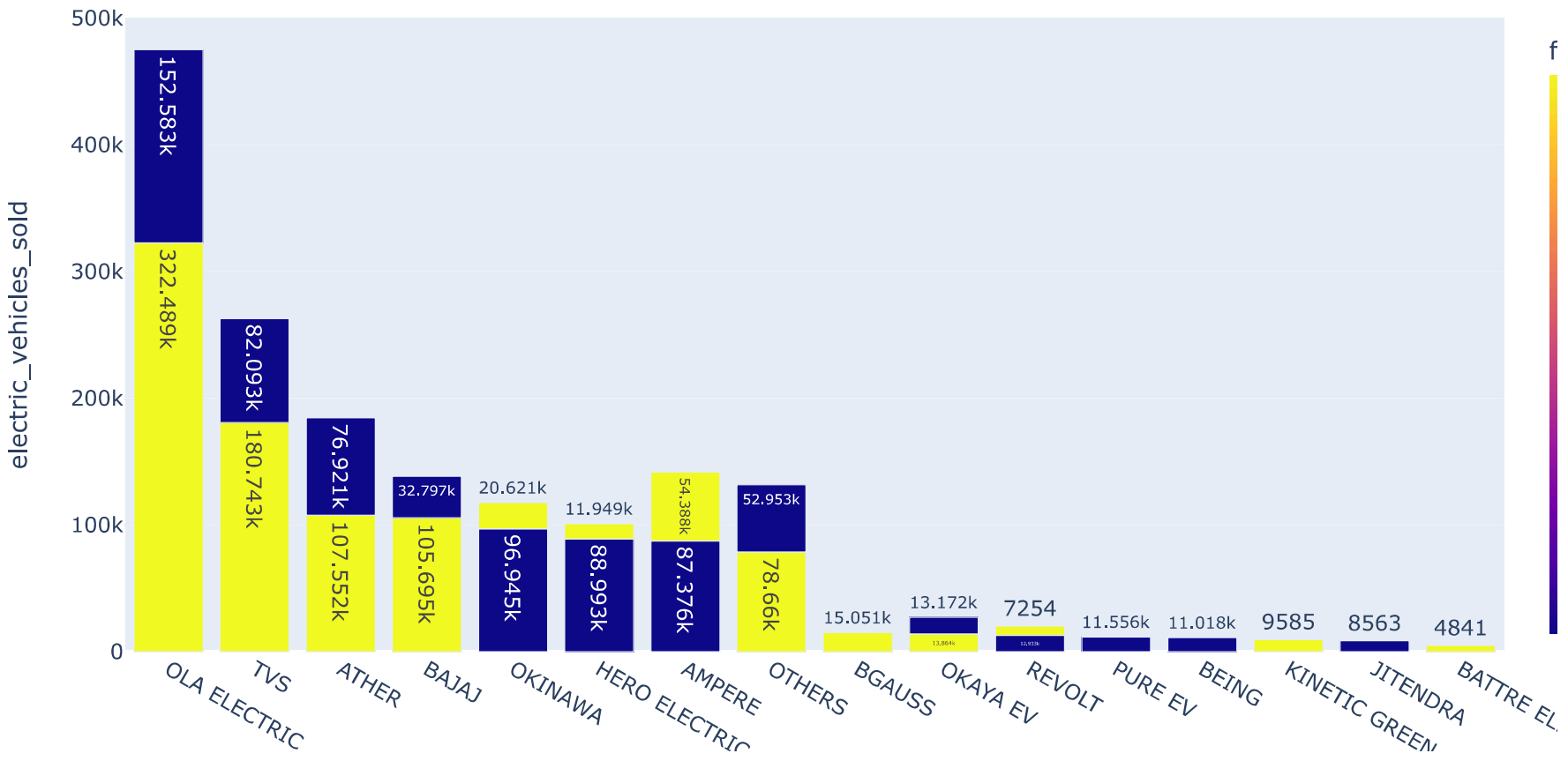
	maker	vehicle_category	fiscal_year	electric_vehicles_sold
1	AMPERE	2-Wheelers	2023	87376
2	AMPERE	2-Wheelers	2024	54388
4	ATHER	2-Wheelers	2023	76921
5	ATHER	2-Wheelers	2024	107552
7	BAJAJ	2-Wheelers	2023	32797
8	BAJAJ	2-Wheelers	2024	105695
9	BATTRE ELECTRIC	2-Wheelers	2024	4841
11	BEING	2-Wheelers	2023	11018
12	BGAUSS	2-Wheelers	2024	15051
20	HERO ELECTRIC	2-Wheelers	2023	88993
21	HERO ELECTRIC	2-Wheelers	2024	11949
26	JITENDRA	2-Wheelers	2023	8563
30	KINETIC GREEN	2-Wheelers	2024	9585
40	OKAYA EV	2-Wheelers	2023	13172
41	OKAYA EV	2-Wheelers	2024	13864
43	OKINAWA	2-Wheelers	2023	96945
44	OKINAWA	2-Wheelers	2024	20621
46	OLA ELECTRIC	2-Wheelers	2023	152583
47	OLA ELECTRIC	2-Wheelers	2024	322489
49	OTHERS	2-Wheelers	2023	52953
50	OTHERS	2-Wheelers	2024	78660
55	PURE EV	2-Wheelers	2023	11556
57	REVOLT	2-Wheelers	2023	12933
58	REVOLT	2-Wheelers	2024	7254
60	TVS	2-Wheelers	2023	82093
61	TVS	2-Wheelers	2024	180743

In [25]:
```
maker2=maker1.sort_values(by='electric_vehicles_sold',ascending=False)
maker2
```

Out[25]:

	maker	vehicle_category	fiscal_year	electric_vehicles_sold
47	OLA ELECTRIC	2-Wheelers	2024	322489
61	TVS	2-Wheelers	2024	180743
46	OLA ELECTRIC	2-Wheelers	2023	152583
5	ATHER	2-Wheelers	2024	107552
8	BAJAJ	2-Wheelers	2024	105695
43	OKINAWA	2-Wheelers	2023	96945
20	HERO ELECTRIC	2-Wheelers	2023	88993
1	AMPERE	2-Wheelers	2023	87376
60	TVS	2-Wheelers	2023	82093
50	OTHERS	2-Wheelers	2024	78660
4	ATHER	2-Wheelers	2023	76921
2	AMPERE	2-Wheelers	2024	54388
49	OTHERS	2-Wheelers	2023	52953
7	BAJAJ	2-Wheelers	2023	32797
44	OKINAWA	2-Wheelers	2024	20621
12	BGAUSS	2-Wheelers	2024	15051
41	OKAYA EV	2-Wheelers	2024	13864
40	OKAYA EV	2-Wheelers	2023	13172
57	REVOLT	2-Wheelers	2023	12933
21	HERO ELECTRIC	2-Wheelers	2024	11949
55	PURE EV	2-Wheelers	2023	11556
11	BEING	2-Wheelers	2023	11018
30	KINETIC GREEN	2-Wheelers	2024	9585
26	JITENDRA	2-Wheelers	2023	8563
58	REVOLT	2-Wheelers	2024	7254
9	BATTRE ELECTRIC	2-Wheelers	2024	4841

In [163]:
```
fig=px.bar(maker2,x='maker',y='electric_vehicles_sold',color='fiscal_year',text_auto=True)
fig.show()
```



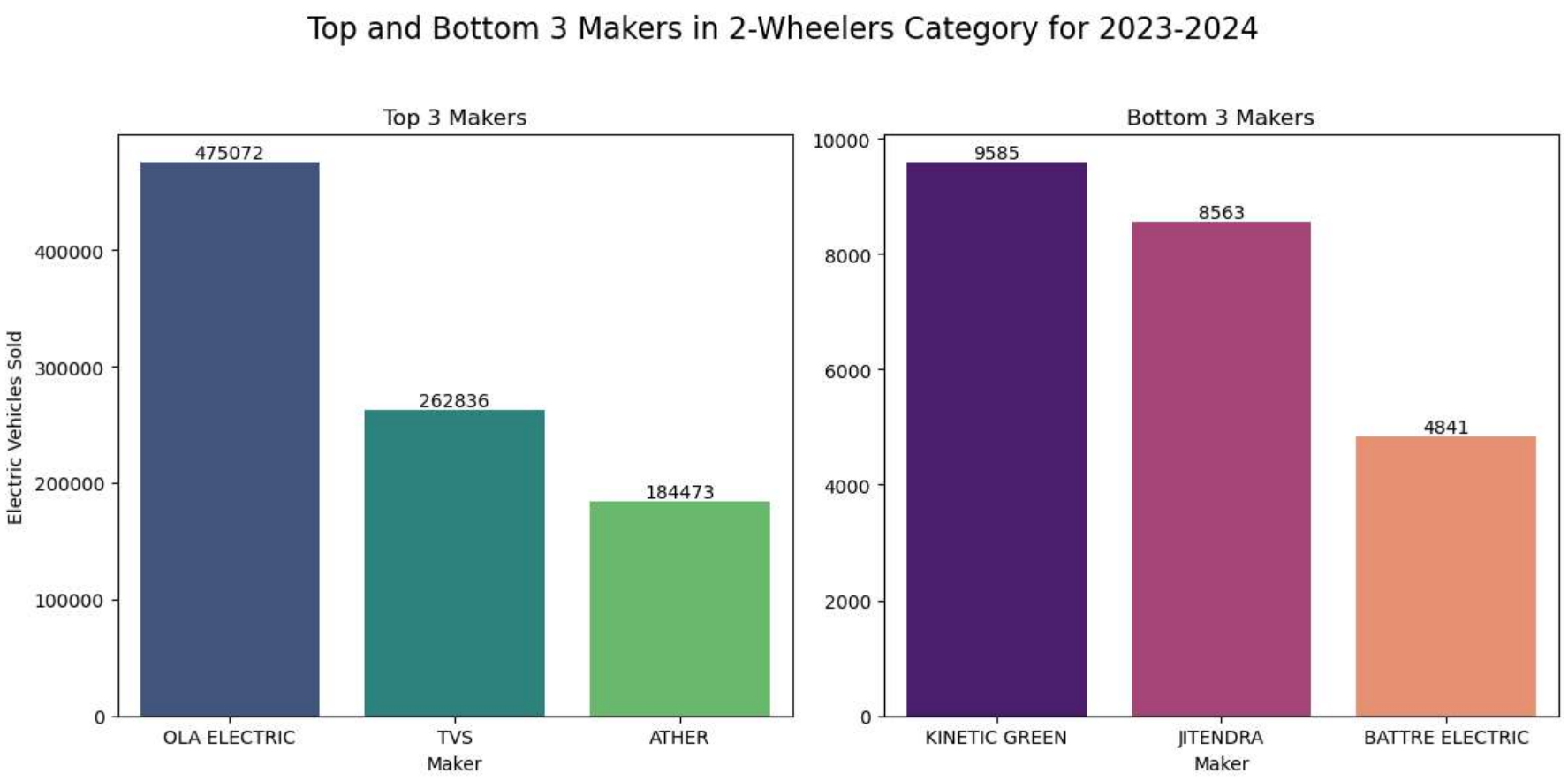
In [27]:
```
maker3=maker2.groupby('maker')['electric_vehicles_sold'].sum().reset_index()
maker3
```

Out[27]:

	maker	electric_vehicles_sold
0	AMPERE	141764
1	ATHER	184473
2	BAJAJ	138492
3	BATTRE ELECTRIC	4841
4	BEING	11018
5	BGAUSS	15051
6	HERO ELECTRIC	100942
7	JITENDRA	8563
8	KINETIC GREEN	9585
9	OKAYA EV	27036
10	OKINAWA	117566
11	OLA ELECTRIC	475072
12	OTHERS	131613
13	PURE EV	11556
14	REVOLT	20187
15	TVS	262836

In [28]:
```
maker4=maker3.sort_values(by='electric_vehicles_sold',ascending=False)
maker4
top3=maker4.head(3)
bottom3=maker4.tail(3)
```

In [151]:
```
import seaborn as sns
import matplotlib.pyplot as plt

fig, axes = plt.subplots(1, 2, figsize=(12, 6))

sns.barplot(x='maker', y='electric_vehicles_sold', data=top3, ax=axes[0], palette='viridis')
axes[0].set_title('Top 3 Makers')
axes[0].set_xlabel('Maker')
axes[0].set_ylabel('Electric Vehicles Sold')

for container in axes[0].containers:
    axes[0].bar_label(container, fmt='%.0f')

sns.barplot(x='maker', y='electric_vehicles_sold', data=bottom3, ax=axes[1], palette='magma')
axes[1].set_title('Bottom 3 Makers')
axes[1].set_xlabel('Maker')
axes[1].set_ylabel('')

for container in axes[1].containers:
    axes[1].bar_label(container, fmt='%.0f')

fig.suptitle('Top and Bottom 3 Makers in 2-Wheelers Category for 2023-2024', fontsize=16)

plt.tight_layout(rect=[0, 0, 1, 0.95])


plt.show()
```



