In [1]:
```
###Electric Vehicle Charging Stations in Canada: Data Analysis and Visualization
#Prepared by: Aakash Shiket
#Contact: shiket13@gmail.com
```

In [ ]:
```
##Data Source:
#The dataset used in this analysis was obtained from Natural Resources Canada’s
#(NRCan) open data portal: Electric Charging and Alternative Fuelling Stations Locator.
```

In [3]:
```
## Objective
#This project analyzes electric vehicle (EV) charging station data in Canada using the dataset provided by Natural Resources Canada (NRCan).

## Key Findings:
#- Growth Trends: A significant rise in EV charging stations since 2019, reflecting increased adoption of electric vehicles.
#- Regional Insights: Provinces like Quebec, Ontario, and British Columbia lead in both Level 2 and DC fast charging infrastructure.
#- Connector Types: The J1772 connector dominates the charging network, followed by CHAdeMO and CCS connectors.
#- Top Charging Networks: Flo, Tesla, and Circuit électrique dominate the Canadian EV market.

## Impact:
#This analysis highlights Canada’s readiness to support the growing EV market, with strong investments in both standard and fast charging infrastructure.
#It also identifies gaps in charging accessibility in smaller provinces, providing actionable insights for future network expansion.
```

In [139…
```
# Import essential libraries
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

# Load the NRCan dataset
data_file = "data.csv"  # Replace with your CSV file's path
df = pd.read_csv("data.csv",low_memory=False)

# Check the dataset information
print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 31562 entries, 0 to 31561
Data columns (total 83 columns):
 #   Column                                  Non-Null Count  Dtype
---  ------                                  --------------  -----
 0   Fuel Type Code                          31562 non-null  object
 1   Station Name                            31562 non-null  object
 2   Street Address                          31562 non-null  object
 3   Intersection Directions                 3415 non-null   object
 4   City                                    31562 non-null  object
 5   State                                   31562 non-null  object
 6   ZIP                                     31562 non-null  object
 7   Plus4                                   0 non-null      float64
 8   Station Phone                           31185 non-null  object
 9   Status Code                             31562 non-null  object
 10  Expected Date                           0 non-null      float64
 11  Groups With Access Code                 31562 non-null  object
 12  Access Days Time                        28355 non-null  object
 13  Cards Accepted                          3439 non-null   object
 14  BD Blends                               0 non-null      float64
 15  NG Fill Type Code                       0 non-null      float64
 16  NG PSI                                  0 non-null      float64
 17  EV Level1 EVSE Num                      56 non-null     float64
 18  EV Level2 EVSE Num                      26060 non-null  float64
 19  EV DC Fast Count                        6553 non-null   float64
 20  EV Other Info                           0 non-null      float64
 21  EV Network                              31562 non-null  object
 22  EV Network Web                          29550 non-null  object
 23  Geocode Status                          31561 non-null  object
 24  Latitude                                31562 non-null  float64
 25  Longitude                               31562 non-null  float64
 26  Date Last Confirmed                     31444 non-null  object
 27  ID                                      31562 non-null  int64
 28  Updated At                              31562 non-null  object
 29  Owner Type Code                         8709 non-null   object
 30  Federal Agency ID                       4 non-null      float64
 31  Federal Agency Name                     4 non-null      object
 32  Open Date                               31498 non-null  object
 33  Hydrogen Status Link                    0 non-null      float64
 34  NG Vehicle Class                        0 non-null      float64
 35  LPG Primary                             0 non-null      float64
 36  E85 Blender Pump                        0 non-null      float64
 37  EV Connector Types                      31562 non-null  object
 38  Country                                 31562 non-null  object
 39  Intersection Directions (French)        263 non-null    object
 40  Access Days Time (French)               28027 non-null  object
 41  BD Blends (French)                      0 non-null      float64
 42  Groups With Access Code (French)        31562 non-null  object
 43  Hydrogen Is Retail                      0 non-null      float64
 44  Access Code                             31562 non-null  object
 45  Access Detail Code                      1165 non-null   object
 46  Federal Agency Code                     4 non-null      object
 47  Facility Type                           6682 non-null   object
 48  CNG Dispenser Num                       0 non-null      float64
 49  CNG On-Site Renewable Source            0 non-null      float64
 50  CNG Total Compression Capacity          0 non-null      float64
 51  CNG Storage Capacity                    0 non-null      float64
 52  LNG On-Site Renewable Source            0 non-null      float64
 53  E85 Other Ethanol Blends                0 non-null      float64
 54  EV Pricing                              5552 non-null   object
 55  EV Pricing (French)                     5493 non-null   object
 56  LPG Nozzle Types                        0 non-null      float64
 57  Hydrogen Pressures                      0 non-null      float64
 58  Hydrogen Standards                      0 non-null      float64
 59  CNG Fill Type Code                      0 non-null      float64
 60  CNG PSI                                 0 non-null      float64
 61  CNG Vehicle Class                       0 non-null      float64
 62  LNG Vehicle Class                       0 non-null      float64
 63  EV On-Site Renewable Source             58 non-null     object
 64  Restricted Access                       5568 non-null   object
 65  RD Blends                               0 non-null      float64
 66  RD Blends (French)                      0 non-null      float64
 67  RD Blended with Biodiesel               0 non-null      float64
 68  RD Maximum Biodiesel Level              0 non-null      float64
 69  NPS Unit Name                           0 non-null      float64
 70  CNG Station Sells Renewable Natural Gas  0 non-null     float64
 71  LNG Station Sells Renewable Natural Gas  0 non-null     float64
 72  Maximum Vehicle Class                   4070 non-null   object
 73  EV Workplace Charging                   31562 non-null  bool
 74  Funding Sources                         0 non-null      float64
 75  EV J1772 Connector Count                31562 non-null  int64
 76  EV J1772 Power Output (kW)              20986 non-null  float64
 77  EV CCS Connector Count                  31562 non-null  int64
 78  EV CCS Power Output (kW)                3543 non-null   float64
 79  EV CHAdeMO Connector Count              31562 non-null  int64
 80  EV CHAdeMO Power Output (kW)            2635 non-null   float64
 81  EV J3400 Connector Count                31562 non-null  int64
 82  EV J3400 Power Output (kW)              363 non-null    float64
dtypes: bool(1), float64(43), int64(5), object(34)
memory usage: 19.8+ MB
None
```

In [141…

```python
# Step 1: Identifying Null Values in the Dataset
# This step helps us find missing data in each column to decide on further cleaning actions
null_values = df.isnull().sum()  # Count of null values in each column
print(null_values)
```

```
Fuel Type Code                          0
Station Name                            0
Street Address                          0
Intersection Directions                 28147
City                                    0
State                                   0
ZIP                                     0
Plus4                                   31562
Station Phone                           377
Status Code                             0
Expected Date                           31562
Groups With Access Code                 0
Access Days Time                        3207
Cards Accepted                          28123
BD Blends                               31562
NG Fill Type Code                       31562
NG PSI                                  31562
EV Level1 EVSE Num                      31506
EV Level2 EVSE Num                      5502
EV DC Fast Count                        25009
EV Other Info                           31562
EV Network                              0
EV Network Web                          2012
Geocode Status                          1
Latitude                                0
Longitude                               0
Date Last Confirmed                     118
ID                                      0
Updated At                              0
Owner Type Code                         22853
Federal Agency ID                       31558
Federal Agency Name                     31558
Open Date                               64
Hydrogen Status Link                    31562
NG Vehicle Class                        31562
LPG Primary                             31562
E85 Blender Pump                        31562
EV Connector Types                      0
Country                                 0
Intersection Directions (French)        31299
Access Days Time (French)               3535
BD Blends (French)                      31562
Groups With Access Code (French)        0
Hydrogen Is Retail                      31562
Access Code                             0
Access Detail Code                      30397
Federal Agency Code                     31558
Facility Type                           24880
CNG Dispenser Num                       31562
CNG On-Site Renewable Source            31562
CNG Total Compression Capacity          31562
CNG Storage Capacity                    31562
LNG On-Site Renewable Source            31562
E85 Other Ethanol Blends                31562
EV Pricing                              26010
EV Pricing (French)                     26069
LPG Nozzle Types                        31562
Hydrogen Pressures                      31562
Hydrogen Standards                      31562
CNG Fill Type Code                      31562
CNG PSI                                 31562
CNG Vehicle Class                       31562
LNG Vehicle Class                       31562
EV On-Site Renewable Source             31504
Restricted Access                       25994
RD Blends                               31562
RD Blends (French)                      31562
RD Blended with Biodiesel               31562
RD Maximum Biodiesel Level              31562
NPS Unit Name                           31562
CNG Station Sells Renewable Natural Gas 31562
LNG Station Sells Renewable Natural Gas 31562
Maximum Vehicle Class                   27492
EV Workplace Charging                   0
Funding Sources                         31562
EV J1772 Connector Count                0
EV J1772 Power Output (kW)              10576
EV CCS Connector Count                  0
EV CCS Power Output (kW)                28019
EV CHAdeMO Connector Count              0
EV CHAdeMO Power Output (kW)            28927
EV J3400 Connector Count                0
EV J3400 Power Output (kW)              31199
dtype: int64
```

In [143…
```
pd.set_option('display.max_rows', None)
```

In [145…
```
# Calculate the percentage of missing data for better understanding
total_rows = len(df)  # Total number of rows in the dataset
null_percentage = (null_values / total_rows) * 100  # Percentage of missing data
print(null_percentage)
```

```
Fuel Type Code                          0.000000
Station Name                            0.000000
Street Address                          0.000000
Intersection Directions                89.180027
City                                    0.000000
State                                   0.000000
ZIP                                     0.000000
Plus4                                 100.000000
Station Phone                           1.194474
Status Code                             0.000000
Expected Date                         100.000000
Groups With Access Code                 0.000000
Access Days Time                       10.160953
Cards Accepted                         89.103986
BD Blends                             100.000000
NG Fill Type Code                     100.000000
NG PSI                                100.000000
EV Level1 EVSE Num                     99.822571
EV Level2 EVSE Num                     17.432355
EV DC Fast Count                       79.237691
EV Other Info                         100.000000
EV Network                              0.000000
EV Network Web                          6.374754
Geocode Status                          0.003168
Latitude                                0.000000
Longitude                               0.000000
Date Last Confirmed                     0.373867
ID                                      0.000000
Updated At                              0.000000
Owner Type Code                        72.406692
Federal Agency ID                      99.987327
Federal Agency Name                    99.987327
Open Date                               0.202775
Hydrogen Status Link                  100.000000
NG Vehicle Class                      100.000000
LPG Primary                           100.000000
E85 Blender Pump                      100.000000
EV Connector Types                      0.000000
Country                                 0.000000
Intersection Directions (French)       99.166719
Access Days Time (French)              11.200177
BD Blends (French)                    100.000000
Groups With Access Code (French)        0.000000
Hydrogen Is Retail                    100.000000
Access Code                             0.000000
Access Detail Code                     96.308852
Federal Agency Code                    99.987327
Facility Type                          78.828972
CNG Dispenser Num                     100.000000
CNG On-Site Renewable Source          100.000000
CNG Total Compression Capacity        100.000000
CNG Storage Capacity                  100.000000
LNG On-Site Renewable Source          100.000000
E85 Other Ethanol Blends              100.000000
EV Pricing                             82.409226
EV Pricing (French)                    82.596160
LPG Nozzle Types                      100.000000
Hydrogen Pressures                    100.000000
Hydrogen Standards                    100.000000
CNG Fill Type Code                    100.000000
CNG PSI                               100.000000
CNG Vehicle Class                     100.000000
LNG Vehicle Class                     100.000000
EV On-Site Renewable Source            99.816235
Restricted Access                      82.358532
RD Blends                             100.000000
RD Blends (French)                    100.000000
RD Blended with Biodiesel             100.000000
RD Maximum Biodiesel Level            100.000000
NPS Unit Name                         100.000000
CNG Station Sells Renewable Natural Gas  100.000000
LNG Station Sells Renewable Natural Gas  100.000000
Maximum Vehicle Class                  87.104746
EV Workplace Charging                   0.000000
Funding Sources                       100.000000
EV J1772 Connector Count                0.000000
EV J1772 Power Output (kW)             33.508650
EV CCS Connector Count                  0.000000
EV CCS Power Output (kW)               88.774476
EV CHAdeMO Connector Count              0.000000
EV CHAdeMO Power Output (kW)           91.651353
EV J3400 Connector Count                0.000000
EV J3400 Power Output (kW)             98.849883
dtype: float64
```

In [147…

```python
# Remove columns with more than 80% missing data (example threshold)
columns_to_drop = null_percentage[null_percentage > 80].index  # Identify columns to drop
df = df.drop(columns=columns_to_drop, axis=1)  # Drop the identified columns
print(f"Columns dropped: {list(columns_to_drop)}")
```

```
Columns dropped: ['Intersection Directions', 'Plus4', 'Expected Date', 'Cards Accepted', 'BD Blends', 'NG Fill Type Code', 'NG PSI', 'EV Level1 EVSE Num', 'E
V Other Info', 'Federal Agency ID', 'Federal Agency Name', 'Hydrogen Status Link', 'NG Vehicle Class', 'LPG Primary', 'E85 Blender Pump', 'Intersection Direc
tions (French)', 'BD Blends (French)', 'Hydrogen Is Retail', 'Access Detail Code', 'Federal Agency Code', 'CNG Dispenser Num', 'CNG On-Site Renewable Sourc
e', 'CNG Total Compression Capacity', 'CNG Storage Capacity', 'LNG On-Site Renewable Source', 'E85 Other Ethanol Blends', 'EV Pricing', 'EV Pricing (Frenc
h)', 'LPG Nozzle Types', 'Hydrogen Pressures', 'Hydrogen Standards', 'CNG Fill Type Code', 'CNG PSI', 'CNG Vehicle Class', 'LNG Vehicle Class', 'EV On-Site R
enewable Source', 'Restricted Access', 'RD Blends', 'RD Blends (French)', 'RD Blended with Biodiesel', 'RD Maximum Biodiesel Level', 'NPS Unit Name', 'CNG St
ation Sells Renewable Natural Gas', 'LNG Station Sells Renewable Natural Gas', 'Maximum Vehicle Class', 'Funding Sources', 'EV CCS Power Output (kW)', 'EV CH
AdeMO Power Output (kW)', 'EV J3400 Power Output (kW)']
```

In [149…

```python
df.info() #checking the info after dropping key columns comtaining null values >80%
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 31562 entries, 0 to 31561
Data columns (total 34 columns):
 #   Column                           Non-Null Count  Dtype
---  ------                           --------------  -----
 0   Fuel Type Code                   31562 non-null  object
 1   Station Name                     31562 non-null  object
 2   Street Address                   31562 non-null  object
 3   City                             31562 non-null  object
 4   State                            31562 non-null  object
 5   ZIP                              31562 non-null  object
 6   Station Phone                    31185 non-null  object
 7   Status Code                      31562 non-null  object
 8   Groups With Access Code          31562 non-null  object
 9   Access Days Time                 28355 non-null  object
 10  EV Level2 EVSE Num               26060 non-null  float64
 11  EV DC Fast Count                 6553 non-null   float64
 12  EV Network                       31562 non-null  object
 13  EV Network Web                   29550 non-null  object
 14  Geocode Status                   31561 non-null  object
 15  Latitude                         31562 non-null  float64
 16  Longitude                        31562 non-null  float64
 17  Date Last Confirmed              31444 non-null  object
 18  ID                               31562 non-null  int64
 19  Updated At                       31562 non-null  object
 20  Owner Type Code                  8709 non-null   object
 21  Open Date                        31498 non-null  object
 22  EV Connector Types               31562 non-null  object
 23  Country                          31562 non-null  object
 24  Access Days Time (French)        28027 non-null  object
 25  Groups With Access Code (French) 31562 non-null  object
 26  Access Code                      31562 non-null  object
 27  Facility Type                    6682 non-null   object
 28  EV Workplace Charging            31562 non-null  bool
 29  EV J1772 Connector Count         31562 non-null  int64
 30  EV J1772 Power Output (kW)       20986 non-null  float64
 31  EV CCS Connector Count           31562 non-null  int64
 32  EV CHAdeMO Connector Count       31562 non-null  int64
 33  EV J3400 Connector Count         31562 non-null  int64
dtypes: bool(1), float64(5), int64(5), object(23)
memory usage: 8.0+ MB
```

In [151…

```
df.head() #getting top few rows in th dataset
```

Out[151…

	Fuel Type Code	Station Name	Street Address	City	State	ZIP	Station Phone	Status Code	Groups With Access Code	Access Days Time	...	Access Days Time (French)	Groups With Access Code (French)	Access Code	Facility Type	EV Workplace Charging	EV J1772 Connector Count	EV J1772 Power Output (kW)	Cc
0	ELEC	Ramada	1319 2nd St W	Brooks	AB	T1R 1P7	403-362-6440	E	Public - Call ahead	24 hours daily; see front desk for access	...	24 heures par jour; voire le concierge pour acces	Public - Appeler à l'avance	public	HOTEL	False	1	NaN	
1	ELEC	Davis Chevrolet	149 E Lake Crescent NE	Airdrie	AB	T4A 2H9	403-948-6909	E	Public	24 hours daily; for client use only	...	24 heures par jour; à l'usage des clients seul...	Public	public	CAR_DEALER	False	1	NaN	
2	ELEC	Gasonic Instruments	8-823 41st Ave NE	Calgary	AB	T2E 6Y3	403-276-2201	E	Public - Limited hours	8am-5pm M-F; remaining hours and all weekends ...	...	8:00-17:00 LUN-VEN; disponible au public le re...	Public - Heures limitées	public	OFFICE_BLDG	True	1	NaN	
3	ELEC	International Motor Cars	7220 Railway St SE	Calgary	AB	T2H 3A8	844-288-8918	E	Public - Call ahead	24 hours daily	...	Accessible 24 heures par jour	Public - Appeler à l'avance	public	CAR_DEALER	False	1	NaN	
4	ELEC	Residence Inn	3710 Market St SE	Calgary	AB	T3M 2P2	587-349-8633	E	Public	24 hours daily; for guest use only; parking fe...	...	24 heures par jour; des clients seulement; fra...	Public	public	HOTEL	False	1	NaN	

5 rows × 34 columns

In [153…

```
# Dropping irrelevant columns that are not needed for the analysis
columns_to_remove = [
    'Station Phone',              # Contact details, not relevant for analysis
    'Groups With Access Code',    # Access code information, likely not useful
    'EV Network Web',             # Website links, not needed
    'Geocode Status',             # Geocoding status, unnecessary for the objectives
    'ID',                         # Unique ID, no analytical value
    'Access Days Time (French)',  # French duplicate of 'Access Days Time'
    'Groups With Access Code (French)', # French duplicate of access-related column
]

# Drop the columns from the dataset
df = df.drop(columns=columns_to_remove, axis=1)

# Check the updated DataFrame
print(f"Remaining columns: {df.columns}")
```

```
Remaining columns: Index(['Fuel Type Code', 'Station Name', 'Street Address', 'City', 'State',
       'ZIP', 'Status Code', 'Access Days Time', 'EV Level2 EVSE Num',
       'EV DC Fast Count', 'EV Network', 'Latitude', 'Longitude',
       'Date Last Confirmed', 'Updated At', 'Owner Type Code', 'Open Date',
       'EV Connector Types', 'Country', 'Access Code', 'Facility Type',
       'EV Workplace Charging', 'EV J1772 Connector Count',
       'EV J1772 Power Output (kW)', 'EV CCS Connector Count',
       'EV CHAdeMO Connector Count', 'EV J3400 Connector Count'],
      dtype='object')
```

In [155…

```python
# Extracting the year from 'Open Date'
df['Year']=pd.to_datetime(df['Open Date'], errors='coerce').dt.year.astype('Int64')
```

In [157…

```python
# Sort the DataFrame by the 'Year' column in ascending order
df_sorted = df.sort_values(by='Year', ascending=True)

# Display the first few rows to confirm sorting
df_sorted.head()
```

Out[157…

	Fuel Type Code	Station Name	Street Address	City	State	ZIP	Status Code	Access Days Time	EV Level2 EVSE Num	EV DC Fast Count	...	Country	Access Code	Facility Type	EV Workplace Charging	EV J1772 Connector Count	EV J1772 Power Output (kW)	EV CCS Connector Count	CH Co
190	ELEC	Paul Sadlon Motors Inc	550 Bayfield St	Barrie	ON	L4M 5A2	E	Dealership business hours	3.0	NaN	...	CA	public	CAR_DEALER	False	1	NaN	0	
191	ELEC	Paul Sadlon Motors Inc	550 Bayfield St	Barrie	ON	L4M 5A2	E	Dealership business hours	3.0	NaN	...	CA	public	CAR_DEALER	False	1	NaN	0	
192	ELEC	Paul Sadlon Motors Inc	550 Bayfield St	Barrie	ON	L4M 5A2	E	Dealership business hours	3.0	NaN	...	CA	public	CAR_DEALER	False	1	NaN	0	
649	ELEC	Gabriel Ford Lincoln	7100 rue Saint-Jacques	Montreal	QC	H4B 1V2	E	Dealership business hours; For client use only	1.0	NaN	...	CA	public	CAR_DEALER	False	1	NaN	0	
403	ELEC	Chevrolet GMC Roberval	321 boul. Marcotte	Roberval	QC	G8H 1Z4	E	24 hours daily; for client use only	1.0	1.0	...	CA	public	CAR_DEALER	False	0	NaN	1	

5 rows × 28 columns

In [159…

```python
# Additional columns to drop
more_columns_to_remove = [
    'Facility Type',                # May not directly affect trends or visuals
    'EV J1772 Power Output (kW)',   # Technical details about power output
    'Updated At',                   # Metadata, not relevant for analysis
    ]


# Drop these columns from the DataFrame
df = df.drop(columns=more_columns_to_remove, axis=1)

# Check the remaining columns to confirm
print(f"Remaining columns: {df.columns}")
```

```
Remaining columns: Index(['Fuel Type Code', 'Station Name', 'Street Address', 'City', 'State',
       'ZIP', 'Status Code', 'Access Days Time', 'EV Level2 EVSE Num',
       'EV DC Fast Count', 'EV Network', 'Latitude', 'Longitude',
       'Date Last Confirmed', 'Owner Type Code', 'Open Date',
       'EV Connector Types', 'Country', 'Access Code', 'EV Workplace Charging',
       'EV J1772 Connector Count', 'EV CCS Connector Count',
       'EV CHAdeMO Connector Count', 'EV J3400 Connector Count', 'Year'],
      dtype='object')
```

In [161…

```python
# Check the unique values in the Access Code column
print(df['Access Code'].unique())
```

```
['public']
```

In [163…

```python
df = df.drop(columns=['Access Code']) #as it contains only public unique value
```

In [165…

```python
df.isnull().sum()/len(df)*100  #checking the null percentage again
```

Out[165…
```
Fuel Type Code                0.000000
Station Name                  0.000000
Street Address                0.000000
City                          0.000000
State                         0.000000
ZIP                           0.000000
Status Code                   0.000000
Access Days Time             10.160953
EV Level2 EVSE Num           17.432355
EV DC Fast Count             79.237691
EV Network                    0.000000
Latitude                      0.000000
Longitude                     0.000000
Date Last Confirmed           0.373867
Owner Type Code              72.406692
Open Date                     0.202775
EV Connector Types            0.000000
Country                       0.000000
EV Workplace Charging         0.000000
EV J1772 Connector Count      0.000000
EV CCS Connector Count        0.000000
EV CHAdeMO Connector Count    0.000000
EV J3400 Connector Count      0.000000
Year                          0.202775
dtype: float64
```

In [167…
```
# Fill categorical columns with 'Unknown'
df['Access Days Time'] = df['Access Days Time'].fillna('Unknown')
df['Owner Type Code'] = df['Owner Type Code'].fillna('Unknown')
```

In [169…
```
# Fill numerical columns with median
# - Median is chosen because it is robust to outliers and represents the central tendency
df['EV Level2 EVSE Num'] = df['EV Level2 EVSE Num'].fillna(df['EV Level2 EVSE Num'].median())



#  Fill missing values in 'EV DC Fast Count' with 0
# - 0 is used because missing values likely mean the absence of DC fast chargers
df['EV DC Fast Count'] = df['EV DC Fast Count'].fillna(0)



# Fill missing values in 'Open Date' with the placeholder 'Unknown'
# - 'Unknown' is used as a string placeholder because:
#   1. Open Date might not always be available in the dataset.
#   2. This avoids dropping rows while clearly indicating missing values.
df['Open Date'] = df['Open Date'].fillna('Unknown')



# Fill missing values in 'Date Last Confirmed' with the most frequent value (mode)
# - Mode is chosen because:
#   1. It's the most common value and a reasonable assumption for missing data.
#   2. It prevents introducing misleading or biased information into the dataset.
df['Date Last Confirmed'] = df['Date Last Confirmed'].fillna(df['Date Last Confirmed'].mode()[0])



# Check for remaining null values (to verify)
print(df.isnull().sum())
```

```
Fuel Type Code                0
Station Name                  0
Street Address                0
City                          0
State                         0
ZIP                           0
Status Code                   0
Access Days Time              0
EV Level2 EVSE Num            0
EV DC Fast Count              0
EV Network                    0
Latitude                      0
Longitude                     0
Date Last Confirmed           0
Owner Type Code               0
Open Date                     0
EV Connector Types            0
Country                       0
EV Workplace Charging         0
EV J1772 Connector Count      0
EV CCS Connector Count        0
EV CHAdeMO Connector Count    0
EV J3400 Connector Count      0
Year                         64
dtype: int64
```

In [171…
```
# Drop rows where 'Year' is NaN
# - The 'Year' column is critical for time-series analysis.
# - Rows with missing 'Year' values (~0.2% of the dataset) were dropped
#   to ensure the accuracy and clarity of trends over time.
df = df.dropna(subset=['Year'])

print(df.isnull().sum())
```

```
Fuel Type Code                0
Station Name                  0
Street Address                0
City                          0
State                         0
ZIP                           0
Status Code                   0
Access Days Time              0
EV Level2 EVSE Num            0
EV DC Fast Count              0
EV Network                    0
Latitude                      0
Longitude                     0
Date Last Confirmed           0
Owner Type Code               0
Open Date                     0
EV Connector Types            0
Country                       0
EV Workplace Charging         0
EV J1772 Connector Count      0
EV CCS Connector Count        0
EV CHAdeMO Connector Count    0
EV J3400 Connector Count      0
Year                          0
dtype: int64
```

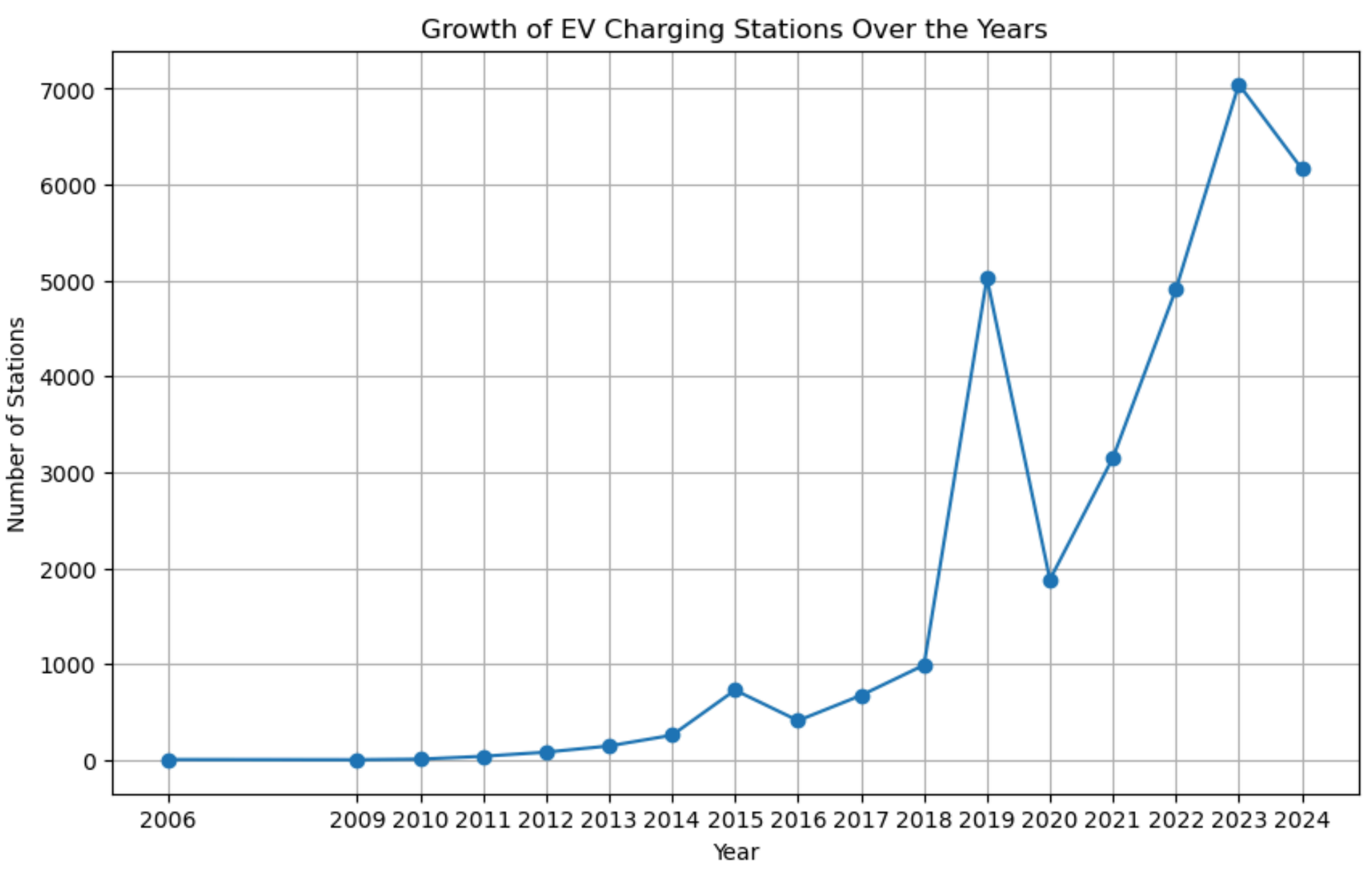
In [ ]:

In [ ]:

In [69]:
```
#Data Exploration & visulization
```

In [173…
```
# Group data by Year and count the number of stations
# Using .size() here instead of .count() because:
# - .size() counts all rows, regardless of column values
# - We've already handled missing values by replacing NaN with 'Unknown',
#   so .size() and .count() would give the same result in this case.
stations_by_year = df.groupby('Year').size()
```

In [175…
```
# Plot year-by-year trends
plt.figure(figsize=(10, 6))
stations_by_year.plot(kind='line', marker='o', title='Growth of EV Charging Stations Over the Years')
plt.xlabel('Year')
plt.ylabel('Number of Stations')
plt.xticks(stations_by_year.index)
plt.grid()
plt.show()
```

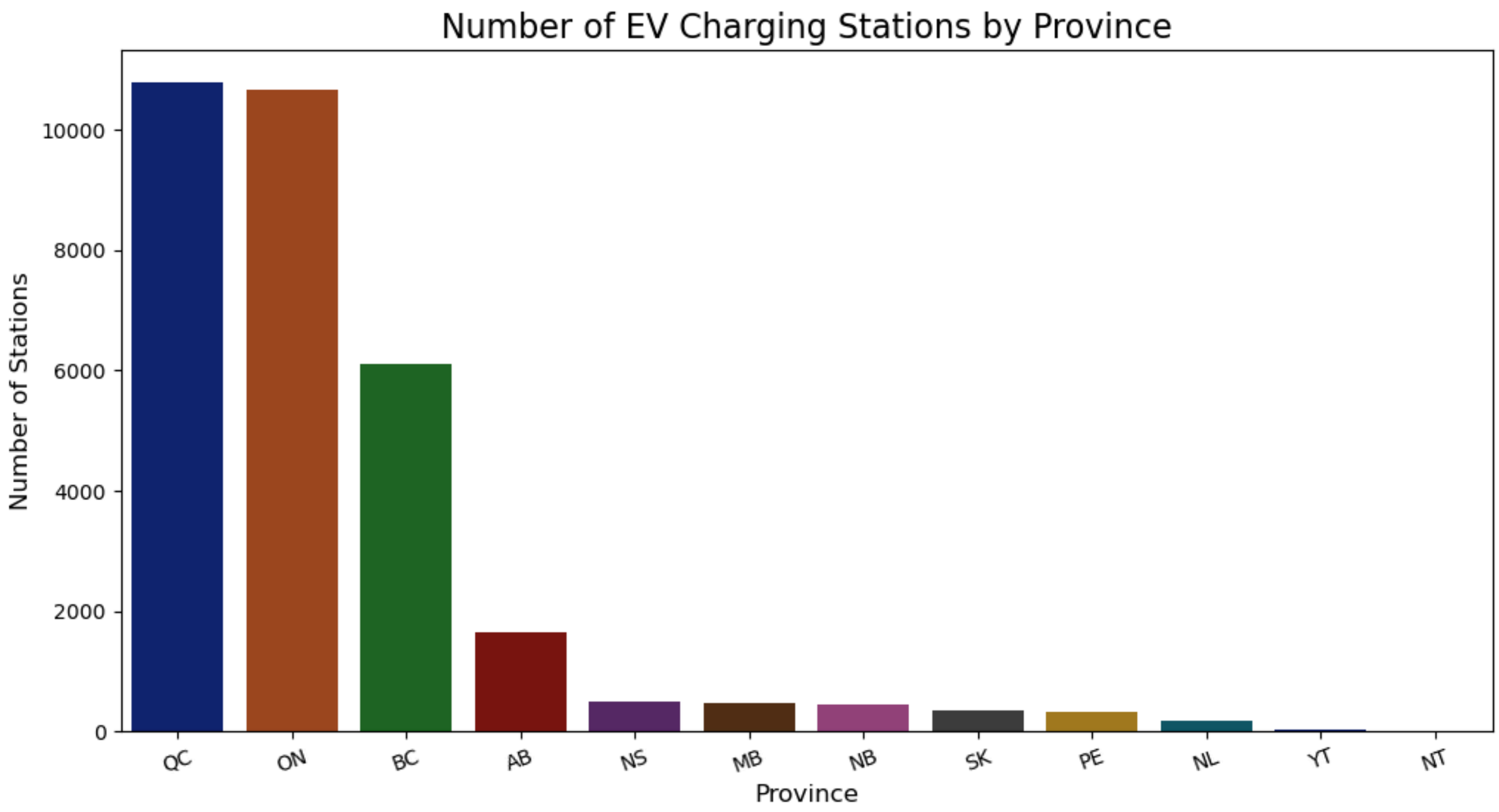


In [ ]:
```
#Observation:
#The line chart illustrates the steady growth of EV charging stations in Canada over the years.
#Starting with modest growth until 2018, there is a significant spike in the number of stations from 2019 onward,
#reflecting increased investment in EV infrastructure.
#The dip in 2020 could be attributed to the COVID-19 pandemic, which likely impacted infrastructure projects.
#However, the rapid growth from 2021 onward showcases a strong push toward supporting EV adoption and expanding charging accessibility across the country.
```

In [ ]:

In [47]:
```
# Count the number of stations per province
stations_by_province = df['State'].value_counts()
```

In [241…
```
# Bar plot for province-wise distribution
plt.figure(figsize=(12, 6))
sns.barplot(x=stations_by_province.index, y=stations_by_province.values, hue=stations_by_province.index,palette='dark')
#Assigning a dummy hue to use palette &avoid warning
plt.title('Number of EV Charging Stations by Province', fontsize=16)
plt.xlabel('Province', fontsize=12)
plt.ylabel('Number of Stations', fontsize=12)
plt.xticks(rotation=20)
plt.show()
```



In [ ]:
```
##Observation = The bar chart highlights the distribution of EV charging stations across provinces.
#Quebec, Ontario, and British Columbia have the highest number of stations, showing a strong focus on EV infrastructure in these regions.
```

In [ ]:
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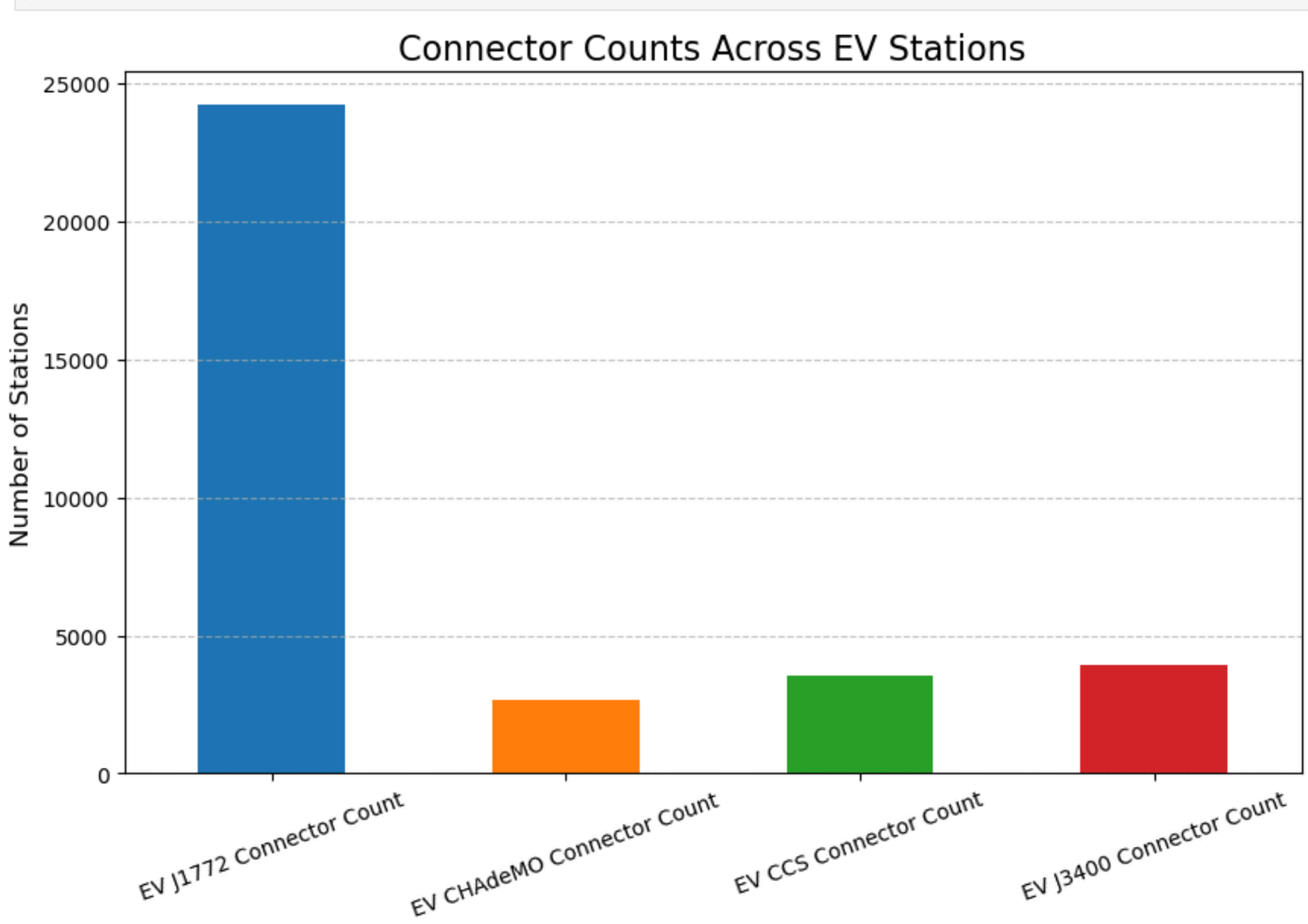
```

In [243…
```
# Sum the counts of each connector type
connector_counts_by_type = df[['EV J1772 Connector Count', 'EV CHAdeMO Connector Count', 'EV CCS Connector Count', 'EV J3400 Connector Count']].sum()

# Plot as a bar chart
plt.figure(figsize=(10, 6))
connector_counts_by_type.plot(kind='bar', color=['#1f77b4', '#ff7f0e', '#2ca02c', '#d62728'])
plt.title('Connector Counts Across EV Stations', fontsize=16)
plt.xlabel('Connector Type', fontsize=12)
plt.ylabel('Number of Stations', fontsize=12)
plt.xticks(rotation=20)
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.show()
```



In [ ]:
```
#Observation:
#The above bar chart displays the distribution of connector counts across EV stations in Canada.
#The J1772 connector dominates, reflecting its widespread use in Level 2 charging infrastructure.
#CHAdeMO, CCS, and J3400 connectors are less common and are critical for fast charging, supporting diverse EV models and use cases.
#This distribution underscores the focus on both standard and fast charging infrastructure.
```

In [ ]:
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```

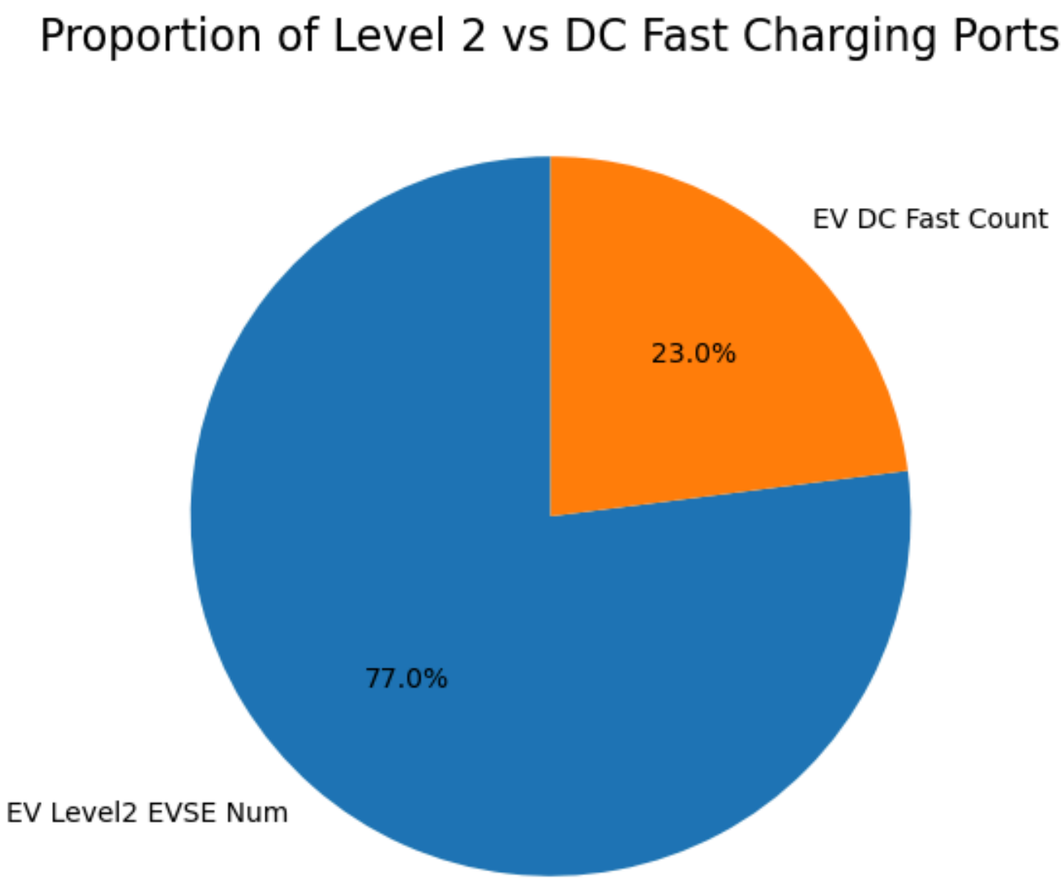
In [107…
```
print(df["EV Connector Types"].unique()) #different types of EV connectors
```

```
['J1772' 'CHADEMO J1772 J1772COMBO NEMA520' 'CHADEMO J1772COMBO'
 'J1772COMBO' 'TESLA' 'CHADEMO J1772 J1772COMBO' 'J1772 TESLA'
 'J1772 J1772COMBO' 'J1772 NEMA515' 'CHADEMO J1772' 'CHADEMO'
 'J1772 NEMA520' 'CHADEMO J1772 NEMA520' 'NEMA520' 'J1772COMBO TESLA'
 'CHADEMO J1772COMBO TESLA' 'J1772 NEMA1450']
```

In [193…

```python
# Sum Level 2 and DC Fast charging ports
charging_counts = df[['EV Level2 EVSE Num', 'EV DC Fast Count']].sum()

# Plot a pie chart
plt.figure(figsize=(8, 6))
charging_counts.plot(kind='pie', autopct='%1.1f%%', startangle=90, colors=['#1f77b4', '#ff7f0e'])
plt.title('Proportion of Level 2 vs DC Fast Charging Ports', fontsize=16)
plt.ylabel('')  # Removing the y-axis label
plt.show()
```



In [ ]:

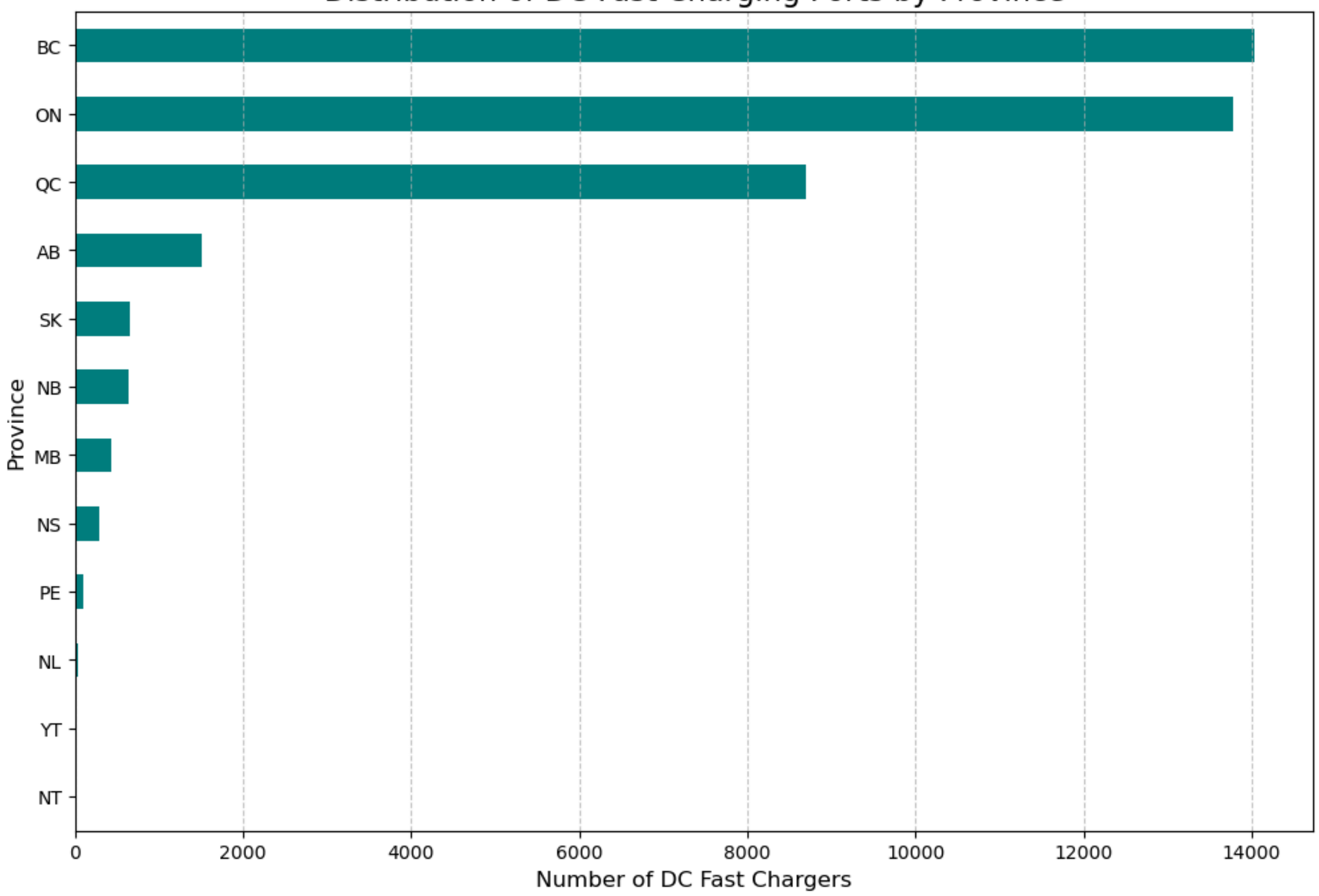
```python
#Observation:
#The above pie chart shows the proportion of Level 2 and DC fast chargers in Canada’s EV charging network.
#Level 2 chargers dominate, accounting for the majority of charging infrastructure,
#while DC fast chargers make up a smaller but critical proportion for rapid charging needs.
```

In [ ]:

In [195…

```python
# Group by State and sum DC fast chargers
dc_fast_by_state = df.groupby('State')['EV DC Fast Count'].sum().sort_values()

# Plot a horizontal bar chart
plt.figure(figsize=(12, 8))
dc_fast_by_state.plot(kind='barh', color='teal')
plt.title('Distribution of DC Fast Charging Ports by Province', fontsize=16)
plt.xlabel('Number of DC Fast Chargers', fontsize=12)
plt.ylabel('Province', fontsize=12)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.show()
```



In [ ]:
```
#Observation:
#The above horizontal bar chart highlights the distribution of DC fast chargers across provinces.
#Quebec, Ontario, and British Columbia lead in fast charging infrastructure,
#while smaller provinces have limited availability, potentially requiring more investments.
```

In [ ]:
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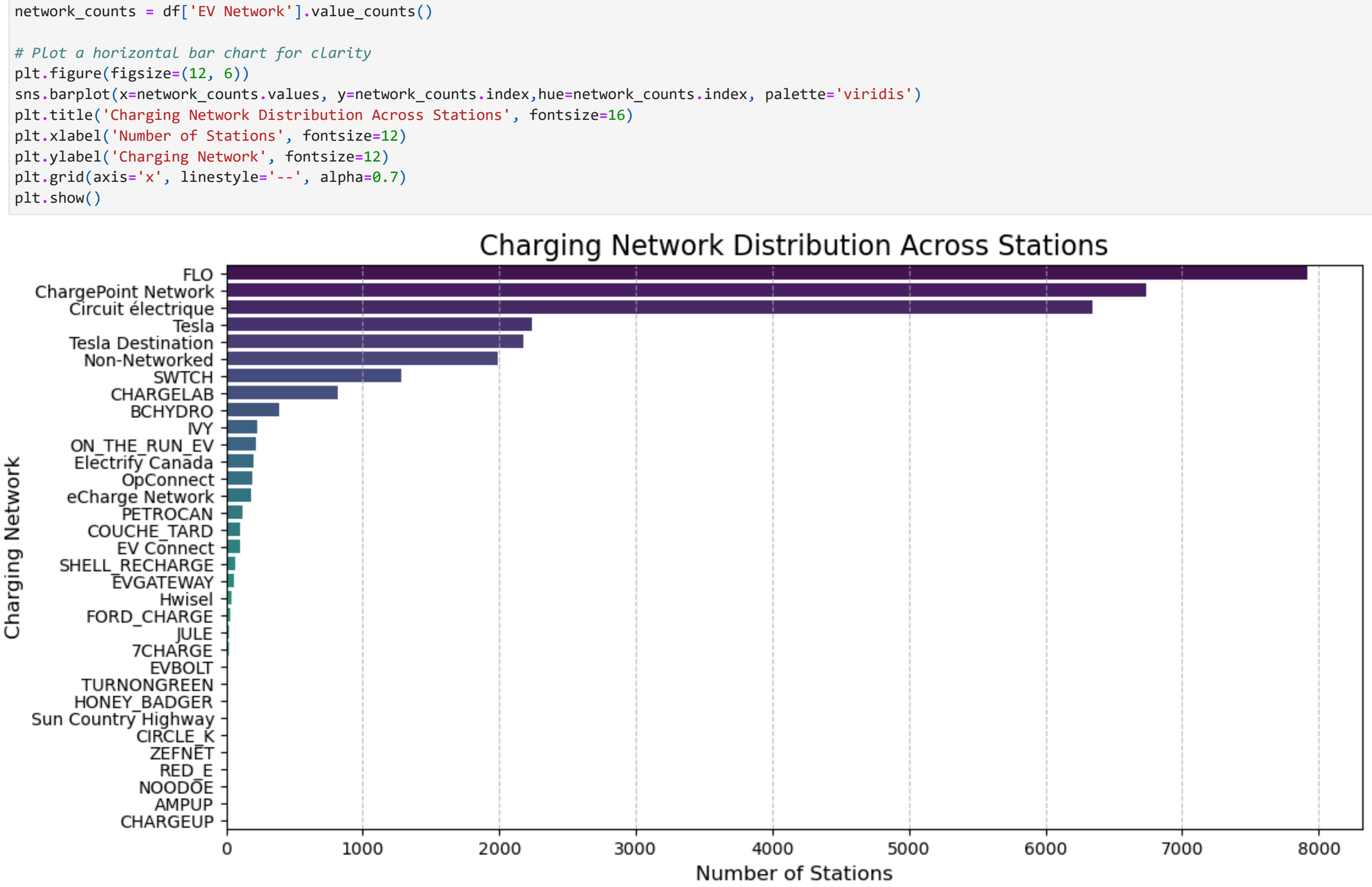
```

In [213…
```
# Count stations by network
network_counts = df['EV Network'].value_counts()

# Plot a horizontal bar chart for clarity
plt.figure(figsize=(12, 6))
sns.barplot(x=network_counts.values, y=network_counts.index,hue=network_counts.index, palette='viridis')
plt.title('Charging Network Distribution Across Stations', fontsize=16)
plt.xlabel('Number of Stations', fontsize=12)
plt.ylabel('Charging Network', fontsize=12)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.show()
```



In [ ]:
```
#Observation:
#The horizontal bar chart shows the distribution of charging stations across networks.
#Flo and Tesla dominate, showcasing their extensive infrastructure.
#Other networks contribute significantly in specific regions, supporting diverse EV user needs.
```

In [ ]:
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```

In [215…
```
# Calculate the total number of stations per network
overall_top_networks = df['EV Network'].value_counts().head(5).index
```

```
print("Top 5 Charging Networks:", list(overall_top_networks))
```

```
Top 5 Charging Networks: ['FLO', 'ChargePoint Network', 'Circuit électrique', 'Tesla', 'Tesla Destination']
```

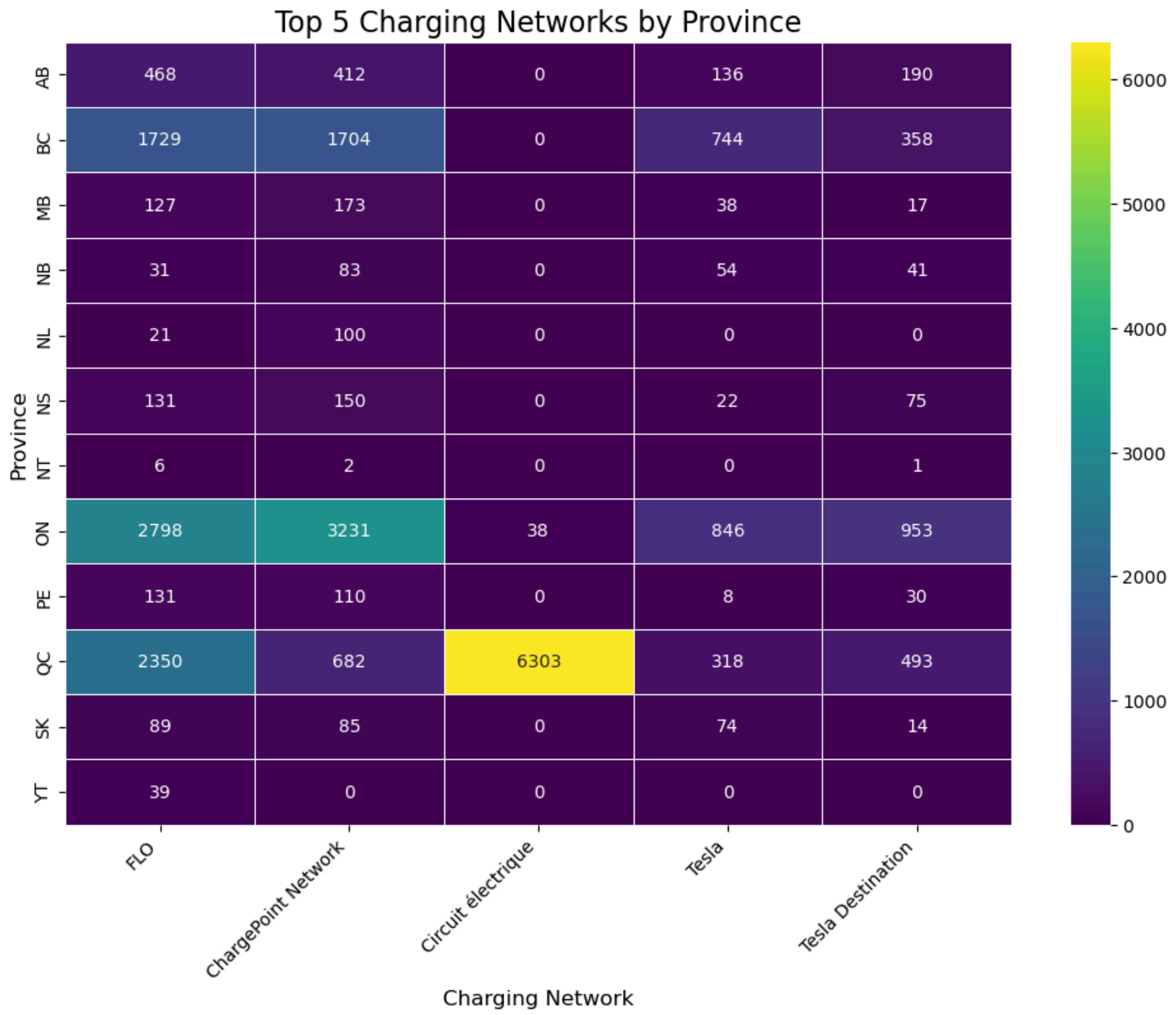
In [217…

```
# Group by State and EV Network and count the stations
network_by_state = df.groupby(['State', 'EV Network']).size().unstack(fill_value=0)

# Filter for only the top 5 networks
top_network_by_state = network_by_state[overall_top_networks]
```

In [227…

```
# Plot the heatmap
plt.figure(figsize=(12, 8))
sns.heatmap(top_network_by_state, cmap="viridis", annot=True, fmt="d", linewidths=.5, cbar=True)
plt.title('Top 5 Charging Networks by Province', fontsize=16)
plt.xlabel('Charging Network', fontsize=12)
plt.ylabel('Province', fontsize=12)
plt.xticks(rotation=45, ha='right')
plt.show()
```



In [ ]:

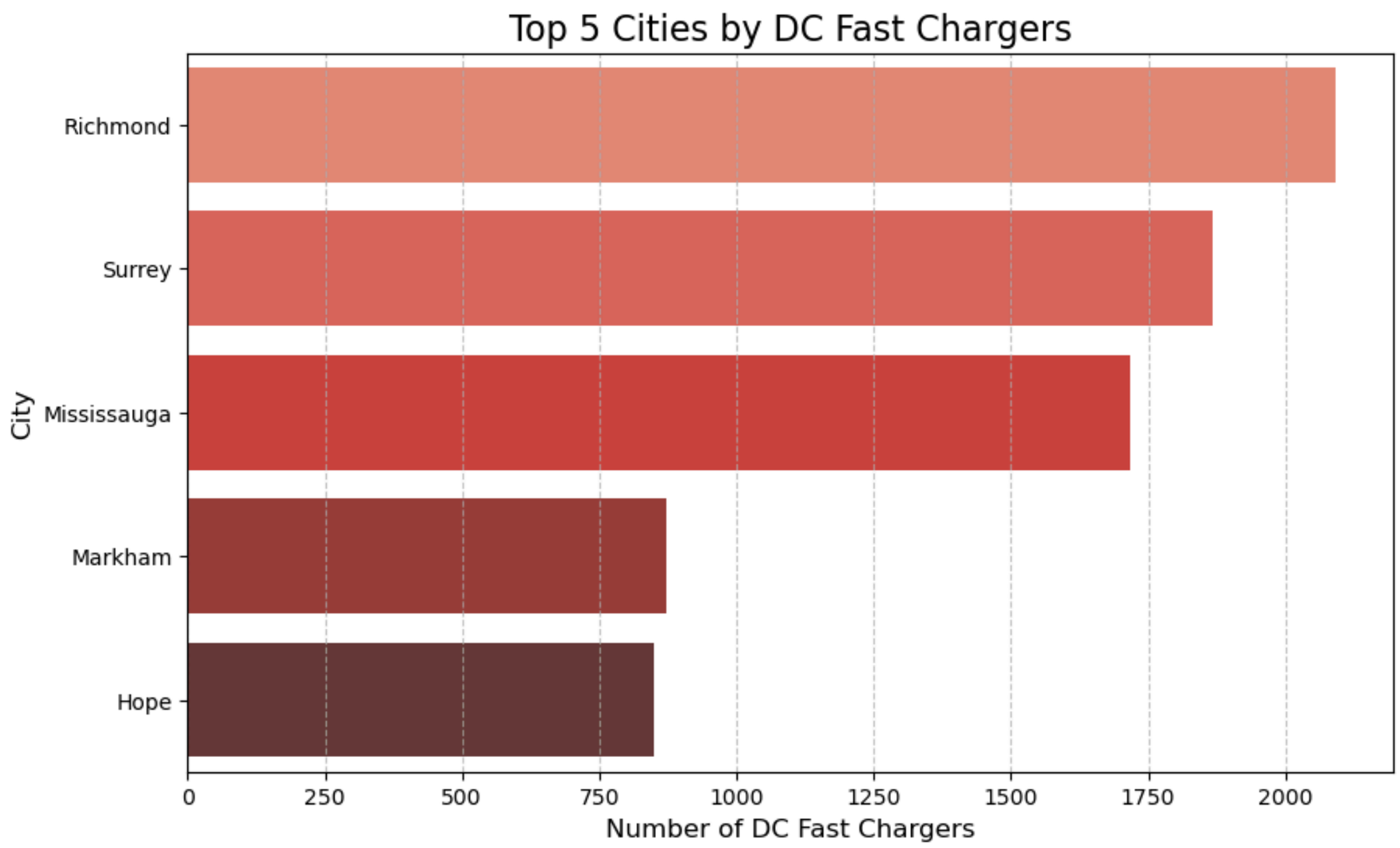
```
#Observation:
#The above heatmap shows the distribution of the top 5 charging networks across provinces.
#Flo is the most dominant network, with significant presence across most provinces.
#Tesla has a strong presence in regions like Ontario and British Columbia.
#Circuit électrique dominating in quebec and ChargePoint Network dominating in Ontario, reflecting their partnerships in key regions.
```

In [ ]:

In [239…

```
# Group by city and sum DC fast chargers
top_cities_dc_fast = df.groupby('City')['EV DC Fast Count'].sum().sort_values(ascending=False).head(5)

# Plot the top 5 cities by DC fast chargers
plt.figure(figsize=(10, 6))
sns.barplot(x=top_cities_dc_fast.values, y=top_cities_dc_fast.index,hue=top_cities_dc_fast.index, palette="Reds_d")
plt.title('Top 5 Cities by DC Fast Chargers', fontsize=16)
plt.xlabel('Number of DC Fast Chargers', fontsize=12)
plt.ylabel('City', fontsize=12)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.show()
```

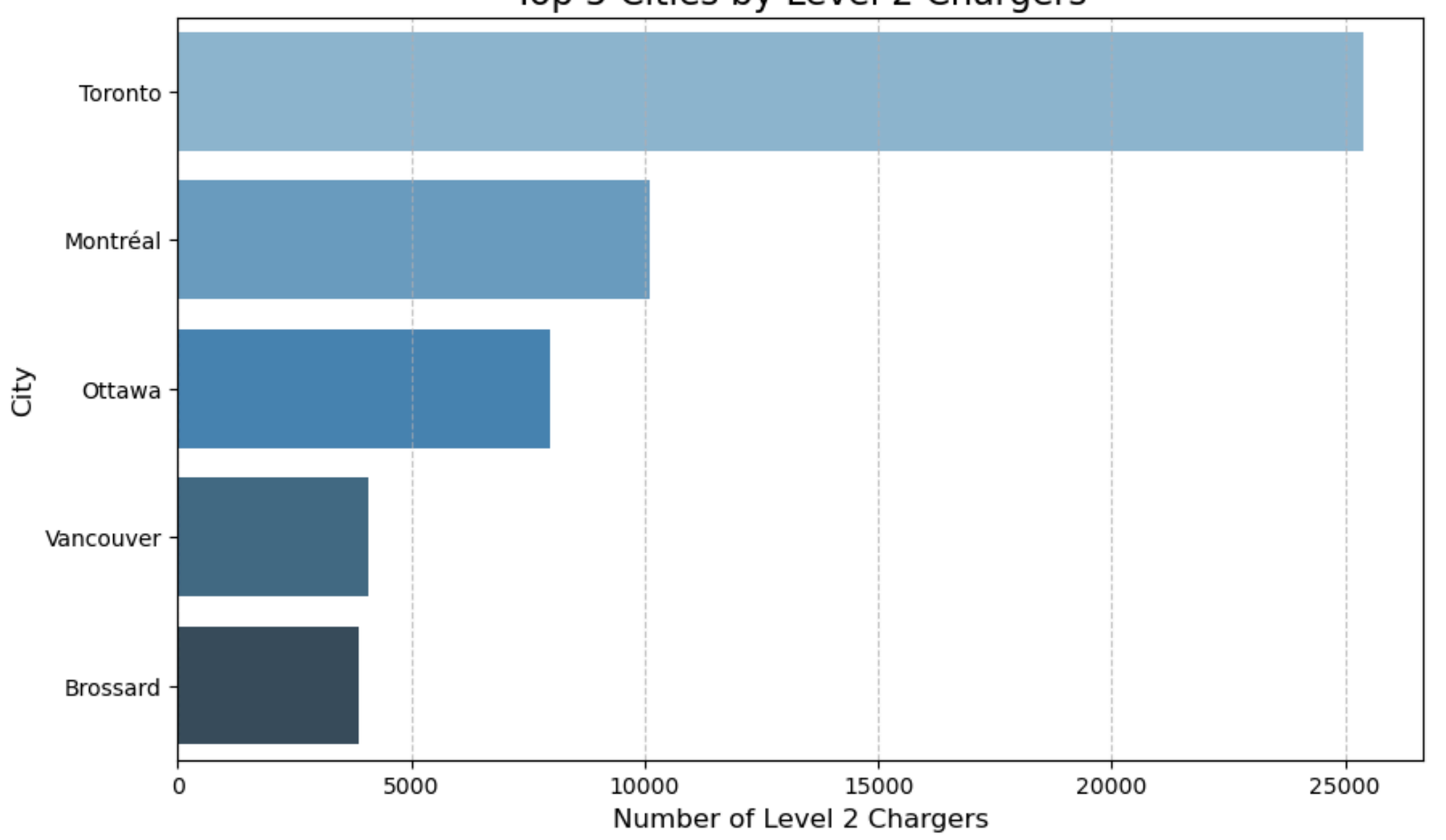


In [ ]:
```
#Observation:
#The above chart shows the top 5 cities with the highest number of DC fast chargers.
#These cities are crucial for enabling long-distance EV travel and reducing range anxiety.
```

In [ ]:
```
```

In [235…
```
# Group by city and sum Level 2 chargers
top_cities_level2 = df.groupby('City')['EV Level2 EVSE Num'].sum().sort_values(ascending=False).head(5)

# Plot the top 5 cities by Level 2 chargers
plt.figure(figsize=(10, 6))
sns.barplot(x=top_cities_level2.values, y=top_cities_level2.index, hue=top_cities_level2.index,palette="Blues_d")
plt.title('Top 5 Cities by Level 2 Chargers', fontsize=16)
plt.xlabel('Number of Level 2 Chargers', fontsize=12)
plt.ylabel('City', fontsize=12)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.show()
```



In [ ]:
```
#Observation:
#The above chart highlights cities with the highest capacity for Level 2 chargers,
#reflecting their focus on standard EV charging infrastructure.
```