In [7]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
```

In [8]:
```
#Introduction
```

Scandinavian countries provide a trove of data on how the implementation of a Carbon tax and cap-and-trade systems affects air pollution and quality; this is because these countries have been at the forefront of the "green" movement to combat climate change and other environmental issues. The data interest me from an economic perspective as environmental economics is a burgeoning field of study that fuses science and economics with public policy in fascinating ways. While most major countries have endorsed the cap-and-trade systems over a Carbon tax, Scandinavian countries have each been bold in their endorsements of a Carbon tax since the early 1990s. The goal of this project is to investigate how successful these carbon pricing techniques have been in ameliorating air quality. Hopefully, this examination will better explain pathways to incorporating similar policies for major world powers.

The first focus on analysis is to demystify the Carbon pricing mechanisms like carbon taxes and cap-and-trade systems countries have used for the last several years. For the sake of simplicity, brevity, and pertinence to Scandinavia, I will dedicate the major of my analysis under the carbon tax pricing mechanism. It is worth noting that these three countries stick out like a sore thumb in how radical their carbon taxes have been compared to the rest of the world since 2010 (2010 marks the first year of environmental air quality data from the WHO and we will begin our analysis there).

Next, we will be to break down how the pricing affects different energy sectors (oil, coal, and natural gas) and categorize data across each country individually and in comparison. This will be compared to a selection of air particles that have been sampled from Finland, Norway, and Sweden's capital cities across many years.

My hypothesis is that countries who are more aggressive in carbon pricing will have improved air quality. Of course, the investigation will be nuanced: it is not reasonable to expect rapid air quality improvement in only a few years of certain types of pricing. However, we should expect that countries who have consistently taxed fossil fuels at high levels will have better air quality than those who have only recently enacted policy.

In this project, we have three countries with similar geographic and meteorological features but varying degrees of carbon pricing via a Carbon tax. Remarkably, it is noted that each country independently introduced a Carbon tax within 1990-1991. With our WHO data only going back until 2010, we will use this year as a starting metric in an attempt to discover patterns that may determine the effectiveness of the tax.

The overall goal of the project is to determine whether of not using pricing instruments like the Carbon tax are effective or detrimental to improving air quality. We will discuss the possible limitations of doing this sort of maneuver on a grander scale for other nations around the world. Also, I will examine the economic tradeoffs countries with a Carbon tax exhibit in order to gauge the soundness of expanding the policy internationally. If there is an inverse correlation between a Carbon tax % and air quality particulate matter when examining each of the countries, we may be able to conclude that the methods are successful. If there is little correlation, it will be important to decipher why and point out certain externalities and see if the cap-and-trade systems are affecting the data at play. Additionally, it will be useful to explore how these taxes on fossil-fuel sectors embolden clean energy production like wind, solar, and nuclear. Hopefully, the analysis will determine the legitimacy of "green economics" for solving the international problem of improving air quality and respiratory health.

In [9]:
```
#Data Explained
```

The first source out of the two sources is from Resources for the Future World Carbon Pricing database, specifically from the three Scandinavian countries (Norway, Sweden and Finland). The data will explain how these countries use pricing instruments like carbon taxes, which set a price on carbon, and cap-and-trade systems, which cap the overall volume of emissions and creates a market for emissions allowances. Attached is the Github dataset with all countries listed but we will only focus on the aforementioned three countries.

https://github.com/g-dolphin/WorldCarbonPricingDatabase/tree/master/_dataset/data/CO2/national

The WHO data is individualized for each country, so we will analyze Finland, Norway, and Sweden with separate dictionaries in three different cases. The columns that we will incorporate into our analysis are WHO Country Name, City or Locality, Measurement Year, PM2.5 (μg/m3), PM10 (μg/m3), and NO2 (μg/m3) and we will only focus on the air samples taken from the three countries capital cities from 2010 through 2019 such that

PM2.5 (μg/m3) - describes the concentration of fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller

PM10 (μg/m3) - describes the concentration of fine inhalable particles, with diameters that are generally 10 micrometers and smaller

NO2 (μg/m3) - describes the concentration of Nitrogen Dioxide

In [10]:
```
#Dictionary for Finland Data
import pandas as pd
import matplotlib.pyplot as plt
data = pd.DataFrame({
    'WHO Country Name': ['Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland'],
    'City or Locality': ['Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [10.23, 8.48, 9.95, 6.48, 6.98, 6.22, 8.23, 7.29],
    'PM10 (μg/m3)': [19.23, 20.93, 21.96, 22.54, 21.24, 18.78, 22.29, 18.42],
    'NO2 (μg/m3)': [35.73, 30.66, 34.52, 37.71, 34.72, 29.57, 29.92, 26.99],
})
```

In [11]:
```
#Dictionary for Norway Data
data = pd.DataFrame({
    'WHO Country Name': ['Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway'],
    'City or Locality': ['Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [11.82, 11.23, 9.7, 8.13, 8.5, 7.14, 8.61, 7.51],
    'PM10 (μg/m3)': [22.91, 22.49, 18.3, 18.82, 18.16, 15.37, 18.31, 16.29],
    'NO2 (μg/m3)': [51.57, 46.9, 38.74, 38.94, 40.37, 33.57, 32.71, 29.77],
})
```

In [12]:
```
#Dictionary for Sweden Data
data = pd.DataFrame({
    'WHO Country Name': ['Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden'],
    'City or Locality': ['Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [7.84, 6.13, 7.13, 5.01, 5.5, 4.82, 6.21, 5.9],
    'PM10 (μg/m3)': [23.29, 24.81, 20.26, 18.96, 20.3, 18.17, 20.53, 17.89],
    'NO2 (μg/m3)': [37.57, 31.09, 27.31, 33.84, 28.84, 23.71, 26.34, 21.58],
})
```

The second source is from the WHO Air Quality database which lists air quality metrics for most if not all countries dating back to 2010. The Excel file appears by clicking the top hyperlink under "Excel Version - WHO Air Quality Database (Update 2022)" from this site:

https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database

This dataset is massive as it brings in Carbon taxing and cap and trade methods for countries all around the world. Of course, we will drop data from irrelevant countries and only focus on the Jurisdiction, Year, Product, tax_rate_excl_ex_clcu, and ets_price columns such that

Product - identifies specific commodity that faces Carbon pricing

tax_rate_excl_ex_clcu - identifies the tax rate per unit of carbon emissions, excluding any exemptions or exclusions that may apply, which provides a more accurate reflection of the actual cost of carbon emissions (Carbon Tax)

ets_price - Through a market-based approach for controlling pollution by allowing companies to buy and sell emissions allowances or permits, ets_price represents the cost of these permits to the right to emit a certain amount of a specific pollutant (Cap and Trade)

In [13]:
```
#Finland Tax Rate Data
years = np.arange(2010, 2023)
coal_tax_rates = [18.82442748, 27.6221374, 27.6221374, 32.22519084, 32.22519084, 40.51145038, 49.71755725, 53.40076336, 57.08396947, 56.41603053, 56.416030
natural_gas_tax_rates = [8.99009901, 29.40594059, 29.40594059, 34.30693069, 34.30693069, 43.11881188, 52.92079208, 56.83168317, 60.79207921, 64.05940594, 6
oil_tax_rates = [18.0, 18.0, 53.0, 53.0, 62.03333333, 62.03333333, 62.03333333, 66.33333333, 66.33333333, 66.33333333, 66.33333333, 66.33333333, 80.8]
```

In [15]:
```
#Norway Tax Rate Data
years = np.arange(2010, 2023)
##Norway has no coal data
natural_gas_tax_rates = [0.0, 220.0, 225.0, 230.0, 330.0, 372.5, 420.0, 450.0, 500.0, 510.0, 540.0, np.nan, np.nan]
oil_tax_rates = [430.0, 440.0, 445.0, 455.0, 465.0, 475.0, 485.0, 520.0, 580.0, 590.0, 590.0, 53.54, 80.82]
```

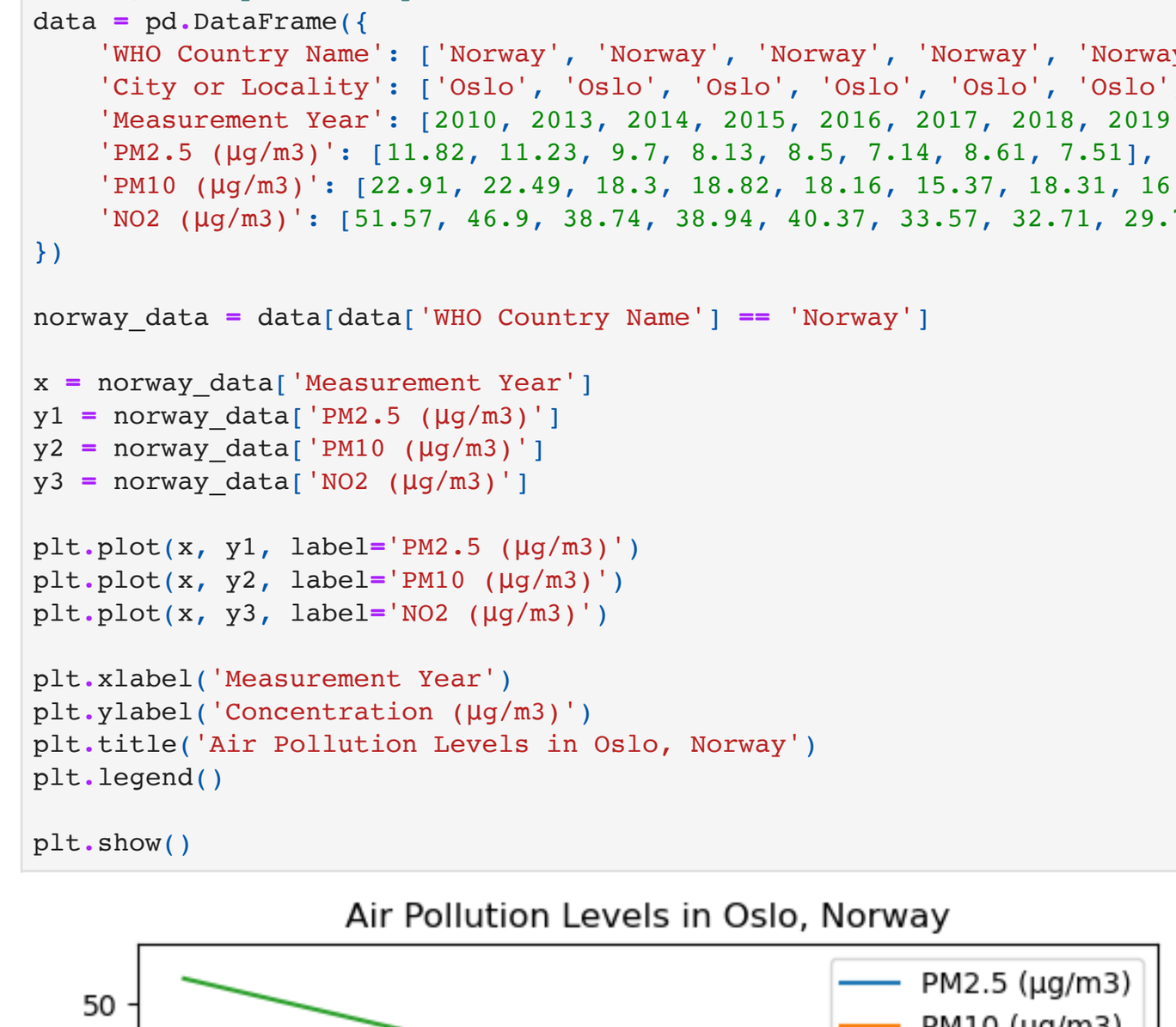
In [16]:
```
#Sweden Tax Rate Data
years = np.arange(2010, 2023)
coal_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.869565, 1205
natural_gas_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.86956
oil_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.869565, 1205.
```

In [17]:
```
#Data for ETS pricing or the cost to emit a certain amount of emissions

##Data for Finland
finland_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
finland_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]

##Data for Norway
norway_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
norway_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]

##Data for Sweden
sweden_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
sweden_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]
```

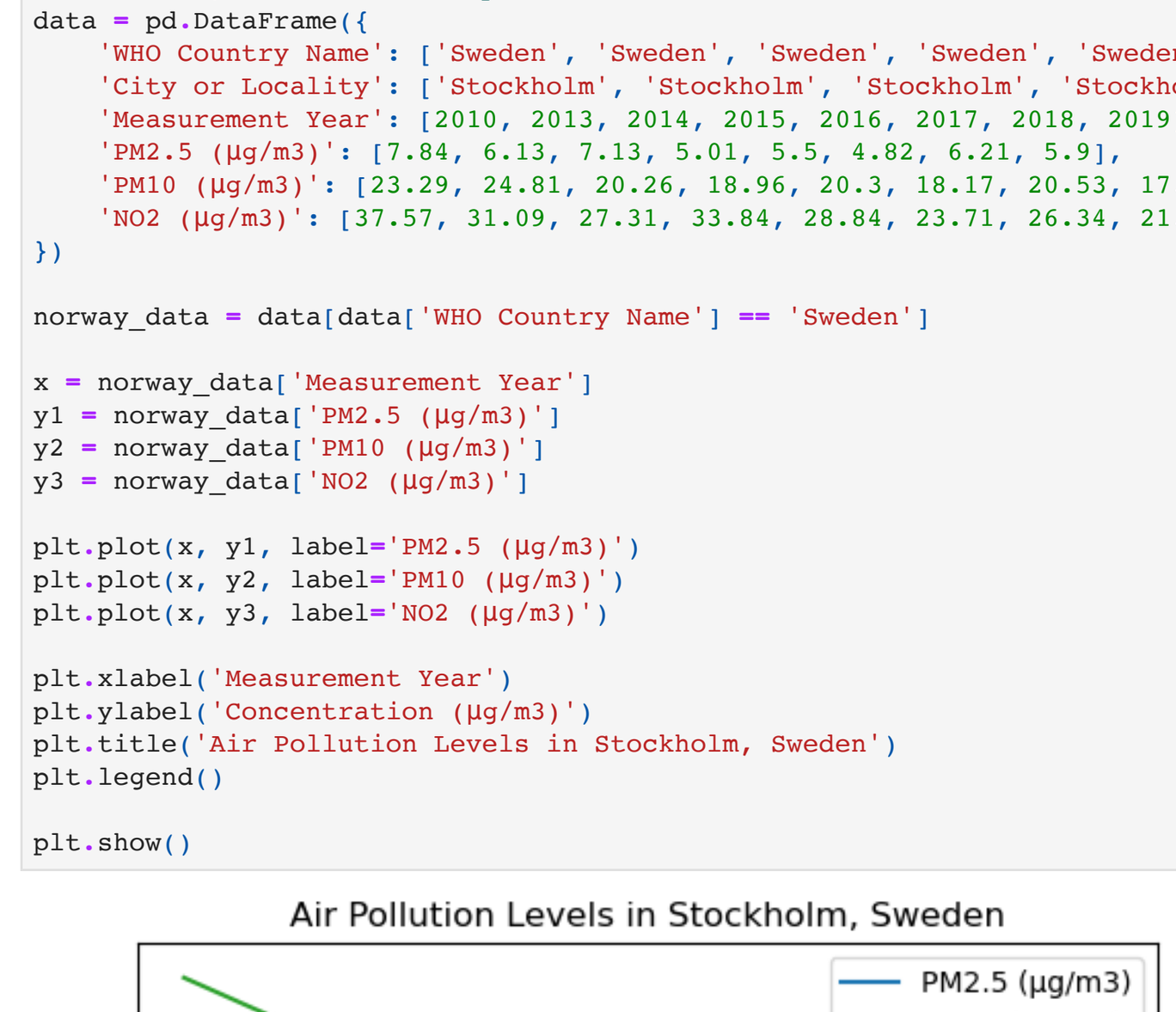
In [18]:
```
# Results
```

In [19]:
```
## We will begin with a line graph that tracks environmental metrics for each of the three countries
```

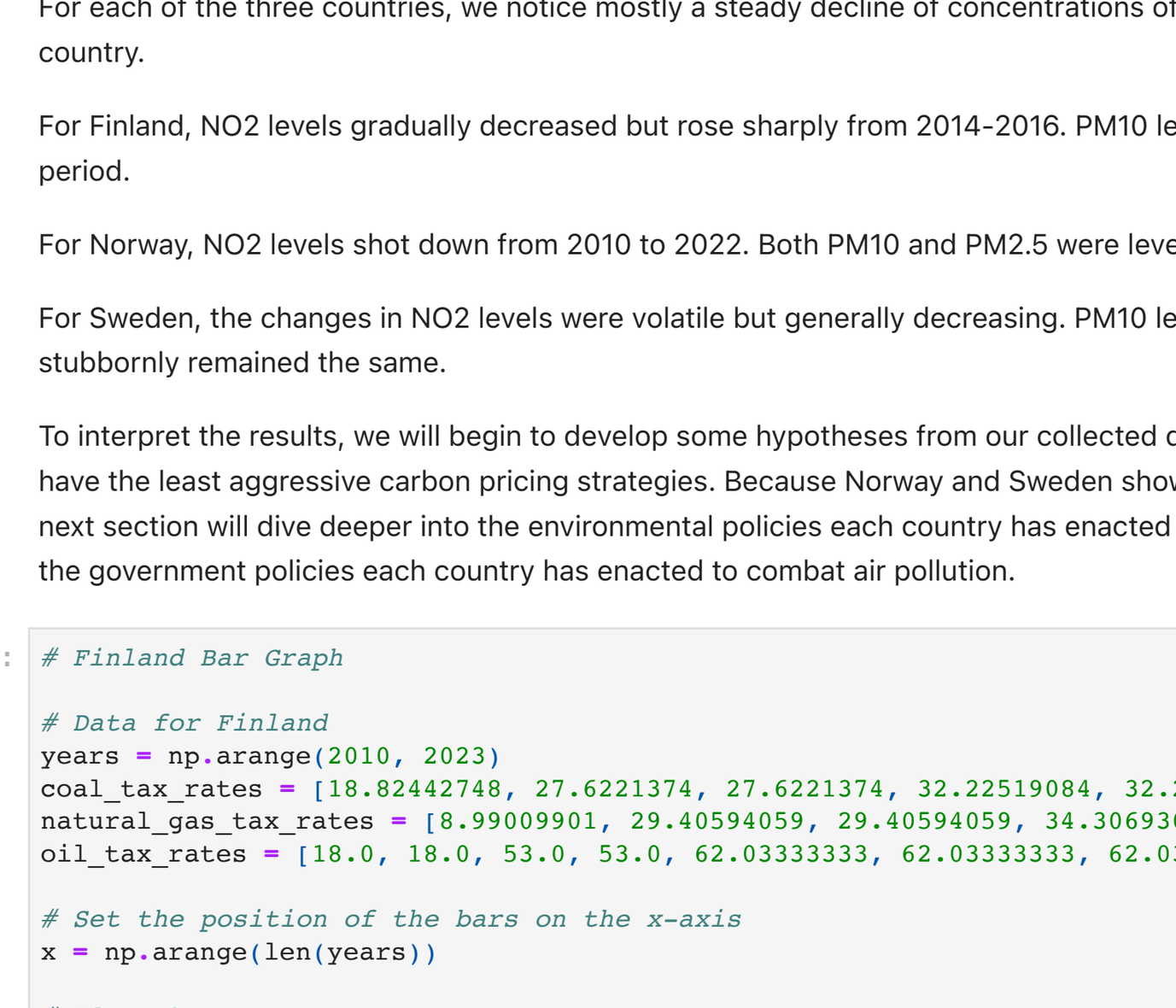
In [20]:
```
#Helsinki, Finland Line Graph

data = pd.DataFrame({
    'WHO Country Name': ['Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland', 'Finland'],
    'City or Locality': ['Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki', 'Helsinki'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [10.23, 8.48, 9.95, 6.48, 6.98, 6.22, 8.23, 7.29],
    'PM10 (μg/m3)': [19.23, 20.93, 21.96, 22.54, 21.24, 18.78, 22.29, 18.42],
    'NO2 (μg/m3)': [35.73, 30.66, 34.52, 37.71, 34.72, 29.57, 29.92, 26.99],
})

finland_data = data[data['WHO Country Name'] == 'Finland']

x = finland_data['Measurement Year']
y1 = finland_data['PM2.5 (μg/m3)']
y2 = finland_data['PM10 (μg/m3)']
y3 = finland_data['NO2 (μg/m3)']

plt.plot(x, y1, label='PM2.5 (μg/m3)')
plt.plot(x, y2, label='PM10 (μg/m3)')
plt.plot(x, y3, label='NO2 (μg/m3)')

plt.xlabel('Measurement Year')
plt.ylabel('Concentration (μg/m3)')
plt.title('Air Pollution Levels in Helsinki, Finland')
plt.legend()

plt.show()
```



In [21]:
```
# Oslo, Norway Line Graph
data = pd.DataFrame({
    'WHO Country Name': ['Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway', 'Norway'],
    'City or Locality': ['Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo', 'Oslo'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [11.82, 11.23, 9.7, 8.13, 8.5, 7.14, 8.61, 7.51],
    'PM10 (μg/m3)': [22.91, 22.49, 18.3, 18.82, 18.16, 15.37, 18.31, 16.29],
    'NO2 (μg/m3)': [51.57, 46.9, 38.74, 38.94, 40.37, 33.57, 32.71, 29.77],
})

norway_data = data[data['WHO Country Name'] == 'Norway']

x = norway_data['Measurement Year']
y1 = norway_data['PM2.5 (μg/m3)']
y2 = norway_data['PM10 (μg/m3)']
y3 = norway_data['NO2 (μg/m3)']

plt.plot(x, y1, label='PM2.5 (μg/m3)')
plt.plot(x, y2, label='PM10 (μg/m3)')
plt.plot(x, y3, label='NO2 (μg/m3)')

plt.xlabel('Measurement Year')
plt.ylabel('Concentration (μg/m3)')
plt.title('Air Pollution Levels in Oslo, Norway')
plt.legend()

plt.show()
```



In [22]:
```
# Stockholm, Sweden Line Graph
data = pd.DataFrame({
    'WHO Country Name': ['Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden', 'Sweden'],
    'City or Locality': ['Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm', 'Stockholm'],
    'Measurement Year': [2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019],
    'PM2.5 (μg/m3)': [7.84, 6.13, 7.13, 5.01, 5.5, 4.82, 6.21, 5.9],
    'PM10 (μg/m3)': [23.29, 24.81, 20.26, 18.96, 20.3, 18.17, 20.53, 17.89],
    'NO2 (μg/m3)': [37.57, 31.09, 27.31, 33.84, 28.84, 23.71, 26.34, 21.58],
})

norway_data = data[data['WHO Country Name'] == 'Sweden']

x = norway_data['Measurement Year']
y1 = norway_data['PM2.5 (μg/m3)']
y2 = norway_data['PM10 (μg/m3)']
y3 = norway_data['NO2 (μg/m3)']

plt.plot(x, y1, label='PM2.5 (μg/m3)')
plt.plot(x, y2, label='PM10 (μg/m3)')
plt.plot(x, y3, label='NO2 (μg/m3)')

plt.xlabel('Measurement Year')
plt.ylabel('Concentration (μg/m3)')
plt.title('Air Pollution Levels in Stockholm, Sweden')
plt.legend()

plt.show()
```



For each of the three countries, we notice mostly a steady decline of concentrations of the three different air particles. However, there are some important details to note for each country.

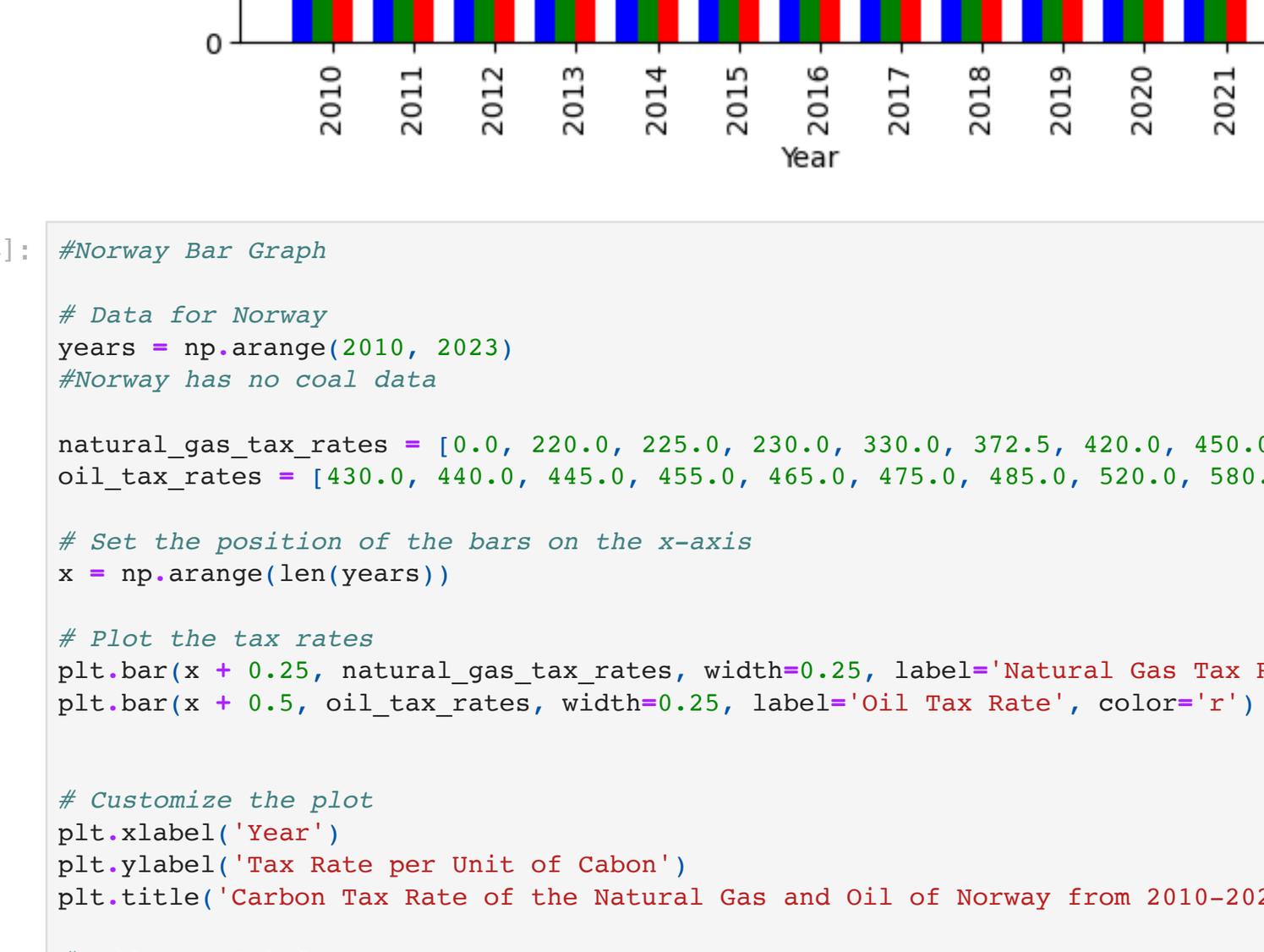
For Finland, NO2 levels gradually decreased but rose sharply from 2014-2016. PM10 levels generally remained stable, while PM2.5 were generally unchanged over the observed time period.

For Norway, NO2 levels shot down from 2010 to 2022. Both PM10 and PM2.5 were level with a gradual decreased in the same span.

For Sweden, the changes in NO2 levels were volatile but generally decreasing. PM10 levels increased from 2010-2012 but decreased for the rest of the chart. PM2.5 concentrations stubbornly remained the same.

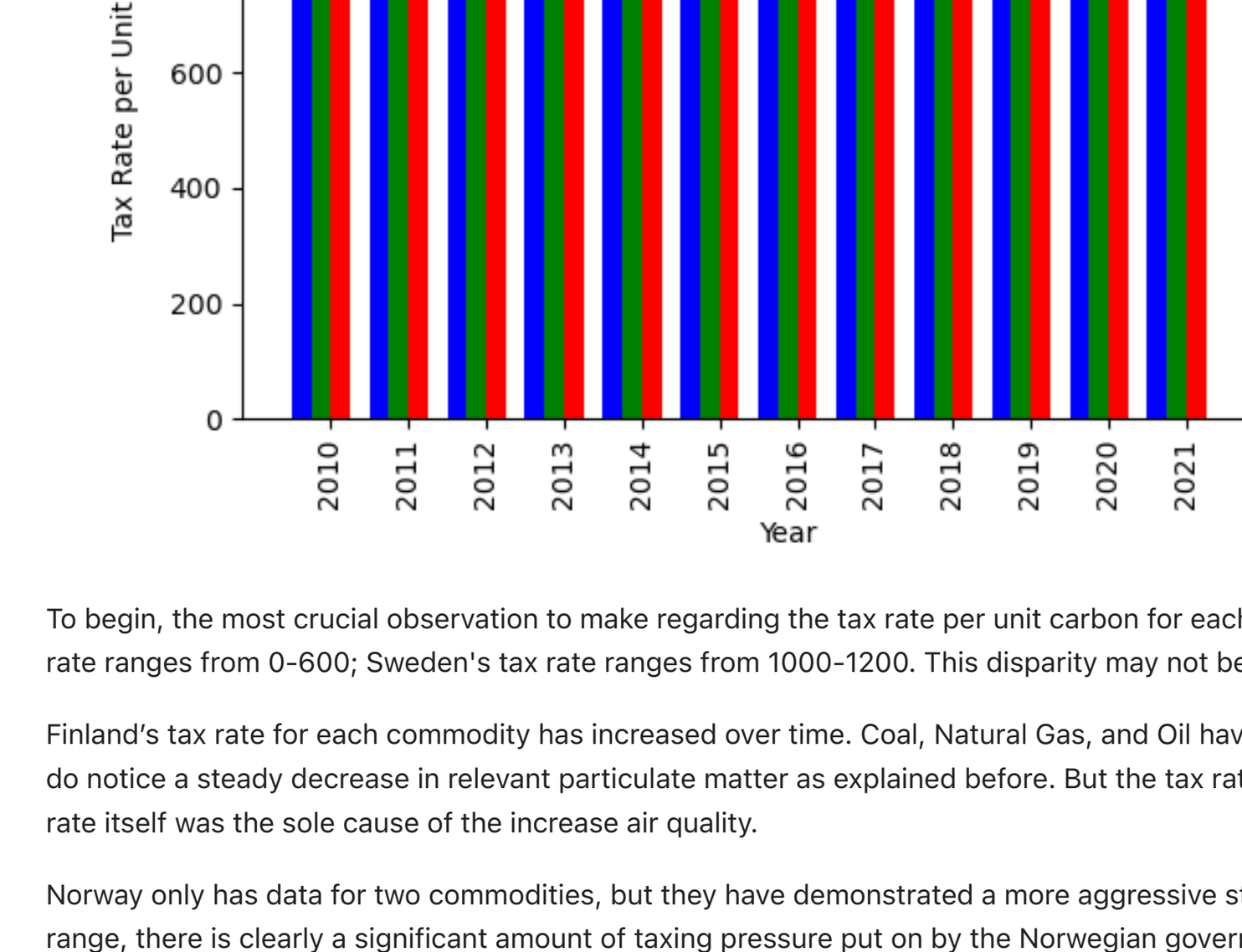
To interpret the results, we will begin to develop some hypotheses from our collected data. Since Finland showed the least amount of air quality improvement, I would expect them to have the least aggressive carbon pricing strategies. Because Norway and Sweden showed gradual decreases, I anticipate them to be more aggressive in their pricing techniques. The next section will dive deeper into the environmental policies each country has enacted with regards to carbon taxing on fossil fuels and cap and trade policies. These will bring to light the government policies each country has enacted to combat air pollution.

In [23]:
```
# Finland Bar Graph

# Data for Finland
years = np.arange(2010, 2023)
coal_tax_rates = [18.82442748, 27.6221374, 27.6221374, 32.22519084, 32.22519084, 40.51145038, 49.71755725, 53.40076336, 57.08396947, 56.41603053, 56.416030
natural_gas_tax_rates = [8.99009901, 29.40594059, 29.40594059, 34.30693069, 34.30693069, 43.11881188, 52.92079208, 56.83168317, 60.79207921, 64.05940594, 6
oil_tax_rates = [18.0, 18.0, 53.0, 53.0, 62.03333333, 62.03333333, 62.03333333, 66.33333333, 66.33333333, 66.33333333, 66.33333333, 66.33333333, 80.8]

# Set the position of the bars on the x-axis
x = np.arange(len(years))

# Plot the tax rates
plt.bar(x, coal_tax_rates, width=0.25, label='Coal Tax Rate', color='b')
plt.bar(x + 0.25, natural_gas_tax_rates, width=0.25, label='Natural Gas Tax Rate', color='g')
plt.bar(x + 0.5, oil_tax_rates, width=0.25, label='Oil Tax Rate', color='r')


# Customize the plot
plt.xlabel('Year')
plt.ylabel('Tax Rate per Unit of Cabon')
plt.title('Carbon Tax Rate of the Three Basic Fossil Fuel Commodities of Finland from 2010-2022  ')

# Add year labels
plt.xticks(x + 0.375, years, rotation='vertical')

# Add a legend
plt.legend()

# Display the plot
plt.tight_layout()
plt.show()
```



In [24]:
```
#Norway Bar Graph

# Data for Norway
years = np.arange(2010, 2023)
#Norway has no coal data

natural_gas_tax_rates = [0.0, 220.0, 225.0, 230.0, 330.0, 372.5, 420.0, 450.0, 500.0, 510.0, 540.0, np.nan, np.nan]
oil_tax_rates = [430.0, 440.0, 445.0, 455.0, 465.0, 475.0, 485.0, 520.0, 580.0, 590.0, 590.0, 53.54, 80.82]

# Set the position of the bars on the x-axis
x = np.arange(len(years))

# Plot the tax rates
plt.bar(x + 0.25, natural_gas_tax_rates, width=0.25, label='Natural Gas Tax Rate', color='g')
plt.bar(x + 0.5, oil_tax_rates, width=0.25, label='Oil Tax Rate', color='r')


# Customize the plot
plt.xlabel('Year')
plt.ylabel('Tax Rate per Unit of Cabon')
plt.title('Carbon Tax Rate of the Natural Gas and Oil of Norway from 2010-2022')

# Add year labels
plt.xticks(x + 0.75, years, rotation='vertical')

# Add a legend
plt.legend()

# Display the plot
plt.tight_layout()
plt.show()
```

In [25]:
```
# Sweden Bar Graph
# Data for Sweden
years = np.arange(2010, 2023)
coal_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.869565, 1205
natural_gas_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.86956
oil_tax_rates = [1054.5, 1055.706522, 1084.663043, 1082.25, 1080.641304, 1126.086957, 1121.26087, 1132.923913, 1152.228261, 1175.956522, 1196.869565, 1205.

# Set the position of the bars on the x-axis
x = np.arange(len(years))

# Plot the tax rates
plt.bar(x, coal_tax_rates, width=0.25, label='Coal Tax Rate', color='b')
plt.bar(x + 0.25, natural_gas_tax_rates, width=0.25, label='Natural Gas Tax Rate', color='g')
plt.bar(x + 0.5, oil_tax_rates, width=0.25, label='Oil Tax Rate', color='r')


# Customize the plot
plt.xlabel('Year')
plt.ylabel('Tax Rate per Unit of Cabon')
plt.title('Carbon Tax Rate of the Three Basic Fossil Fuel Commodities of Sweden from 2010-2022')

# Add year labels
plt.xticks(x + 0.375, years, rotation='vertical')

# Add a legend
plt.legend()

# Display the plot
plt.tight_layout()
plt.show()
```



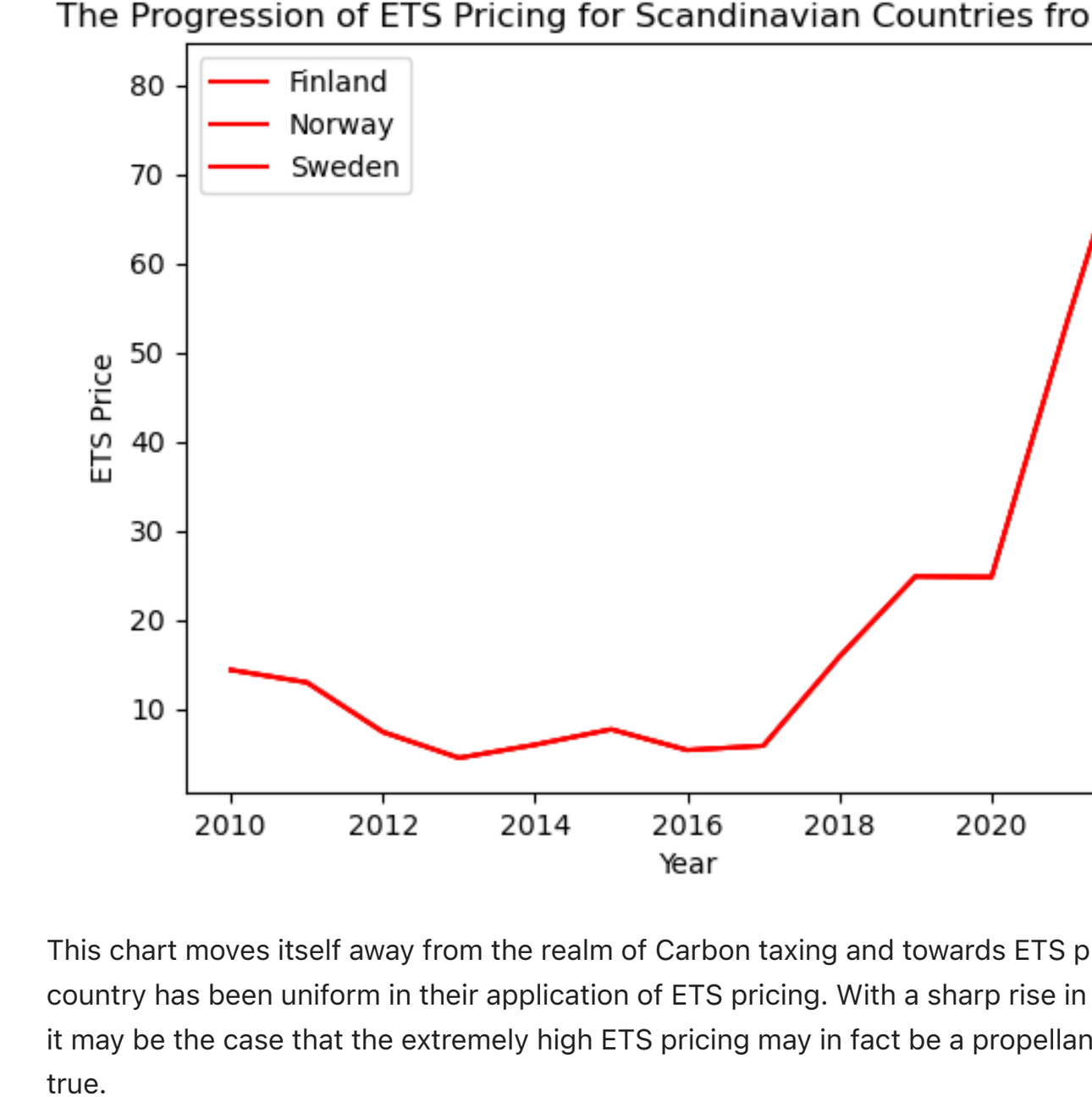
To begin, the most crucial observation to make regarding the tax rate per unit carbon for each commodity is the scale in the y-axis. Finland's tax rate ranges from 0-100; Norway's tax rate ranges from 0-600; Sweden's tax rate ranges from 1000-1200. This disparity may not be noticed at first, but it is important to note as we move forward.

Finland's tax rate for each commodity has increased over time. Coal, Natural Gas, and Oil have all had their tax rates increased over the last 13 years. As their tax rate has increased, we do notice a steady decrease in relevant particulate matter as explained before. But the tax rate is so minor (even though it increased) that is would be difficult to conclude that the tax rate itself was the sole cause of the increase air quality.

Norway only has data for two commodities, but they have demonstrated a more aggressive standard for taxing Natural Gas and Oil. With a tax rate increasing over time into the 600 range, there is clearly a significant amount of taxing pressure put on by the Norwegian government. This may contribute to the noticeable plunge in particulate matter we observed in the previous graph. It would not be far-fetched to conclude that aggressive Carbon taxing polices have ameliorated air pollution in Norway.

Sweden, by far, has the most aggressive Carbon taxing policy with a rate almost double than Norway. While the rate has not been increasing substantially, the Swedish government has keep it standard to have a tax rate in the 1000s for each of the three observed commodities. Despite this, their drop in NO2, PM10, and PM2.5 has not been as sharp as Norway; this may insinuate that a moderate Carbon tax rather than an extremely aggressive one may be most effective in curbing air pollution.

In [26]:
```
#ETS pricing or the cost to emit a certain amount of emissions for each country (note it is the same for all three)

# Data for Finland
finland_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
finland_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]

# Data for Norway
norway_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
norway_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]

# Data for Sweden
sweden_years = [2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022]
sweden_prices = [14.34, 12.94, 7.38, 4.47, 5.95, 7.68, 5.35, 5.83, 15.82, 24.84, 24.76, 53.54, 80.82]

# Plotting the data
plt.plot(finland_years, finland_prices, color='red', label='Finland')
plt.plot(norway_years, norway_prices, color='red', label='Norway')
plt.plot(sweden_years, sweden_prices, color='red', label='Sweden')

#The pattern of all countries will be represented by red

# Adding labels and title
plt.xlabel('Year')
plt.ylabel('ETS Price')
plt.title('The Progression of ETS Pricing for Scandinavian Countries from 2010-2022')
plt.legend()

# Displaying the graph
plt.show()#
```



This chart moves itself away from the realm of Carbon taxing and towards ETS pricing (which puts a cost on emitting a certain amount of emissions). Surprisingly, each Scandinavian country has been uniform in their application of ETS pricing. With a sharp rise in ETS pricing from 2018 onward, it would not be expected for us to see these results immediately. Instead, it may be the case that the extremely high ETS pricing may in fact be a propellant for better air quality several years from now in the late 2020s. Time will only tell if this turns out to be true.

In [27]:
```
#Summary
```

Overall, we have constructed a basic analysis of public policy regarding environmental issues. We analyzed the concentration of harmful air particles in three similar countries to set the framework for the rest of the analysis. With the air quality metrics in mind, we then investigated the Carbon tax rates each country has implemented for three fossil fuel commodities (coal, natural gas, and oil). Fortunately, both datasets from different sources were still congruent in the timespan (from 2010 and onward). Lastly, we found that each country was uniform in ETS pricing with each of the three countries all rapidly increasing ETS pricing in recent years.

Over the years, each of the air pollution levels of each of the countries have improved with Norway and Sweden having noticeable decreases in NO2 levels; each country also did have a steady decrease in PM10 and PM2.5 levels but they do not firmly correspond to tax levels. That is, Sweden's extremely aggressive tax policy did not rapidly increase air quality as one might expect. However, with noticeably strong increases in ETS pricing across all three countries, there may be optimism moving forward as these enactments may prove fruitful over the next couple decades.

Some difficulties we faced is the lack of coal data for Norway and the omission of the year 2012 for the tax data. Also, the datasets were of different file formats (csv and excel) so it was not possible to merge the two datasets in the notebook and we had to create different dictionaries for each country and had to compartmentalize our data into chunks.

Some next steps would be to better enhance our environmental data by choosing say the 5 most populated cities of each country when analyzing air quality data rather than just the capital city of each country. This would be more comprehensive and would provide more fruitful results than simply resorting to the capital city of each country. Of course, it may also be important to wait several years to see if increases in tax rates or increases in ETS pricing decrease air pollution in the long run.

The big question as to whether world powers should use these same types of methods is a difficult one to answer. With noticeable improvements for the three Scandinavian countries, it may be worthwhile for major world economies to start with a gentle Carbon tax or cap and trade policy and perform a similar type of analysis on whether or not the tradeoffs are worth it. With climate change and other ESG investing being important discussion points for politicians around the world, I do expect other countries to follow suit with similar enactments.

In [ ]: