Exploratory Data Analysis - Electric Vehicle Charging Stations

Electric Vehicle Charging stations dataset is the key driver for the project to understand the current infrastructure of EV Charging stations across US and Canada. This dataset contains alternate EV Charging stations details for the past 10 years.

Dataset Downloaded from AFDC Site

This dataset has US and Canada regional coverage

This dataset contains ONLY Public charging stations

MetaData available here

In [1]:

```
#Install libraries if needed , uncomment below statement and execute

#pip install geopandas
#pip install folium
```

In [2]:

```
#Importing libraries needed for EDA

import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline

import altair as alt

import geopandas

# Suppress all warnings
import warnings
warnings.filterwarnings('ignore')


import folium

from branca.element import Template, MacroElement


alt.themes.enable('fivethirtyeight')
```

```
Out[2]: ThemeRegistry.enable('fivethirtyeight')
```

```
In [3]: #Loading the EV Charging Station CSV file into Pandas Dataframe
        evcs_all = pd.read_csv("assets/alt_fuel_stations.csv")
```

```
In [4]: #Let's take look at the columns in the dataset
        evcs_all.columns
```

```
Out[4]: Index(['Fuel Type Code', 'Station Name', 'Street Address',
               'Intersection Directions', 'City', 'State', 'ZIP', 'Plus4',
               'Station Phone', 'Status Code', 'Expected Date',
               'Groups With Access Code', 'Access Days Time', 'Cards Accepted',
               'BD Blends', 'NG Fill Type Code', 'NG PSI', 'EV Level1 EVSE Num',
               'EV Level2 EVSE Num', 'EV DC Fast Count', 'EV Other Info', 'EV Network',
               'EV Network Web', 'Geocode Status', 'Latitude', 'Longitude',
               'Date Last Confirmed', 'ID', 'Updated At', 'Owner Type Code',
               'Federal Agency ID', 'Federal Agency Name', 'Open Date',
               'Hydrogen Status Link', 'NG Vehicle Class', 'LPG Primary',
               'E85 Blender Pump', 'EV Connector Types', 'Country',
               'Intersection Directions (French)', 'Access Days Time (French)',
               'BD Blends (French)', 'Groups With Access Code (French)',
               'Hydrogen Is Retail', 'Access Code', 'Access Detail Code',
               'Federal Agency Code', 'Facility Type', 'CNG Dispenser Num',
               'CNG On-Site Renewable Source', 'CNG Total Compression Capacity',
               'CNG Storage Capacity', 'LNG On-Site Renewable Source',
               'E85 Other Ethanol Blends', 'EV Pricing', 'EV Pricing (French)',
               'LPG Nozzle Types', 'Hydrogen Pressures', 'Hydrogen Standards',
               'CNG Fill Type Code', 'CNG PSI', 'CNG Vehicle Class',
               'LNG Vehicle Class', 'EV On-Site Renewable Source',
               'Restricted Access'],
              dtype='object')
```

```
In [5]: #Checking the sample data
        evcs_all.head()
```

Out[5]:

	Fuel Type Code	Station Name	Street Address	Intersection Directions	City	State	ZIP	Plus4	Station Phone	Status Code	...	EV Pricing (French)	LPG Nozzle Types	Hydrogen Pressures	Hydrog Standa
0	ELEC	Los Angeles Convention Center	1201 S Figueroa St	West hall and South hall	Los Angeles	CA	90015	NaN	213-741-1151	E	...	NaN	NaN	NaN	N

	Fuel Type Code	Station Name	Street Address	Intersection Directions	City	State	ZIP	Plus4	Station Phone	Status Code	...	EV Pricing (French)	LPG Nozzle Types	Hydrogen Pressures	Hydrog Standa
1	ELEC	California Air Resources Board	9530 Telstar Ave	NaN	El Monte	CA	91731	NaN	626-575-6800	E	...	NaN	NaN	NaN	N
2	ELEC	Scripps Green Hospital	10666 N Torrey Pines Rd	Patient Parking Structure, level G	La Jolla	CA	92037	NaN	NaN	E	...	NaN	NaN	NaN	N
3	ELEC	San Diego Wild Animal Park	15500 San Pasqual Valley Rd	NaN	Escondido	CA	92027	NaN	760-747-8702	E	...	NaN	NaN	NaN	N
4	ELEC	Galpin Motors	15421 Roscoe Blvd	NaN	Sepulveda	CA	91343	NaN	800-256-6219	E	...	NaN	NaN	NaN	N

5 rows × 65 columns

Time to see some of high level counts

In [6]:

```
count = len(evcs_all)
print("There are {} EV charging stations in the US and Canada as of July 30 2021".format(count))
```

```
There are 43724 EV charging stations in the US and Canada as of July 30 2021
```

In [7]:

```
#Dataframe for US EV Charge Stations
us_evcs = evcs_all[evcs_all['Country'] == 'US']
```

In [8]:

```
us_count = len(us_evcs)
print("There are {} EV charging stations in the United States as of July 30 2021".format(us_count))
```

```
There are 43724 EV charging stations in the United States as of July 30 2021
```

In [9]:

```
ca_count = len(evcs_all[evcs_all['Country'] == 'CA'])
```

```
print("There are {} EV charging stations in the United States as of July 30 2021".format(ca_count))
```

```
There are 0 EV charging stations in the United States as of July 30 2021
```

Basic Visualization

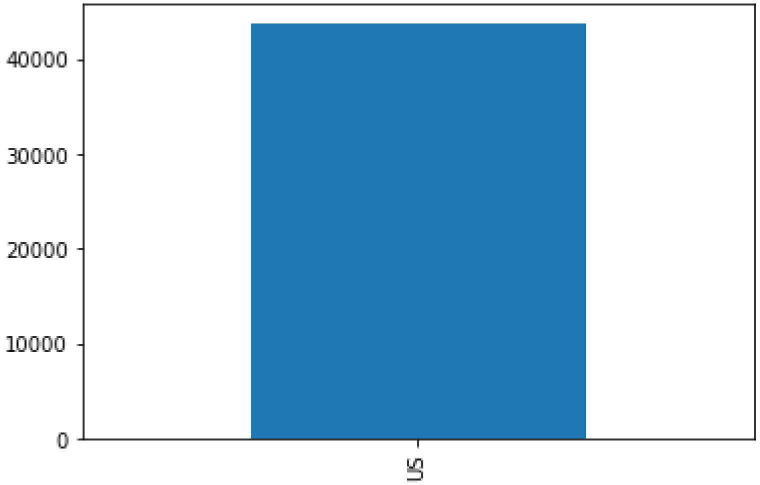
We have used matplotlib to create some basic vislization and altair libraries to visualize the data further in details.

In [10]:

```
evcs_all['Country'].value_counts().plot(kind='bar')
```

Out[10]:

```
<AxesSubplot:>
```



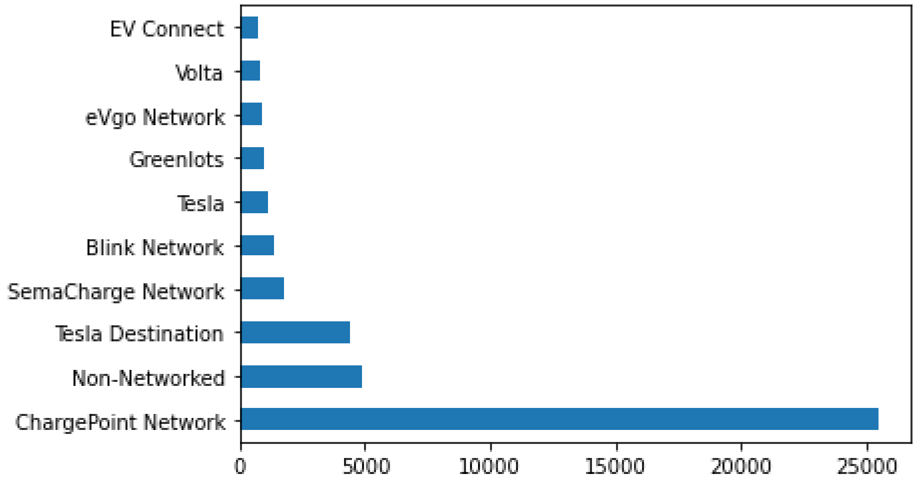
US EV Charging Stations by EV Network

In [11]:

```
us_evcs['EV Network'].value_counts()[:10].plot(kind='barh')
```

Out[11]:

```
<AxesSubplot:>
```



As we see in the bar chart above, CharePoint is leading the way in number of EV Charging Stations across US ans Tesla as an OEM is at 3rd place after the Non-networked which are mostly Government owned stations.

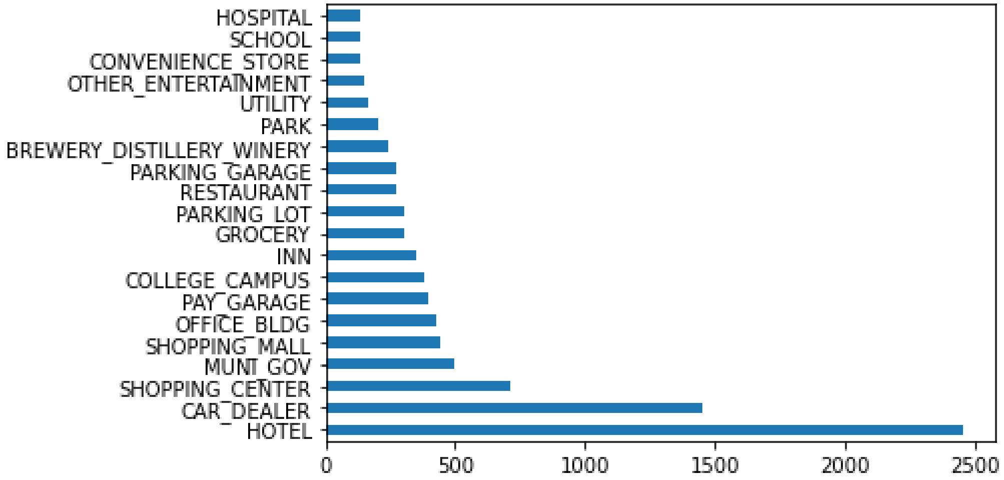
US EV Charging Stations by Facility Type

In [12]:

```
us_evcs['Facility Type'].value_counts()[:20].plot(kind='barh')
```

Out[12]:

```
<AxesSubplot:>
```



EV Charging Stations opened by Year

In [13]:

```
#Adding a year column from Open Date field
us_evcs['year_opened'] = pd.DatetimeIndex(us_evcs['Open Date']).year
```

In [14]:

```
# Filling NaNs to 0
us_evcs['year_opened'] = us_evcs['year_opened'].fillna(0)
```

In [15]:

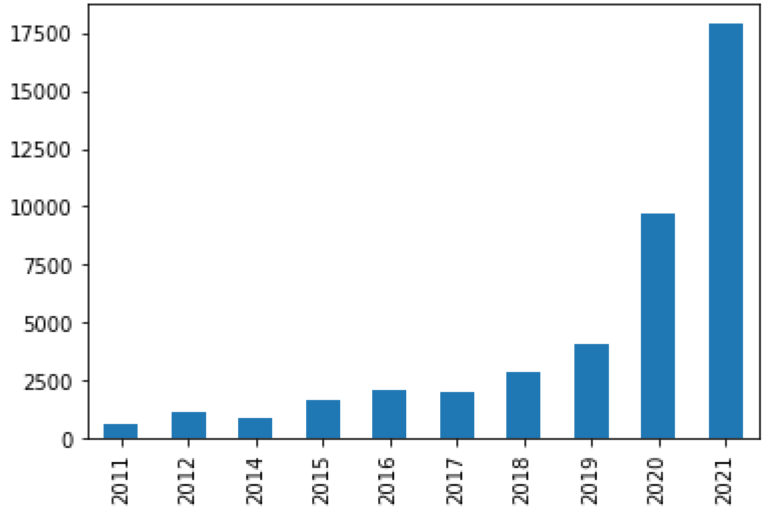
```
# Converting the data type to integer
us_evcs['year_opened'] = us_evcs['year_opened'].astype('int')
```

In [16]:

```
us_evcs['year_opened'].value_counts()[:10].sort_index().plot(kind='bar')
```

Out[16]:

```
<AxesSubplot:>
```



EV Charging Stations by States

Let's take a look at the data by States

In [17]:

```
#Dataframe for charging stations by State
evcs_by_state = us_evcs.groupby('State').size().reset_index(name='station_count').sort_values(by='station_count

#Creating a dictionary for State name Mapping
states_mapping = {"AL":"Alabama","AK":"Alaska","AZ":"Arizona","AR":"Arkansas","CA":"California","CO":"Colorado"
          "FL":"Florida","GA":"Georgia","HI":"Hawaii","ID":"Idaho","IL":"Illinois","IN":"Indiana","IA":"Iowa","
```

```
           "LA":"Louisiana","ME":"Maine","MD":"Maryland","MA":"Massachusetts","MI":"Michigan","MN":"Minnesota","
           "MT":"Montana","NE":"Nebraska","NV":"Nevada","NH":"New Hampshire","NJ":"New Jersey","NM":"New Mexico"
           "ND":"North Dakota","OH":"Ohio","OK":"Oklahoma","OR":"Oregon","PA":"Pennsylvania","RI":"Rhode Island"
           "TN":"Tennessee","TX":"Texas","UT":"Utah","VT":"Vermont","VA":"Virginia","WA":"Washington","WV":"West
          "PR":"Puerto Rico", "DC":"District of Columbia"}

evcs_by_state['State_Name'] = evcs_by_state.State.map(states_mapping)
evcs_by_state.head()
```

Out[17]:

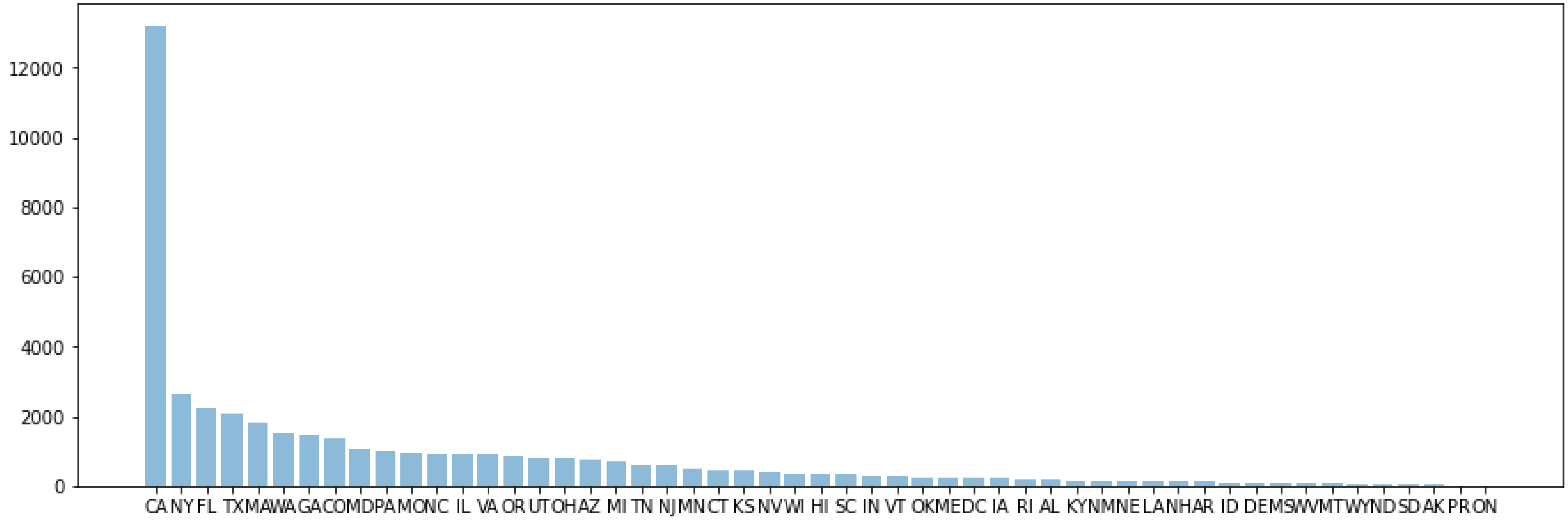
	State	station_count	State_Name
0	CA	13200	California
1	NY	2632	New York
2	FL	2254	Florida
3	TX	2081	Texas
4	MA	1844	Massachusetts

In [18]:

```
# Plotting the number of EV Charging stations by State
plt.figure(figsize=(15,5))
plt.bar(evcs_by_state['State'].values, evcs_by_state['station_count'].values, align='center', alpha=0.5)
```

Out[18]:

```
<BarContainer object of 53 artists>
```



We would like to create effective visualization for the same data. Using altair, we created most of the visualizations for EDA.

In [19]:

```
alt.themes.enable('fivethirtyeight')

#Creating Bar Chart with State Names and Station Count
bars = alt.Chart(evcs_by_state).mark_bar(color='#1e90ff').encode(
    x=alt.Y("State_Name:N", sort='-y', title='State',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("station_count:Q", title='Number of EV Charging Stations',
           axis=alt.Axis(domain=False, labelColor='black'))
)

#Adding number of stations as text
text = bars.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 10,
    dy=-10
).encode(
    text='station_count:Q'
)

#Combining Bar Chart and Text
(bars + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Vehicle Charging Stations per State',
          }
    ).configure_view(strokeWidth=0)
```

Out[19]:

Wow, California clearly leads the way for Electric vehicle infrastructure!

Let's filter the dataset and see the top 10 states

In [20]:

```
alt.themes.enable('fivethirtyeight')

#Creating Bar Chart with State Names and Station Count for top 10 states
bars = alt.Chart(evcs_by_state[:10]).mark_bar(color='#1e90ff').encode(
    x=alt.Y("State_Name:N", sort='-y', title='State',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("station_count:Q", title='Number of EV Charging Stations',
           axis=alt.Axis(domain=False, labelColor='black'))
)

#Adding number of stations as text
text = bars.mark_text(
    align='center',
    baseline='middle',
    dx= 10,
    dy=-10,
    fontSize=20
).encode(
    text='station_count:Q'
)

#Combining Bar Chart and Text
(bars + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Vehicle Charging Stations - Top 10 States',
          }
    ).configure_axis(
    labelFontSize=20,
    titleFontSize=20
)
```

Out[20]:

New York state is at second place which has just around 2500 charging station which drawn our interest to explore the EV infrastructure in NY state.

EV Charging Stations in New York State

while EV registrations are growing at a near exponential rate in NY, the charging infrastructure does not adequately supply this demand. The ranges of EVs are increasing greatly, but the availability and speed of charging has not kept up.

NY state has provided a $4,000 tax credit to businesses to install new chargers. Additionally, New York City (NYC) has begun installing curbside public stations to meet the demand. This motivated us to seek to identify gaps in this infrastructure and propose specific sites for development to fill these gaps.

Time to deep dive into NY specific data and explore with visualization

```
In [21]:
#Dataframe for US EV Charge Stations
ny_evcs = us_evcs[us_evcs['State'] == 'NY']
```

```
In [22]:
ny_evcs.head()
```

Out[22]:

	Fuel Type Code	Station Name	Street Address	Intersection Directions	City	State	ZIP	Plus4	Station Phone	Status Code	...	LPG Nozzle Types	Hydrogen Pressures	Hydrogen Standards	(T C
611	ELEC	AAA Car Care Plus	2131 Eggert Rd	NaN	Amherst	NY	14226	NaN	716-362-0562	E	...	NaN	NaN	NaN	
612	ELEC	AAA Car Care Plus	8120 Main St	NaN	Clarence	NY	14221	NaN	716-932-3900 855-443-3873	E	...	NaN	NaN	NaN	
672	ELEC	Thruway Nissan	79 Route 17K	NaN	Newburgh	NY	12550	NaN	845-562-1000	E	...	NaN	NaN	NaN	
673	ELEC	Country Club Imports	55 Oneida St	NaN	Oneonta	NY	13820	NaN	607-432-2800	E	...	NaN	NaN	NaN	

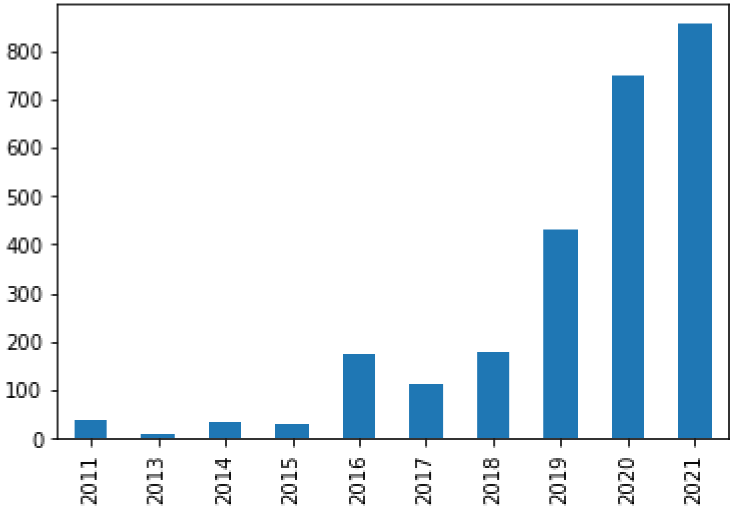
	Fuel Type Code	Station Name	Street Address	Intersection Directions	City	State	ZIP	Plus4	Station Phone	Status Code	...	LPG Nozzle Types	Hydrogen Pressures	Hydrogen Standards
674	ELEC	West-Herr Nissan	3580 Southwestern Blvd	NaN	Orchard Park	NY	14127	NaN	716-662-8008	E	...	NaN	NaN	NaN

5 rows × 66 columns

In [23]:

```
#Plotting simple barchart to see the Year over Year growth of the EV Charging Stations in NY State
ny_evcs['year_opened'].value_counts()[:10].sort_index().plot(kind='bar')
```

Out[23]: `<AxesSubplot:>`



In [24]:

```
#Grouping the data by year and getting the count for each year
ny_yr_evcs = ny_evcs.groupby('year_opened').size().reset_index(name='year_count').sort_values(by='year_count',
ny_yr_evcs.head()
```

Out[24]:

	year_opened	year_count
0	2021	855
1	2020	750

	year_opened	year_count
2	2019	430
3	2018	179
4	2016	175

In [25]:

```
# Dropping NULL year
ny_yr_evcs = ny_yr_evcs.drop(labels=9, axis=0)
ny_yr_evcs.head()
```

Out[25]:

	year_opened	year_count
0	2021	855
1	2020	750
2	2019	430
3	2018	179
4	2016	175

In [26]:

```
#Creating Bar Chart with Year opened and Station Count
bars_yr = alt.Chart(ny_yr_evcs[:20]).mark_bar(color='#FFA500').encode(
    x=alt.Y("year_opened:N", sort='x', title='Year',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("year_count:Q", title='Number of EV Charging Stations Opened',
           axis=alt.Axis(domain=False, labelColor='black'))
)

#Adding number of stations as text
text = bars_yr.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 20,
    dy=-20,
    fontSize=25
).encode(
    text='year_count:Q'
)
```

```
#Combining Bar Chart and Text
(bars_yr + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Car Charging Stations opened per Year in NY State',
          }
    ).configure_axis(
    labelFontSize=20,
    titleFontSize=20
)
```

Out[26]:

The number of EV charging stations in New York are increasing exponentially Year over year. NY is adding almost 500+ new charging stations every year.

In [27]:

```
#Getting the number of EV charging stations by Cities in NY state
ny_cities_evcs = ny_evcs.groupby('City').size().reset_index(name='station_count').sort_values(by='station_count
ny_cities_evcs.head()
```

Out[27]:

	City	station_count
0	New York	331
1	Buffalo	132
2	Albany	125
3	Rochester	116
4	Brooklyn	76

In [28]:

```
#Creating Bar Chart with cities in NY and Station Count
bars = alt.Chart(ny_cities_evcs[:5]).mark_bar(color='#FFA500').encode(
    x=alt.Y("City:N", sort='-y', title='City Name',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("station_count:Q", title='Number of EV Charging Stations',
           axis=alt.Axis(domain=False, labelColor='black'))
)

#Adding number of stations as text
text = bars.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 10,
    dy=-10,
    fontSize=25
).encode(
    text='station_count:Q'
)

#Combining Bar Chart and Text
(bars + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Car Charging Stations per Cities in NY',
          }
    ).configure_axis(
    labelFontSize=20,
    titleFontSize=20
)
```

Out[28]:

New York city tops in number of charging stations with 330, Buffalo with 132, Albany with 118, Rochester with 115 and Brooklyn has 73 made it to top 5 cities with most number of EV Charging stations.

Geographical Visualization

US State Map - EV Charge Stations

We have used geopandas libraries to read the US Geographical Shape files.

GeoPandas: GeoPandas is an open source project to make working with geospatial data in python easier. GeoPandas extends the datatypes used by pandas to allow spatial operations on geometric types. Geometric operations are performed by shapely. Geopandas further depends on fiona for file access and matplotlib for plotting.

More details on geopandas, please refer here - https://github.com/geopandas/geopandas

US State Boundaries Shape File

The cartographic boundary files are simplified representations of selected geographic areas from the Census Bureau’s MAF/TIGER geographic database. These boundary files are specifically designed for small scale thematic mapping.

The cartographic boundary files are available in shapefile and KML format. A shapefile is a geospatial data format for use in geographic information system (GIS) software. For KML versions of these files, please see our Cartographic Boundary Files - KML page.

Downloaded from census.gov

Metadata availale here

In [29]:
```
#Reading the Shape File for US State Boundaries using geopandas
state_boundaries = geopandas.read_file('assets/US_State_Boundaries/cb_2018_us_state_20m.shp')

#The Coordinate Reference System (CRS) is important because the geometric shapes in a GeoSeries or GeoDataFrame
# simply a collection of coordinates in an arbitrary space.
#A CRS tells Python how those coordinates relate to places on the Earth.
# In our case, WGS84 Latitude/Longitude: "EPSG:4326" is used.
state_boundaries.crs = "EPSG:4326"
```

In [30]:
```
state_boundaries.columns
```

Out[30]:
```
Index(['STATEFP', 'STATENS', 'AFFGEOID', 'GEOID', 'STUSPS', 'NAME', 'LSAD',
       'ALAND', 'AWATER', 'geometry'],
      dtype='object')
```

In [31]:
```
#Creating State column using USPS State codes
state_boundaries['State'] = state_boundaries['STUSPS']
```

In [32]:
```
state_boundaries.head()
```

Out[32]:

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State
0	24	01714934	0400000US24	24	MD	Maryland	00	25151100280	6979966958	MULTIPOLYGON (((-76.04621 38.02553, -76.00734 ...	MD
1	19	01779785	0400000US19	19	IA	Iowa	00	144661267977	1084180812	POLYGON ((-96.62187 42.77925, -96.57794 42.827...	IA

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State
2	10	01779781	0400000US10	10	DE	Delaware	00	5045925646	1399985648	POLYGON ((-75.77379 39.72220, -75.75323 39.757...	DE
3	39	01085497	0400000US39	39	OH	Ohio	00	105828882568	10268850702	MULTIPOLYGON (((-82.86334 41.69369, -82.82572 ...	OH
4	42	01779798	0400000US42	42	PA	Pennsylvania	00	115884442321	3394589990	POLYGON ((-80.51989 40.90666, -80.51964 40.987...	PA

In [33]:

```
# Merging the EV charging Station dataframe with State Boundaries dataframe to get the geo cocordinates from sh
evcs_state_boundaries = state_boundaries.merge(evcs_by_state, how='outer', on='State')

evcs_state_boundaries.sort_values(by='station_count', ascending=True)
evcs_state_boundaries.head()
```

Out[33]:

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State	stati
0	24	01714934	0400000US24	24	MD	Maryland	00	2.515110e+10	6.979967e+09	MULTIPOLYGON (((-76.04621 38.02553, -76.00734 ...	MD	
1	19	01779785	0400000US19	19	IA	Iowa	00	1.446613e+11	1.084181e+09	POLYGON ((-96.62187 42.77925, -96.57794 42.827...	IA	
2	10	01779781	0400000US10	10	DE	Delaware	00	5.045926e+09	1.399986e+09	POLYGON ((-75.77379 39.72220, -75.75323 39.757...	DE	

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State	stati
3	39	01085497	0400000US39	39	OH	Ohio	00	1.058289e+11	1.026885e+10	MULTIPOLYGON (((-82.86334 41.69369, -82.82572 ...	OH	
4	42	01779798	0400000US42	42	PA	Pennsylvania	00	1.158844e+11	3.394590e+09	POLYGON ((-80.51989 40.90666, -80.51964 40.987...	PA	

In [34]:

```
#Cleaning up the dataframe
evcs_state_boundaries = evcs_state_boundaries[evcs_state_boundaries['geometry'].notna()]
evcs_state_boundaries = evcs_state_boundaries.fillna(0)

evcs_state_boundaries.head()
```

Out[34]:

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State	stati
0	24	01714934	0400000US24	24	MD	Maryland	00	2.515110e+10	6.979967e+09	MULTIPOLYGON (((-76.04621 38.02553, -76.00734 ...	MD	
1	19	01779785	0400000US19	19	IA	Iowa	00	1.446613e+11	1.084181e+09	POLYGON ((-96.62187 42.77925, -96.57794 42.827...	IA	
2	10	01779781	0400000US10	10	DE	Delaware	00	5.045926e+09	1.399986e+09	POLYGON ((-75.77379 39.72220, -75.75323 39.757...	DE	
3	39	01085497	0400000US39	39	OH	Ohio	00	1.058289e+11	1.026885e+10	MULTIPOLYGON (((-82.86334 41.69369, -82.82572 ...	OH	

	STATEFP	STATENS	AFFGEOID	GEOID	STUSPS	NAME	LSAD	ALAND	AWATER	geometry	State	stati
4	42	01779798	0400000US42	42	PA	Pennsylvania	00	1.158844e+11	3.394590e+09	POLYGON ((-80.51989 40.90666, -80.51964 40.987...	PA	

In [35]:

```
evcs_state_boundaries.station_count.max()
```

Out[35]:

```
13200
```

Folium Mapping

Folium is a powerful Python library that helps you create several types of Leaflet maps. The fact that the Folium results are interactive makes this library very useful for dashboard building.