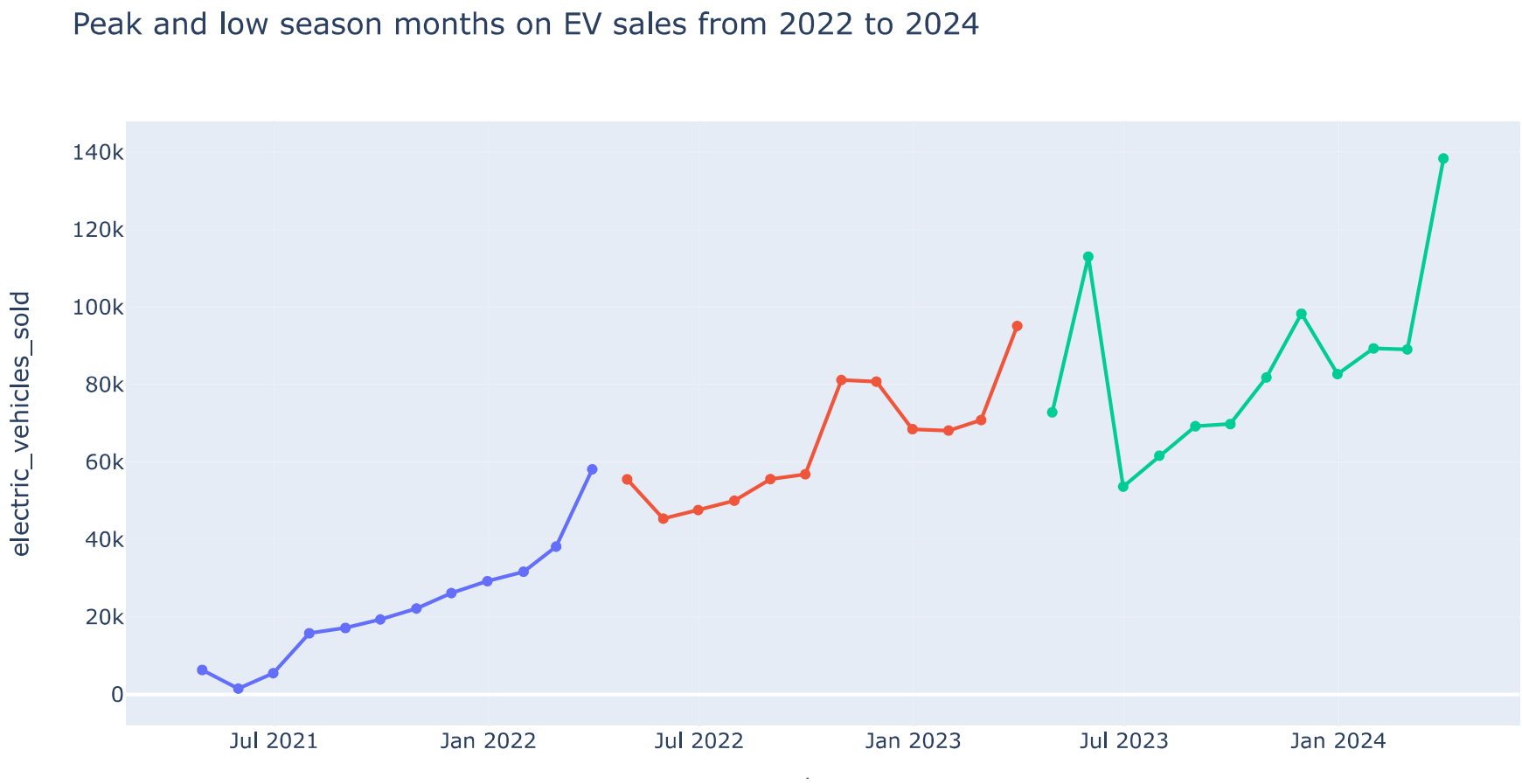
What are the peak and low season months for EV sales based on the data from 2022 to 2024?

In [30]:
```
maker_month=new_m.set_index('date')
maker_month=maker_month.groupby([pd.Grouper(freq='M'),'fiscal_year'])['electric_vehicles_sold'].sum().reset_index()
maker_month.head()
```

Out[30]:

	date	fiscal_year	electric_vehicles_sold
0	2021-04-30	2022	6315
1	2021-05-31	2022	1499
2	2021-06-30	2022	5487
3	2021-07-31	2022	15794
4	2021-08-31	2022	17153

In [31]:
```
fig=px.line(maker_month,x='date',y='electric_vehicles_sold',color='fiscal_year',markers=True,title='Peak and low seas
fig.show()
```



In FY 2022 may is low season and march is peak season In FY 2023 may is low season and march is peak season In FY 2022 June is low season and march is peak season

Identify the top 5 states with the highest penetration rate in 2-wheeler and 4-wheeler EV sales in FY 2024.

In [32]:
```
fy24=new_s[(new_s['fiscal_year']==2024)]
fy24
```

Out[32]:

	date	fiscal_year	quarter	state	vehicle_category	electric_vehicles_sold	total_vehicles_sold
1631	2023-04-01	2024	Q1	Sikkim	2-Wheelers	0	465
1632	2023-04-01	2024	Q1	Sikkim	4-Wheelers	0	439
1633	2023-04-01	2024	Q1	Andaman & Nicobar Island	2-Wheelers	0	325
1634	2023-04-01	2024	Q1	Arunachal Pradesh	2-Wheelers	0	971
1635	2023-04-01	2024	Q1	Ladakh	2-Wheelers	0	43
...	...	...	...	...	...	...	...
2440	2024-03-01	2024	Q4	Mizoram	2-Wheelers	58	1932
2441	2024-03-01	2024	Q4	DNH and DD	2-Wheelers	25	780
2442	2024-03-01	2024	Q4	Manipur	2-Wheelers	13	1394
2443	2024-03-01	2024	Q4	Andaman & Nicobar Island	2-Wheelers	2	447
2444	2024-03-01	2024	Q4	Nagaland	2-Wheelers	2	1180

814 rows × 7 columns

In [33]:
```
state_group=fy24.groupby('state').sum(['electric_vehicles_sold','total_vehicles_sold']).reset_index()
state_group
```

Out[33]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	4048	2	660
1	Andaman & Nicobar Island	44528	33	6543
2	Andhra Pradesh	48576	33183	782865
3	Arunachal Pradesh	48576	31	27892
4	Assam	48576	3497	547626
5	Bihar	48576	15069	1132703
6	Chandigarh	48576	2877	45147
7	Chhattisgarh	48576	28540	503068
8	DNH and DD	48576	198	16400
9	Delhi	48576	46724	606348
10	Goa	48576	10799	78524
11	Gujarat	48576	84359	1590987
12	Haryana	48576	11793	732029
13	Himachal Pradesh	48576	1048	117084
14	Jammu and Kashmir	48576	2283	139359
15	Jharkhand	48576	7830	495011
16	Karnataka	48576	160989	1581988
17	Kerala	48576	73938	638114
18	Ladakh	48576	31	3206
19	Madhya Pradesh	48576	43223	1286182
20	Maharashtra	48576	197169	2293994
21	Manipur	48576	126	18422
22	Meghalaya	48576	133	36628
23	Mizoram	48576	275	27422
24	Nagaland	48576	9	16972
25	Odisha	44528	39118	618149
26	Puducherry	48576	3098	57692
27	Punjab	48576	11198	574486
28	Rajasthan	48576	66444	1300476
29	Sikkim	48576	0	10518
30	Tamil Nadu	48576	94314	1716940
31	Tripura	48576	304	46447
32	Uttar Pradesh	48576	57758	2932347
33	Uttarakhand	48576	6336	233111
34	West Bengal	48576	16864	961909

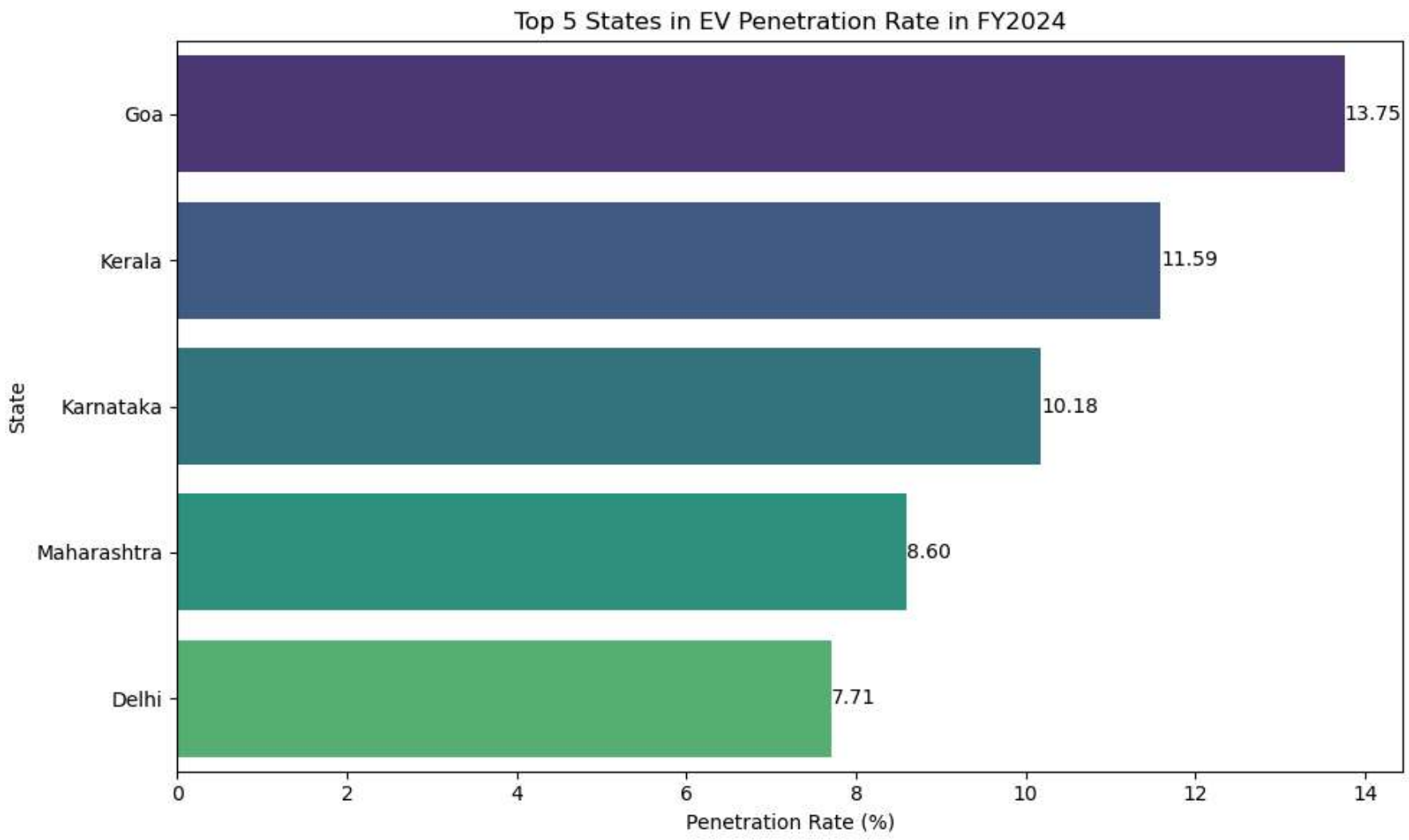
In [34]:
```
state_group['PRate']=((state_group['electric_vehicles_sold'])/(state_group['total_vehicles_sold']))*100
state_group
```

Out[34]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate
0	Andaman & Nicobar	4048	2	660	0.303030
1	Andaman & Nicobar Island	44528	33	6543	0.504356
2	Andhra Pradesh	48576	33183	782865	4.238662
3	Arunachal Pradesh	48576	31	27892	0.111143
4	Assam	48576	3497	547626	0.638575
5	Bihar	48576	15069	1132703	1.330358
6	Chandigarh	48576	2877	45147	6.372516
7	Chhattisgarh	48576	28540	503068	5.673189
8	DNH and DD	48576	198	16400	1.207317
9	Delhi	48576	46724	606348	7.705806
10	Goa	48576	10799	78524	13.752483
11	Gujarat	48576	84359	1590987	5.302306
12	Haryana	48576	11793	732029	1.611002
13	Himachal Pradesh	48576	1048	117084	0.895084
14	Jammu and Kashmir	48576	2283	139359	1.638215
15	Jharkhand	48576	7830	495011	1.581783
16	Karnataka	48576	160989	1581988	10.176373
17	Kerala	48576	73938	638114	11.586958
18	Ladakh	48576	31	3206	0.966937
19	Madhya Pradesh	48576	43223	1286182	3.360566
20	Maharashtra	48576	197169	2293994	8.595009
21	Manipur	48576	126	18422	0.683965
22	Meghalaya	48576	133	36628	0.363110
23	Mizoram	48576	275	27422	1.002844
24	Nagaland	48576	9	16972	0.053029
25	Odisha	44528	39118	618149	6.328248
26	Puducherry	48576	3098	57692	5.369895
27	Punjab	48576	11198	574486	1.949221
28	Rajasthan	48576	66444	1300476	5.109206
29	Sikkim	48576	0	10518	0.000000
30	Tamil Nadu	48576	94314	1716940	5.493145
31	Tripura	48576	304	46447	0.654509
32	Uttar Pradesh	48576	57758	2932347	1.969685
33	Uttarakhand	48576	6336	233111	2.718018
34	West Bengal	48576	16864	961909	1.753180

In [35]:
```
Topstates=state_group.sort_values(by='PRate',ascending=False)
top5=Topstates.head()
```

In [150]:
```
import seaborn as sns
import matplotlib.pyplot as plt

sns.set_palette("viridis")

fig, ax = plt.subplots(figsize=(10, 6))

bar_plot = sns.barplot(data=top5,
                       x='PRate',
                       y='state',
                       palette=sns.color_palette("viridis"))

for container in ax.containers:
    ax.bar_label(container, fmt='%.2f')

ax.set_title('Top 5 States in EV Penetration Rate in FY2024')
ax.set_xlabel('Penetration Rate (%)')
ax.set_ylabel('State')

plt.tight_layout()

plt.show()
```



In [37]:
```
stateP=new_s.groupby(['state','fiscal_year']).sum(['electric_vehicles_sold','total_vehicles_sold']).reset_index()
stateP
```

Out[37]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	2024	2	660
1	Andaman & Nicobar Island	2022	22	5148
2	Andaman & Nicobar Island	2023	23	6534
3	Andaman & Nicobar Island	2024	33	6543
4	Andhra Pradesh	2022	13928	772748
...	...	...	...	...
98	Uttarakhand	2023	6712	216265
99	Uttarakhand	2024	6336	233111
100	West Bengal	2022	2685	860709
101	West Bengal	2023	11011	913558
102	West Bengal	2024	16864	961909

103 rows × 4 columns

In [38]:
```
def PRate(stateP):
    stateP['PRate22'] = stateP.apply(lambda row: ((row['electric_vehicles_sold'] / row['total_vehicles_sold']) * 100)
                                     if row['fiscal_year'] == 2022 else 0, axis=1)

    stateP['PRate23'] = stateP.apply(lambda row: ((row['electric_vehicles_sold'] / row['total_vehicles_sold']) * 100)
                                     if row['fiscal_year'] == 2023 else 0, axis=1)

    stateP['PRate24'] = stateP.apply(lambda row: ((row['electric_vehicles_sold'] / row['total_vehicles_sold']) * 100)
                                     if row['fiscal_year'] == 2024 else 0, axis=1)

    return stateP
statePRate = PRate(stateP)
statePRate
```

Out[38]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate22	PRate23	PRate24
0	Andaman & Nicobar	2024	2	660	0.000000	0.000000	0.303030
1	Andaman & Nicobar Island	2022	22	5148	0.427350	0.000000	0.000000
2	Andaman & Nicobar Island	2023	23	6534	0.000000	0.352005	0.000000
3	Andaman & Nicobar Island	2024	33	6543	0.000000	0.000000	0.504356
4	Andhra Pradesh	2022	13928	772748	1.802399	0.000000	0.000000
...	...	...	...	...	...	...	...
98	Uttarakhand	2023	6712	216265	0.000000	3.103600	0.000000
99	Uttarakhand	2024	6336	233111	0.000000	0.000000	2.718018
100	West Bengal	2022	2685	860709	0.311952	0.000000	0.000000
101	West Bengal	2023	11011	913558	0.000000	1.205287	0.000000
102	West Bengal	2024	16864	961909	0.000000	0.000000	1.753180

103 rows × 7 columns

In [39]:
```
statePRate['PRate22'] = statePRate['PRate22'].replace(0, np.nan).dropna()
statePRate['PRate23'] = statePRate['PRate23'].replace(0, np.nan).dropna()
statePRate['PRate24'] = statePRate['PRate24'].replace(0, np.nan).dropna()
statePRate
```

Out[39]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate22	PRate23	PRate24
0	Andaman & Nicobar	2024	2	660	NaN	NaN	0.303030
1	Andaman & Nicobar Island	2022	22	5148	0.427350	NaN	NaN
2	Andaman & Nicobar Island	2023	23	6534	NaN	0.352005	NaN
3	Andaman & Nicobar Island	2024	33	6543	NaN	NaN	0.504356
4	Andhra Pradesh	2022	13928	772748	1.802399	NaN	NaN
...	...	...	...	...	...	...	...
98	Uttarakhand	2023	6712	216265	NaN	3.103600	NaN
99	Uttarakhand	2024	6336	233111	NaN	NaN	2.718018
100	West Bengal	2022	2685	860709	0.311952	NaN	NaN
101	West Bengal	2023	11011	913558	NaN	1.205287	NaN
102	West Bengal	2024	16864	961909	NaN	NaN	1.753180

103 rows × 7 columns

In [40]:
```
state_group = new_s.groupby(['state', 'fiscal_year']).agg(
    electric_vehicles_sold=('electric_vehicles_sold', 'sum'),
    total_vehicles_sold=('total_vehicles_sold', 'sum')
).reset_index()
state_group
```

Out[40]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	2024	2	660
1	Andaman & Nicobar Island	2022	22	5148
2	Andaman & Nicobar Island	2023	23	6534
3	Andaman & Nicobar Island	2024	33	6543
4	Andhra Pradesh	2022	13928	772748
...	...	...	...	...
98	Uttarakhand	2023	6712	216265
99	Uttarakhand	2024	6336	233111
100	West Bengal	2022	2685	860709
101	West Bengal	2023	11011	913558
102	West Bengal	2024	16864	961909

103 rows × 4 columns

In [41]:
```
state_group['PRate'] = (state_group['electric_vehicles_sold'] / state_group['total_vehicles_sold']) * 100
state_group
```

Out[41]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate
0	Andaman & Nicobar	2024	2	660	0.303030
1	Andaman & Nicobar Island	2022	22	5148	0.427350
2	Andaman & Nicobar Island	2023	23	6534	0.352005
3	Andaman & Nicobar Island	2024	33	6543	0.504356
4	Andhra Pradesh	2022	13928	772748	1.802399
...	...	...	...	...	...
98	Uttarakhand	2023	6712	216265	3.103600
99	Uttarakhand	2024	6336	233111	2.718018
100	West Bengal	2022	2685	860709	0.311952
101	West Bengal	2023	11011	913558	1.205287
102	West Bengal	2024	16864	961909	1.753180

103 rows × 5 columns

In [42]:
```
penetration_rate = state_group.pivot(index='state', columns='fiscal_year', values='PRate').reset_index()
penetration_rate
```

Out[42]:

fiscal_year	state	2022	2023	2024
0	Andaman & Nicobar	NaN	NaN	0.303030
1	Andaman & Nicobar Island	0.427350	0.352005	0.504356
2	Andhra Pradesh	1.802399	4.162124	4.238662
3	Arunachal Pradesh	0.000000	0.008430	0.111143
4	Assam	0.192384	0.460106	0.638575
5	Bihar	0.540838	1.087313	1.330358
6	Chandigarh	1.112194	4.102871	6.372516
7	Chhattisgarh	1.161754	4.693773	5.673189
8	DNH and DD	0.281962	0.836533	1.207317
9	Delhi	4.117896	7.588175	7.705806
10	Goa	3.675680	9.725757	13.752483
11	Gujarat	1.646403	5.487563	5.302306
12	Haryana	1.121094	2.036602	1.611002
13	Himachal Pradesh	0.450817	1.003490	0.895084
14	Jammu and Kashmir	1.070605	1.595741	1.638215
15	Jharkhand	0.659114	1.727833	1.581783
16	Karnataka	4.277335	7.753586	10.176373
17	Kerala	1.977885	6.714221	11.586958
18	Ladakh	0.412229	0.570907	0.966937
19	Madhya Pradesh	0.818463	2.235539	3.360566
20	Maharashtra	2.901856	7.031381	8.595009
21	Manipur	0.069196	0.296225	0.683965
22	Meghalaya	0.018024	0.127543	0.363110
23	Mizoram	0.000000	0.265892	1.002844
24	Nagaland	0.007781	0.021026	0.053029
25	Odisha	1.980702	5.016088	6.328248
26	Puducherry	1.709163	3.397061	5.369895
27	Punjab	1.021587	1.540540	1.949221
28	Rajasthan	2.280062	5.668529	5.109206
29	Sikkim	0.000000	0.000000	0.000000
30	Tamil Nadu	2.740709	4.331284	5.493145
31	Tripura	0.074202	0.560511	0.654509
32	Uttar Pradesh	0.409324	1.009213	1.969685
33	Uttarakhand	1.199439	3.103600	2.718018
34	West Bengal	0.311952	1.205287	1.753180

In [43]:
```
penetration_rate.rename(columns={2022: 'PRate22', 2023: 'PRate23', 2024: 'PRate24'}, inplace=True)
penetration_rate
```

Out[43]:

fiscal_year	state	PRate22	PRate23	PRate24
0	Andaman & Nicobar	NaN	NaN	0.303030
1	Andaman & Nicobar Island	0.427350	0.352005	0.504356
2	Andhra Pradesh	1.802399	4.162124	4.238662
3	Arunachal Pradesh	0.000000	0.008430	0.111143
4	Assam	0.192384	0.460106	0.638575
5	Bihar	0.540838	1.087313	1.330358
6	Chandigarh	1.112194	4.102871	6.372516
7	Chhattisgarh	1.161754	4.693773	5.673189
8	DNH and DD	0.281962	0.836533	1.207317
9	Delhi	4.117896	7.588175	7.705806
10	Goa	3.675680	9.725757	13.752483
11	Gujarat	1.646403	5.487563	5.302306
12	Haryana	1.121094	2.036602	1.611002
13	Himachal Pradesh	0.450817	1.003490	0.895084
14	Jammu and Kashmir	1.070605	1.595741	1.638215
15	Jharkhand	0.659114	1.727833	1.581783
16	Karnataka	4.277335	7.753586	10.176373
17	Kerala	1.977885	6.714221	11.586958
18	Ladakh	0.412229	0.570907	0.966937
19	Madhya Pradesh	0.818463	2.235539	3.360566
20	Maharashtra	2.901856	7.031381	8.595009
21	Manipur	0.069196	0.296225	0.683965
22	Meghalaya	0.018024	0.127543	0.363110
23	Mizoram	0.000000	0.265892	1.002844
24	Nagaland	0.007781	0.021026	0.053029
25	Odisha	1.980702	5.016088	6.328248
26	Puducherry	1.709163	3.397061	5.369895
27	Punjab	1.021587	1.540540	1.949221
28	Rajasthan	2.280062	5.668529	5.109206
29	Sikkim	0.000000	0.000000	0.000000
30	Tamil Nadu	2.740709	4.331284	5.493145
31	Tripura	0.074202	0.560511	0.654509
32	Uttar Pradesh	0.409324	1.009213	1.969685
33	Uttarakhand	1.199439	3.103600	2.718018
34	West Bengal	0.311952	1.205287	1.753180

In [44]:
```
penetration_rate['PRate22']=pd.to_numeric(penetration_rate['PRate22'],errors='coerce')
penetration_rate['PRate23']=pd.to_numeric(penetration_rate['PRate23'],errors='coerce')
penetration_rate['PRate24']=pd.to_numeric(penetration_rate['PRate24'],errors='coerce')
penetration_rate
```

Out[44]:

fiscal_year	state	PRate22	PRate23	PRate24
0	Andaman & Nicobar	NaN	NaN	0.303030
1	Andaman & Nicobar Island	0.427350	0.352005	0.504356
2	Andhra Pradesh	1.802399	4.162124	4.238662
3	Arunachal Pradesh	0.000000	0.008430	0.111143
4	Assam	0.192384	0.460106	0.638575
5	Bihar	0.540838	1.087313	1.330358
6	Chandigarh	1.112194	4.102871	6.372516
7	Chhattisgarh	1.161754	4.693773	5.673189
8	DNH and DD	0.281962	0.836533	1.207317
9	Delhi	4.117896	7.588175	7.705806
10	Goa	3.675680	9.725757	13.752483
11	Gujarat	1.646403	5.487563	5.302306
12	Haryana	1.121094	2.036602	1.611002
13	Himachal Pradesh	0.450817	1.003490	0.895084
14	Jammu and Kashmir	1.070605	1.595741	1.638215
15	Jharkhand	0.659114	1.727833	1.581783
16	Karnataka	4.277335	7.753586	10.176373
17	Kerala	1.977885	6.714221	11.586958
18	Ladakh	0.412229	0.570907	0.966937
19	Madhya Pradesh	0.818463	2.235539	3.360566
20	Maharashtra	2.901856	7.031381	8.595009
21	Manipur	0.069196	0.296225	0.683965
22	Meghalaya	0.018024	0.127543	0.363110
23	Mizoram	0.000000	0.265892	1.002844
24	Nagaland	0.007781	0.021026	0.053029
25	Odisha	1.980702	5.016088	6.328248
26	Puducherry	1.709163	3.397061	5.369895
27	Punjab	1.021587	1.540540	1.949221
28	Rajasthan	2.280062	5.668529	5.109206
29	Sikkim	0.000000	0.000000	0.000000
30	Tamil Nadu	2.740709	4.331284	5.493145
31	Tripura	0.074202	0.560511	0.654509
32	Uttar Pradesh	0.409324	1.009213	1.969685
33	Uttarakhand	1.199439	3.103600	2.718018
34	West Bengal	0.311952	1.205287	1.753180

In [45]:
```
penetration_rate['22_23'] = penetration_rate['PRate23'] - penetration_rate['PRate22']
penetration_rate['23_24'] = penetration_rate['PRate24'] - penetration_rate['PRate23']
penetration_rate
```

Out[45]:

	fiscal_year	state	PRate22	PRate23	PRate24	22_23	23_24
0		Andaman & Nicobar	NaN	NaN	0.303030	NaN	NaN
1		Andaman & Nicobar Island	0.427350	0.352005	0.504356	-0.075346	0.152351
2		Andhra Pradesh	1.802399	4.162124	4.238662	2.359725	0.076538
3		Arunachal Pradesh	0.000000	0.008430	0.111143	0.008430	0.102713
4		Assam	0.192384	0.460106	0.638575	0.267722	0.178469
5		Bihar	0.540838	1.087313	1.330358	0.546474	0.243045
6		Chandigarh	1.112194	4.102871	6.372516	2.990677	2.269646
7		Chhattisgarh	1.161754	4.693773	5.673189	3.532019	0.979417
8		DNH and DD	0.281962	0.836533	1.207317	0.554571	0.370784
9		Delhi	4.117896	7.588175	7.705806	3.470279	0.117631
10		Goa	3.675680	9.725757	13.752483	6.050077	4.026726
11		Gujarat	1.646403	5.487563	5.302306	3.841160	-0.185257
12		Haryana	1.121094	2.036602	1.611002	0.915509	-0.425600
13		Himachal Pradesh	0.450817	1.003490	0.895084	0.552673	-0.108407
14		Jammu and Kashmir	1.070605	1.595741	1.638215	0.525136	0.042474
15		Jharkhand	0.659114	1.727833	1.581783	1.068718	-0.146050
16		Karnataka	4.277335	7.753586	10.176373	3.476251	2.422787
17		Kerala	1.977885	6.714221	11.586958	4.736336	4.872737
18		Ladakh	0.412229	0.570907	0.966937	0.158677	0.396030
19		Madhya Pradesh	0.818463	2.235539	3.360566	1.417077	1.125027
20		Maharashtra	2.901856	7.031381	8.595009	4.129525	1.563628
21		Manipur	0.069196	0.296225	0.683965	0.227029	0.387740
22		Meghalaya	0.018024	0.127543	0.363110	0.109519	0.235567
23		Mizoram	0.000000	0.265892	1.002844	0.265892	0.736952
24		Nagaland	0.007781	0.021026	0.053029	0.013245	0.032002
25		Odisha	1.980702	5.016088	6.328248	3.035386	1.312160
26		Puducherry	1.709163	3.397061	5.369895	1.687899	1.972834
27		Punjab	1.021587	1.540540	1.949221	0.518953	0.408681
28		Rajasthan	2.280062	5.668529	5.109206	3.388467	-0.559322
29		Sikkim	0.000000	0.000000	0.000000	0.000000	0.000000
30		Tamil Nadu	2.740709	4.331284	5.493145	1.590575	1.161861
31		Tripura	0.074202	0.560511	0.654509	0.486309	0.093999
32		Uttar Pradesh	0.409324	1.009213	1.969685	0.599889	0.960472
33		Uttarakhand	1.199439	3.103600	2.718018	1.904161	-0.385581
34		West Bengal	0.311952	1.205287	1.753180	0.893335	0.547893

In [46]:
```
neg_prate=penetration_rate[['state','22_23','23_24']]
neg_sort=neg_prate.sort_values(by=(['22_23','23_24']),ascending=True)
neg_sort
```

Out[46]:

fiscal_year	state	22_23	23_24
1	Andaman & Nicobar Island	-0.075346	0.152351
29	Sikkim	0.000000	0.000000
3	Arunachal Pradesh	0.008430	0.102713
24	Nagaland	0.013245	0.032002
22	Meghalaya	0.109519	0.235567
18	Ladakh	0.158677	0.396030
21	Manipur	0.227029	0.387740
23	Mizoram	0.265892	0.736952
4	Assam	0.267722	0.178469
31	Tripura	0.486309	0.093999
27	Punjab	0.518953	0.408681
14	Jammu and Kashmir	0.525136	0.042474
5	Bihar	0.546474	0.243045
13	Himachal Pradesh	0.552673	-0.108407
8	DNH and DD	0.554571	0.370784
32	Uttar Pradesh	0.599889	0.960472
34	West Bengal	0.893335	0.547893
12	Haryana	0.915509	-0.425600
15	Jharkhand	1.068718	-0.146050
19	Madhya Pradesh	1.417077	1.125027
30	Tamil Nadu	1.590575	1.161861
26	Puducherry	1.687899	1.972834
33	Uttarakhand	1.904161	-0.385581
2	Andhra Pradesh	2.359725	0.076538
6	Chandigarh	2.990677	2.269646
25	Odisha	3.035386	1.312160
28	Rajasthan	3.388467	-0.559322
9	Delhi	3.470279	0.117631
16	Karnataka	3.476251	2.422787
7	Chhattisgarh	3.532019	0.979417
11	Gujarat	3.841160	-0.185257
20	Maharashtra	4.129525	1.563628
17	Kerala	4.736336	4.872737
10	Goa	6.050077	4.026726
0	Andaman & Nicobar	NaN	NaN

In [47]:
```
import plotly.graph_objects as go
neg_melt=neg_prate.melt(id_vars='state',value_vars=['22_23','23_24'],var_name='Fiscal_year',value_name='Penetration R
neg_melt
```

Out[47]:

	state	Fiscal_year	Penetration Rate
0	Andaman & Nicobar	22_23	NaN
1	Andaman & Nicobar Island	22_23	-0.075346
2	Andhra Pradesh	22_23	2.359725
3	Arunachal Pradesh	22_23	0.008430
4	Assam	22_23	0.267722
...	...	...	...
65	Tamil Nadu	23_24	1.161861
66	Tripura	23_24	0.093999
67	Uttar Pradesh	23_24	0.960472
68	Uttarakhand	23_24	-0.385581
69	West Bengal	23_24	0.547893

70 rows × 3 columns

In [187]:
```
fig = px.bar(neg_melt,x='state',y='Penetration Rate',color='Fiscal_year',barmode='group',labels={'Penetration Rate':
             height=700,width=1000,
             text_auto=True,title="Penetration Rate by State for Fiscal Years 2022-23 and 2023-24")

fig.show()
```


Observed
Negative Penetrarion rate for the year 23 to 24 Gujarat,Haryana,Himachal pradesh,Jharkhand,Rajasthan,Uttarakhand.

Negative Penetrarion rate for the year 22 to 23 Andaman & Nicobar Island

What are the quarterly trends based on sales volume for the top 5 EV makers (4-wheelers) from 2022 to 2024?

In [49]:
```
maker_4=new_m[(new_m['vehicle_category']=='4-Wheelers')]
maker_4.head(10)
```

Out[49]:

	date	fiscal_year	quarter	vehicle_category	maker	electric_vehicles_sold
1	2021-04-01	2022	Q1	4-Wheelers	BYD India	0
2	2021-04-01	2022	Q1	4-Wheelers	PCA Automobiles	0
3	2021-04-01	2022	Q1	4-Wheelers	BMW India	0
4	2021-04-01	2022	Q1	4-Wheelers	Volvo Auto India	0
5	2021-04-01	2022	Q1	4-Wheelers	KIA Motors	0
6	2021-04-01	2022	Q1	4-Wheelers	Tata Motors	322
7	2021-04-01	2022	Q1	4-Wheelers	MG Motor	118
8	2021-04-01	2022	Q1	4-Wheelers	Mahindra & Mahindra	171
9	2021-04-01	2022	Q1	4-Wheelers	Hyundai Motor	12
10	2021-04-01	2022	Q1	4-Wheelers	Mercedes -Benz AG	3

In [50]:
```
maker_q=maker_4.groupby(['maker','fiscal_year','quarter']).sum('electric_vehicles_sold').reset_index()
maker_q
```

Out[50]:

	maker	fiscal_year	quarter	electric_vehicles_sold
0	BMW India	2022	Q1	0
1	BMW India	2022	Q2	0
2	BMW India	2022	Q3	0
3	BMW India	2022	Q4	7
4	BMW India	2023	Q1	22
...	...	...	...	...
115	Volvo Auto India	2023	Q4	84
116	Volvo Auto India	2024	Q1	94
117	Volvo Auto India	2024	Q2	104
118	Volvo Auto India	2024	Q3	145
119	Volvo Auto India	2024	Q4	116

120 rows × 4 columns

In [51]:
```
top_m=maker_4.groupby('maker').sum('electric_vehicles_sold').reset_index()
top_m
```

Out[51]:

	maker	fiscal_year	electric_vehicles_sold
0	BMW India	72828	1370
1	BYD India	72828	2419
2	Hyundai Motor	72828	2076
3	KIA Motors	72828	557
4	MG Motor	72828	13753
5	Mahindra & Mahindra	72828	41193
6	Mercedes -Benz AG	72828	388
7	PCA Automobiles	72828	1684
8	Tata Motors	72828	88935
9	Volvo Auto India	72828	568

In [52]:
```
top_sort=top_m.sort_values(by='electric_vehicles_sold',ascending=False)
top_s=top_sort.head()
top_s
```

Out[52]:

	maker	fiscal_year	electric_vehicles_sold
8	Tata Motors	72828	88935
5	Mahindra & Mahindra	72828	41193
4	MG Motor	72828	13753
1	BYD India	72828	2419
2	Hyundai Motor	72828	2076

In [53]:
```
top5_q=maker_q[maker_q['maker'].isin(top_s['maker'])]
top5_q
```

Out[53]:

	maker	fiscal_year	quarter	electric_vehicles_sold
12	BYD India	2022	Q1	0
13	BYD India	2022	Q2	0
14	BYD India	2022	Q3	1
15	BYD India	2022	Q4	32
16	BYD India	2023	Q1	81
17	BYD India	2023	Q2	113
18	BYD India	2023	Q3	103
19	BYD India	2023	Q4	623
20	BYD India	2024	Q1	406
21	BYD India	2024	Q2	310
22	BYD India	2024	Q3	350
23	BYD India	2024	Q4	400
24	Hyundai Motor	2022	Q1	25
25	Hyundai Motor	2022	Q2	34
26	Hyundai Motor	2022	Q3	25
27	Hyundai Motor	2022	Q4	26
28	Hyundai Motor	2023	Q1	75
29	Hyundai Motor	2023	Q2	155
30	Hyundai Motor	2023	Q3	191
31	Hyundai Motor	2023	Q4	155
32	Hyundai Motor	2024	Q1	292
33	Hyundai Motor	2024	Q2	390
34	Hyundai Motor	2024	Q3	370
35	Hyundai Motor	2024	Q4	338
48	MG Motor	2022	Q1	285
49	MG Motor	2022	Q2	798
50	MG Motor	2022	Q3	411
51	MG Motor	2022	Q4	153
52	MG Motor	2023	Q1	531
53	MG Motor	2023	Q2	635
54	MG Motor	2023	Q3	1165
55	MG Motor	2023	Q4	946
56	MG Motor	2024	Q1	1493
57	MG Motor	2024	Q2	2524
58	MG Motor	2024	Q3	2190
59	MG Motor	2024	Q4	2622
60	Mahindra & Mahindra	2022	Q1	355
61	Mahindra & Mahindra	2022	Q2	651
62	Mahindra & Mahindra	2022	Q3	1383
63	Mahindra & Mahindra	2022	Q4	1653
64	Mahindra & Mahindra	2023	Q1	2020
65	Mahindra & Mahindra	2023	Q2	3164
66	Mahindra & Mahindra	2023	Q3	3378
67	Mahindra & Mahindra	2023	Q4	5243
68	Mahindra & Mahindra	2024	Q1	10911
69	Mahindra & Mahindra	2024	Q2	5855
70	Mahindra & Mahindra	2024	Q3	4264
71	Mahindra & Mahindra	2024	Q4	2316
96	Tata Motors	2022	Q1	1031
97	Tata Motors	2022	Q2	2052
98	Tata Motors	2022	Q3	3791
99	Tata Motors	2022	Q4	5834
100	Tata Motors	2023	Q1	5675
101	Tata Motors	2023	Q2	6192
102	Tata Motors	2023	Q3	6651
103	Tata Motors	2023	Q4	9528

	maker	fiscal_year	quarter	electric_vehicles_sold
104	Tata Motors	2024	Q1	7247
105	Tata Motors	2024	Q2	10337
106	Tata Motors	2024	Q3	13236
107	Tata Motors	2024	Q4	17361

```
fig=px.line(top5_q,x='quarter',y='electric_vehicles_sold',color='maker',title='Quarterly Sales Trends for Top 5 EV
Makers (4-wheelers) from 2022 to 2024')
fig.show()
```

In [55]:
```
fig = px.line(top5_q, x='quarter', y='electric_vehicles_sold', color='maker', line_group='maker',markers=True,
              facet_col='fiscal_year', title='Quarterly Sales Trends for Top 5 EV Makers (4-wheelers) from 2022 to 20
fig.show()
```


```
How do the EV sales and penetration rates in Delhi compare to Karnataka for 2024?
```

In [56]:
```
dk=new_s[(new_s['state'].isin(['Delhi','Karnataka']))& (new_s['fiscal_year']==2024)]
dk
```

Out[56]:

	date	fiscal_year	quarter	state	vehicle_category	electric_vehicles_sold	total_vehicles_sold
1650	2023-04-01	2024	Q1	Delhi	4-Wheelers	551	14861
1657	2023-04-01	2024	Q1	Karnataka	4-Wheelers	762	22368
1676	2023-04-01	2024	Q1	Delhi	2-Wheelers	2738	28590
1683	2023-04-01	2024	Q1	Karnataka	2-Wheelers	9711	91491
1715	2023-05-01	2024	Q1	Delhi	4-Wheelers	787	16609
1722	2023-05-01	2024	Q1	Karnataka	4-Wheelers	999	22601
1743	2023-05-01	2024	Q1	Delhi	2-Wheelers	4977	32282
1750	2023-05-01	2024	Q1	Karnataka	2-Wheelers	17292	97074
1785	2023-06-01	2024	Q1	Delhi	4-Wheelers	935	15723
1792	2023-06-01	2024	Q1	Karnataka	4-Wheelers	1142	24603
1812	2023-06-01	2024	Q1	Delhi	2-Wheelers	1787	28279
1819	2023-06-01	2024	Q1	Karnataka	2-Wheelers	7730	101825
1852	2023-07-01	2024	Q2	Delhi	4-Wheelers	831	15285
1859	2023-07-01	2024	Q2	Karnataka	4-Wheelers	1221	23154
1880	2023-07-01	2024	Q2	Delhi	2-Wheelers	2068	31269
1887	2023-07-01	2024	Q2	Karnataka	2-Wheelers	9632	95036
1920	2023-08-01	2024	Q2	Delhi	4-Wheelers	440	15852
1927	2023-08-01	2024	Q2	Karnataka	4-Wheelers	1196	28235
1948	2023-08-01	2024	Q2	Delhi	2-Wheelers	2116	33120
1955	2023-08-01	2024	Q2	Karnataka	2-Wheelers	9720	101545
1990	2023-09-01	2024	Q2	Delhi	4-Wheelers	380	15776
1997	2023-09-01	2024	Q2	Karnataka	4-Wheelers	942	24184
2017	2023-09-01	2024	Q2	Delhi	2-Wheelers	2002	31468
2024	2023-09-01	2024	Q2	Karnataka	2-Wheelers	10590	106981
2058	2023-10-01	2024	Q3	Delhi	4-Wheelers	519	16459
2065	2023-10-01	2024	Q3	Karnataka	4-Wheelers	1154	25652
2085	2023-10-01	2024	Q3	Delhi	2-Wheelers	2611	35861
2092	2023-10-01	2024	Q3	Karnataka	2-Wheelers	11137	108712
2123	2023-11-01	2024	Q3	Delhi	4-Wheelers	538	18675
2130	2023-11-01	2024	Q3	Karnataka	4-Wheelers	822	26232
2152	2023-11-01	2024	Q3	Delhi	2-Wheelers	3976	56736
2159	2023-11-01	2024	Q3	Karnataka	2-Wheelers	14300	136535
2192	2023-12-01	2024	Q3	Delhi	4-Wheelers	811	16567
2199	2023-12-01	2024	Q3	Karnataka	4-Wheelers	1155	22859
2221	2023-12-01	2024	Q3	Delhi	2-Wheelers	5380	27097
2228	2023-12-01	2024	Q3	Karnataka	2-Wheelers	10237	91996
2254	2024-01-01	2024	Q4	Karnataka	4-Wheelers	1080	30770
2259	2024-01-01	2024	Q4	Delhi	4-Wheelers	1345	21520
2282	2024-01-01	2024	Q4	Karnataka	2-Wheelers	12415	115920
2287	2024-01-01	2024	Q4	Delhi	2-Wheelers	3073	38413
2322	2024-02-01	2024	Q4	Karnataka	4-Wheelers	923	24812
2329	2024-02-01	2024	Q4	Delhi	4-Wheelers	596	17898
2351	2024-02-01	2024	Q4	Karnataka	2-Wheelers	12605	108852
2358	2024-02-01	2024	Q4	Delhi	2-Wheelers	2364	30504
2390	2024-03-01	2024	Q4	Karnataka	4-Wheelers	1482	26751
2393	2024-03-01	2024	Q4	Delhi	4-Wheelers	897	15905
2417	2024-03-01	2024	Q4	Karnataka	2-Wheelers	22742	123800
2420	2024-03-01	2024	Q4	Delhi	2-Wheelers	5002	31599

In [57]:
```
dkPRate=dk.groupby('state').sum(['electric_vehicles_sold','total_vehicles_sold']).reset_index()
dkPRate
```

Out[57]:

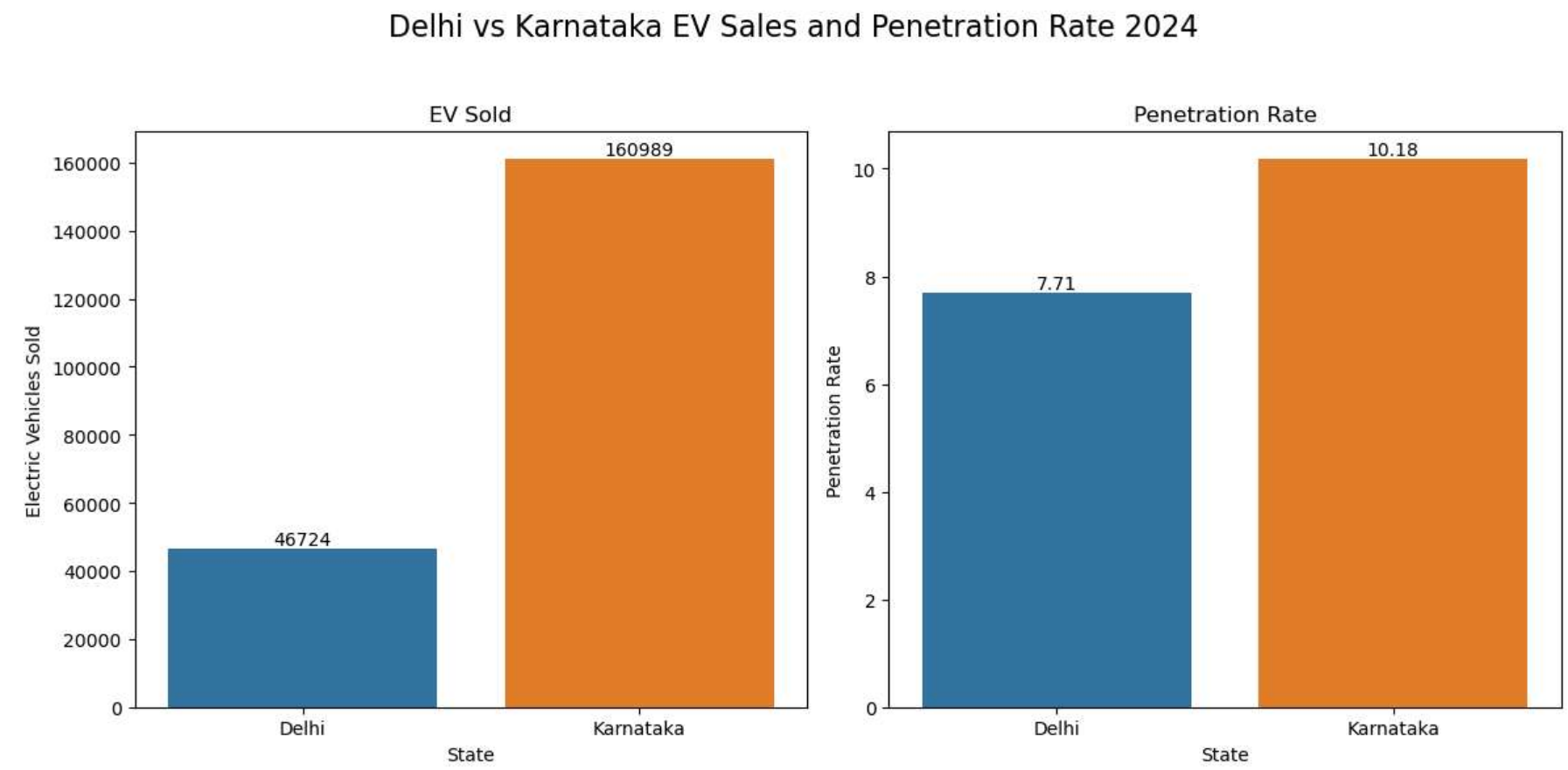
	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Delhi	48576	46724	606348
1	Karnataka	48576	160989	1581988

In [58]:
```
dkPRate['PRate24']=(dkPRate['electric_vehicles_sold']/dkPRate['total_vehicles_sold'])*100
dkPRate
```

Out[58]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate24
0	Delhi	48576	46724	606348	7.705806
1	Karnataka	48576	160989	1581988	10.176373

In [144]:
```
import seaborn as sns
import matplotlib.pyplot as plt

fig, axes = plt.subplots(1, 2, figsize=(12, 6))


sns.barplot(x='state', y='electric_vehicles_sold', data=dkPRate, ax=axes[0])
axes[0].set_title('EV Sold')
axes[0].set_xlabel('State')
axes[0].set_ylabel('Electric Vehicles Sold')

for container in axes[0].containers:
    axes[0].bar_label(container, fmt='%.0f')


sns.barplot(x='state', y='PRate24', data=dkPRate, ax=axes[1])
axes[1].set_title('Penetration Rate')
axes[1].set_xlabel('State')
axes[1].set_ylabel('Penetration Rate')

for container in axes[1].containers:
    axes[1].bar_label(container, fmt='%.2f')


fig.suptitle("Delhi vs Karnataka EV Sales and Penetration Rate 2024", fontsize=16)


fig.tight_layout(rect=[0, 0, 1, 0.95])

plt.show()
```



List down the compounded annual growth rate (CAGR) in 4-wheeler units for the top 5 makers from 2022 to 2024.

In [61]:
```
maker_4=new_m[(new_m['vehicle_category']=='4-Wheelers')]
maker_4
```

Out[61]:

	date	fiscal_year	quarter	vehicle_category	maker	electric_vehicles_sold
1	2021-04-01	2022	Q1	4-Wheelers	BYD India	0
2	2021-04-01	2022	Q1	4-Wheelers	PCA Automobiles	0
3	2021-04-01	2022	Q1	4-Wheelers	BMW India	0
4	2021-04-01	2022	Q1	4-Wheelers	Volvo Auto India	0
5	2021-04-01	2022	Q1	4-Wheelers	KIA Motors	0
...	...	...	...	...	...	...
798	2024-03-01	2024	Q4	4-Wheelers	PCA Automobiles	130
799	2024-03-01	2024	Q4	4-Wheelers	BMW India	55
800	2024-03-01	2024	Q4	4-Wheelers	Mercedes -Benz AG	31
801	2024-03-01	2024	Q4	4-Wheelers	Volvo Auto India	39
802	2024-03-01	2024	Q4	4-Wheelers	KIA Motors	26

360 rows × 6 columns

In [62]:
```
maker_sales=maker_4.groupby('maker').sum('electric_vehicles_sold').reset_index()
maker_sales
```

Out[62]:

	maker	fiscal_year	electric_vehicles_sold
0	BMW India	72828	1370
1	BYD India	72828	2419
2	Hyundai Motor	72828	2076
3	KIA Motors	72828	557
4	MG Motor	72828	13753
5	Mahindra & Mahindra	72828	41193
6	Mercedes -Benz AG	72828	388
7	PCA Automobiles	72828	1684
8	Tata Motors	72828	88935
9	Volvo Auto India	72828	568

In [63]:
```
maker_sort=maker_sales.sort_values(by='electric_vehicles_sold',ascending=False)
maker_top5=maker_sort.head()
maker_top5
```

Out[63]:

	maker	fiscal_year	electric_vehicles_sold
8	Tata Motors	72828	88935
5	Mahindra & Mahindra	72828	41193
4	MG Motor	72828	13753
1	BYD India	72828	2419
2	Hyundai Motor	72828	2076

In [64]:
```
maker_s=maker_4.groupby(['maker','fiscal_year']).sum('electric_vehicles_sold').reset_index()
maker_s
```

Out[64]:

	maker	fiscal_year	electric_vehicles_sold
0	BMW India	2022	7
1	BMW India	2023	285
2	BMW India	2024	1078
3	BYD India	2022	33
4	BYD India	2023	920
5	BYD India	2024	1466
6	Hyundai Motor	2022	110
7	Hyundai Motor	2023	576
8	Hyundai Motor	2024	1390
9	KIA Motors	2022	0
10	KIA Motors	2023	229
11	KIA Motors	2024	328
12	MG Motor	2022	1647
13	MG Motor	2023	3277
14	MG Motor	2024	8829
15	Mahindra & Mahindra	2022	4042
16	Mahindra & Mahindra	2023	13805
17	Mahindra & Mahindra	2024	23346
18	Mercedes -Benz AG	2022	26
19	Mercedes -Benz AG	2023	71
20	Mercedes -Benz AG	2024	291
21	PCA Automobiles	2022	0
22	PCA Automobiles	2023	151
23	PCA Automobiles	2024	1533
24	Tata Motors	2022	12708
25	Tata Motors	2023	28046
26	Tata Motors	2024	48181
27	Volvo Auto India	2022	4
28	Volvo Auto India	2023	105
29	Volvo Auto India	2024	459

In [65]:
```
maker_pivot=pd.pivot_table(maker_s,index='maker',columns='fiscal_year',values='electric_vehicles_sold').reset_index()
maker_pivot
```

Out[65]:

fiscal_year	maker	2022	2023	2024
0	BMW India	7	285	1078
1	BYD India	33	920	1466
2	Hyundai Motor	110	576	1390
3	KIA Motors	0	229	328
4	MG Motor	1647	3277	8829
5	Mahindra & Mahindra	4042	13805	23346
6	Mercedes -Benz AG	26	71	291
7	PCA Automobiles	0	151	1533
8	Tata Motors	12708	28046	48181
9	Volvo Auto India	4	105	459

In [66]:
```
maker_pivot.rename(columns={2022:'EV_sold22',2023:'EV_sold23',2024:'EV_sold24'},inplace=True)
maker_pivot
```

Out[66]:

fiscal_year	maker	EV_sold22	EV_sold23	EV_sold24
0	BMW India	7	285	1078
1	BYD India	33	920	1466
2	Hyundai Motor	110	576	1390
3	KIA Motors	0	229	328
4	MG Motor	1647	3277	8829
5	Mahindra & Mahindra	4042	13805	23346
6	Mercedes -Benz AG	26	71	291
7	PCA Automobiles	0	151	1533
8	Tata Motors	12708	28046	48181
9	Volvo Auto India	4	105	459

In [67]:
```
start_year=2022
end_year=2024
maker_pivot['CAGR']=(((maker_pivot['EV_sold24']/maker_pivot['EV_sold22'])**(1/(end_year-start_year)))-1)*100
maker_pivot
```

Out[67]:

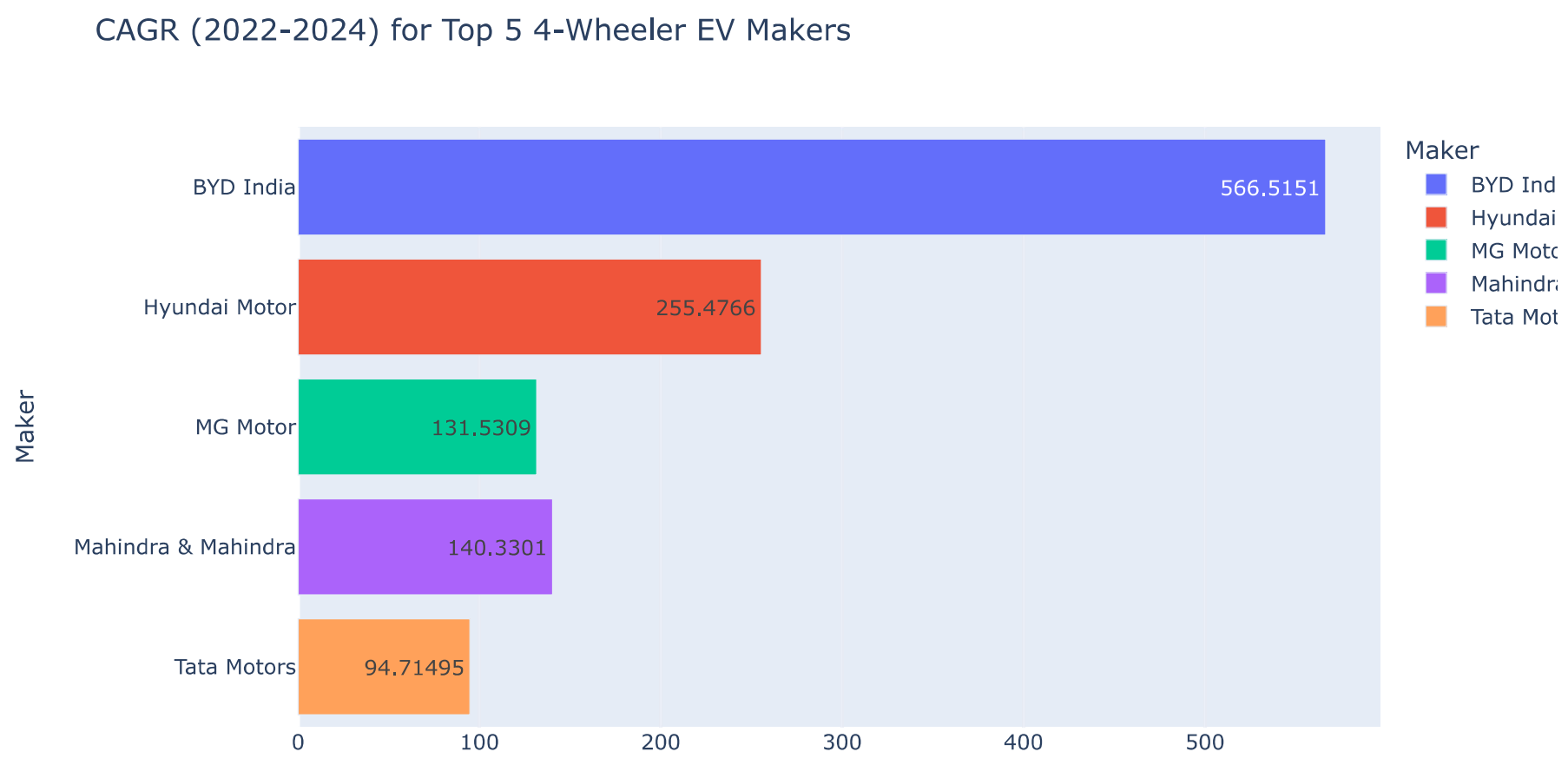
fiscal_year	maker	EV_sold22	EV_sold23	EV_sold24	CAGR
0	BMW India	7	285	1078	1140.967365
1	BYD India	33	920	1466	566.515134
2	Hyundai Motor	110	576	1390	255.476633
3	KIA Motors	0	229	328	inf
4	MG Motor	1647	3277	8829	131.530899
5	Mahindra & Mahindra	4042	13805	23346	140.330055
6	Mercedes -Benz AG	26	71	291	234.549065
7	PCA Automobiles	0	151	1533	inf
8	Tata Motors	12708	28046	48181	94.714952
9	Volvo Auto India	4	105	459	971.214264

In [68]:
```
top5_cagr=maker_pivot[maker_pivot['maker'].isin(maker_top5['maker'])]
top5_cagr
```

Out[68]:

fiscal_year	maker	EV_sold22	EV_sold23	EV_sold24	CAGR
1	BYD India	33	920	1466	566.515134
2	Hyundai Motor	110	576	1390	255.476633
4	MG Motor	1647	3277	8829	131.530899
5	Mahindra & Mahindra	4042	13805	23346	140.330055
8	Tata Motors	12708	28046	48181	94.714952

In [69]:
```
import plotly.express as px

fig = px.bar(top5_cagr, x='CAGR', y='maker',
             title='CAGR (2022-2024) for Top 5 4-Wheeler EV Makers',
             labels={'CAGR_2022_2024': 'CAGR (%)', 'maker': 'Maker'},
             text_auto=True,color='maker')

fig.show()
```



List down the top 10 states that had the highest compounded annual growth rate (CAGR) from 2022 to 2024 in total vehicles sold.

In [70]:
```
state_totalv=new_s.groupby(['state','fiscal_year']).sum('total_vehicles_sold').reset_index()
state_totalv
```

Out[70]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	2024	2	660
1	Andaman & Nicobar Island	2022	22	5148
2	Andaman & Nicobar Island	2023	23	6534
3	Andaman & Nicobar Island	2024	33	6543
4	Andhra Pradesh	2022	13928	772748
...	...	...	...	...
98	Uttarakhand	2023	6712	216265
99	Uttarakhand	2024	6336	233111
100	West Bengal	2022	2685	860709
101	West Bengal	2023	11011	913558
102	West Bengal	2024	16864	961909

103 rows × 4 columns

In [71]:
```
state_pivot=pd.pivot_table(state_totalv,index='state',columns='fiscal_year',values='total_vehicles_sold').reset_index
state_pivot
```

Out[71]:

fiscal_year	state	2022	2023	2024
0	Andaman & Nicobar	NaN	NaN	660.0
1	Andaman & Nicobar Island	5148.0	6534.0	6543.0
2	Andhra Pradesh	772748.0	728258.0	782865.0
3	Arunachal Pradesh	19929.0	23726.0	27892.0
4	Assam	379450.0	476195.0	547626.0
5	Bihar	892873.0	1022797.0	1132703.0
6	Chandigarh	36954.0	48527.0	45147.0
7	Chhattisgarh	390272.0	441649.0	503068.0
8	DNH and DD	12413.0	14584.0	16400.0
9	Delhi	401540.0	580548.0	606348.0
10	Goa	48372.0	73074.0	78524.0
11	Gujarat	1094872.0	1439692.0	1590987.0
12	Haryana	528591.0	642148.0	732029.0
13	Himachal Pradesh	98266.0	110016.0	117084.0
14	Jammu and Kashmir	133943.0	141251.0	139359.0
15	Jharkhand	411613.0	458262.0	495011.0
16	Karnataka	1007894.0	1404447.0	1581988.0
17	Kerala	689575.0	736988.0	638114.0
18	Ladakh	2911.0	4379.0	3206.0
19	Madhya Pradesh	967179.0	1245337.0	1286182.0
20	Maharashtra	1667002.0	2140433.0	2293994.0
21	Manipur	36129.0	49962.0	18422.0
22	Meghalaya	22193.0	31362.0	36628.0
23	Mizoram	19439.0	24446.0	27422.0
24	Nagaland	12852.0	14268.0	16972.0
25	Odisha	479527.0	591118.0	618149.0
26	Puducherry	42945.0	50161.0	57692.0
27	Punjab	443232.0	526244.0	574486.0
28	Rajasthan	880985.0	1126130.0	1300476.0
29	Sikkim	8897.0	9931.0	10518.0
30	Tamil Nadu	1345017.0	1590406.0	1716940.0
31	Tripura	37735.0	41034.0	46447.0
32	Uttar Pradesh	2497288.0	2697449.0	2932347.0
33	Uttarakhand	173331.0	216265.0	233111.0
34	West Bengal	860709.0	913558.0	961909.0

In [72]:
```
state_pivot.rename(columns={2022:'total_sold22',2023:'total_sold23',2024:'total_sold24'},inplace=True)
state_pivot

start_year=2022
end_year=2024
state_pivot['CAGR']=(((state_pivot['total_sold24']/state_pivot['total_sold22'])**(1/(end_year-start_year)))-1)*100
state_pivot
```

Out[72]:

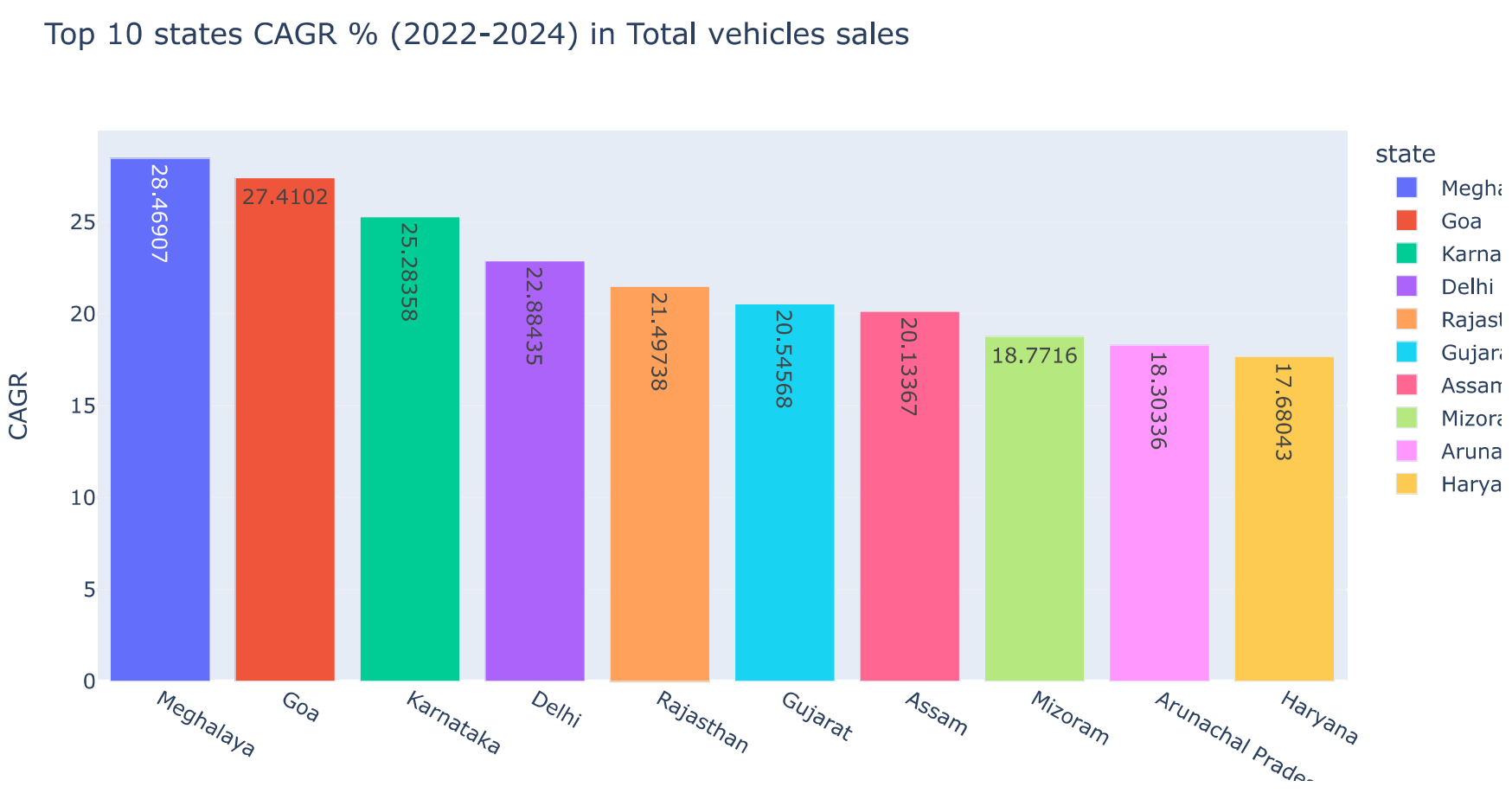
fiscal_year	state	total_sold22	total_sold23	total_sold24	CAGR
0	Andaman & Nicobar	NaN	NaN	660.0	NaN
1	Andaman & Nicobar Island	5148.0	6534.0	6543.0	12.737705
2	Andhra Pradesh	772748.0	728258.0	782865.0	0.652483
3	Arunachal Pradesh	19929.0	23726.0	27892.0	18.303359
4	Assam	379450.0	476195.0	547626.0	20.133672
5	Bihar	892873.0	1022797.0	1132703.0	12.632359
6	Chandigarh	36954.0	48527.0	45147.0	10.530904
7	Chhattisgarh	390272.0	441649.0	503068.0	13.534970
8	DNH and DD	12413.0	14584.0	16400.0	14.943270
9	Delhi	401540.0	580548.0	606348.0	22.884347
10	Goa	48372.0	73074.0	78524.0	27.410196
11	Gujarat	1094872.0	1439692.0	1590987.0	20.545677
12	Haryana	528591.0	642148.0	732029.0	17.680434
13	Himachal Pradesh	98266.0	110016.0	117084.0	9.155880
14	Jammu and Kashmir	133943.0	141251.0	139359.0	2.001721
15	Jharkhand	411613.0	458262.0	495011.0	9.663697
16	Karnataka	1007894.0	1404447.0	1581988.0	25.283582
17	Kerala	689575.0	736988.0	638114.0	-3.803697
18	Ladakh	2911.0	4379.0	3206.0	4.944735
19	Madhya Pradesh	967179.0	1245337.0	1286182.0	15.318181
20	Maharashtra	1667002.0	2140433.0	2293994.0	17.308121
21	Manipur	36129.0	49962.0	18422.0	-28.593061
22	Meghalaya	22193.0	31362.0	36628.0	28.469075
23	Mizoram	19439.0	24446.0	27422.0	18.771599
24	Nagaland	12852.0	14268.0	16972.0	14.916173
25	Odisha	479527.0	591118.0	618149.0	13.537690
26	Puducherry	42945.0	50161.0	57692.0	15.904819
27	Punjab	443232.0	526244.0	574486.0	13.847676
28	Rajasthan	880985.0	1126130.0	1300476.0	21.497380
29	Sikkim	8897.0	9931.0	10518.0	8.728848
30	Tamil Nadu	1345017.0	1590406.0	1716940.0	12.983148
31	Tripura	37735.0	41034.0	46447.0	10.944725
32	Uttar Pradesh	2497288.0	2697449.0	2932347.0	8.361090
33	Uttarakhand	173331.0	216265.0	233111.0	15.969361
34	West Bengal	860709.0	913558.0	961909.0	5.715537

In [73]:
```
state_sort=state_pivot.sort_values(by='CAGR',ascending=False)
state_top10=state_sort.head(10)
state_top10
```

Out[73]:

fiscal_year	state	total_sold22	total_sold23	total_sold24	CAGR
22	Meghalaya	22193.0	31362.0	36628.0	28.469075
10	Goa	48372.0	73074.0	78524.0	27.410196
16	Karnataka	1007894.0	1404447.0	1581988.0	25.283582
9	Delhi	401540.0	580548.0	606348.0	22.884347
28	Rajasthan	880985.0	1126130.0	1300476.0	21.497380
11	Gujarat	1094872.0	1439692.0	1590987.0	20.545677
4	Assam	379450.0	476195.0	547626.0	20.133672
23	Mizoram	19439.0	24446.0	27422.0	18.771599
3	Arunachal Pradesh	19929.0	23726.0	27892.0	18.303359
12	Haryana	528591.0	642148.0	732029.0	17.680434

In [74]:
```
fig=px.bar(state_top10,x='state',y='CAGR',text_auto=True,title='Top 10 states CAGR % (2022-2024) in Total vehicles sa
fig.show()
```



What is the projected number of EV sales (including 2-wheelers and 4-wheelers) for the top 10 states by penetration rate in 2030, based on the compounded annual growth rate (CAGR) from previous years?

In [75]:
```
state_group=new_s.groupby('state').sum('electric_vehicles_sold').reset_index()
state_group
```

Out[75]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	4048	2	660
1	Andaman & Nicobar Island	139586	78	18225
2	Andhra Pradesh	145656	77422	2283871
3	Arunachal Pradesh	145656	33	71547
4	Assam	145656	6418	1403271
5	Bihar	145656	31019	3048373
6	Chandigarh	145656	5279	130628
7	Chhattisgarh	145656	53804	1334989
8	DNH and DD	145656	355	43397
9	Delhi	145656	107312	1588436
10	Goa	145656	19684	199970
11	Gujarat	145656	181389	4125551
12	Haryana	145656	30797	1902768
13	Himachal Pradesh	145656	2595	325366
14	Jammu and Kashmir	145656	5971	414553
15	Jharkhand	145656	18461	1364886
16	Karnataka	145656	312995	3994329
17	Kerala	145656	137060	2064677
18	Ladakh	145656	68	10496
19	Madhya Pradesh	145656	78979	3498698
20	Maharashtra	145656	396045	6101429
21	Manipur	145656	299	104513
22	Meghalaya	145656	177	90183
23	Mizoram	145656	340	71307
24	Nagaland	145656	13	44092
25	Odisha	141608	78267	1688794
26	Puducherry	145656	5536	150798
27	Punjab	145656	23833	1543962
28	Rajasthan	145656	150366	3307591
29	Sikkim	145656	0	29346
30	Tamil Nadu	145656	200062	4652363
31	Tripura	145656	562	125216
32	Uttar Pradesh	145656	95203	8127084
33	Uttarakhand	145656	15127	622707
34	West Bengal	145656	30560	2736176

```
state_pivot=pd.pivot_table(state_group,index='state',columns='fiscal_year',values=['electric_vehicles_sold','total_vehicles_sold']).reset_index()
state_pivot
```

In [76]:
```
state_group['PRate']=((state_group['electric_vehicles_sold'])/(state_group['total_vehicles_sold']))*100
state_group
```

Out[76]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate
0	Andaman & Nicobar	4048	2	660	0.303030
1	Andaman & Nicobar Island	139586	78	18225	0.427984
2	Andhra Pradesh	145656	77422	2283871	3.389946
3	Arunachal Pradesh	145656	33	71547	0.046124
4	Assam	145656	6418	1403271	0.457360
5	Bihar	145656	31019	3048373	1.017559
6	Chandigarh	145656	5279	130628	4.041247
7	Chhattisgarh	145656	53804	1334989	4.030295
8	DNH and DD	145656	355	43397	0.818029
9	Delhi	145656	107312	1588436	6.755828
10	Goa	145656	19684	199970	9.843477
11	Gujarat	145656	181389	4125551	4.396722
12	Haryana	145656	30797	1902768	1.618537
13	Himachal Pradesh	145656	2595	325366	0.797563
14	Jammu and Kashmir	145656	5971	414553	1.440347
15	Jharkhand	145656	18461	1364886	1.352567
16	Karnataka	145656	312995	3994329	7.835984
17	Kerala	145656	137060	2064677	6.638326
18	Ladakh	145656	68	10496	0.647866
19	Madhya Pradesh	145656	78979	3498698	2.257383
20	Maharashtra	145656	396045	6101429	6.491020
21	Manipur	145656	299	104513	0.286089
22	Meghalaya	145656	177	90183	0.196268
23	Mizoram	145656	340	71307	0.476812
24	Nagaland	145656	13	44092	0.029484
25	Odisha	141608	78267	1688794	4.634491
26	Puducherry	145656	5536	150798	3.671136
27	Punjab	145656	23833	1543962	1.543626
28	Rajasthan	145656	150366	3307591	4.546088
29	Sikkim	145656	0	29346	0.000000
30	Tamil Nadu	145656	200062	4652363	4.300223
31	Tripura	145656	562	125216	0.448824
32	Uttar Pradesh	145656	95203	8127084	1.171429
33	Uttarakhand	145656	15127	622707	2.429232
34	West Bengal	145656	30560	2736176	1.116887

In [77]:
```
state_sort=state_group.sort_values(by='PRate',ascending=False)
state_top10=state_sort.head(10)
state_top10
```

Out[77]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold	PRate
10	Goa	145656	19684	199970	9.843477
16	Karnataka	145656	312995	3994329	7.835984
9	Delhi	145656	107312	1588436	6.755828
17	Kerala	145656	137060	2064677	6.638326
20	Maharashtra	145656	396045	6101429	6.491020
25	Odisha	141608	78267	1688794	4.634491
28	Rajasthan	145656	150366	3307591	4.546088
11	Gujarat	145656	181389	4125551	4.396722
30	Tamil Nadu	145656	200062	4652363	4.300223
6	Chandigarh	145656	5279	130628	4.041247

In [78]:
```
state_cag=new_s.groupby(['state','fiscal_year']).sum('electric_vehicles_sold').reset_index()
state_cag
```

Out[78]:

	state	fiscal_year	electric_vehicles_sold	total_vehicles_sold
0	Andaman & Nicobar	2024	2	660
1	Andaman & Nicobar Island	2022	22	5148
2	Andaman & Nicobar Island	2023	23	6534
3	Andaman & Nicobar Island	2024	33	6543
4	Andhra Pradesh	2022	13928	772748
...	...	...	...	...
98	Uttarakhand	2023	6712	216265
99	Uttarakhand	2024	6336	233111
100	West Bengal	2022	2685	860709
101	West Bengal	2023	11011	913558
102	West Bengal	2024	16864	961909

103 rows × 4 columns

In [79]:
```
state_cpivot=pd.pivot_table(state_cag,index='state',columns='fiscal_year',values='electric_vehicles_sold').reset_inde
state_cpivot
```

Out[79]:

fiscal_year	state	2022	2023	2024
0	Andaman & Nicobar	NaN	NaN	2.0
1	Andaman & Nicobar Island	22.0	23.0	33.0
2	Andhra Pradesh	13928.0	30311.0	33183.0
3	Arunachal Pradesh	0.0	2.0	31.0
4	Assam	730.0	2191.0	3497.0
5	Bihar	4829.0	11121.0	15069.0
6	Chandigarh	411.0	1991.0	2877.0
7	Chhattisgarh	4534.0	20730.0	28540.0
8	DNH and DD	35.0	122.0	198.0
9	Delhi	16535.0	44053.0	46724.0
10	Goa	1778.0	7107.0	10799.0
11	Gujarat	18026.0	79004.0	84359.0
12	Haryana	5926.0	13078.0	11793.0
13	Himachal Pradesh	443.0	1104.0	1048.0
14	Jammu and Kashmir	1434.0	2254.0	2283.0
15	Jharkhand	2713.0	7918.0	7830.0
16	Karnataka	43111.0	108895.0	160989.0
17	Kerala	13639.0	49483.0	73938.0
18	Ladakh	12.0	25.0	31.0
19	Madhya Pradesh	7916.0	27840.0	43223.0
20	Maharashtra	48374.0	150502.0	197169.0
21	Manipur	25.0	148.0	126.0
22	Meghalaya	4.0	40.0	133.0
23	Mizoram	0.0	65.0	275.0
24	Nagaland	1.0	3.0	9.0
25	Odisha	9498.0	29651.0	39118.0
26	Puducherry	734.0	1704.0	3098.0
27	Punjab	4528.0	8107.0	11198.0
28	Rajasthan	20087.0	63835.0	66444.0
29	Sikkim	0.0	0.0	0.0
30	Tamil Nadu	36863.0	68885.0	94314.0
31	Tripura	28.0	230.0	304.0
32	Uttar Pradesh	10222.0	27223.0	57758.0
33	Uttarakhand	2079.0	6712.0	6336.0
34	West Bengal	2685.0	11011.0	16864.0

In [80]:
```
state_cpivot.rename(columns={2022:'EV_sold22',2023:'EV_sold23',2024:'EV_sold24'},inplace=True)
state_cpivot
```

Out[80]:

fiscal_year	state	EV_sold22	EV_sold23	EV_sold24
0	Andaman & Nicobar	NaN	NaN	2.0
1	Andaman & Nicobar Island	22.0	23.0	33.0
2	Andhra Pradesh	13928.0	30311.0	33183.0
3	Arunachal Pradesh	0.0	2.0	31.0
4	Assam	730.0	2191.0	3497.0
5	Bihar	4829.0	11121.0	15069.0
6	Chandigarh	411.0	1991.0	2877.0
7	Chhattisgarh	4534.0	20730.0	28540.0
8	DNH and DD	35.0	122.0	198.0
9	Delhi	16535.0	44053.0	46724.0
10	Goa	1778.0	7107.0	10799.0
11	Gujarat	18026.0	79004.0	84359.0
12	Haryana	5926.0	13078.0	11793.0
13	Himachal Pradesh	443.0	1104.0	1048.0
14	Jammu and Kashmir	1434.0	2254.0	2283.0
15	Jharkhand	2713.0	7918.0	7830.0
16	Karnataka	43111.0	108895.0	160989.0
17	Kerala	13639.0	49483.0	73938.0
18	Ladakh	12.0	25.0	31.0
19	Madhya Pradesh	7916.0	27840.0	43223.0
20	Maharashtra	48374.0	150502.0	197169.0
21	Manipur	25.0	148.0	126.0
22	Meghalaya	4.0	40.0	133.0
23	Mizoram	0.0	65.0	275.0
24	Nagaland	1.0	3.0	9.0
25	Odisha	9498.0	29651.0	39118.0
26	Puducherry	734.0	1704.0	3098.0
27	Punjab	4528.0	8107.0	11198.0
28	Rajasthan	20087.0	63835.0	66444.0
29	Sikkim	0.0	0.0	0.0
30	Tamil Nadu	36863.0	68885.0	94314.0
31	Tripura	28.0	230.0	304.0
32	Uttar Pradesh	10222.0	27223.0	57758.0
33	Uttarakhand	2079.0	6712.0	6336.0
34	West Bengal	2685.0	11011.0	16864.0

In [81]:
```
start_year=2022
end_year=2024
state_cpivot['CAGR']=(((state_cpivot['EV_sold24']/state_cpivot['EV_sold22'])**(1/(end_year-start_year)))-1)*100
state_cpivot
```

Out[81]:

fiscal_year	state	EV_sold22	EV_sold23	EV_sold24	CAGR
0	Andaman & Nicobar	NaN	NaN	2.0	NaN
1	Andaman & Nicobar Island	22.0	23.0	33.0	22.474487
2	Andhra Pradesh	13928.0	30311.0	33183.0	54.352421
3	Arunachal Pradesh	0.0	2.0	31.0	inf
4	Assam	730.0	2191.0	3497.0	118.870075
5	Bihar	4829.0	11121.0	15069.0	76.649989
6	Chandigarh	411.0	1991.0	2877.0	164.575131
7	Chhattisgarh	4534.0	20730.0	28540.0	150.891661
8	DNH and DD	35.0	122.0	198.0	137.847490
9	Delhi	16535.0	44053.0	46724.0	68.100075
10	Goa	1778.0	7107.0	10799.0	146.448337
11	Gujarat	18026.0	79004.0	84359.0	116.329640
12	Haryana	5926.0	13078.0	11793.0	41.068915
13	Himachal Pradesh	443.0	1104.0	1048.0	53.807948
14	Jammu and Kashmir	1434.0	2254.0	2283.0	26.176472
15	Jharkhand	2713.0	7918.0	7830.0	69.885371
16	Karnataka	43111.0	108895.0	160989.0	93.243125
17	Kerala	13639.0	49483.0	73938.0	132.831955
18	Ladakh	12.0	25.0	31.0	60.727513
19	Madhya Pradesh	7916.0	27840.0	43223.0	133.670862
20	Maharashtra	48374.0	150502.0	197169.0	101.889307
21	Manipur	25.0	148.0	126.0	124.499443
22	Meghalaya	4.0	40.0	133.0	476.628130
23	Mizoram	0.0	65.0	275.0	inf
24	Nagaland	1.0	3.0	9.0	200.000000
25	Odisha	9498.0	29651.0	39118.0	102.942141
26	Puducherry	734.0	1704.0	3098.0	105.443628
27	Punjab	4528.0	8107.0	11198.0	57.259548
28	Rajasthan	20087.0	63835.0	66444.0	81.873885
29	Sikkim	0.0	0.0	0.0	NaN
30	Tamil Nadu	36863.0	68885.0	94314.0	59.953130
31	Tripura	28.0	230.0	304.0	229.501788
32	Uttar Pradesh	10222.0	27223.0	57758.0	137.704900
33	Uttarakhand	2079.0	6712.0	6336.0	74.574312
34	West Bengal	2685.0	11011.0	16864.0	150.615629

In [82]:
```
state_top10c=state_cpivot[state_cpivot['state'].isin(state_top10['state'])]
state_top10c
```

Out[82]:

fiscal_year	state	EV_sold22	EV_sold23	EV_sold24	CAGR
6	Chandigarh	411.0	1991.0	2877.0	164.575131
9	Delhi	16535.0	44053.0	46724.0	68.100075
10	Goa	1778.0	7107.0	10799.0	146.448337
11	Gujarat	18026.0	79004.0	84359.0	116.329640
16	Karnataka	43111.0	108895.0	160989.0	93.243125
17	Kerala	13639.0	49483.0	73938.0	132.831955
20	Maharashtra	48374.0	150502.0	197169.0	101.889307
25	Odisha	9498.0	29651.0	39118.0	102.942141
28	Rajasthan	20087.0	63835.0	66444.0	81.873885
30	Tamil Nadu	36863.0	68885.0	94314.0	59.953130

In [83]:
```
projected_years=2030-2024
state_top10c['projected_sales2030']=state_top10c['EV_sold24']*(1+(state_top10c['CAGR']/100))**projected_years
state_top10c['projected_sales2030'] = state_top10c['projected_sales2030'].apply(lambda x: int(round(x)))
state_top10c
```

Out[83]:

fiscal_year	state	EV_sold22	EV_sold23	EV_sold24	CAGR	projected_sales2030
6	Chandigarh	411.0	1991.0	2877.0	164.575131	986811
9	Delhi	16535.0	44053.0	46724.0	68.100075	1054259
10	Goa	1778.0	7107.0	10799.0	146.448337	2419574
11	Gujarat	18026.0	79004.0	84359.0	116.329640	8646246
16	Karnataka	43111.0	108895.0	160989.0	93.243125	8383406
17	Kerala	13639.0	49483.0	73938.0	132.831955	11779401
20	Maharashtra	48374.0	150502.0	197169.0	101.889307	13351146
25	Odisha	9498.0	29651.0	39118.0	102.942141	2732814
28	Rajasthan	20087.0	63835.0	66444.0	81.873885	2404794
30	Tamil Nadu	36863.0	68885.0	94314.0	59.953130	1579547

In [88]:
```
state_melt=state_top10c.melt(id_vars='state', value_vars=['EV_sold24', 'projected_sales2030'],var_name='year', value_
state_melt
```

Out[88]:

	state	year	Sales
0	Chandigarh	EV_sold24	2877.0
1	Delhi	EV_sold24	46724.0
2	Goa	EV_sold24	10799.0
3	Gujarat	EV_sold24	84359.0
4	Karnataka	EV_sold24	160989.0
5	Kerala	EV_sold24	73938.0
6	Maharashtra	EV_sold24	197169.0
7	Odisha	EV_sold24	39118.0
8	Rajasthan	EV_sold24	66444.0
9	Tamil Nadu	EV_sold24	94314.0
10	Chandigarh	projected_sales2030	986811.0
11	Delhi	projected_sales2030	1054259.0
12	Goa	projected_sales2030	2419574.0
13	Gujarat	projected_sales2030	8646246.0
14	Karnataka	projected_sales2030	8383406.0
15	Kerala	projected_sales2030	11779401.0
16	Maharashtra	projected_sales2030	13351146.0
17	Odisha	projected_sales2030	2732814.0
18	Rajasthan	projected_sales2030	2404794.0
19	Tamil Nadu	projected_sales2030	1579547.0

In [96]:
```
fig=px.bar(state_melt,x='state',y='Sales',text_auto=True,
        title='Top 10 states current sales vs projected sales',color='year',barmode='group')
fig.show()
```

Estimate the revenue growth rate of 4-wheeler and 2-wheelers EVs in India for 2022 vs 2024 and 2023 vs 2024,assuming an average unit price.2w 85000 4w 1500000

In [102]:
```
import numpy as np

new_m['Revenue']=np.where(
new_m['vehicle_category']=='4-Wheelers',new_m['electric_vehicles_sold']*1500000,new_m['electric_vehicles_sold']*85000
Total_rev_maker=sum(new_m['Revenue'])
Total_rev_maker
```

Out[102]: 392033780000

In [103]:
```
new_m
```

Out[103]:

	date	fiscal_year	quarter	vehicle_category	maker	electric_vehicles_sold	Revenue
0	2021-04-01	2022	Q1	2-Wheelers	OLA ELECTRIC	0	0
1	2021-04-01	2022	Q1	4-Wheelers	BYD India	0	0
2	2021-04-01	2022	Q1	4-Wheelers	PCA Automobiles	0	0
3	2021-04-01	2022	Q1	4-Wheelers	BMW India	0	0
4	2021-04-01	2022	Q1	4-Wheelers	Volvo Auto India	0	0
...	...	...	...	...	...	...	...
811	2024-03-01	2024	Q4	2-Wheelers	BGAUSS	3070	260950000
812	2024-03-01	2024	Q4	2-Wheelers	BATTRE ELECTRIC	625	53125000
813	2024-03-01	2024	Q4	2-Wheelers	KINETIC GREEN	3915	332775000
814	2024-03-01	2024	Q4	2-Wheelers	REVOLT	585	49725000
815	2024-03-01	2024	Q4	2-Wheelers	OTHERS	10579	899215000

816 rows × 7 columns

In [121]:
```
rev_maker=new_m.groupby(['vehicle_category','fiscal_year']).sum('Revenue').reset_index()
rev_maker
```

Out[121]:

	vehicle_category	fiscal_year	electric_vehicles_sold	Revenue
0	2-Wheelers	2022	252573	21468705000
1	2-Wheelers	2023	727903	61871755000
2	2-Wheelers	2024	932692	79278820000
3	4-Wheelers	2022	18577	27865500000
4	4-Wheelers	2023	47465	71197500000
5	4-Wheelers	2024	86901	130351500000

In [123]:
```
rev_pivot=pd.pivot_table(rev_maker,index='vehicle_category',columns='fiscal_year',values='Revenue')
rev_pivot.rename(columns={2022: 'rev22', 2023: 'rev23', 2024: 'rev24'}, inplace=True)
#rev_pivot=rev_pivot.fillna(0)
rev_pivot.reset_index()
```

Out[123]:

fiscal_year	vehicle_category	rev22	rev23	rev24
0	2-Wheelers	21468705000	61871755000	79278820000
1	4-Wheelers	27865500000	71197500000	130351500000

In [124]:
```
rev_pivot['rev22_24']=((rev_pivot['rev24']-rev_pivot['rev22'])/rev_pivot['rev22'])*100
rev_pivot['rev23_24']=((rev_pivot['rev24']-rev_pivot['rev23'])/rev_pivot['rev23'])*100
rev_pivot
```

Out[124]:

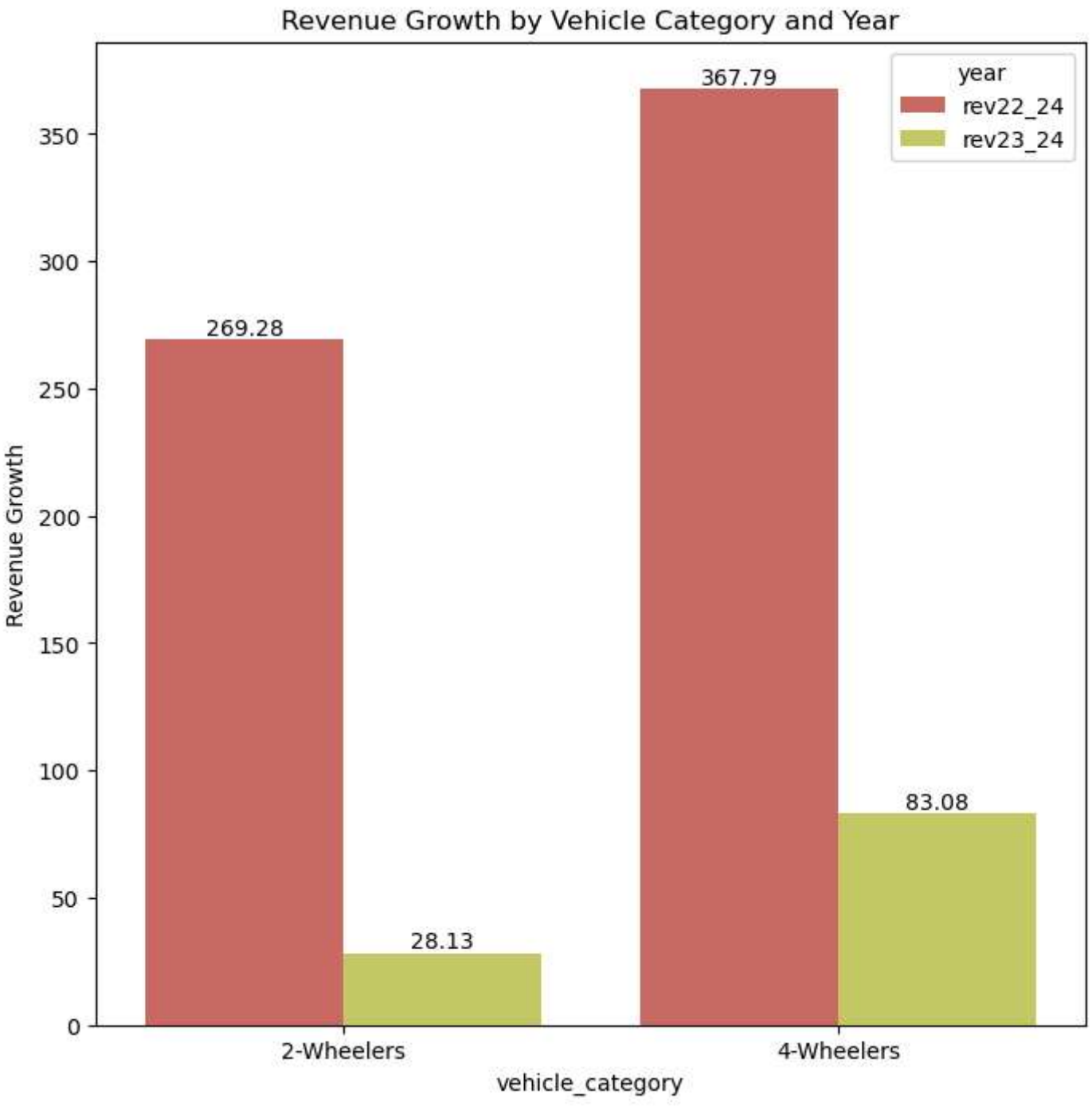
fiscal_year	rev22	rev23	rev24	rev22_24	rev23_24
vehicle_category					
2-Wheelers	21468705000	61871755000	79278820000	269.276209	28.134106
4-Wheelers	27865500000	71197500000	130351500000	367.788125	83.084378

In [127]:
```
rev_pivot=rev_pivot.reset_index()
rev_melt=rev_pivot.melt(id_vars='vehicle_category',value_vars=['rev22_24','rev23_24'],var_name='year',value_name='Rev
rev_melt
```

Out[127]:

	vehicle_category	year	Revenue Growth
0	2-Wheelers	rev22_24	269.276209
1	4-Wheelers	rev22_24	367.788125
2	2-Wheelers	rev23_24	28.134106
3	4-Wheelers	rev23_24	83.084378

In [134]:
```
fig,ax=plt.subplots(figsize=(8,8))
sns.barplot(rev_melt,x='vehicle_category',y='Revenue Growth',hue='year',palette=sns.hls_palette())
container=0
for container in ax.containers:
    ax.bar_label(container,fmt='%.2f')
ax.set_title('Revenue Growth by Vehicle Category and Year')
plt.show()
```



In [ ]: