```
!pip install pyshp
```

    Requirement already satisfied: pyshp in /usr/local/lib/python3.10/dist-packages (2.3.1)

```python
import pandas as pd
import numpy as np
import plotly.express as px
import matplotlib.pyplot as plt
import seaborn as sns
import geopandas as gpd
import shapefile as shp
import plotly.graph_objects as go
from shapely.geometry import Point
from sklearn.cluster import KMeans
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler
sns.set_style('whitegrid')
```

```python
# Load datasets
electric_vehicle_data = pd.read_csv('/content/Current Sales of Electric Vehicles.csv')
charging_stations_data = pd.read_csv('/content/CS_station.csv')
ev_charging_sanctioned_data = pd.read_csv('/content/CS_Sanctioned.csv')
highways_charging_stations_data = pd.read_csv('/content/CS_Highway.csv')
```

```python
electric_vehicle_data
```

	State Name	Two Wheeler	Three Wheeler	Four Wheeler	Goods Vehicles	Public Service Vehicle	Special Category Vehicles	Ambulance/Hearses	Construction Equipment Vehicle	Other	Grand Total
0	Andaman and Nicobar Islands	1	30.0	81	NaN	40.0	NaN	NaN	NaN	7.0	159
1	Arunachal Pradesh	14	NaN	5	NaN	NaN	NaN	NaN	NaN	1.0	20
2	Assam	721	47041.0	161	7.0	15.0	NaN	NaN	NaN	2.0	47947
3	Bihar	5003	59079.0	114	11.0	26.0	NaN	NaN	NaN	8.0	64241
4	Chandigarh	298	1410.0	182	NaN	40.0	NaN	NaN	NaN	1.0	1931
5	Chhattisgarh	6424	5341.0	117	1077.0	1.0	NaN	NaN	368.0	100.0	13428
6	Delhi	14730	112831.0	3051	49.0	39.0	NaN	NaN	NaN	1602.0	132302
7	Goa	1314	28.0	289	13.0	36.0	2.0	NaN	NaN	4.0	1686
8	Gujarat	13662	1869.0	1309	28.0	278.0	344.0	NaN	26.0	77.0	17593
9	Haryana	7777	18595.0	186	122.0	8.0	2.0	NaN	NaN	90.0	26780
10	Himachal Pradesh	368	167.0	37	7.0	86.0	NaN	NaN	NaN	46.0	711
11	Jammu and Kashmir	1417	43.0	10	6.0	43.0	NaN	NaN	NaN	8.0	1527
12	Jharkhand	2961	8986.0	139	24.0	4.0	NaN	NaN	NaN	57.0	12171
13	Karnataka	56737	16478.0	7212	153.0	44.0	1.0	1.0	NaN	1420.0	82046
14	Kerala	10299	2115.0	2524	43.0	23.0	NaN	1.0	NaN	17.0	15022
15	Ladakh	12	NaN	5484	NaN	NaN	NaN	NaN	NaN	NaN	5496
16	Maharashtra	51149	6155.0	2	30.0	851.0	26.0	1.0	NaN	601.0	58815
17	Manipur	86	443.0	9	1.0	NaN	NaN	NaN	NaN	1.0	540
18	Meghalaya	16	6.0	3	3.0	NaN	NaN	NaN	NaN	NaN	28
19	Mizoram	9	1.0	4	2.0	1.0	NaN	NaN	NaN	3.0	20
20	Nagaland	44	NaN	121	3.0	NaN	1.0	NaN	1.0	1.0	171
21	Odisha	10329	1808.0	75	21.0	NaN	25.0	NaN	1.0	23.0	12282
22	Puducherry	1429	32.0	124	9.0	20.0	NaN	NaN	NaN	NaN	1614
23	Punjab	6408	2878.0	798	35.0	2.0	NaN	NaN	NaN	21.0	10142
24	Rajasthan	23446	29631.0	12	25.0	1.0	NaN	1.0	1.0	24.0	53141
25	Sikkim	1	NaN	2414	1.0	NaN	NaN	NaN	NaN	9.0	2425
26	Tamil Nadu	44302	4470.0	13	1281.0	37.0	NaN	NaN	NaN	193.0	50296
27	Tripura	67	7510.0	14	1.0	NaN	NaN	NaN	NaN	1.0	7593
28	Dadra and Nagar Haveli and Daman and Diu	69	36.0	153	2.0	10.0	7.0	NaN	NaN	NaN	277
29	Uttar Pradesh	18295	257159.0	368	53.0	327.0	2.0	NaN	NaN	13.0	276217
30	Uttarakhand	2614	22096.0	709	1.0	10.0	NaN	NaN	NaN	21.0	25451
31	West Bengal	2540	40948.0	615	28.0	97.0	NaN	2.0	NaN	61.0	44291
32	Grand Total	282542	647186.0	26335	3036.0	2039.0	410.0	6.0	397.0	4412.0	966363

```python
charging_stations_data
```

	Sl. No.	State/ UT	Charging Stations
0	1	Telangana	56
1	2	Jharkhand	29
2	3	Goa	26
3	4	Karnataka	48
4	5	Himachal Pradesh	9
5	6	Uttar Pradesh	15
6	7	Rajasthan	49
7	8	Delhi	94
8	9	Chandigarh UT	48
9	Total	Total	374

```python
ev_charging_sanctioned_data
```

	State/UT-wise	Number of Electric Vehicle Charging Sanctioned
0	Maharashtra	317
1	Andhra Pradesh	266
2	Tamil Nadu	256
3	Gujarat	228
4	Uttar Pradesh	207
5	Rajasthan	205
6	Karnataka	172
7	Madhya Pradesh	159
8	West Bengal	141
9	Telangana	138
10	Kerala	131
11	Delhi	72
12	Chandigarh	70
13	Haryana	50
14	Meghalaya	40
15	Bihar	37
16	Sikkim	29
17	Jammu & Kashmir	25
18	Chhattisgarh	25
19	Assam	20
20	Odisha	18
21	Uttarakhand	10
22	Puducherry	10
23	Himachal Pradesh	10
24	Total	2636

```
highways_charging_stations_data
```

	Sl. No.	Highways/Expressways	Charging Stations	🪄	📊
0	1	Mumbai - Pune Expressway	10		
1	2	Surat-Mumbai Expressway	30		
2	3	Mumbai - Delhi Highway	124		
3	4	Mumbai - Panaji Highway	60		
4	5	Mumbai - Nagpur Highway	70		
5	6	Mumbai - Bengaluru Highway	100		
6	7	Agra-Nagpur	80		
7	8	Kolkata- Nagpur	120		
8	9	Delhi-Jaipur- Agra Highway	29		
9	10	Jaipur- Delhi Highway	9		
10	11	Delhi- Chandigarh Highway	24		
11	12	Total	672		

```
# Data Cleaning for Electric Vehicle Data
electric_vehicle_data = electric_vehicle_data.fillna(0)
electric_vehicle_data = electric_vehicle_data[~electric_vehicle_data['State Name'].str.contains('Total')]  # Remove "Total" row
```

```
# Data Cleaning for Charging Stations Data
charging_stations_data = charging_stations_data[~charging_stations_data['State/ UT'].str.contains('Total')]  # Remove "Total" row
```

```
# Data Cleaning for Highways/Expressways Charging Stations Data
highways_charging_stations_data = highways_charging_stations_data[~highways_charging_stations_data['Highways/Expressways'].str.contains('Total')]  # Remove "Total" row
```

```
# Data Cleaning for Charging Sanctioned Data
ev_charging_sanctioned_data = ev_charging_sanctioned_data[~ev_charging_sanctioned_data['State/UT-wise'].str.contains('Total')]  # Remove "Total" row
```

```
# Display cleaned data
print("Cleaned Electric Vehicle Data:")
electric_vehicle_data
```

Cleaned Electric Vehicle Data:

	State Name	Two Wheeler	Three Wheeler	Four Wheeler	Goods Vehicles	Public Service Vehicle	Special Category Vehicles	Ambulance/Hearses	Construction Equipment Vehicle	Other	Grand Total
0	Andaman and Nicobar Islands	1	30.0	81	0.0	40.0	0.0	0.0	0.0	7.0	159
1	Arunachal Pradesh	14	0.0	5	0.0	0.0	0.0	0.0	0.0	1.0	20
2	Assam	721	47041.0	161	7.0	15.0	0.0	0.0	0.0	2.0	47947
3	Bihar	5003	59079.0	114	11.0	26.0	0.0	0.0	0.0	8.0	64241
4	Chandigarh	298	1410.0	182	0.0	40.0	0.0	0.0	0.0	1.0	1931
5	Chhattisgarh	6424	5341.0	117	1077.0	1.0	0.0	0.0	368.0	100.0	13428
6	Delhi	14730	112831.0	3051	49.0	39.0	0.0	0.0	0.0	1602.0	132302
7	Goa	1314	28.0	289	13.0	36.0	2.0	0.0	0.0	4.0	1686
8	Gujarat	13662	1869.0	1309	28.0	278.0	344.0	0.0	26.0	77.0	17593
9	Haryana	7777	18595.0	186	122.0	8.0	2.0	0.0	0.0	90.0	26780
10	Himachal Pradesh	368	167.0	37	7.0	86.0	0.0	0.0	0.0	46.0	711
11	Jammu and Kashmir	1417	43.0	10	6.0	43.0	0.0	0.0	0.0	8.0	1527
12	Jharkhand	2961	8986.0	139	24.0	4.0	0.0	0.0	0.0	57.0	12171
13	Karnataka	56737	16478.0	7212	153.0	44.0	1.0	1.0	0.0	1420.0	82046
14	Kerala	10299	2115.0	2524	43.0	23.0	0.0	1.0	0.0	17.0	15022
15	Ladakh	12	0.0	5484	0.0	0.0	0.0	0.0	0.0	0.0	5496
16	Maharashtra	51149	6155.0	2	30.0	851.0	26.0	1.0	0.0	601.0	58815
17	Manipur	86	443.0	9	1.0	0.0	0.0	0.0	0.0	1.0	540
18	Meghalaya	16	6.0	3	3.0	0.0	0.0	0.0	0.0	0.0	28
19	Mizoram	9	1.0	4	2.0	1.0	0.0	0.0	0.0	3.0	20
20	Nagaland	44	0.0	121	3.0	0.0	1.0	0.0	1.0	1.0	171
21	Odisha	10329	1808.0	75	21.0	0.0	25.0	0.0	1.0	23.0	12282
22	Puducherry	1429	32.0	124	9.0	20.0	0.0	0.0	0.0	0.0	1614
23	Punjab	6408	2878.0	798	35.0	2.0	0.0	0.0	0.0	21.0	10142
24	Rajasthan	23446	29631.0	12	25.0	1.0	0.0	1.0	1.0	24.0	53141
25	Sikkim	1	0.0	2414	1.0	0.0	0.0	0.0	0.0	9.0	2425
26	Tamil Nadu	44302	4470.0	13	1281.0	37.0	0.0	0.0	0.0	193.0	50296
27	Tripura	67	7510.0	14	1.0	0.0	0.0	0.0	0.0	1.0	7593
28	Dadra and Nagar Haveli and Daman and Diu	69	36.0	153	2.0	10.0	7.0	0.0	0.0	0.0	277
29	Uttar Pradesh	18295	257159.0	368	53.0	327.0	2.0	0.0	0.0	13.0	276217
30	Uttarakhand	2614	22096.0	709	1.0	10.0	0.0	0.0	0.0	21.0	25451
31	West Bengal	2540	40948.0	615	28.0	97.0	0.0	2.0	0.0	61.0	44291

🪄 📊

```
print("\nCleaned Charging Stations Data:")
charging_stations_data
```

Cleaned Charging Stations Data:

	Sl. No.	State/ UT	Charging Stations	🪄	📊
0	1	Telangana	56		
1	2	Jharkhand	29		
2	3	Goa	26		
3	4	Karnataka	48		
4	5	Himachal Pradesh	9		
5	6	Uttar Pradesh	15		
6	7	Rajasthan	49		
7	8	Delhi	94		
8	9	Chandigarh UT	48		

```
print("\nCleaned EV Charging Sanctioned Data:")
ev_charging_sanctioned_data
```

Cleaned EV Charging Sanctioned Data:

	State/UT-wise	Number of Electric Vehicle Charging Sanctioned
0	Maharashtra	317
1	Andhra Pradesh	266
2	Tamil Nadu	256
3	Gujarat	228
4	Uttar Pradesh	207
5	Rajasthan	205
6	Karnataka	172
7	Madhya Pradesh	159
8	West Bengal	141

```
print("\nCleaned Highways/Expressways Charging Stations Data:")
highways_charging_stations_data
```

Cleaned Highways/Expressways Charging Stations Data:

	Sl. No.	Highways/Expressways	Charging Stations
0	1	Mumbai - Pune Expressway	10
1	2	Surat-Mumbai Expressway	30
2	3	Mumbai - Delhi Highway	124
3	4	Mumbai - Panaji Highway	60
4	5	Mumbai - Nagpur Highway	70
5	6	Mumbai - Bengaluru Highway	100
6	7	Agra-Nagpur	80
7	8	Kolkata- Nagpur	120
8	9	Delhi-Jaipur- Agra Highway	29
9	10	Jaipur- Delhi Highway	9
10	11	Delhi- Chandigarh Highway	24

▾ Total Electric Vehicle By State

```
fig = px.bar(electric_vehicle_data, x='State Name', y='Grand Total', title='Total Electric Vehicles by State',
             labels={'State Name': 'State/UT', 'Total EVs': 'Total Electric Vehicles'},
             template='plotly_dark')
fig.update_xaxes(tickangle=-45)
fig.show()
```
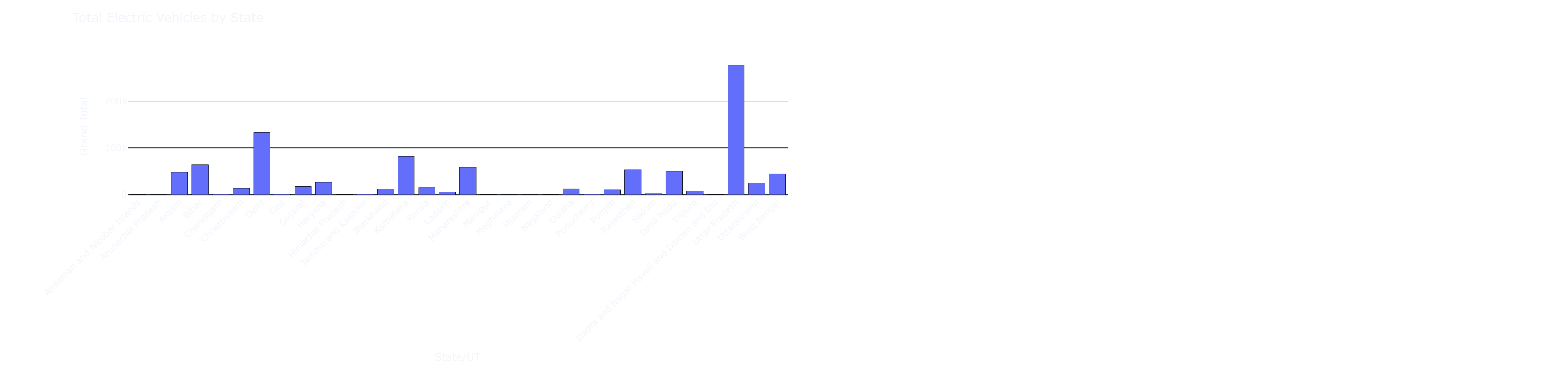

States/UT to target based on Electric Vehicle

- Uttar Pradesh
- Delhi
- Karnataka
- Bihar
- Maharashtra

▾ Different Types of Electric Vehicle Adopted by States

```
# Visualize Electric Vehicle Adoption by State
fig1 = px.bar(electric_vehicle_data, x='State Name', y=['Two Wheeler', 'Three Wheeler', 'Four Wheeler'],
              title='Electric Vehicle Adoption by State',
              labels={'value': 'Number of Vehicles', 'State Name': 'State'}, height=800)
fig1.show()
```
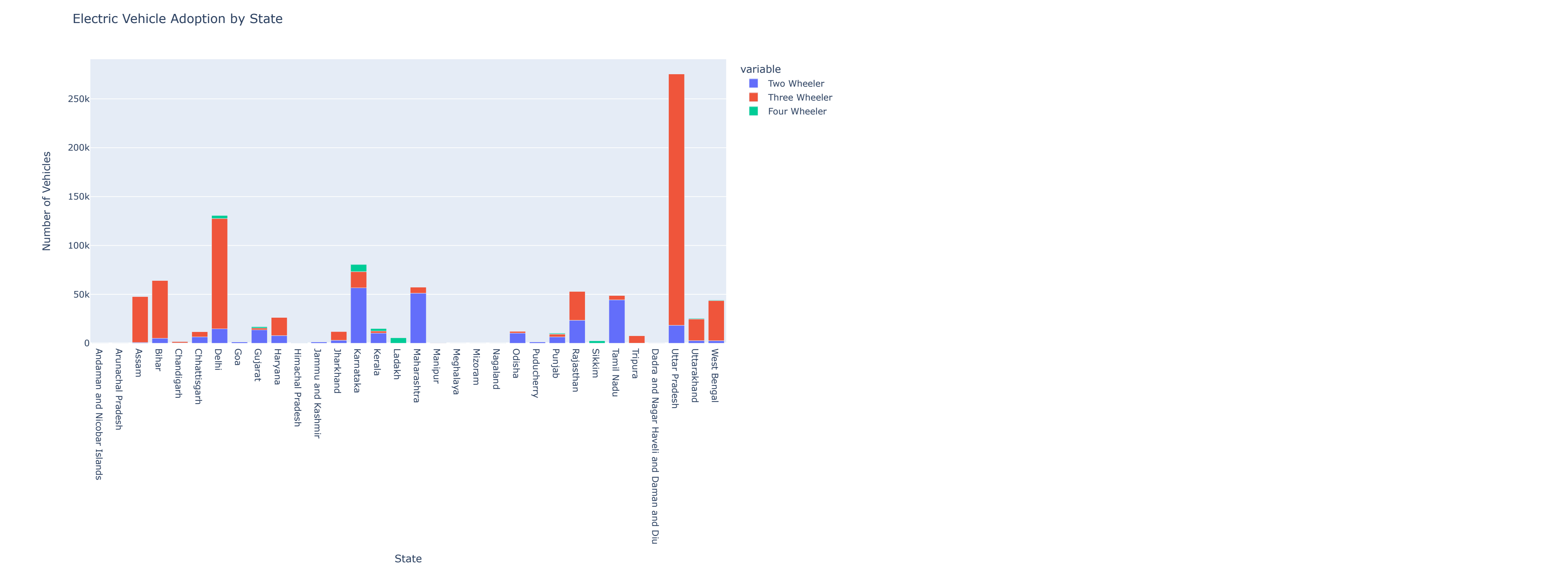

States/UT to target based on High Electric Vehicle Adoption

Two Wheeler:

- Karnataka
- Maharastra
- Tamil Nadu
- Rajasthan

Three Wheeler:

- Uttar Pradesh
- Delhi
- Bihar

- Assam
- West Bengal
- Rajasthan

Four Wheeler:

- Karnataka
- Ladakh
- Delhi

▼ Charging Stations in States/UT:

```
# Visualize Charging Infrastructure by State
fig2 = px.bar(charging_stations_data, x='State/ UT', y='Charging Stations',
              title='Charging Stations by State',
              labels={'Charging Stations': 'Number of Charging Stations', 'State/ UT': 'State'})
fig2.show()
```
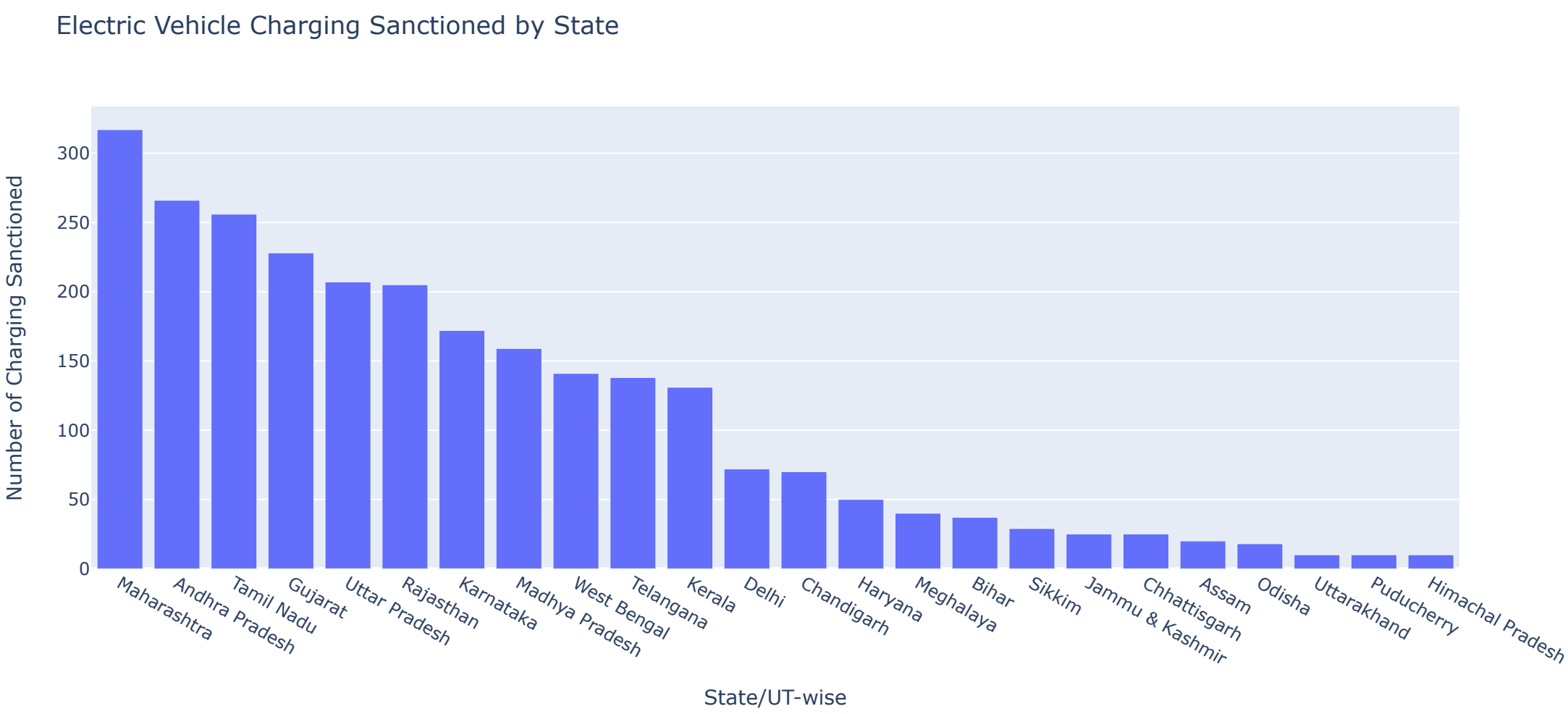
Charging Stations by State
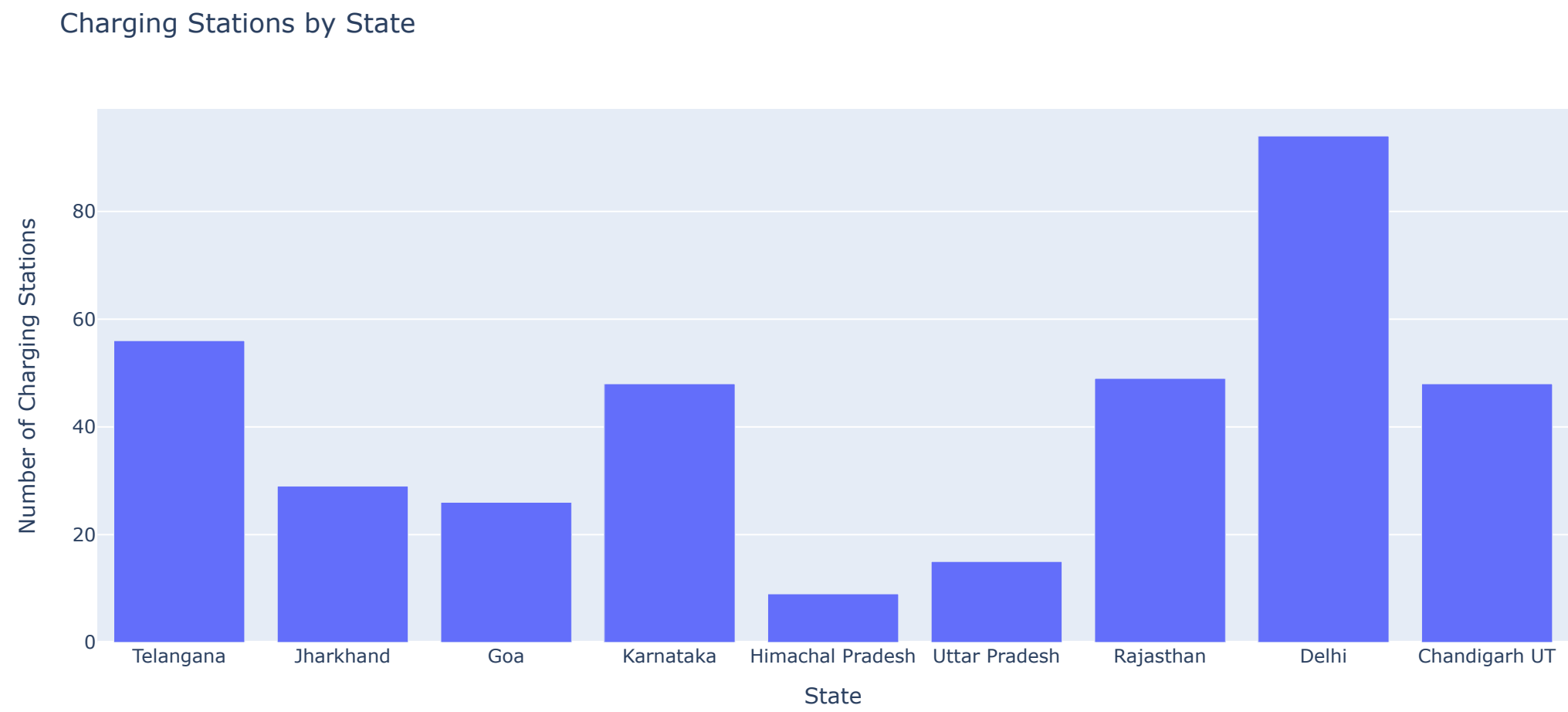
States/UT to target based on Charging Stations

- Delhi
- Telangana
- Rajasthan
- Karnataka
- Chandigarh UT

▼ Sanctioned Charging Stations:

```
# Visualize EV Charging Sanctioned by State
fig3 = px.bar(ev_charging_sanctioned_data, x='State/UT-wise', y='Number of Electric Vehicle Charging Sanctioned',
              title='Electric Vehicle Charging Sanctioned by State',
              labels={'Number of Electric Vehicle Charging Sanctioned': 'Number of Charging Sanctioned', 'State/UT': 'State'})
fig3.show()
```

Electric Vehicle Charging Sanctioned by State

States to target based on charging stations sanctioned

- Maharashtra
- Andhra Pradesh
- Tamil Nadu
- Gujarat
- Uttar Pradesh
- Rajasthan
- Karnataka

▼ Charging stations on highway:

```
# Visualize Charging Stations on Highways/Expressways
fig4 = px.bar(highways_charging_stations_data, x='Highways/Expressways', y='Charging Stations',
              title='Charging Stations on Highways/Expressways',
              labels={'Charging Stations': 'Number of Charging Stations', 'Highways/Expressways': 'Highways/Expressways'})
fig4.show()
```

Charging Stations on Highways/Expressways
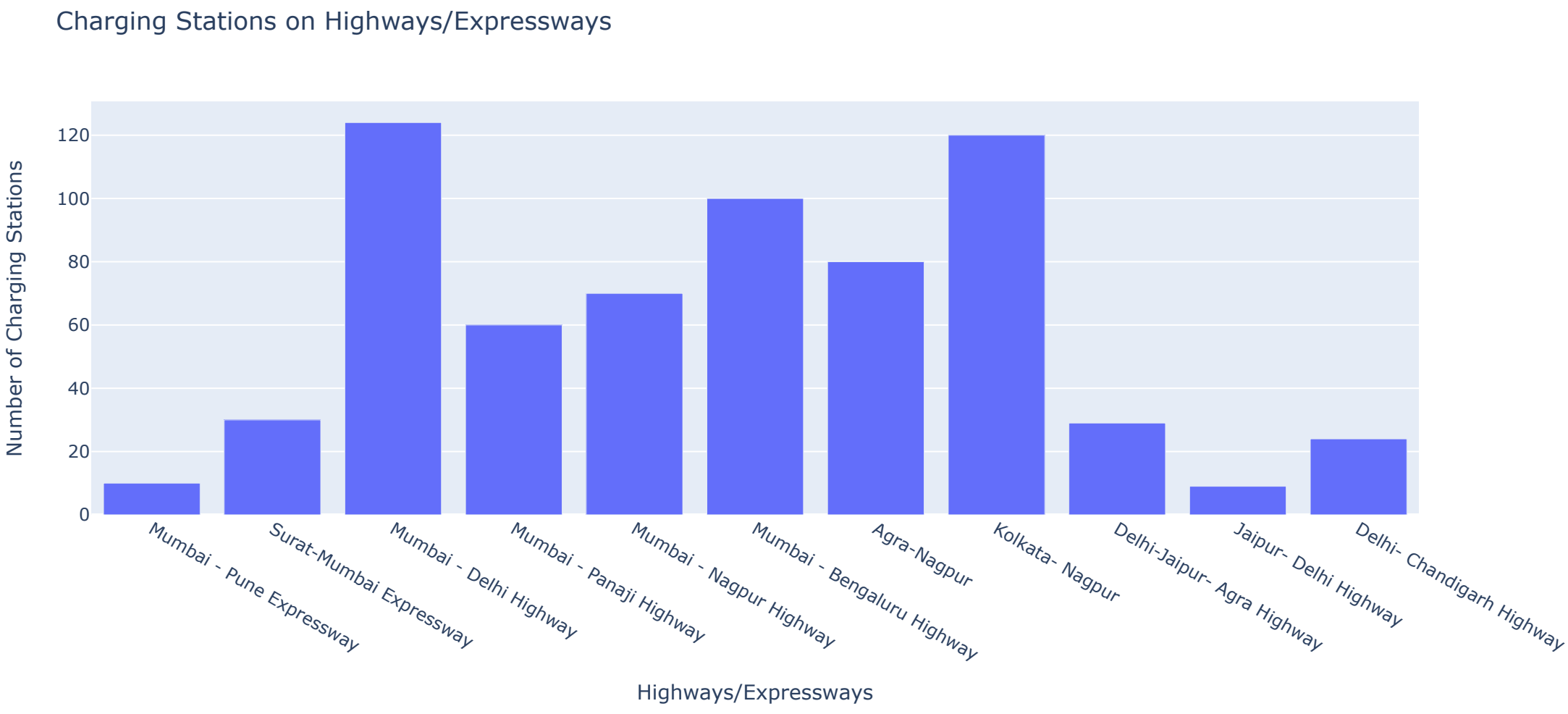
Based on number of charging stations, the following city / state could be targeted

- Mumbai (Maharashtra)
- Nagpur (Maharashtra)
- Delhi
- Kolkata (West Bengal)
- Bengaluru (Karnataka)
- Agra (Uttar Pradesh)

```
fp = r'/content/india_st.shp'
map_df = gpd.read_file(fp)
map_df_copy = gpd.read_file(fp)
map_df.head()
```

	STATE	geometry
0	ANDAMAN AND NICOBAR ISLANDS	MULTIPOLYGON (((94.08923 6.73365, 93.97717 6.9...
1	ANDHRA PRADESH	POLYGON ((82.00063 17.95354, 82.11718 18.02457...
2	ARUNACHAL PRADESH	POLYGON ((95.61476 27.34745, 95.69234 27.33888...
3	ASSAM	POLYGON ((92.82207 25.57781, 92.69672 25.61368...
4	BIHAR	POLYGON ((84.16946 26.28322, 83.91399 26.38523...

```
# Create a new dataframe for state names and total Evs
electric_vehicle_data_copy = electric_vehicle_data[['State Name', 'Grand Total']].copy()
electric_vehicle_data_copy['State Name'] = electric_vehicle_data_copy['State Name'].str.upper()

#Merging the data
merged = map_df.set_index('STATE').join(electric_vehicle_data_copy.set_index('State Name'))
merged['Grand Total'] = merged['Grand Total'].replace(np.nan, 0)

#Create figure and axes for Matplotlib and set the title
fig, ax = plt.subplots(1, figsize=(10, 10))
ax.axis('off')
ax.set_title('Number of Electric Vehicle in the State', fontdict={'fontsize': '20', 'fontweight' : '10'})
# Plot the figure
merged.plot(column='Grand Total', cmap='YlOrRd', linewidth=0.8, ax=ax, edgecolor='0',legend=True,markersize=[39.739192, -104.990337], legend_kwds={"label": "Number of EVs"})
```

```
<Axes: title={'center': 'Number of Electric Vehicle in the State'}>
```
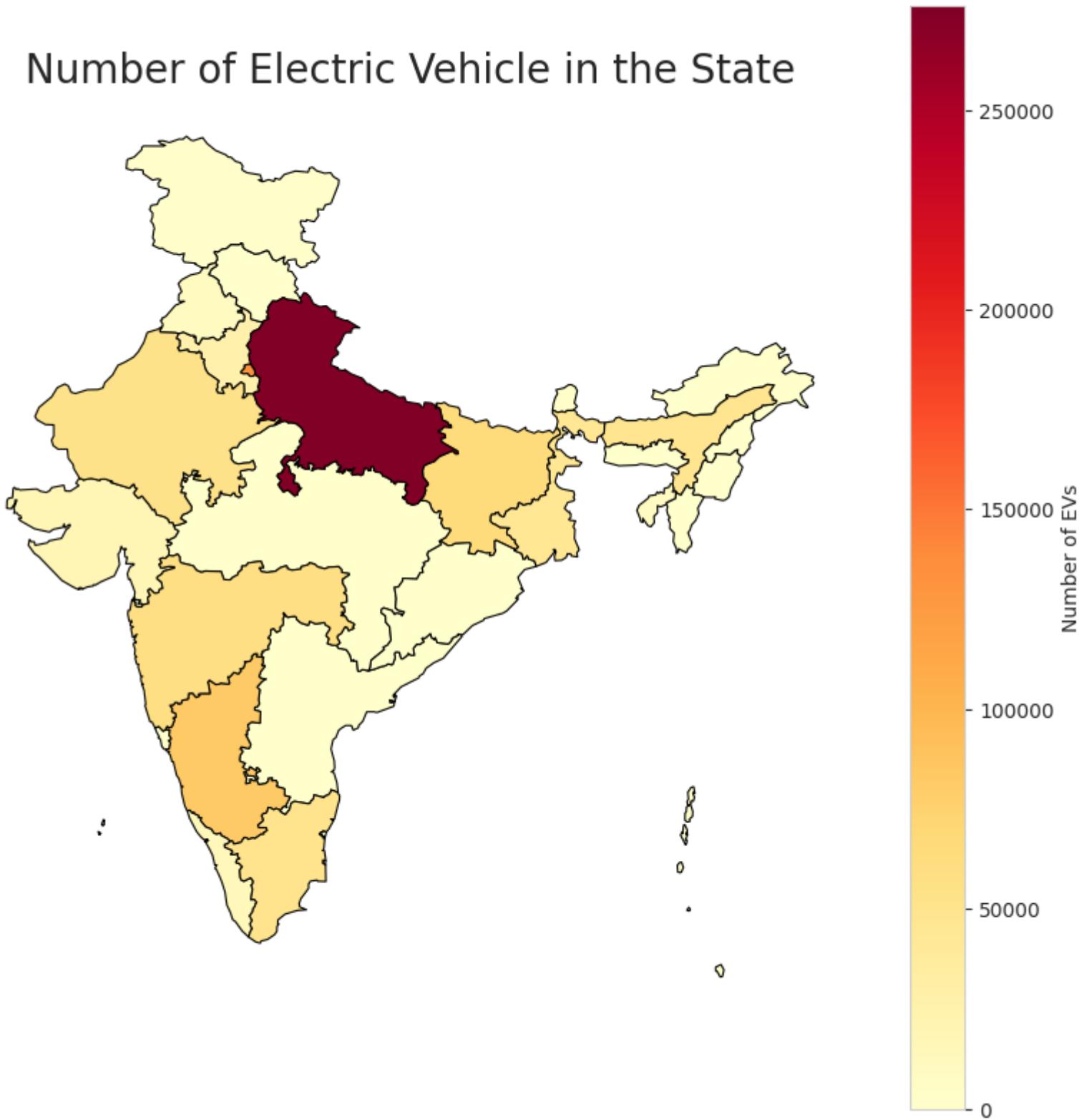

According to the above plot we can conclude that UP consist of highest number of EV's in the country.

```
# Create a new dataframe for state names and charger sanctioned
ev_charging_sanctioned_data_copy = ev_charging_sanctioned_data[['State/UT-wise', 'Number of Electric Vehicle Charging Sanctioned']].copy()
ev_charging_sanctioned_data_copy['State/UT-wise'] = ev_charging_sanctioned_data_copy['State/UT-wise'].str.upper()

#Merging the data
merged = map_df.set_index('STATE').join(ev_charging_sanctioned_data_copy.set_index('State/UT-wise'))
merged['Number of Electric Vehicle Charging Sanctioned'] = merged['Number of Electric Vehicle Charging Sanctioned'].replace(np.nan, 0)

#Create figure and axes for Matplotlib and set the title
fig, ax = plt.subplots(1, figsize=(10, 10))
ax.axis('off')
ax.set_title('Number of Electric Vehicle Charging Sanctioned', fontdict={'fontsize': '20', 'fontweight' : '10'})
# Plot the figure
merged.plot(column='Number of Electric Vehicle Charging Sanctioned',cmap='YlOrRd', linewidth=0.8, ax=ax, edgecolor='0',legend=True,markersize=[39.739192, -104.990337], legend_kwds={"label": "Number of Chargers Sanctioned"})
```

```
<Axes: title={'center': 'Number of Electric Vehicle Charging Sanctioned'}>
```
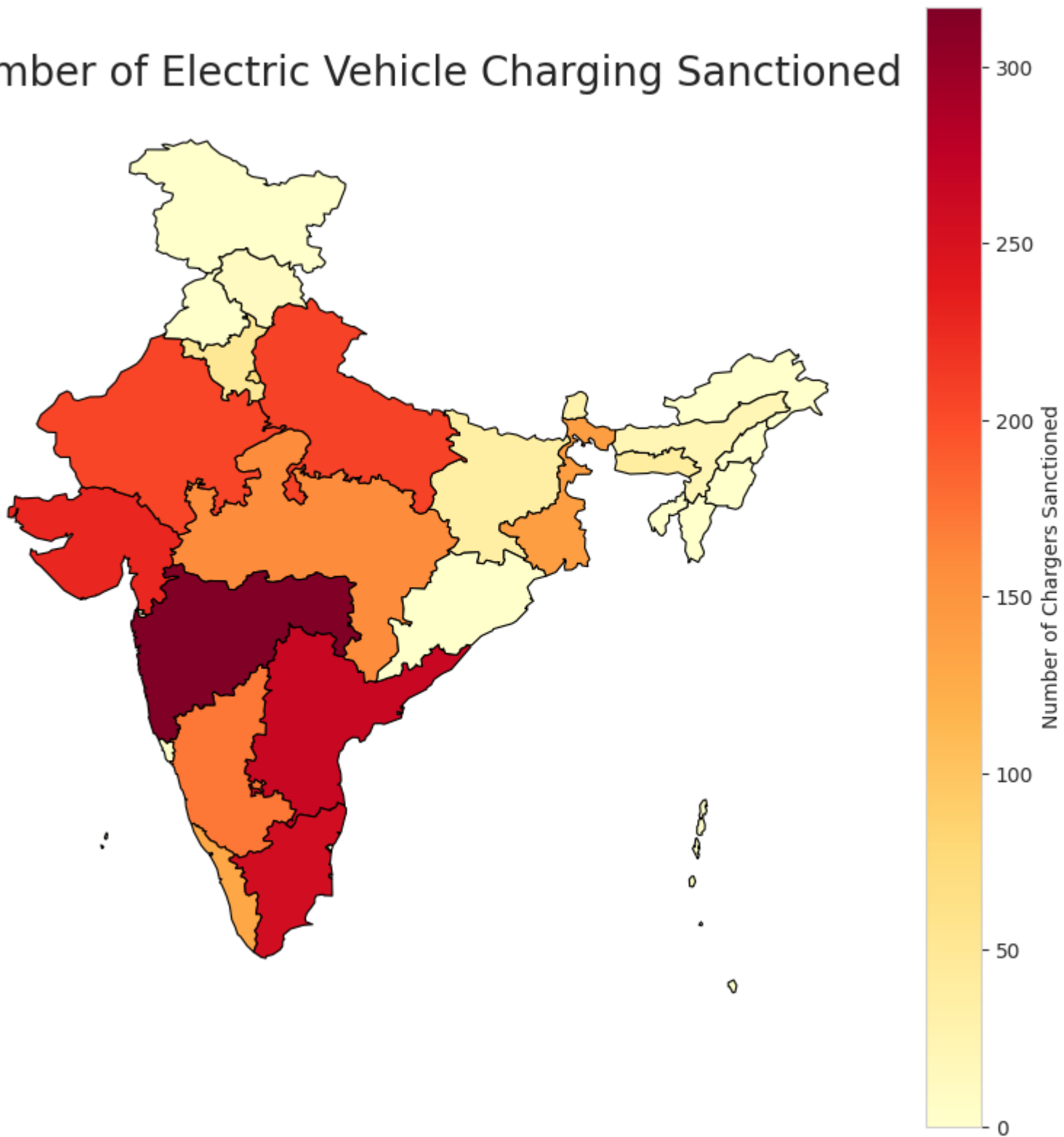

And from the above plot we can see that states like Maharastra, Andhra Pradesh, Tamil Nadu, Gujarat and UP have the highest number of EV charging sanctioned.

```
# Merge datasets based on State/UT
merged_data = pd.merge(electric_vehicle_data, charging_stations_data, how='left', left_on='State Name', right_on='State/ UT')
merged_data = pd.merge(merged_data, ev_charging_sanctioned_data, how='left', left_on='State Name', right_on='State/UT-wise')

# Select relevant columns for clustering
selected_columns = ['State Name', 'Two Wheeler', 'Three Wheeler', 'Four Wheeler', 'Goods Vehicles', 'Charging Stations', 'Number of Electric Vehicle Charging Sanctioned']

# Handle missing values by imputing with zeros
imputer = SimpleImputer(strategy='constant', fill_value=0)
cluster_data_imputed = imputer.fit_transform(merged_data[selected_columns[1:]])  # Exclude 'State Name'

# Standardize the imputed data
scaler = StandardScaler()
cluster_data_scaled = scaler.fit_transform(cluster_data_imputed)

# Perform K-means clustering
num_clusters = 5  # You can adjust the number of clusters based on your needs
kmeans = KMeans(n_clusters=num_clusters, random_state=0)
```

```
cluster_labels = kmeans.fit_predict(cluster_data_scaled)

# Add cluster labels and state names to the merged data
merged_data['Cluster'] = cluster_labels
merged_data['State'] = merged_data['State Name']

# Visualize clusters
fig = px.scatter_3d(merged_data, x='Two Wheeler', y='Three Wheeler', z='Four Wheeler',
                    color='Cluster', title='Clustering of States Based on EV Adoption, Charging Infrastructure, and EV Charging Sanctions',
                    labels={'Two Wheeler': 'Two Wheeler', 'Three Wheeler': 'Three Wheeler', 'Four Wheeler': 'Four Wheeler'},
                    opacity=0.8, hover_name='State')
fig.update_layout(scene=dict(zaxis_title='EV Charging Sanctions'))
fig.show()

# Display the cluster characteristics
cluster_characteristics = merged_data.groupby('Cluster')[selected_columns[1:]].mean()
print(cluster_characteristics)
```
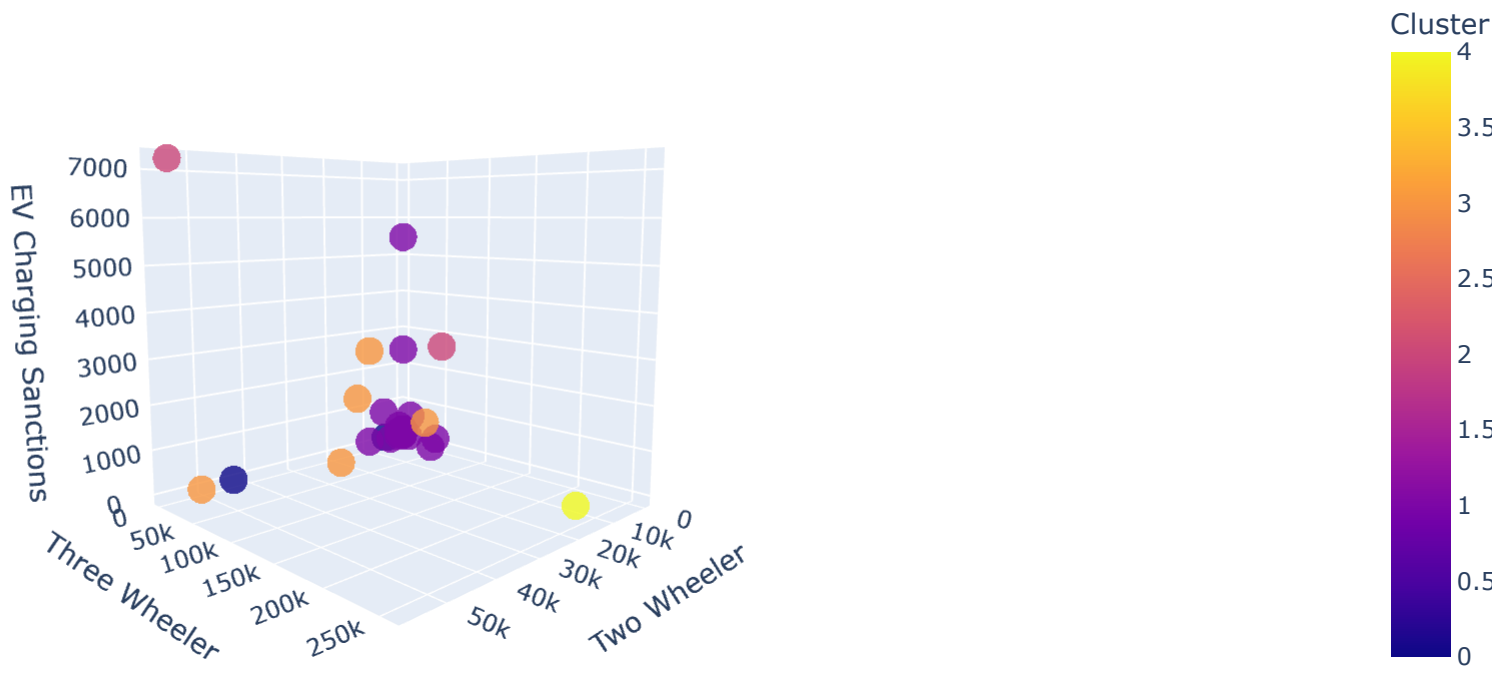
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress the warning

Clustering of States Based on EV Adoption, Charging Infrastructure, and EV Charging Sanctions


```
         Two Wheeler  Three Wheeler  Four Wheeler  Goods Vehicles  \
Cluster
0        25363.000000    4905.500000     65.000000     1179.000000
1         1861.727273    7735.863636    505.090909       12.227273
2        35733.500000   64654.500000   5131.500000      101.000000
3        20219.200000   16143.600000    892.400000       30.800000
4        18295.000000  257159.000000    368.000000       53.000000

         Charging Stations  Number of Electric Vehicle Charging Sanctioned
Cluster
0              NaN                                                   140.5
1        21.333333                                                    29.4
2        71.000000                                                   122.0
3        49.000000                                                   204.4
4        15.000000                                                   207.0
```

Let's examine the average characteristics of each cluster:

- Cluster 0 - High EV Adoption, Moderate Charging Infrastructure, Moderate EV Charging Sanctions.

```
States: Tamil Nadu and Chattisgarh
```

- Cluster 1 - Low to Moderate EV Adoption, Low Charging Infrastructure, Low EV Charging Sanctions.

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States: Odisha, Punjab, Bihar, Assam, Haryana, Ladhakh, Sikkim, Jharkhand, Puducherry, Goa, Jammu Kashmir, Himachal Pradesh, Nagaland, Tirupura, (
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- Cluster 2 - High EV Adoption, High Charging Infrastructure, High EV Charging Sanctions.

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States: Karrnataka And Delhi
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- Cluster 3 - Moderate EV Adoption, Moderate Charging Infrastructure, High EV Charging Sanctions.

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States: Maharastra, Rajasthan, West Bengal, Gujarat, Kerela
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- Cluster 4 - High EV Adoption (Mainly Three Wheelers and Four Wheelers), Low Charging Infrastructure, Low EV Charging Sanctions.

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States: Uttar Pradesh
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- Recommendation:

Based on the clustering analysis and our goal of maximizing profit, it is recommended to start the EV company in a state from Cluster 2. This cluster represents states with high adoption of various types of vehicles (Two Wheelers, Three Wheelers, and Four Wheelers), a substantial number of Charging Stations, and a significant number of Electric Vehicle Charging Sanctions. These factors indicate a favorable environment for EV adoption and a potentially lucrative market.

- Profitable Vehicle Type:

Given the characteristics of Cluster 2, the company should consider producing a range of electric vehicles, including Two Wheelers, Three Wheelers, and Four Wheelers. However, since the adoption of Four Wheelers is relatively high in this cluster, focusing on producing electric Four Wheelers could potentially lead to maximum profitability.

In summary, the recommended strategy is to start the EV company in a state from Cluster 2, where high adoption of various vehicle types and a supportive charging infrastructure provide a strong foundation for success. The company should prioritize the production of electric Four Wheelers to tap into the existing demand and achieve maximum profitability in the chosen state.

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