In [36]:

```
# Creating a map using folium
m1 = folium.Map([39.8283, -98.5795], zoom_start=4)

folium.TileLayer(tiles='CartoDB positron',control=True, opacity=0.0).add_to(m1)

folium.Choropleth(
    geo_data=evcs_state_boundaries,
    name="choropleth",
    data=evcs_state_boundaries,
    columns=["State", "station_count"],
    key_on="feature.properties.State",
    fill_color="OrRd",
    fill_opacity=0.6,
    line_opacity=0.2,
    legend_name="Number of EV Charging Stations in US",
).add_to(m1)
```

Out[36]:

```
<folium.features.Choropleth at 0x7f8987d98160>
```

In [37]:

```
#Display the map
m1
```

Out[37]: Make this Notebook Trusted to load map: File -> Trust Notebook

Cool, as we already seen in the previous bar charts, California, New York and Florida stand out with more number of EV Charging Stations

US Zip Code Dataset

EV Charging Stations dataset only contains ZIP code and we need to add County Name to analyze the data by Counties. We will use the Zip Code database file to join the Charging stations dataset to map the zipcode to County Name

We have downloaded the Zip Code - County Mapping from here

In [38]:

```
#Loading the EV Charging Station CSV file into dataframe
zip_county = pd.read_csv('assets/ZIP_database/zip_code_database.csv')
```

```
#Keeping only the columns needed
zip_county = zip_county[['zip','county','state']]
zip_county = zip_county.set_index('zip')

#Let's create zip-county dictionary from zipcode datadrame
zip_county_dict = zip_county.to_dict('index')
```

In [39]:

```
zip_county.head()
```

Out[39]:

	county	state
zip		
501	Suffolk County	NY
544	Suffolk County	NY
601	Adjuntas Municipio	PR
602	Aguada Municipio	PR
603	Aguadilla Municipio	PR

In [40]:

```
evcs_by_zip = evcs_all.copy()
evcs_by_zip.columns
```

Out[40]:

```
Index(['Fuel Type Code', 'Station Name', 'Street Address',
       'Intersection Directions', 'City', 'State', 'ZIP', 'Plus4',
       'Station Phone', 'Status Code', 'Expected Date',
       'Groups With Access Code', 'Access Days Time', 'Cards Accepted',
       'BD Blends', 'NG Fill Type Code', 'NG PSI', 'EV Level1 EVSE Num',
       'EV Level2 EVSE Num', 'EV DC Fast Count', 'EV Other Info', 'EV Network',
       'EV Network Web', 'Geocode Status', 'Latitude', 'Longitude',
       'Date Last Confirmed', 'ID', 'Updated At', 'Owner Type Code',
       'Federal Agency ID', 'Federal Agency Name', 'Open Date',
       'Hydrogen Status Link', 'NG Vehicle Class', 'LPG Primary',
       'E85 Blender Pump', 'EV Connector Types', 'Country',
       'Intersection Directions (French)', 'Access Days Time (French)',
       'BD Blends (French)', 'Groups With Access Code (French)',
       'Hydrogen Is Retail', 'Access Code', 'Access Detail Code',
       'Federal Agency Code', 'Facility Type', 'CNG Dispenser Num',
       'CNG On-Site Renewable Source', 'CNG Total Compression Capacity',
       'CNG Storage Capacity', 'LNG On-Site Renewable Source',
       'E85 Other Ethanol Blends', 'EV Pricing', 'EV Pricing (French)',
       'LPG Nozzle Types', 'Hydrogen Pressures', 'Hydrogen Standards',
       'CNG Fill Type Code', 'CNG PSI', 'CNG Vehicle Class',
       'LNG Vehicle Class', 'EV On-Site Renewable Source',
       'Restricted Access'],
      dtype='object')
```

In [41]:

```
#Keeping only the columns needed
evcs_by_zip = evcs_by_zip[['City','State','ZIP','Access Code','Access Days Time', 'Latitude',
                                'Longitude','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fast Count']]
evcs_by_zip.head()
```

Out[41]:

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
0	Los Angeles	CA	90015	public	24 hours daily; pay lot	34.040539	-118.271387	NaN	12.0	NaN
1	El Monte	CA	91731	public	24 hours daily	34.068720	-118.064000	NaN	3.0	NaN
2	La Jolla	CA	92037	public	24 hours daily	32.899470	-117.243000	NaN	1.0	NaN
3	Escondido	CA	92027	public	24 hours daily	33.098589	-117.004433	NaN	2.0	NaN
4	Sepulveda	CA	91343	public	Dealership business hours	34.221665	-118.468371	NaN	2.0	NaN

In [42]:

```
#Data Manipulation

#Convert zip codes from objects to numbers
evcs_by_zip.ZIP =evcs_by_zip.ZIP.apply(pd.to_numeric, errors='coerce')

#Use zip_dict to map to counties
evcs_by_zip['County1'] = evcs_by_zip['ZIP'].map(zip_county_dict)
```

In [43]:

```
evcs_by_zip.head()
```

Out[43]:

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1
0	Los Angeles	CA	90015.0	public	24 hours daily; pay lot	34.040539	-118.271387	NaN	12.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1
1	El Monte	CA	91731.0	public	24 hours daily	34.068720	-118.064000	NaN	3.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}
2	La Jolla	CA	92037.0	public	24 hours daily	32.899470	-117.243000	NaN	1.0	NaN	{'county': 'San Diego County', 'state': 'CA'}
3	Escondido	CA	92027.0	public	24 hours daily	33.098589	-117.004433	NaN	2.0	NaN	{'county': 'San Diego County', 'state': 'CA'}
4	Sepulveda	CA	91343.0	public	Dealership business hours	34.221665	-118.468371	NaN	2.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}

In [44]:

```python
#Create dataframe with counties separated
temp_df = evcs_by_zip['County1'].apply(pd.Series)
```

In [45]:

```python
temp_df.head()
```

Out[45]:

	0	county	state
0	NaN	Los Angeles County	CA
1	NaN	Los Angeles County	CA
2	NaN	San Diego County	CA
3	NaN	San Diego County	CA
4	NaN	Los Angeles County	CA

In [46]:

```python
# Concatenating EV Charging Station and temporary dataframes to add county name
evcs_by_zip = pd.concat([evcs_by_zip, temp_df['county']], axis=1)
evcs_by_zip.head()
```

Out[46]:

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1	county

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1	county
0	Los Angeles	CA	90015.0	public	24 hours daily; pay lot	34.040539	-118.271387	NaN	12.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County
1	El Monte	CA	91731.0	public	24 hours daily	34.068720	-118.064000	NaN	3.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County
2	La Jolla	CA	92037.0	public	24 hours daily	32.899470	-117.243000	NaN	1.0	NaN	{'county': 'San Diego County', 'state': 'CA'}	San Diego County
3	Escondido	CA	92027.0	public	24 hours daily	33.098589	-117.004433	NaN	2.0	NaN	{'county': 'San Diego County', 'state': 'CA'}	San Diego County
4	Sepulveda	CA	91343.0	public	Dealership business hours	34.221665	-118.468371	NaN	2.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County

In [47]:

```python
#Adding a new column to combine county and state
evcs_by_zip['county_state'] = evcs_by_zip['county'] + ',' + evcs_by_zip['State']
```

In [48]:

```python
evcs_by_zip.head()
```

Out[48]:

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1	county	county_state
0	Los Angeles	CA	90015.0	public	24 hours daily; pay lot	34.040539	-118.271387	NaN	12.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County	Los Angeles County,CA

	City	State	ZIP	Access Code	Access Days Time	Latitude	Longitude	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	County1	county	county_state
1	El Monte	CA	91731.0	public	24 hours daily	34.068720	-118.064000	NaN	3.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County	Los Angeles County,CA
2	La Jolla	CA	92037.0	public	24 hours daily	32.899470	-117.243000	NaN	1.0	NaN	{'county': 'San Diego County', 'state': 'CA'}	San Diego County	San Diego County,CA
3	Escondido	CA	92027.0	public	24 hours daily	33.098589	-117.004433	NaN	2.0	NaN	{'county': 'San Diego County', 'state': 'CA'}	San Diego County	San Diego County,CA
4	Sepulveda	CA	91343.0	public	Dealership business hours	34.221665	-118.468371	NaN	2.0	NaN	{'county': 'Los Angeles County', 'state': 'CA'}	Los Angeles County	Los Angeles County,CA

In [49]:

```
#Grouping by County State
evcs_by_county = evcs_by_zip.groupby('county_state').agg({'City': 'size', 'EV Level1 EVSE Num': 'count',\
                                                                 'EV Level2 EVSE Num':'count','EV DC Fast Count'
                                                                     reset_index().sort_values(by='City', ascend


evcs_by_county.columns = ['county_state','counts','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fast Count'

evcs_by_county.head()
```

Out[49]:

	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
0	Los Angeles County,CA	3168	8	2976	240

	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
1	Santa Clara County,CA	1539	1	1465	98
2	Orange County,CA	1452	8	1333	149
3	San Mateo County,CA	1031	0	953	90
4	San Diego County,CA	937	2	878	87

In [50]:

```python
#Plotting EV Level 1 Charging Ports

bars = alt.Chart(evcs_by_county[:20]).mark_bar(color='#1e90ff').encode(
    x=alt.Y("county_state:N", sort='-y', title='County and State',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("EV Level1 EVSE Num:Q", title='Number of L1 EV Charging Stations',
           axis=alt.Axis(domain=False, labelColor='black'))
)

text = bars.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 10,
    dy=-10
).encode(
    text='EV Level1 EVSE Num:Q'
)

(bars + text).properties(
    height=500, width=1000,
    title={'text': 'L1 Electric Car Charging Stations in Top 20 Counties acrosss US',
          }
    ).configure_view(strokeWidth=0)
```

Out[50]:

US State& County Map - EV Charge Stations

County Boundary

Similar to the State boundaries shape file, census Bureau provides the boundary maps for US counties as well.

The shape file for US county boundaries downloaded fronm US Census Bureau

In [51]:

```
#Reading the Shape File for US State Boundaries using geopandas
county_boundaries = geopandas.read_file('assets/County_Boundaries/cb_2019_us_county_20m.shp')

#The Coordinate Reference System (CRS) is important because the geometric shapes in a GeoSeries or GeoDataFrame
# simply a collection of coordinates in an arbitrary space.
#A CRS tells Python how those coordinates relate to places on the Earth.
# In our case, WGS84 Latitude/Longitude: "EPSG:4326" is used.
county_boundaries.crs = "EPSG:4326"
```

In [52]:

```
#Data Manipulation

#Keeping only the key data elelments needed.
county_boundaries_1 = county_boundaries[['geometry','STATEFP','COUNTYFP','NAME']]
#Setting CRS to 4326
county_boundaries_1.crs = "EPSG:4326"

#Concatenate STATEFP and COUNTYFP, this will provide the full name for State and County
county_boundaries_1['STCOUNTYFP'] = county_boundaries_1['STATEFP'] + county_boundaries_1['COUNTYFP']

#Changing the data type to integer
county_boundaries_1['STCOUNTYFP'] = county_boundaries_1['STCOUNTYFP'].astype(int)
```

ZIP Code & County Mapping - Geographical dataset

The County Cross Reference File is a product which provides a relationship between ZIP+4 codes and Federal Information Processing Standard (FIPS) county codes. The file allows users who have assigned ZIP+4 codes to their address files to obtain county data at the ZIP+4 level.

This dataset is available in various place but found the latest in Kaggle

In [53]:

```
#Reading the CSV file and loading into dataframe
zip_fips= pd.read_csv('assets/ZIP_County_FIPS/ZIP-COUNTY-FIPS_2017-06.csv')
```

In [54]:

```
zip_fips.columns
```

Out[54]:

```
Index(['ZIP', 'COUNTYNAME', 'STATE', 'STCOUNTYFP', 'CLASSFP'], dtype='object')
```

In [55]:

```
#Data Manipulation

#Removing Duplicate reows
zip_fips = zip_fips.drop_duplicates(subset=['STCOUNTYFP'],keep='first')

#Keeping only columns that are needed
zip_fips = zip_fips[['COUNTYNAME','STATE','STCOUNTYFP']]
```

Now, we have US County dataset and County ZIP mapped dataset. Time to merge the dataframes to have all required columns in one place.

In [56]:

```
#Merging County Boundaries data with ZIP_FIPS dataset using STCOUNTYFP column
county_fips = county_boundaries_1.merge(zip_fips, how='outer', on='STCOUNTYFP')

#Creating a new column to concatenate County with State for better display
county_fips['county_state'] = county_fips['COUNTYNAME'] + ',' + county_fips['STATE']

county_fips.head()
```

Out[56]:

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state
0	POLYGON ((-94.63203 40.57176, -94.53388 40.570...	29	227	Worth	29227	Worth County	MO	Worth County,MO
1	POLYGON ((-99.17940 40.35068, -98.72683 40.350...	31	061	Franklin	31061	Franklin County	NE	Franklin County,NE
2	POLYGON ((-79.76195 42.26986, -79.62748 42.324...	36	013	Chautauqua	36013	Chautauqua County	NY	Chautauqua County,NY
3	POLYGON ((-78.49773 36.51467, -78.45728 36.541...	37	181	Vance	37181	Vance County	NC	Vance County,NC
4	POLYGON ((-88.94916 36.41010, -88.81642 36.410...	47	183	Weakley	47183	Weakley County	TN	Weakley County,TN

Now, we have County boundaries and County State name in one place, lets merge this into EV Charging stations by County dataframe to visualize in Folium map.

In [57]:

```
evcs_by_county.head()
```

Out[57]:

	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count

	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
0	Los Angeles County,CA	3168	8	2976	240
1	Santa Clara County,CA	1539	1	1465	98
2	Orange County,CA	1452	8	1333	149
3	San Mateo County,CA	1031	0	953	90
4	San Diego County,CA	937	2	878	87

In [58]:

```python
# Merging the County boundaries dataset with EV Charging stations by County dataset
evcs_county_state = county_fips.merge(evcs_by_county, how='outer', on='county_state')
evcs_county_state.head()
```

Out[58]:

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
0	POLYGON ((-94.63203 40.57176, -94.53388 40.570...	29	227	Worth	29227.0	Worth County	MO	Worth County,MO	NaN	NaN	NaN	NaN
1	POLYGON ((-99.17940 40.35068, -98.72683 40.350...	31	061	Franklin	31061.0	Franklin County	NE	Franklin County,NE	NaN	NaN	NaN	NaN
2	POLYGON ((-79.76195 42.26986, -79.62748 42.324...	36	013	Chautauqua	36013.0	Chautauqua County	NY	Chautauqua County,NY	14.0	0.0	12.0	2.0
3	POLYGON ((-78.49773 36.51467, -78.45728 36.541...	37	181	Vance	37181.0	Vance County	NC	Vance County,NC	4.0	0.0	2.0	2.0

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
4	POLYGON ((-88.94916 36.41010, -88.81642 36.410...	47	183	Weakley	47183.0	Weakley County	TN	Weakley County,TN	1.0	0.0	1.0	0.0

In [59]:

```
#Sorting the dataframe by counts column
evcs_county_state.sort_values(by='counts', ascending=True)

#Cleaning up records, removing records with no geographical values
evcs_county_state = evcs_county_state[evcs_county_state['geometry'].notna()]

#Replacing null values with 0
evcs_county_state = evcs_county_state.fillna(0)

evcs_county_state.head()
```

Out[59]:

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
0	POLYGON ((-94.63203 40.57176, -94.53388 40.570...	29	227	Worth	29227.0	Worth County	MO	Worth County,MO	0.0	0.0	0.0	0.0
1	POLYGON ((-99.17940 40.35068, -98.72683 40.350...	31	061	Franklin	31061.0	Franklin County	NE	Franklin County,NE	0.0	0.0	0.0	0.0
2	POLYGON ((-79.76195 42.26986, -79.62748 42.324...	36	013	Chautauqua	36013.0	Chautauqua County	NY	Chautauqua County,NY	14.0	0.0	12.0	2.0

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
3	POLYGON ((-78.49773 36.51467, -78.45728 36.541...	37	181	Vance	37181.0	Vance County	NC	Vance County,NC	4.0	0.0	2.0	2.0
4	POLYGON ((-88.94916 36.41010, -88.81642 36.410...	47	183	Weakley	47183.0	Weakley County	TN	Weakley County,TN	1.0	0.0	1.0	0.0

In [60]:

```
evcs_county_state.info()
```

```
<class 'geopandas.geodataframe.GeoDataFrame'>
Int64Index: 3220 entries, 0 to 3219
Data columns (total 12 columns):
 #   Column              Non-Null Count  Dtype   
---  ------              --------------  -----   
 0   geometry            3220 non-null   geometry
 1   STATEFP             3220 non-null   object  
 2   COUNTYFP            3220 non-null   object  
 3   NAME                3220 non-null   object  
 4   STCOUNTYFP          3220 non-null   float64 
 5   COUNTYNAME          3220 non-null   object  
 6   STATE               3220 non-null   object  
 7   county_state        3220 non-null   object  
 8   counts              3220 non-null   float64 
 9   EV Level1 EVSE Num  3220 non-null   float64 
 10  EV Level2 EVSE Num  3220 non-null   float64 
 11  EV DC Fast Count    3220 non-null   float64 
dtypes: float64(5), geometry(1), object(6)
memory usage: 327.0+ KB
```

In [61]:

```
len(evcs_county_state)
```

Out[61]:

```
3220
```

We have used branca elements to have CSS style Legend for the Folium choropleth.

For more details on branca - please refere here - https://python-visualization.github.io/branca/element.html#element

In [62]:

```
# Code for creating Legend for the map

from branca.element import Template, MacroElement

legend = """
{% macro html(this, kwargs) %}

<!doctype html>
<html lang="en">
<head>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">
  <title>jQuery UI Draggable - Default functionality</title>
  <link rel="stylesheet" href="//code.jquery.com/ui/1.12.1/themes/base/jquery-ui.css">

  <script src="https://code.jquery.com/jquery-1.12.4.js"></script>
  <script src="https://code.jquery.com/ui/1.12.1/jquery-ui.js"></script>

  <script>
  $( function() {
    $( "#maplegend" ).draggable({
                    start: function (event, ui) {
                        $(this).css({
                            right: "auto",
                            top: "auto",
                            bottom: "auto"
                        });
                    }
                });
});

  </script>
</head>
<body>


<div id='maplegend' class='maplegend'
    style='position: absolute; z-index:9999; border:2px solid grey; background-color:rgba(255, 255, 255, 0.8);
     border-radius:6px; padding: 10px; font-size:14px; left: 20px; bottom: 20px;'>

<div class='legend-title'>EV Charging</div>
<div class='legend-title'>Stations</div>
<div class='legend-scale'>
```

```
  <ul class='legend-labels'>
    <li><span style='background:#EC6D10;opacity:0.8;'></span>0</li>
    <li><span style='background:#EF7C24;opacity:0.8;'></span>1 - 2</li>
    <li><span style='background:#E73927;opacity:0.8;'></span>3 - 11</li>
    <li><span style='background:#DD1F13;opacity:0.8;'></span>12 - 65</li>
    <li><span style='background:#CF0107;opacity:0.8;'></span>66 - 2699</li>

  </ul>
</div>
</div>

</body>
</html>

<style type='text/css'>
  .maplegend .legend-title {
    text-align: left;
    margin-bottom: 5px;
    font-weight: bold;
    font-size: 90%;
    }
  .maplegend .legend-scale ul {
    margin: 0;
    margin-bottom: 5px;
    padding: 0;
    float: left;
    list-style: none;
    }
  .maplegend .legend-scale ul li {
    font-size: 80%;
    list-style: none;
    margin-left: 0;
    line-height: 18px;
    margin-bottom: 2px;
    }
  .maplegend ul.legend-labels li span {
    display: block;
    float: left;
    height: 16px;
    width: 30px;
    margin-right: 5px;
    margin-left: 0;
    border: 1px solid #999;
    }
  .maplegend .legend-source {
    font-size: 80%;
    color: #777;
    clear: both;
    }
  .maplegend a {
    color: #777;
    }
</style>
{% endmacro %}"""
```

In [63]:

```
import folium

us_map = folium.Map([39.8283, -98.5795], zoom_start=4)

#Mapbox Bright
folium.TileLayer('CartoDB positron',name='Positron').add_to(us_map)

myscale = [0, 1, 3, 12, 66, evcs_county_state.counts.max()]

colors = ['#d1eca0', '#9ed688', '#62bb6e', '#329750', '#0e723b']

choropleth = folium.Choropleth(
    geo_data=evcs_county_state,
    data=evcs_county_state,
    columns=["county_state", "counts"],
    key_on="feature.properties.county_state",
    fill_color = 'OrRd',
    threshold_scale=myscale,
    fill_opacity =  1,
    line_color='white',
    line_weight = .2,
    line_opacity=.6,
    name="Charging Stations",
    show=True,
    legend_name = 'Charging Stations in County',
    highlight = True,
    smooth_factor = .2
).add_to(us_map)

#Using Macro and Legend templates
macro = MacroElement()
macro._template = Template(legend)

us_map.get_root().add_child(macro)

folium.LayerControl(collapsed=True).add_to(us_map)
```

```
choropleth.geojson.add_child(folium.features.GeoJsonTooltip(
        fields=['COUNTYNAME', 'STATE', 'counts', 'EV Level1 EVSE Num', 'EV Level2 EVSE Num', 'EV DC Fast Count'
        aliases=['County:     ', 'State:     ', 'Charging Stations:     ',\
                'Number of Stations w/ Lvl. 1 Charging:     ',
                'Number of Stations w/ Lvl. 2 Charging:     ',\
                'Number of Stations w/ DC Fast Charging:     '],
        style=("background-color: white; color: #333333; font-family: arial; font-size: 12px; padding: 10px;"),
        localize=True
        )
)

for key in choropleth._children:
    if key.startswith('color_map'):
        del(choropleth._children[key])

us_map.save(outfile= "EV_Charging_Stations_US.html")

from IPython.display import IFrame

IFrame(src='EV_Charging_Stations_US.html', width=850, height=450)
```

Out[63]:

Based on the color distribution, the states/counties with darker color has relatively more EV Charging stations. California tops in the list as there are more number of EV vehicles on the road and the EV Charging Infrastructure is more complete. New York state is at second place which has just around 2500 charging station which drawn our interest to explore the EV infrastructure in NY state.

California's push to decarbonize transportation made the state to top in the list, similar actions are proposed in other states, especially in New York. Our scope for this project is to analyze the EV charging infrastructure in New York state and identify the possible gaps based on the EV vehicles on the road.

EV Charging Infrastructure in New York

Time to explore the dataset specific to New York and understand the current EV Charging infrastructure.

We have used same datasets, EV Charging Stations, County Boundaries, Zip code and Count mapping. But, this time the dataframes are filtered to use only NY state specific data.

In [64]:
```
#Dataframe for US EV Charge Stations
ny_evcs = us_evcs[us_evcs['State'] == 'NY']
```

In [65]:
```
ny_evcs.head()
```

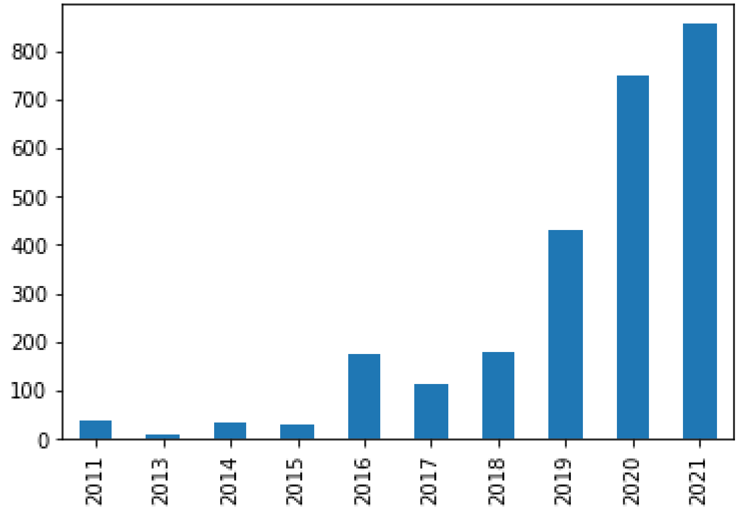
Out[65]:

	Fuel Type Code	Station Name	Street Address	Intersection Directions	City	State	ZIP	Plus4	Station Phone	Status Code	...	LPG Nozzle Types	Hydrogen Pressures	Hydrogen Standards
611	ELEC	AAA Car Care Plus	2131 Eggert Rd	NaN	Amherst	NY	14226	NaN	716-362-0562	E	...	NaN	NaN	NaN
612	ELEC	AAA Car Care Plus	8120 Main St	NaN	Clarence	NY	14221	NaN	716-932-3900 855-443-3873	E	...	NaN	NaN	NaN
672	ELEC	Thruway Nissan	79 Route 17K	NaN	Newburgh	NY	12550	NaN	845-562-1000	E	...	NaN	NaN	NaN
673	ELEC	Country Club Imports	55 Oneida St	NaN	Oneonta	NY	13820	NaN	607-432-2800	E	...	NaN	NaN	NaN
674	ELEC	West-Herr Nissan	3580 Southwestern Blvd	NaN	Orchard Park	NY	14127	NaN	716-662-8008	E	...	NaN	NaN	NaN

5 rows × 66 columns

In [66]:
```
#Plotting Basic charts
ny_evcs['year_opened'].value_counts()[:10].sort_index().plot(kind='bar')
```

Out[66]:
```
<AxesSubplot:>
```



In [67]:

```
# Creating a dataframe grouping by year opened and count the charging stations per year.
ny_yr_evcs = ny_evcs.groupby('year_opened').size().reset_index(name='year_count').sort_values(by='year_count',
ny_yr_evcs.head()
```

Out[67]:

	year_opened	year_count
0	2021	855
1	2020	750
2	2019	430
3	2018	179
4	2016	175

In [68]:

```
# Removing NULL year records
ny_yr_evcs = ny_yr_evcs.drop(labels=9, axis=0)
```

EV Charging stations count by Year

In [69]:

```
#Plotting the same dataset but using altair now...

bars_yr = alt.Chart(ny_yr_evcs[:20]).mark_bar(color='#FFA500').encode(
    x=alt.Y("year_opened:N", sort='x', title='Year',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("year_count:Q", title='Number of EV Charging Stations Opened',
           axis=alt.Axis(domain=False, labelColor='black'))
)

text = bars_yr.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 20,
    dy=-20,
    fontSize=25
).encode(
    text='year_count:Q'
)

(bars_yr + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Vehicle Charging Stations opened per Year in NY State',
          }
    ).configure_axis(
    labelFontSize=20,
    titleFontSize=20
)
```

Out[69]:

The number of EV charging stations in New York are increasing exponentially Year over year. NY is adding almost 500+ new charging stations every year.

EV Charging Station in top 5 cities in NY state

In [70]:

```
# Grouping the data by City
ny_cities_evcs = ny_evcs.groupby('City').size().reset_index(name='station_count').sort_values(by='station_count
ny_cities_evcs.head()
```

Out[70]:

	City	station_count
0	New York	331
1	Buffalo	132
2	Albany	125
3	Rochester	116

	City	station_count
4	Brooklyn	76

In [71]:

```
bars = alt.Chart(ny_cities_evcs[:5]).mark_bar(color='#FFA500').encode(
    x=alt.Y("City:N", sort='-y', title='City Name',
           axis=alt.Axis(labelAngle=-45, domain=False, labelColor='black')),
    y=alt.Y("station_count:Q", title='Number of EV Charging Stations',
           axis=alt.Axis(domain=False, labelColor='black'))
)

text = bars.mark_text(
    angle=315,
    align='center',
    baseline='top',
    dx= 10,
    dy=-10
).encode(
    text='station_count:Q'
)

(bars + text).properties(
    height=500, width=1000,
    title={'text': 'Electric Car Charging Stations per Cities in NY',
          }
    ).configure_axis(
    labelFontSize=20,
    titleFontSize=20
)
```

Out[71]:

New York city tops in number of charging stations with 330, Buffalo with 132, Albany with 118, Rochester with 115 and Brooklyn has 73 made it to top 5 cities with most number of EV Charging stations.

New York County Map for EV Charging Stations

In [72]:

```
#Filtering the dataset just for NY state
evcs_county_ny = evcs_county_state[evcs_county_state['STATE'].str.contains('NY')]
```

In [73]:

```
evcs_county_ny.head()
```

Out[73]:

	geometry	STATEFP	COUNTYFP	NAME	STCOUNTYFP	COUNTYNAME	STATE	county_state	counts	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fas Coun
2	POLYGON ((-79.76195 42.26986, -79.62748 42.324...	36	013	Chautauqua	36013.0	Chautauqua County	NY	Chautauqua County,NY	14.0	0.0	12.0	2.
53	POLYGON ((-78.46550 43.12862, -77.99729 43.132...	36	037	Genesee	36037.0	Genesee County	NY	Genesee County,NY	10.0	0.0	9.0	1.
69	POLYGON ((-73.60672 43.56714, -73.49291 43.657...	36	115	Washington	36115.0	Washington County	NY	Washington County,NY	3.0	0.0	3.0	0.
80	POLYGON ((-76.98133 42.86121, -76.96393 43.013...	36	099	Seneca	36099.0	Seneca County	NY	Seneca County,NY	5.0	0.0	3.0	2.
101	POLYGON ((-79.06078 42.53785, -78.99170 42.529...	36	009	Cattaraugus	36009.0	Cattaraugus County	NY	Cattaraugus County,NY	8.0	0.0	7.0	1.

In [74]:

```
import folium

m = folium.Map([42.3, -74],control_scale=True,zoom_start=6)

#Mapbox Bright
folium.TileLayer('CartoDB positron',name='Positron').add_to(m)

myscale = [0, 1, 3, 12, 66, evcs_county_ny.counts.max()]

colors = ['#EC6D10', '#EF7C24', '#EF7C24', '#DD1F13', '#CF0107']
```

```
choropleth = folium.Choropleth(
    geo_data=evcs_county_ny,
    data=evcs_county_ny,
    columns=["county_state", "counts"],
    key_on="feature.properties.county_state",
    fill_color = 'OrRd',
    threshold_scale=myscale,
    fill_opacity =  1,
    line_color='white',
    line_weight = .2,
    line_opacity=.6,
    name="Charging Stations",
    show=True,
    legend_name = 'Charging Stations in County',
    highlight = True,
    smooth_factor = .2
).add_to(m)

macro = MacroElement()
macro._template = Template(legend)

m.get_root().add_child(macro)

folium.LayerControl(collapsed=True).add_to(m)

choropleth.geojson.add_child(folium.features.GeoJsonTooltip(
        fields=['COUNTYNAME', 'STATE', 'counts', 'EV Level1 EVSE Num', 'EV Level2 EVSE Num', 'EV DC Fast Count'
        aliases=['County:     ', 'State:     ', 'Charging Stations:     ',\
                'Number of Stations w/ Lvl. 1 Charging:     ',
                'Number of Stations w/ Lvl. 2 Charging:     ',\
                'Number of Stations w/ DC Fast Charging:     '],
        style=("background-color: white; color: #333333; font-family: arial; font-size: 12px; padding: 10px;"),
        localize=True
        )
)

#Delete Default color scale (It overlaps)
for key in choropleth._children:
    if key.startswith('color_map'):
        del(choropleth._children[key])

#Display the map and save
m.save(outfile= "ny_chargingstations_county.html")

from IPython.display import IFrame
```

```
IFrame(src='ny_chargingstations_county.html', width=850, height=450)
```

Out[74]:

EV Charging Network Map

There are various stakeholders in the EV Charging infrastructure such as Vehicle OEMs, Standa alone charging companies and Government. Now, let take look into the different EV Charging network available in NY State.

In [75]:

```
#Creating a dataframe with EV Charging network specific columns
ny_evcs_nw = ny_evcs[['Latitude','Longitude','EV Network','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fas
                      'State','ZIP','Open Date','Groups With Access Code']]

#Creating a list of Lat and Long values
ny_evcs_nw['LatLong'] = list(zip(ny_evcs_nw["Latitude"], ny_evcs_nw["Longitude"]))
```

In [76]:

```
#Data Cleaning and Manipulation

#Filling Nan values with 0
ny_evcs_nw.fillna({'EV Level1 EVSE Num':0, 'EV Level2 EVSE Num':0, 'EV DC Fast Count':0}, inplace=True)

#Creating new column with Total Port counts available in every charging station
ny_evcs_nw['Port Count'] = ny_evcs_nw['EV Level1 EVSE Num']+ny_evcs_nw['EV Level2 EVSE Num']+ny_evcs_nw['EV DC

ny_evcs_nw.head()
```

Out[76]:

	Latitude	Longitude	EV Network	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count	Station Name	Street Address	City	State	ZIP	Open Date	Groups With Access Code	La
611	42.979363	-78.821443	Non-Networked	0.0	1.0	0.0	AAA Car Care Plus	2131 Eggert Rd	Amherst	NY	14226	2011-12-31	Public	(42.97 -78.82
612	42.965851	-78.692780	Non-Networked	0.0	1.0	0.0	AAA Car Care Plus	8120 Main St	Clarence	NY	14221	2018-12-17	Public	(42.96 -78.6
672	41.504105	-74.068916	Non-Networked	0.0	1.0	0.0	Thruway Nissan	79 Route 17K	Newburgh	NY	12550	2011-11-30	Public - Call ahead	(41.50 -74.06
673	42.451285	-75.100333	Non-Networked	0.0	2.0	2.0	Country Club Imports	55 Oneida St	Oneonta	NY	13820	2011-11-30	Public - Call ahead	(42.45 -75.10
674	42.784867	-78.765580	Non-Networked	0.0	1.0	0.0	West-Herr Nissan	3580 Southwestern Blvd	Orchard Park	NY	14127	2011-11-30	Public - Call ahead	(42.78 -78.7

In [77]:

```
#Converting the datatype to integer
ny_evcs_nw['Port Count'] = ny_evcs_nw['Port Count'].astype(int)
```

In [78]:

```
#Let's take a look at unique EV networks available in NY
ny_evcs_nw['EV Network'].unique()
```

Out[78]:

```
array(['Non-Networked', 'ChargePoint Network', 'EV Connect',
           'Blink Network', 'Tesla', 'Tesla Destination', 'Greenlots',
           'OpConnect', 'Electrify America', 'SemaCharge Network', 'Volta',
           'FLO', 'AMPUP', 'LIVINGSTON', 'eVgo Network', 'EVGATEWAY'],
          dtype=object)
```

In [79]:

```
ny_evnw_cnt = ny_evcs_nw.groupby('EV Network').size().reset_index(name='Station Count').sort_values(by='Station
ny_evnw_cnt
```

Out[79]:

	EV Network	Station Count
0	ChargePoint Network	1474
1	Tesla Destination	480
2	EV Connect	263
3	Non-Networked	162
4	Blink Network	76
5	Tesla	54
6	LIVINGSTON	29
7	eVgo Network	23
8	Electrify America	18
9	FLO	14
10	SemaCharge Network	14
11	Greenlots	12
12	Volta	9
13	OpConnect	2
14	AMPUP	1
15	EVGATEWAY	1

In [80]:

```
#Creating Folium map with EV Charging Network in NY

nw_map = folium.Map(width=1000, height=700,location=[42.3, -74], tiles = 'OpenStreetMap', zoom_start=7)

# add markers to map
for lat, lng in zip(ny_evcs_nw['Latitude'], ny_evcs_nw['Longitude']):
    try:
        folium.CircleMarker(
            [lat, lng],
            radius=5,
            #popup=label,
            color='blue',
            fill=True,
            fill_color='#e3942d',
            fill_opacity=0.7).add_to(nw_map)
    except:
        print(lat)

nw_map
```

```
Out[80]: Make this Notebook Trusted to load map: File -> Trust Notebook
```

So, as we identified earlier, New York city tops in number of charging stations. Buffalo, Albany, Rochester and Brooklyn areas are having more number of charging stations.

We can also add more details to the map interms of number of stations, port counts, etc.,

In [81]:

```
# Folium Map with EV Charging Network

# Creating a legend

legend_html = '''
        <div style="position: fixed; bottom: 75px; right: 10px; width: 250px; height: 350px;
                    background-color: light grey; border:1px grey; z-index:9999; font-size:14px"
                    >&nbsp; <b>EV Network</b> <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#5C2D91"></i>
                    &nbsp; ChargePoint Network &nbsp&nbsp&nbsp; <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#E81123"></i>
                    &nbsp; Tesla &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#2683C6"></i>
                    &nbsp; Tesla Destination &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#FF8C00"></i>
                    &nbsp; EV Connect <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#107C10"></i>
                    &nbsp; Blink Network <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#004B1C"></i>
                    &nbsp; Greenlots <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#F4D25A"></i>
                    &nbsp; OpConnect <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#4AC5BB"></i>
                    &nbsp; Electrify America <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#3599B8"></i>
                    &nbsp; SemaCharge Network <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#DFBFBF"></i>
                    &nbsp; Volta <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#FB8281"></i>
                    &nbsp; FLO <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#7F898A"></i>
                    &nbsp; AMPUP <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#5F6B6D"></i>
                    &nbsp; LINVINGSTON <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#E3008C"></i>
                    &nbsp; eVgo Network <br>
                        <i class="fa fa-circle" style="font-size:25px;color:#FFD700"></i>
                    &nbsp; Non-Networked
        </div>
        '''


def color(nw):
    # Color range
    if (nw == 'ChargePoint Network'):
            color = "#5C2D91"
    elif (nw == 'Tesla'):
            color = "#E81123"
    elif (nw == 'EV Connect'):
            color = "#FF8C00"
    elif (nw == 'Blink Network'):
            color = "#107C10"
    elif (nw == 'Tesla Destination'):
            color = "#2683C6"
    elif (nw == 'Greenlots'):
            color = "#004B1C"
    elif (nw == 'OpConnect'):
            color = "#F4D25A"
    elif (nw == 'Electrify America'):
            color = "#4AC5BB"
    elif (nw == 'SemaCharge Network'):
            color = "#3599B8"
    elif (nw == 'Volta'):
            color = "#DFBFBF"
    elif (nw == 'FLO'):
            color = "#FB8281"
    elif (nw == 'AMPUP'):
            color = "#7F898A"
    elif (nw == 'LINVINGSTON'):
            color = "#5F6B6D"
    elif (nw == 'eVgo Network'):
            color = "#E3008C"
    else:
            color = "#FFD700"
    return color

def rad(total):
    if ( 1 <= total <= 10):
            rad = 10
    elif (11 <= total <= 20):
            rad = 30
    elif (21 <= total <= 30):
            rad = 50
    elif (31 <= total <= 40):
            rad = 70
    elif (41 <= total <= 50):
            rad = 90
    else:
            rad = 120
    return rad

import folium
from   folium import plugins

map0 = folium.Map(location= [42.3, -74], control_scale=True, zoom_start=7)
folium.TileLayer('openstreetmap').add_to(map0)
folium.TileLayer('CartoDB positron',name='Positron').add_to(map0)
folium.TileLayer('CartoDB dark_matter',name='Dark Matter').add_to(map0)
folium.TileLayer('Stamen Terrain',name='Terrain').add_to(map0)
folium.TileLayer('Stamen Toner',name='Toner').add_to(map0)
# Enable the layer control
folium.LayerControl().add_to(map0)
# Enable Expand fullscreen feature
plugins.Fullscreen( position='topleft', title='Expand', title_cancel='Exit', force_separate_button=True ).add_t
map0.get_root().html.add_child(folium.Element(legend_html))

for index, row in ny_evcs_nw.iterrows():
    #'EV Network','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fast Count'
    ev_nw      = row['EV Network']
    port_cnt = row['Port Count']
    l1_cnt = row["EV Level1 EVSE Num"]
    l2_cnt  = row["EV Level2 EVSE Num"]
    DC_Fast_cnt  = row['EV DC Fast Count']
    lat    = row["Latitude"]
    long  = row["Longitude"]

    # generate the popup message that is shown on click.
    popup_text = "<b>EV Network:</b> {}<br><b>Port Count: </b>{}"
    popup_text = popup_text.format(ev_nw, port_cnt)


    # select colors and radius
    col1 = color(ev_nw)
    rad1 = rad(port_cnt)
    folium.CircleMarker(location=(lat,long), radius = rad1, color=col1, popup=popup_text,
                        opacity= 0.2, fill_opacity = 0.5 ,fill=True).add_to(map0)


map0.save('EV_Network.html')
display(map0)
```

Make this Notebook Trusted to load map: File -> Trust Notebook

Now, we can see the different EV Charging networks based on the colors and number of ports with the size of the circle.

New York EV Charging Level Map

When we are away from home, there are thousands of charging stations that you can take advantage of across New York State. This level of charging is known as Level 2 and it is at least two times faster than Level 1.

Level 2 charging stations are mainly installed at stores, office buildings, municipal parking lots, parks, hotels, theaters and hospitals. All Level 2 charging stations have a common plug that all electric cars can use, while DC fast chargers may not be compatible with every model.

DC fast charging uses direct current (DC), as opposed to households which use alternating current (AC), and can provide close to a full charge in under an hour. Only public sites can support DC fast charging and they are most often installed along major travel corridors to support long distance drivers.

In [82]:

```
#Creating a dataframe pertaining to EV Charging level
ny_evcs_level = ny_evcs_nw[['Latitude','Longitude','EV Network','EV Level1 EVSE Num','EV Level2 EVSE Num','EV D
```

In [83]:

```
ny_evcs_level.head()
```

Out[83]:

	Latitude	Longitude	EV Network	EV Level1 EVSE Num	EV Level2 EVSE Num	EV DC Fast Count
611	42.979363	-78.821443	Non-Networked	0.0	1.0	0.0
612	42.965851	-78.692780	Non-Networked	0.0	1.0	0.0
672	41.504105	-74.068916	Non-Networked	0.0	1.0	0.0
673	42.451285	-75.100333	Non-Networked	0.0	2.0	2.0
674	42.784867	-78.765580	Non-Networked	0.0	1.0	0.0

In [84]:

```
# Converting the data types to integer
ny_evcs_level['EV Level1 EVSE Num'] = ny_evcs_level['EV Level1 EVSE Num'].astype(int)
ny_evcs_level['EV Level2 EVSE Num'] = ny_evcs_level['EV Level2 EVSE Num'].astype(int)
ny_evcs_level['EV DC Fast Count'] = ny_evcs_level['EV DC Fast Count'].astype(int)
```

In [85]:

```
#Pivoting or transposing the dataframe to have the data by EV levels and their count
ny_evcs_level_1 = ny_evcs_level.melt(id_vars=['Latitude','Longitude','EV Network'])
```

In [86]:

```
ny_evcs_level_1.head()
```

Out[86]:

	Latitude	Longitude	EV Network	variable	value
0	42.979363	-78.821443	Non-Networked	EV Level1 EVSE Num	0
1	42.965851	-78.692780	Non-Networked	EV Level1 EVSE Num	0
2	41.504105	-74.068916	Non-Networked	EV Level1 EVSE Num	0
3	42.451285	-75.100333	Non-Networked	EV Level1 EVSE Num	0

	Latitude	Longitude	EV Network	variable	value
4	42.784867	-78.765580	Non-Networked	EV Level1 EVSE Num	0

In [87]:

```
#Renaming the columns with correct name
ny_evcs_level_1 = ny_evcs_level_1.rename(columns={'variable' : 'Charging Level','value' : 'count'})
```

In [88]:

```
# Folium Map with EV Charging Levels

# Creating a legend

legend_html = '''
        <div style="position: fixed; bottom: 75px; right: 10px; width: 250px; height: 350px;
                    background-color: light grey; border:1px grey; z-index:9999; font-size:14px"
                    >&nbsp; <b>Charging Level</b> <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#FFD700"></i>
                    &nbsp; EV Level1 EVSE &nbsp&nbsp&nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#E81123"></i>
                    &nbsp; EV Level2 EVSE &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#3599B8"></i>
                    &nbsp; EV DC Fast &nbsp; <br>
        </div>
        '''


def color(level):
    # Color range
    if (level == 'EV Level1 EVSE Num'):
            color = "#FFD700"
    elif (level == 'EV Level2 EVSE Num'):
            color = "#E81123"
    elif (level == 'EV DC Fast Count'):
            color = "#3599B8"
    else:
            color = "#FFFFFF"
    return color

def rad(total):
    if ( 1 <= total <= 3):
            rad = 5
    elif (4 <= total <= 6):
            rad = 10
    elif (7 <= total <= 10):
            rad = 15
    elif (11 <= total <= 15):
            rad = 20
    elif (16 <= total <= 20):
            rad = 25
    else:
            rad = 0
    return rad

# read the region coordinates from region.csv

import folium
from   folium import plugins

map1 = folium.Map(location= [42.3, -74], control_scale=True, zoom_start=7)
folium.TileLayer('openstreetmap').add_to(map1)
folium.TileLayer('CartoDB positron',name='Positron').add_to(map1)
folium.TileLayer('CartoDB dark_matter',name='Dark Matter').add_to(map1)
folium.TileLayer('Stamen Terrain',name='Terrain').add_to(map1)
folium.TileLayer('Stamen Toner',name='Toner').add_to(map1)
# Enable the layer control
folium.LayerControl().add_to(map1)
# Enable Expand fullscreen feature
plugins.Fullscreen( position='topleft', title='Expand', title_cancel='Exit', force_separate_button=True ).add_t
map1.get_root().html.add_child(folium.Element(legend_html))

for index, row in ny_evcs_level_1.iterrows():
    #'EV Network','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fast Count'
    charge_level  = row['Charging Level']
    ev_nw = row['EV Network']
    port_cnt = row['count']
    lat    = row["Latitude"]
    long   = row["Longitude"]

    # generate the popup message that is shown on click.
    popup_text = "<b>EV Network:</b> {}<br><b>Port Count: </b>{}"
    popup_text = popup_text.format(ev_nw, port_cnt)


    # select colors and radius
    col1 = color(charge_level)
    rad1 = rad(port_cnt)
    folium.CircleMarker(location=(lat,long), radius = rad1, color=col1, popup=popup_text,
                        opacity= 0.5, fill_opacity = 0.1).add_to(map1)
```

```
map1.save('EV_Network_Chargelevel.html')
display(map1)
```

Make this Notebook Trusted to load map: File -> Trust Notebook

Currently, there are 6471 Level 2 Charging ports and 729 DC Fast Charging ports available in New York. Most of the Level 2 ports are owned by ChargePoint and Tesla owns most of the DC Fast Charging stations.

New York EV Connector Type Map

Now, lets take a look at the different EV charging connector types available across NY State

In [89]:
```
# Creating a dataframe for EV charging connector type
ny_evcs_connector = ny_evcs[['Latitude','Longitude','EV Network','EV Connector Types']]
```

In [90]:
```
ny_evcs_connector.head()
```

Out[90]:

	Latitude	Longitude	EV Network	EV Connector Types
611	42.979363	-78.821443	Non-Networked	J1772
612	42.965851	-78.692780	Non-Networked	J1772
672	41.504105	-74.068916	Non-Networked	J1772
673	42.451285	-75.100333	Non-Networked	CHADEMO J1772 J1772COMBO
674	42.784867	-78.765580	Non-Networked	J1772

In [91]:
```
ny_evcs_connector['EV Connector Types'].unique()
```

Out[91]:
```
array(['J1772', 'CHADEMO J1772 J1772COMBO', 'CHADEMO J1772',
       'J1772 J1772COMBO', 'J1772 NEMA1450 NEMA520', 'CHADEMO',
       'J1772 NEMA520', 'TESLA', 'CHADEMO J1772COMBO', 'J1772 TESLA',
       'J1772COMBO', 'CHADEMO J1772COMBO TESLA'], dtype=object)
```

In [92]:
```
ny_evcs_connector1 = ny_evcs_connector.join(pd.DataFrame(ny_evcs_connector['EV Connector Types'].str.split(' ',
                  ,columns=['EV Connector Types '])).drop('EV Connector Types',1).rename(columns=str.strip).reset
```

In [93]:
```
ny_evcs_connector1.head()
```

Out[93]:

	Latitude	Longitude	EV Network	EV Connector Types
0	42.979363	-78.821443	Non-Networked	J1772
1	42.965851	-78.692780	Non-Networked	J1772
2	41.504105	-74.068916	Non-Networked	J1772
3	42.451285	-75.100333	Non-Networked	CHADEMO
4	42.451285	-75.100333	Non-Networked	J1772

In [94]:

```
# Creating a legend

legend_html = '''
        <div style="position: fixed; bottom: 75px; right: 10px; width: 250px; height: 350px;
                    background-color: light grey; border:1px grey; z-index:9999; font-size:14px"
                    >&nbsp; <b>EV Connector Type</b> <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#2683C6"></i>
                    &nbsp; J1772 &nbsp&nbsp&nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#FFD700"></i>
                    &nbsp; CHADEMO &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#3599B8"></i>
                    &nbsp; J1772COMBO &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#DFBFBF"></i>
                    &nbsp; NEMA1450 &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#5F6B6D"></i>
                    &nbsp; NEMA520 &nbsp; <br>
                        <i class="fa fa-circle" style="font-size:14px;color:#E81123"></i>
                    &nbsp; TESLA &nbsp; <br>
        </div>
        '''


def color(level):
    # Color range
    if (level == 'J1772'):
            color = "#2683C6"
    elif (level == 'CHADEMO'):
            color = "#FFD700"
    elif (level == 'J1772COMBO'):
            color = "#3599B8"
    elif (level == 'NEMA1450'):
            color = "#DFBFBF"
    elif (level == 'NEMA520'):
            color = "#5F6B6D"
    else:
            color = "#E81123"
    return color

def rad(total):
    if ( 1 <= total <= 3):
            rad = 5
    elif (4 <= total <= 6):
            rad = 10
    elif (7 <= total <= 10):
            rad = 15
    elif (11 <= total <= 15):
            rad = 20
    elif (16 <= total <= 20):
            rad = 25
    else:
            rad = 0
    return rad

# read the region coordinates from region.csv

import folium
from   folium import plugins

map2 = folium.Map(location= [42.3, -74], control_scale=True, zoom_start=7)
folium.TileLayer('openstreetmap').add_to(map2)
folium.TileLayer('CartoDB positron',name='Positron').add_to(map2)
folium.TileLayer('CartoDB dark_matter',name='Dark Matter').add_to(map2)
folium.TileLayer('Stamen Terrain',name='Terrain').add_to(map2)
folium.TileLayer('Stamen Toner',name='Toner').add_to(map2)
# Enable the layer control
folium.LayerControl().add_to(map2)
# Enable Expand fullscreen feature
plugins.Fullscreen( position='topleft', title='Expand', title_cancel='Exit', force_separate_button=True ).add_t
map2.get_root().html.add_child(folium.Element(legend_html))

for index, row in ny_evcs_connector1.iterrows():
    #'EV Network','EV Level1 EVSE Num','EV Level2 EVSE Num', 'EV DC Fast Count'
    con_type  = row['EV Connector Types']
    ev_nw = row['EV Network']
    lat   = row["Latitude"]
    long  = row["Longitude"]

    # generate the popup message that is shown on click.
    popup_text = "<b>EV Network:</b> {}<br><b>Port Count: </b>{}"
    popup_text = popup_text.format(ev_nw, con_type)


    # select colors and radius
    col1 = color(con_type)
    folium.CircleMarker(location=(lat,long), radius = 10, color=col1, popup=popup_text,
                        opacity= 0.2, fill_opacity = 0.3 ,fill=True).add_to(map2)


map2.save('EV_Network.html')
display(map2)
```

Make this Notebook Trusted to load map: File -> Trust Notebook

So, As per Electrifying New York plan, NYC will expand its network of city-operated DC fast chargers by over 80 plugs by 2025. Currently, there are 117 DC fast chargers located throughout the city. These fast chargers are capable of producing an 80% charge in 30 to 60 minutes, depending on the vehicle. All city municipal parking lots and garages will have 20% of their parking spots equipped with L2 chargers by 2025, and 40% by 2030.

The Electrifying New York plan, including its ambitious vision for a new network of public EV chargers, will play a key role in reducing climate-changing greenhouse gases, lowering the risk of respiratory illnesses, reducing noise, and ending our reliance on fossil fuels.

In [ ]: