Sample_Project_1

March 20, 2023

1 Sample Project 1

[2]:
```
%matplotlib inline
import matplotlib
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import random
import numpy as np
import pandas as pd
pd.options.display.max_rows = 20
```

1.1 Reading In The Data

This data was retrieved from the UN open data website using the Energy Statistics Database, which was created by the United Nations Statistics Division (UNSD)

[25]:
```
df_gross = pd.read_csv('Gross.csv').round(2)
df_hydro = pd.read_csv('Hydro.csv').round(2)
df_nuclear = pd.read_csv('Nuclear.csv').round(2)
df_solar = pd.read_csv('Solar.csv').round(2)
df_wind = pd.read_csv('Wind.csv').round(2)

display(df_gross)
display(df_hydro)
```

```
     Country or Area         Commodity - Transaction    Year  \
0        Afghanistan  Electricity - Gross production  2019.0
1        Afghanistan  Electricity - Gross production  2018.0
2        Afghanistan  Electricity - Gross production  2017.0
3        Afghanistan  Electricity - Gross production  2016.0
4        Afghanistan  Electricity - Gross production  2015.0
…              …                             …     …
6646        Zimbabwe  Electricity - Gross production  1992.0
6647        Zimbabwe  Electricity - Gross production  1991.0
6648        Zimbabwe  Electricity - Gross production  1990.0
6649         fnSeqID                        Footnote     NaN
6650               1                        Estimate     NaN
```

```
                         Unit  Quantity  Quantity Footnotes
0     Kilowatt-hours, million   1591.50                 NaN
1     Kilowatt-hours, million   1265.72                 NaN
2     Kilowatt-hours, million   1420.04                 NaN
3     Kilowatt-hours, million   1393.90                 NaN
4     Kilowatt-hours, million   1338.70                 NaN
…                       …       …                 …
6646  Kilowatt-hours, million   8237.00                 NaN
6647  Kilowatt-hours, million   8886.00                 NaN
6648  Kilowatt-hours, million   9362.00                 NaN
6649                      NaN       NaN                 NaN
6650                      NaN       NaN                 NaN

[6651 rows x 6 columns]
     Country or Area               Commodity - Transaction    Year  \
0        Afghanistan  Electricity - total hydro production  2019.0
1        Afghanistan  Electricity - total hydro production  2018.0
2        Afghanistan  Electricity - total hydro production  2017.0
3        Afghanistan  Electricity - total hydro production  2016.0
4        Afghanistan  Electricity - total hydro production  2015.0
…              …                                   …     …
4553        Zimbabwe  Electricity - total hydro production  1992.0
4554        Zimbabwe  Electricity - total hydro production  1991.0
4555        Zimbabwe  Electricity - total hydro production  1990.0
4556         fnSeqID                              Footnote     NaN
4557               1                              Estimate     NaN

                         Unit  Quantity  Quantity Footnotes
0     Kilowatt-hours, million   1388.04                 NaN
1     Kilowatt-hours, million   1065.79                 NaN
2     Kilowatt-hours, million   1243.78                 NaN
3     Kilowatt-hours, million   1239.20                 NaN
4     Kilowatt-hours, million   1189.50                 NaN
…                       …       …                 …
4553  Kilowatt-hours, million   3161.00                 NaN
4554  Kilowatt-hours, million   3114.00                 NaN
4555  Kilowatt-hours, million   4369.00                 NaN
4556                      NaN       NaN                 NaN
4557                      NaN       NaN                 NaN

[4558 rows x 6 columns]
```

Cleaning The Data

[26]:

```
df_gross = df_gross.drop('Quantity Footnotes', axis = 1)
df_gross = df_gross.drop([df_gross.shape[0] - 1, df_gross.shape[0] - 2])
df_gross['Year'] = df_gross['Year'].astype(int)
```

```
df_hydro = df_hydro.drop('Quantity Footnotes', axis = 1)
df_hydro = df_hydro.drop([df_hydro.shape[0] - 1, df_hydro.shape[0] - 2])
df_hydro['Year'] = df_hydro['Year'].astype(int)

df_nuclear = df_nuclear.drop('Quantity Footnotes', axis = 1)
df_nuclear = df_nuclear.drop([df_nuclear.shape[0] - 1, df_nuclear.shape[0] - 2])
df_nuclear['Year'] = df_nuclear['Year'].astype(int)

df_solar = df_solar.drop('Quantity Footnotes', axis = 1)
df_solar = df_solar.drop([df_solar.shape[0] - 1, df_solar.shape[0] - 2])
df_solar['Year'] = df_solar['Year'].astype(int)

df_wind = df_wind.drop('Quantity Footnotes', axis = 1)
df_wind = df_wind.drop([df_wind.shape[0] - 1, df_wind.shape[0] - 2])
df_wind['Year'] = df_wind['Year'].astype(int)

df_gross = df_gross.rename(columns={'Quantity' : 'Gross Quantity'})
df_hydro = df_hydro.rename(columns={'Quantity': ('Hydro Quantity')})
df_nuclear = df_nuclear.rename(columns={'Quantity': ('Nuclear Quantity')})
df_solar = df_solar.rename(columns={'Quantity': ('Solar Quantity')})
df_wind = df_wind.rename(columns={'Quantity': ('Wind Quantity')})
print("Dataframe after cleaning:")
display(df_hydro, df_gross)
```

```
Dataframe after cleaning:

     Country or Area               Commodity - Transaction  Year  \
0        Afghanistan  Electricity - total hydro production  2019
1        Afghanistan  Electricity - total hydro production  2018
2        Afghanistan  Electricity - total hydro production  2017
3        Afghanistan  Electricity - total hydro production  2016
4        Afghanistan  Electricity - total hydro production  2015
…              …                                   …   …
4551        Zimbabwe  Electricity - total hydro production  1994
4552        Zimbabwe  Electricity - total hydro production  1993
4553        Zimbabwe  Electricity - total hydro production  1992
4554        Zimbabwe  Electricity - total hydro production  1991
4555        Zimbabwe  Electricity - total hydro production  1990

                         Unit  Hydro Quantity
0     Kilowatt-hours, million         1388.04
1     Kilowatt-hours, million         1065.79
2     Kilowatt-hours, million         1243.78
3     Kilowatt-hours, million         1239.20
4     Kilowatt-hours, million         1189.50
…                       …             …
```

```
4551  Kilowatt-hours, million         2375.00
4552  Kilowatt-hours, million         2062.00
4553  Kilowatt-hours, million         3161.00
4554  Kilowatt-hours, million         3114.00
4555  Kilowatt-hours, million         4369.00

[4556 rows x 5 columns]
     Country or Area         Commodity - Transaction  Year  \
0        Afghanistan  Electricity - Gross production  2019
1        Afghanistan  Electricity - Gross production  2018
2        Afghanistan  Electricity - Gross production  2017
3        Afghanistan  Electricity - Gross production  2016
4        Afghanistan  Electricity - Gross production  2015
…              …                             …   …
6644        Zimbabwe  Electricity - Gross production  1994
6645        Zimbabwe  Electricity - Gross production  1993
6646        Zimbabwe  Electricity - Gross production  1992
6647        Zimbabwe  Electricity - Gross production  1991
6648        Zimbabwe  Electricity - Gross production  1990

                         Unit  Gross Quantity
0     Kilowatt-hours, million         1591.50
1     Kilowatt-hours, million         1265.72
2     Kilowatt-hours, million         1420.04
3     Kilowatt-hours, million         1393.90
4     Kilowatt-hours, million         1338.70
…                       …             …
6644  Kilowatt-hours, million         7815.00
6645  Kilowatt-hours, million         7468.00
6646  Kilowatt-hours, million         8237.00
6647  Kilowatt-hours, million         8886.00
6648  Kilowatt-hours, million         9362.00

[6649 rows x 5 columns]
```

Leaders In Energy Production

[27]:

```
def getLeaders(df, s):
    return df[df['Year'] == 2018].sort_values(s + ' Quantity', ascending=False).
 ↪head(10).reset_index(drop=True)


df_gross_leaders = getLeaders(df_gross, 'Gross')
df_hydro_leaders = getLeaders(df_hydro, 'Hydro')
df_nuclear_leaders = getLeaders(df_nuclear, 'Nuclear')
df_solar_leaders = getLeaders(df_solar, 'Solar')
df_wind_leaders = getLeaders(df_wind, 'Wind')
```

```
display(df_gross_leaders)
display(df_hydro_leaders)
display(df_nuclear_leaders)
display(df_solar_leaders)
display(df_wind_leaders)
```

```
     Country or Area        Commodity - Transaction  Year  \
0              China  Electricity - Gross production  2018
1      United States  Electricity - Gross production  2018
2              India  Electricity - Gross production  2018
3 Russian Federation  Electricity - Gross production  2018
4              Japan  Electricity - Gross production  2018
5             Canada  Electricity - Gross production  2018
6            Germany  Electricity - Gross production  2018
7             Brazil  Electricity - Gross production  2018
8 Korea, Republic of  Electricity - Gross production  2018
9             France  Electricity - Gross production  2018

                    Unit  Gross Quantity
0 Kilowatt-hours, million      7166133.00
1 Kilowatt-hours, million      4455439.00
2 Kilowatt-hours, million      1521785.00
3 Kilowatt-hours, million      1115093.19
4 Kilowatt-hours, million      1057755.00
5 Kilowatt-hours, million       654399.00
6 Kilowatt-hours, million       643159.00
7 Kilowatt-hours, million       601396.00
8 Kilowatt-hours, million       590108.00
9 Kilowatt-hours, million       581943.00
```

```
     Country or Area              Commodity - Transaction  Year  \
0              China  Electricity - total hydro production  2018
1             Brazil  Electricity - total hydro production  2018
2             Canada  Electricity - total hydro production  2018
3      United States  Electricity - total hydro production  2018
4 Russian Federation  Electricity - total hydro production  2018
5             Norway  Electricity - total hydro production  2018
6              India  Electricity - total hydro production  2018
7              Japan  Electricity - total hydro production  2018
8           Viet Nam  Electricity - total hydro production  2018
9             France  Electricity - total hydro production  2018

                    Unit  Hydro Quantity
0 Kilowatt-hours, million      1231787.00
1 Kilowatt-hours, million       388971.00
```

```
2  Kilowatt-hours, million       385951.00
3  Kilowatt-hours, million       317004.00
4  Kilowatt-hours, million       193027.31
5  Kilowatt-hours, million       139509.00
6  Kilowatt-hours, million       134991.00
7  Kilowatt-hours, million        88348.00
8  Kilowatt-hours, million        84205.00
9  Kilowatt-hours, million        70590.00
      Country or Area                Commodity - Transaction  Year  \
0       United States  Electricity - total nuclear production  2018
1              France  Electricity - total nuclear production  2018
2               China  Electricity - total nuclear production  2018
3  Russian Federation  Electricity - total nuclear production  2018
4  Korea, Republic of  Electricity - total nuclear production  2018
5              Canada  Electricity - total nuclear production  2018
6             Ukraine  Electricity - total nuclear production  2018
7             Germany  Electricity - total nuclear production  2018
8              Sweden  Electricity - total nuclear production  2018
9      United Kingdom  Electricity - total nuclear production  2018

                      Unit  Nuclear Quantity
0  Kilowatt-hours, million         841329.00
1  Kilowatt-hours, million         412942.00
2  Kilowatt-hours, million         294359.00
3  Kilowatt-hours, million         204569.14
4  Kilowatt-hours, million         133505.00
5  Kilowatt-hours, million         100731.00
6  Kilowatt-hours, million          84398.00
7  Kilowatt-hours, million          76005.00
8  Kilowatt-hours, million          68549.00
9  Kilowatt-hours, million          65064.00
  Country or Area              Commodity - Transaction  Year  \
0           China  Electricity - total solar production  2018
1   United States  Electricity - total solar production  2018
2           Japan  Electricity - total solar production  2018
3         Germany  Electricity - total solar production  2018
4           India  Electricity - total solar production  2018
5           Italy  Electricity - total solar production  2018
6  United Kingdom  Electricity - total solar production  2018
7           Spain  Electricity - total solar production  2018
8          France  Electricity - total solar production  2018
9       Australia  Electricity - total solar production  2018

                      Unit  Solar Quantity
0  Kilowatt-hours, million        177517.0
1  Kilowatt-hours, million         85184.0
2  Kilowatt-hours, million         62668.0
```

```
3  Kilowatt-hours, million         45784.0
4  Kilowatt-hours, million         39728.0
5  Kilowatt-hours, million         22654.0
6  Kilowatt-hours, million         12858.0
7  Kilowatt-hours, million         12744.0
8  Kilowatt-hours, million         10569.0
9  Kilowatt-hours, million          9929.0

  Country or Area              Commodity - Transaction  Year  \
0           China  Electricity - total wind production  2018
1   United States  Electricity - total wind production  2018
2         Germany  Electricity - total wind production  2018
3           India  Electricity - total wind production  2018
4  United Kingdom  Electricity - total wind production  2018
5           Spain  Electricity - total wind production  2018
6          Brazil  Electricity - total wind production  2018
7          Canada  Electricity - total wind production  2018
8          France  Electricity - total wind production  2018
9          Turkey  Electricity - total wind production  2018

                      Unit  Wind Quantity
0  Kilowatt-hours, million       365971.0
1  Kilowatt-hours, million       275834.0
2  Kilowatt-hours, million       109951.0
3  Kilowatt-hours, million        64294.0
4  Kilowatt-hours, million        56904.0
5  Kilowatt-hours, million        50896.0
6  Kilowatt-hours, million        48475.0
7  Kilowatt-hours, million        33183.0
8  Kilowatt-hours, million        28600.0
9  Kilowatt-hours, million        19949.0
```

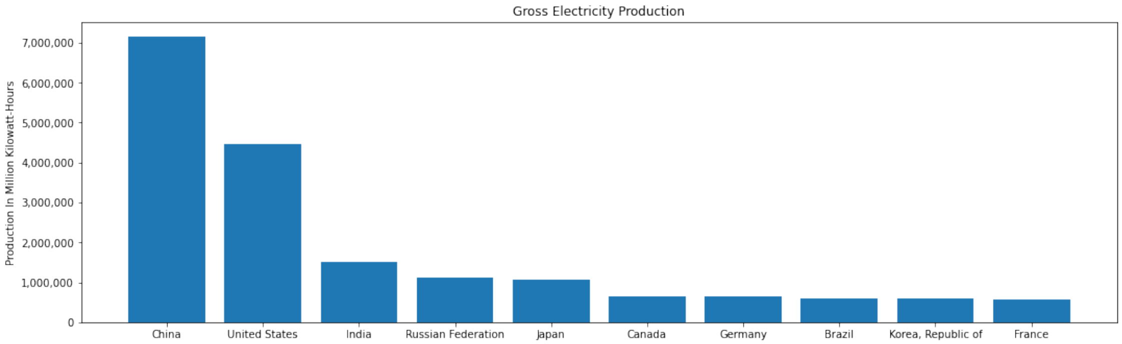
1.2 Visualizing The Data

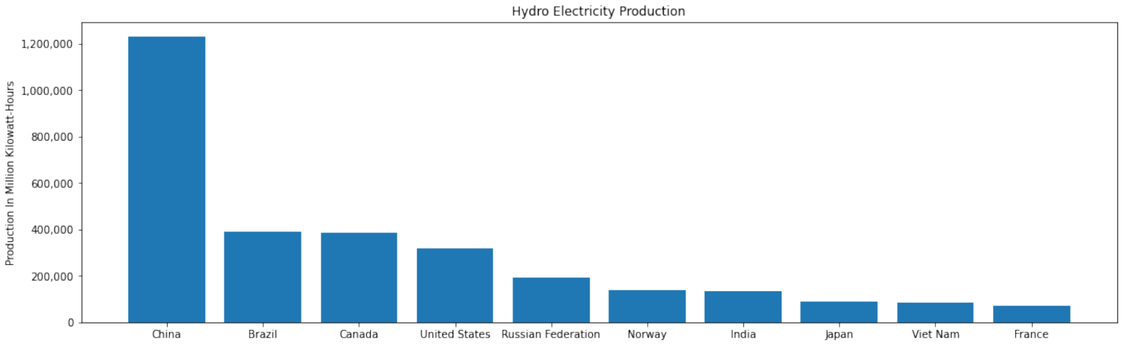
Visualizing The Leaders In Energy Production

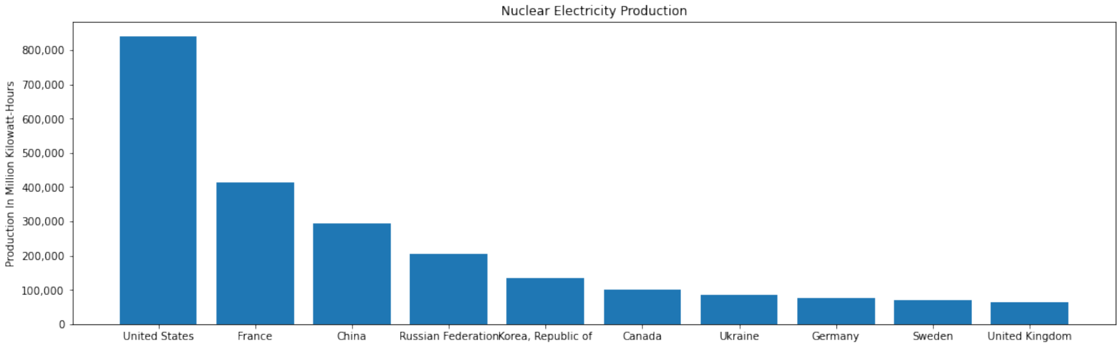
[28]:

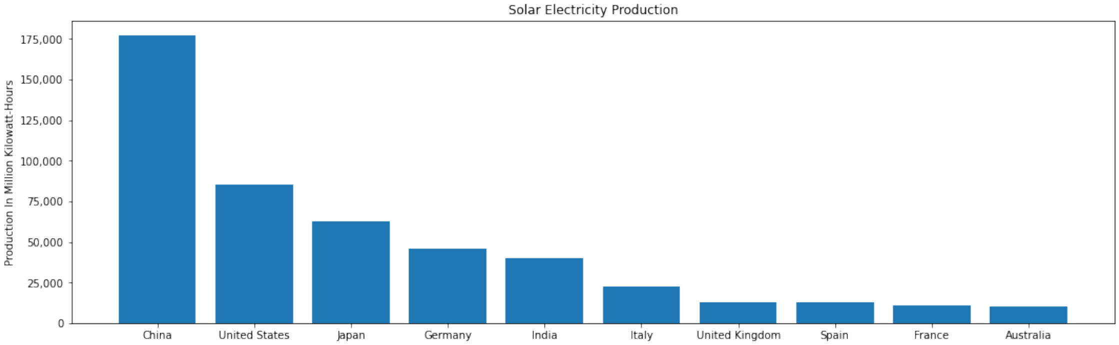
```python
fig = plt.figure()
countries = df_gross_leaders['Country or Area']
production = df_gross_leaders['Gross Quantity']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Gross Electricity Production")
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")


fig = plt.figure()
countries = df_hydro_leaders['Country or Area']
```

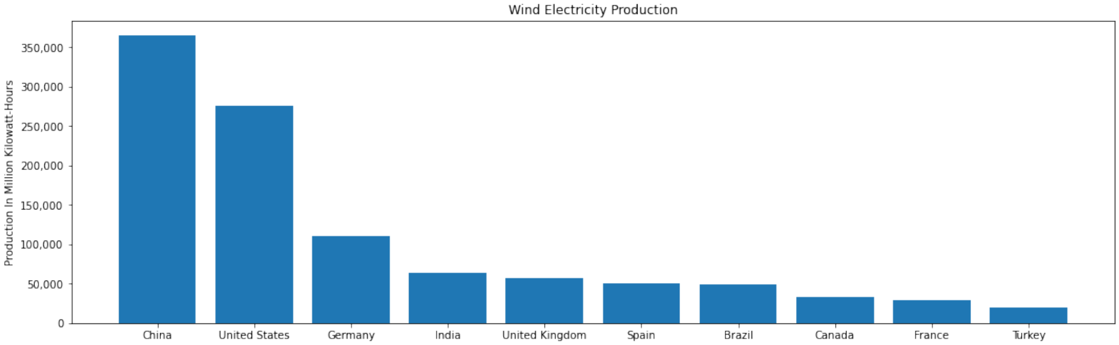
```
production = df_hydro_leaders['Hydro Quantity']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Hydro Electricity Production")
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")

fig = plt.figure()
countries = df_nuclear_leaders['Country or Area']
production = df_nuclear_leaders['Nuclear Quantity']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Nuclear Electricity Production")
ax.set_ylabel("Production In Million Kilowatt-Hours")
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))

fig = plt.figure()
countries = df_solar_leaders['Country or Area']
production = df_solar_leaders['Solar Quantity']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Solar Electricity Production")
ax.set_ylabel("Production In Million Kilowatt-Hours")
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))


fig = plt.figure()
countries = df_wind_leaders['Country or Area']
production = df_wind_leaders['Wind Quantity']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Wind Electricity Production")
ax.set_ylabel("Production In Million Kilowatt-Hours")
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')));
```


Gross Electricity Production
Production In Million Kilowatt-Hours
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
China
United States
India
Russian Federation
Japan
Canada
Germany
Brazil
Korea, Republic of
France


Hydro Electricity Production
Production In Million Kilowatt-Hours
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
China
Brazil
Canada
United States
Russian Federation
Norway
India
Japan
Viet Nam
France


Nuclear Electricity Production
Production In Million Kilowatt-Hours
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
United States
France
China
Russian Federation
Korea, Republic of
Canada
Ukraine
Germany
Sweden
United Kingdom



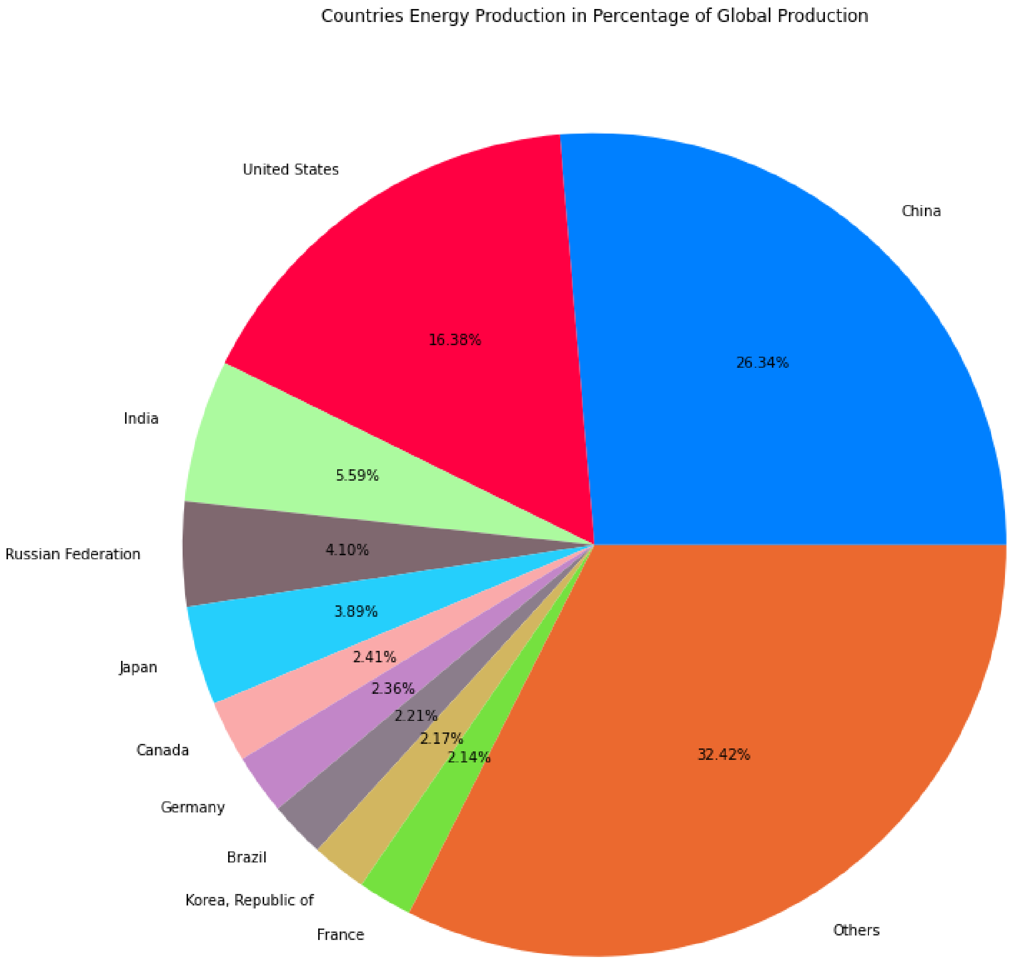


Visualizing Gross Energy Production

[29]:

```
df_gross_sorted = df_gross[df_gross['Year'] == 2018].sort_values(
    'Gross Quantity', ascending=False).reset_index(drop=True)

x = df_gross_sorted.iloc[9:]["Gross Quantity"].sum()
others = pd.DataFrame({'Country or Area': ['Others'], 'Gross Quantity': [x]})
df_leaders_with_others = df_gross_sorted.iloc[:10].filter(['Country or Area',␣
  ↪'Gross Quantity'])
df_leaders_with_others = df_leaders_with_others.append(others,␣
  ↪ignore_index=True)


fig = plt.figure()
ax = fig.add_axes([0,0,2.5,2.5])
countries = df_leaders_with_others['Country or Area']
production = df_leaders_with_others['Gross Quantity']
c = ['#0080ff', '#FF0042', '#ACFA9F', '#7F686F', '#25CFFC',
     '#FAAAAA', '#C286C8', '#8B7D8B', '#D2B660', '#75E13F', '#EB692F',␣
  ↪'#DF4D5D']
```

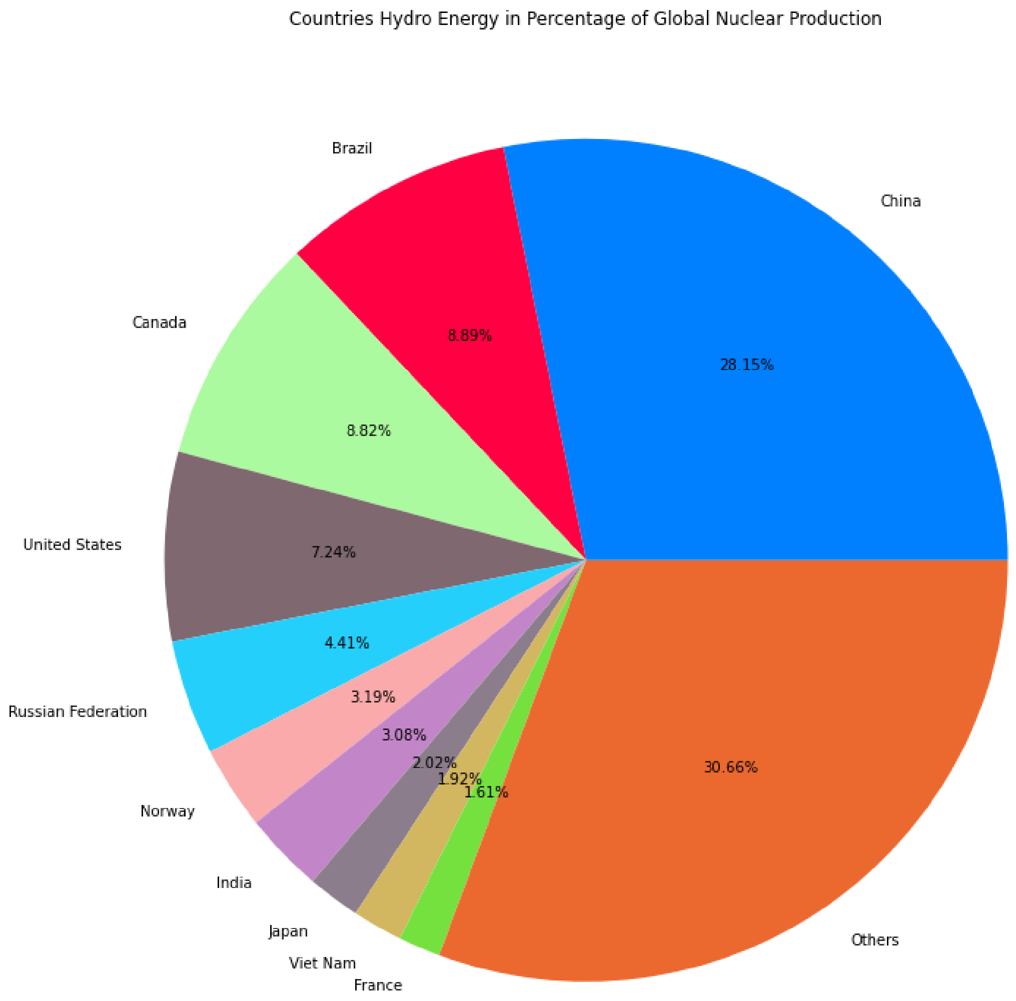
```
plt.title('Countries Energy Production in Percentage of Global Production')
plt.pie(production, labels = countries,autopct='%1.2f%%', colors=c);
```



Visualizing Gross Energy Production

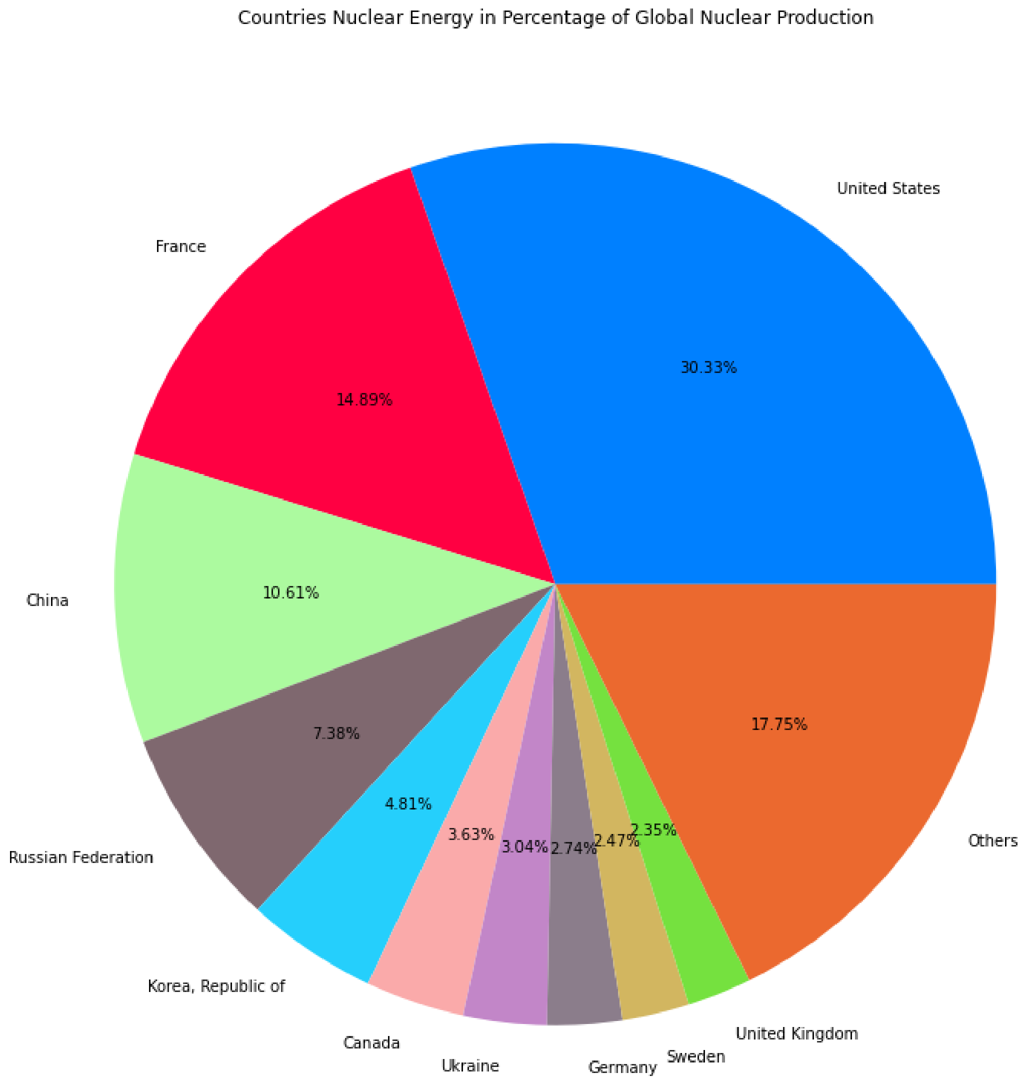
```
[8]: df_hydro_sorted = df_hydro[df_hydro['Year'] == 2018].sort_values('Hydro␣
      ↪Quantity', ascending=False).reset_index(drop=True)

     x = df_hydro_sorted.iloc[9:]["Hydro Quantity"].sum()
     others = pd.DataFrame({'Country or Area': ['Others'], 'Hydro Quantity': [x]})
     df_leaders_with_others = df_hydro_sorted.iloc[:10].filter(['Country or Area',␣
      ↪'Hydro Quantity'])
     df_leaders_with_others = df_leaders_with_others.append(others,␣
      ↪ignore_index=True)
```

```
fig = plt.figure()
ax = fig.add_axes([0,0,2.5,2.5])
countries = df_leaders_with_others['Country or Area']
production = df_leaders_with_others['Hydro Quantity']
c = ['#0080ff', '#FF0042', '#ACFA9F', '#7F686F', '#25CFFC',
     '#FAAAAA', '#C286C8', '#8B7D8B', '#D2B660', '#75E13F', '#EB692F',␣
 ↪'#DF4D5D']
plt.title('Countries Hydro Energy in Percentage of Global Nuclear Production')
plt.pie(production, labels = countries,autopct='%1.2f%%', colors=c);
```



Visualizing Nuclear Energy Production

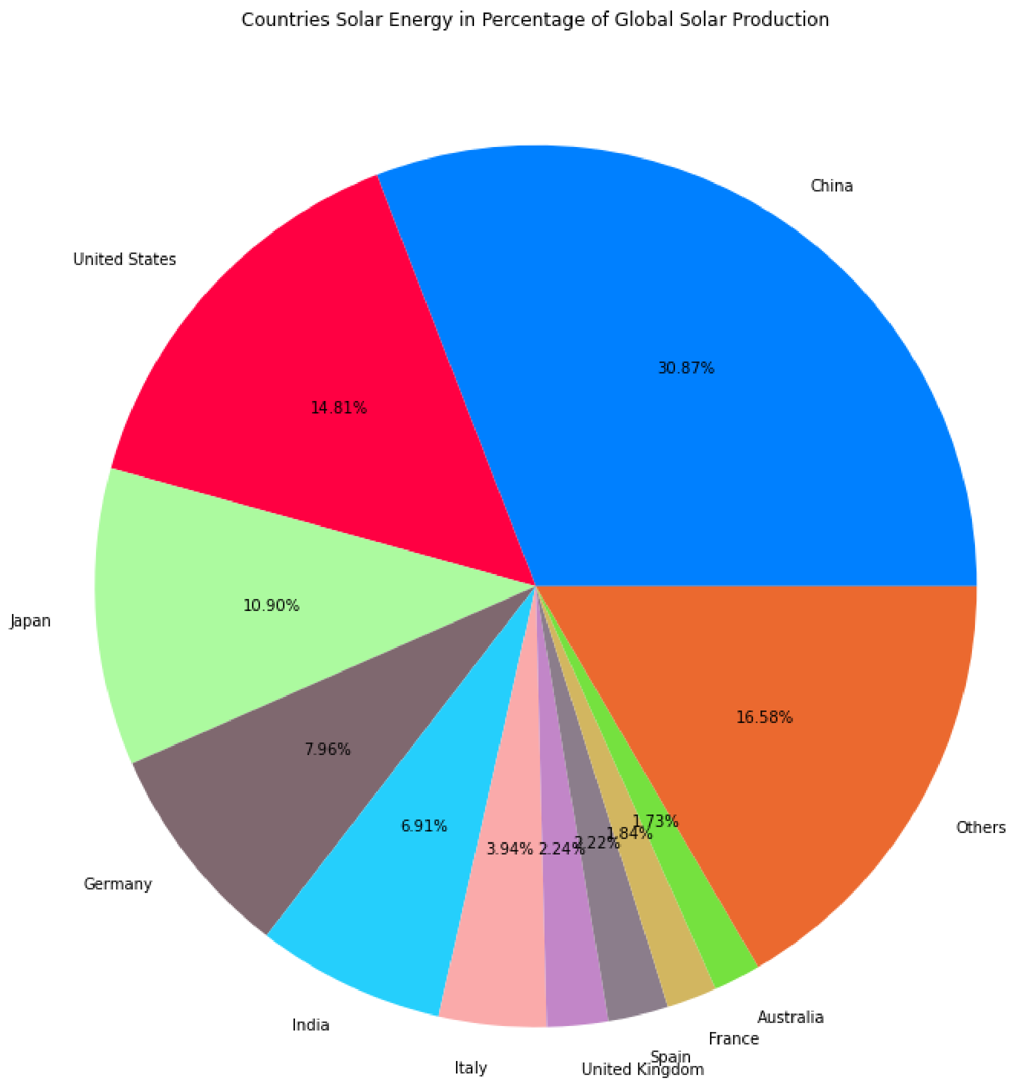
```
[9]: df_nuclear_sorted = df_nuclear[df_nuclear['Year'] == 2018].sort_values('Nuclear␣
      ↪Quantity', ascending=False).reset_index(drop=True)

     x = df_nuclear_sorted.iloc[9:]["Nuclear Quantity"].sum()
     others = pd.DataFrame({'Country or Area': ['Others'], 'Nuclear Quantity': [x]})
     df_leaders_with_others = df_nuclear_sorted.iloc[:10].filter(['Country or Area',␣
      ↪'Nuclear Quantity'])
     df_leaders_with_others = df_leaders_with_others.append(others,␣
      ↪ignore_index=True)

     fig = plt.figure()
     ax = fig.add_axes([0,0,2.5,2.5])
     countries = df_leaders_with_others['Country or Area']
     production = df_leaders_with_others['Nuclear Quantity']
     c = ['#0080ff', '#FF0042', '#ACFA9F', '#7F686F', '#25CFFC',
          '#FAAAAA', '#C286C8', '#8B7D8B', '#D2B660', '#75E13F', '#EB692F',␣
      ↪'#DF4D5D']

     plt.title('Countries Nuclear Energy in Percentage of Global Nuclear Production')
     plt.pie(production, labels = countries,autopct='%1.2f%%', colors=c);
```



Visualizing Solar Energy Production

[10]:
```
df_solar_sorted = df_solar[df_solar['Year'] == 2018].sort_values('Solar␣
 ↪Quantity', ascending=False).reset_index(drop=True)

x = df_solar_sorted.iloc[9:]["Solar Quantity"].sum()
others = pd.DataFrame({'Country or Area': ['Others'], 'Solar Quantity': [x]})
df_leaders_with_others = df_solar_sorted.iloc[:10].filter(['Country or Area',␣
 ↪'Solar Quantity'])
df_leaders_with_others = df_leaders_with_others.append(others,␣
 ↪ignore_index=True)
```

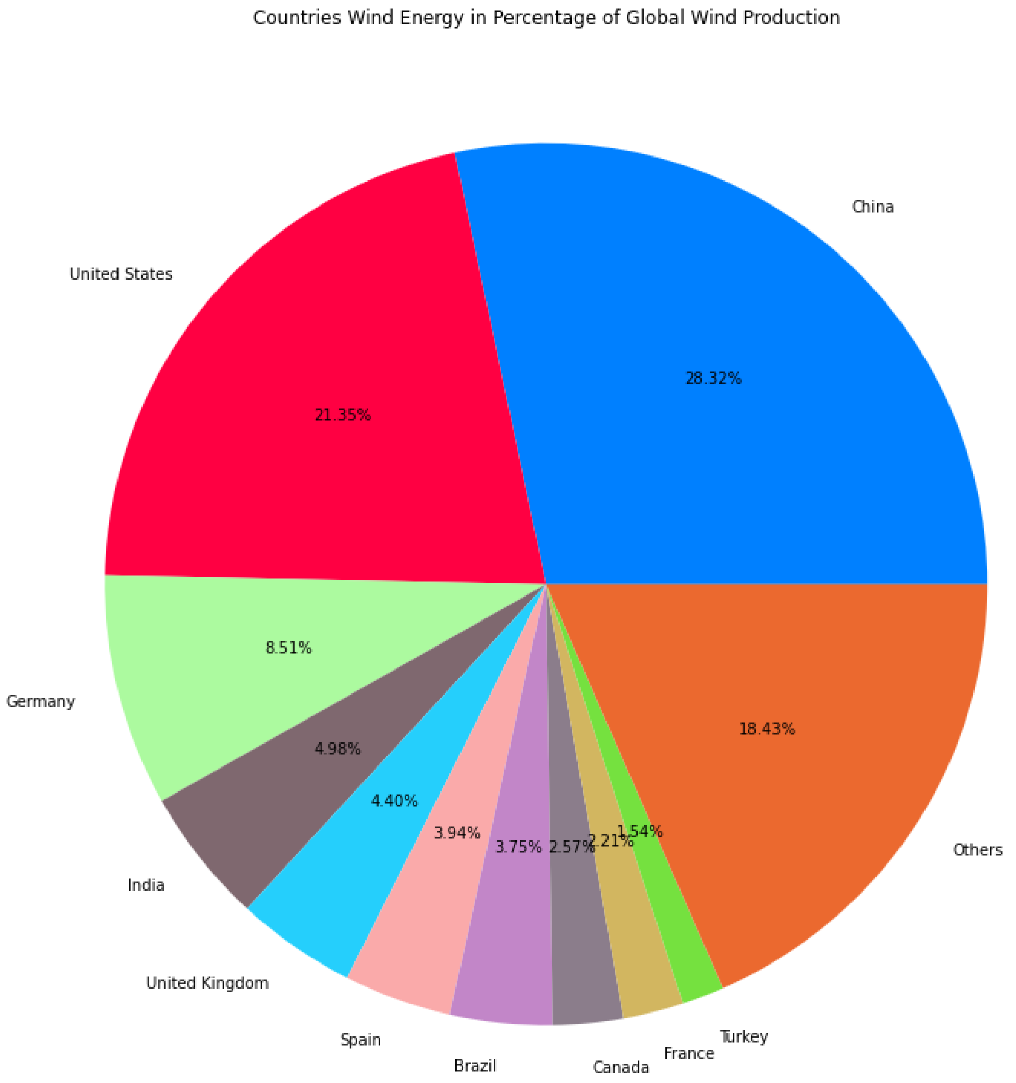
```
fig = plt.figure()
ax = fig.add_axes([0,0,2.5,2.5])
countries = df_leaders_with_others['Country or Area']
production = df_leaders_with_others['Solar Quantity']
c = ['#0080ff', '#FF0042', '#ACFA9F', '#7F686F', '#25CFFC',
     '#FAAAAA', '#C286C8', '#8B7D8B', '#D2B660', '#75E13F', '#EB692F',␣
 ↪'#DF4D5D']

plt.title('Countries Solar Energy in Percentage of Global Solar Production')
plt.pie(production, labels = countries,autopct='%1.2f%%', colors=c);
```



Visualizing Wind Energy Production

[11]:

```
df_wind_sorted = df_wind[df_wind['Year'] == 2018].sort_values('Wind Quantity',␣
 ↪ascending=False).reset_index(drop=True)

x = df_wind_sorted.iloc[9:]["Wind Quantity"].sum()
others = pd.DataFrame({'Country or Area': ['Others'], 'Wind Quantity': [x]})
df_leaders_with_others = df_wind_sorted.iloc[:10].filter(['Country or Area',␣
 ↪'Wind Quantity'])
df_leaders_with_others = df_leaders_with_others.append(others,␣
 ↪ignore_index=True)

fig = plt.figure()
ax = fig.add_axes([0,0,2.5,2.5])
countries = df_leaders_with_others['Country or Area']
production = df_leaders_with_others['Wind Quantity']
c = ['#0080ff', '#FF0042', '#ACFA9F', '#7F686F', '#25CFFC',
     '#FAAAAA', '#C286C8', '#8B7D8B', '#D2B660', '#75E13F', '#EB692F',␣
 ↪'#DF4D5D']

plt.title('Countries Wind Energy in Percentage of Global Wind Production')
plt.pie(production, labels = countries,autopct='%1.2f%%', colors=c);
```



Countries Wind Energy in Percentage of Global Wind Production

2 Percentage

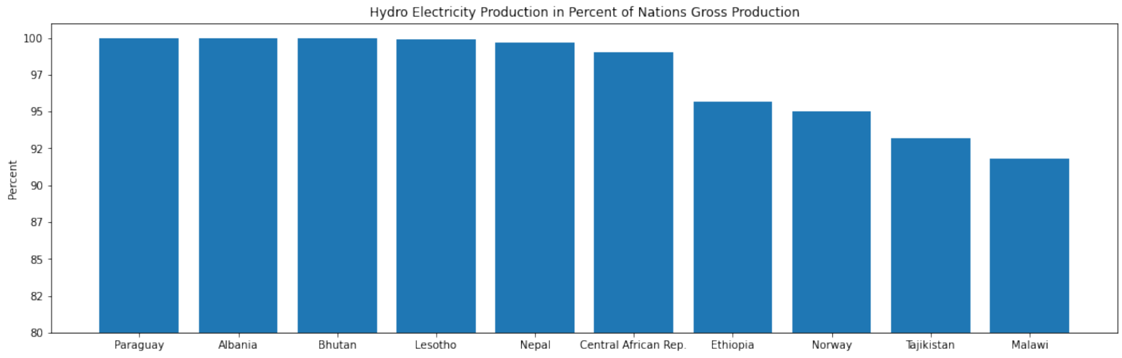
```
[22]: def getPercentOf(df, s):
          df_percent = pd.merge(df.filter(['Country or Area', 'Year', (s + ' Quantity')]),
                                df_gross.filter(['Country or Area', 'Year', 'Gross Quantity']), how='inner')

          df_percent[s + ' Percent'] = (df_percent[s + ' Quantity']/df_percent['Gross Quantity'] * 100).round(2)
          return df_percent
```

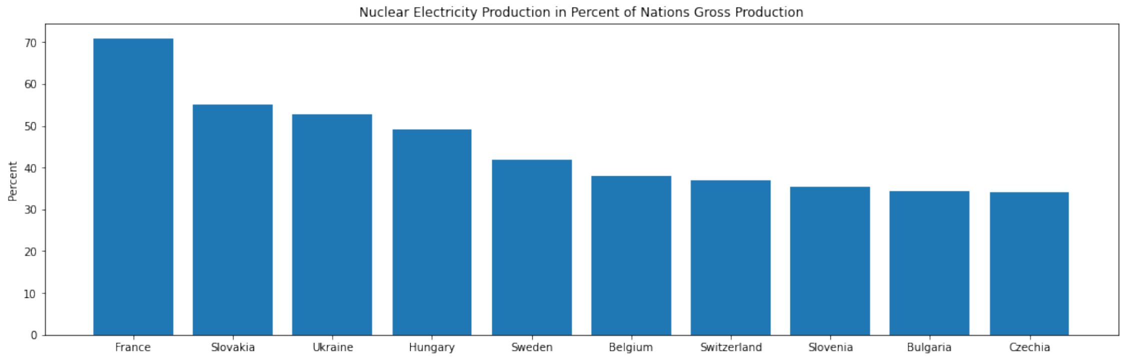
```
df_hydro_percent = getPercentOf(df_hydro, 'Hydro')
df_nuclear_percent = getPercentOf(df_nuclear, 'Nuclear')
df_solar_percent = getPercentOf(df_solar, 'Solar')
df_wind_percent = getPercentOf(df_wind, 'Wind')

df_hydro_percent = df_hydro_percent[df_hydro_percent['Year'] == 2018].
 ↪sort_values('Hydro Percent',
                                                                          ␣
 ↪ascending=False).head(10).reset_index(drop=True)
df_nuclear_percent = df_nuclear_percent[df_nuclear_percent['Year'] == 2018].
 ↪sort_values('Nuclear Percent',
                                                                          ␣
 ↪ascending=False).head(10).reset_index(drop=True)
df_solar_percent = df_solar_percent[df_solar_percent['Year'] == 2018].
 ↪sort_values('Solar Percent',
                                                                          ␣
 ↪ascending=False).head(10).reset_index(drop=True)
df_wind_percent = df_wind_percent[df_wind_percent['Year'] == 2018].
 ↪sort_values('Wind Percent',
                                                                          ␣
 ↪ascending=False).head(10).reset_index(drop=True)

print("example dataframe:")
display(df_solar_percent)
```

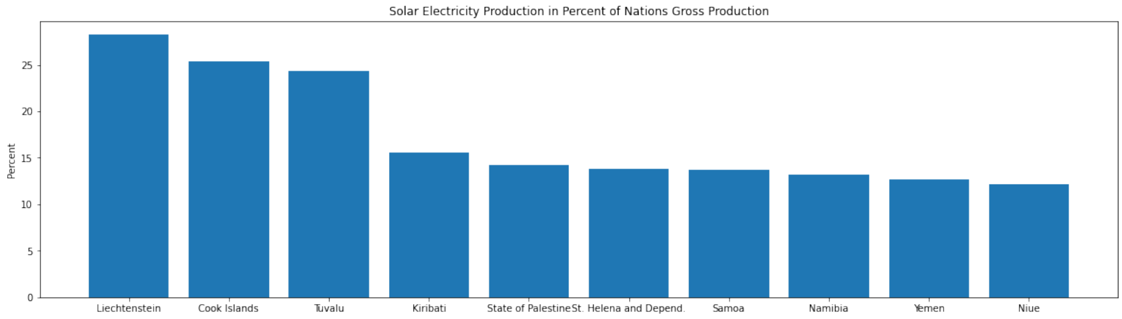
```
example dataframe:

         Country or Area  Year  Solar Quantity  Gross Quantity  Solar Percent
0          Liechtenstein  2018           25.20           89.00          28.31
1           Cook Islands  2018           10.50           41.40          25.36
2                 Tuvalu  2018            2.05            8.42          24.35
3               Kiribati  2018            4.90           31.40          15.61
4     State of Palestine  2018           60.00          420.40          14.27
5   St. Helena and Depend.  2018          1.65           11.93          13.83
6                  Samoa  2018           21.12          153.55          13.75
7                Namibia  2018          180.00         1363.10          13.21
8                  Yemen  2018          458.00         3609.00          12.69
9                   Niue  2018            0.47            3.87          12.14
```

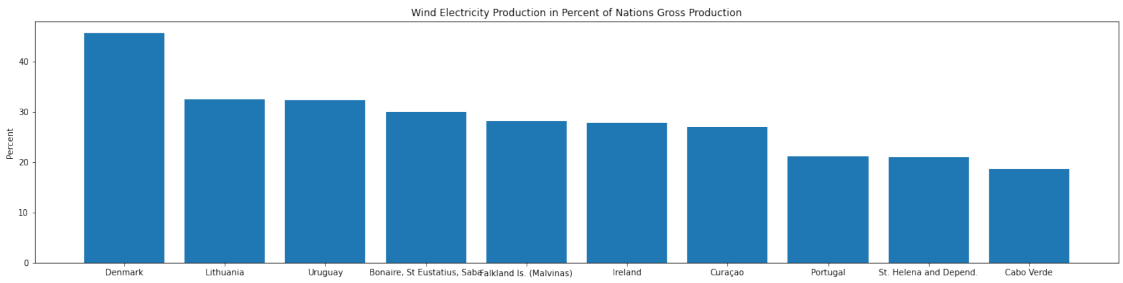
Visualizing Percentage Data

```
[13]: fig = plt.figure()
      countries = df_hydro_percent['Country or Area']
      production = df_hydro_percent['Hydro Percent']
      ax = fig.add_axes([0,0,2.3,1])
      ax.bar(countries, production)
      ax.set_title("Hydro Electricity Production in Percent of Nations Gross␣
       ↪Production")
      ax.set_ylabel("Percent")
      ax.set_ylim(80,101)
      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')));

      fig = plt.figure()
      countries = df_nuclear_percent['Country or Area']
      production = df_nuclear_percent['Nuclear Percent']
      ax = fig.add_axes([0,0,2.3,1])
      ax.bar(countries, production)
      ax.set_title("Nuclear Electricity Production in Percent of Nations Gross␣
       ↪Production")
      ax.set_ylabel("Percent")
      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')));

      fig = plt.figure()
      countries = df_solar_percent['Country or Area']
      production = df_solar_percent['Solar Percent']
      ax = fig.add_axes([0,0,2.6,1])
      ax.bar(countries, production)
      ax.set_title("Solar Electricity Production in Percent of Nations Gross␣
       ↪Production")
      ax.set_ylabel("Percent")
      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')));

      fig = plt.figure()
      countries = df_wind_percent['Country or Area']
      production = df_wind_percent['Wind Percent']
      ax = fig.add_axes([0,0,3,1])
      ax.bar(countries, production)
      ax.set_title("Wind Electricity Production in Percent of Nations Gross␣
       ↪Production")
      ax.set_ylabel("Percent")
      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')));
```


Hydro Electricity Production in Percent of Nations Gross Production
Percent
100
97
95
92
90
87
85
82
80
Paraguay
Albania
Bhutan
Lesotho
Nepal
Central African Rep.
Ethiopia
Norway
Tajikistan
Malawi


Nuclear Electricity Production in Percent of Nations Gross Production
Percent
70
60
50
40
30
20
10
0
France
Slovakia
Ukraine
Hungary
Sweden
Belgium
Switzerland
Slovenia
Bulgaria
Czechia

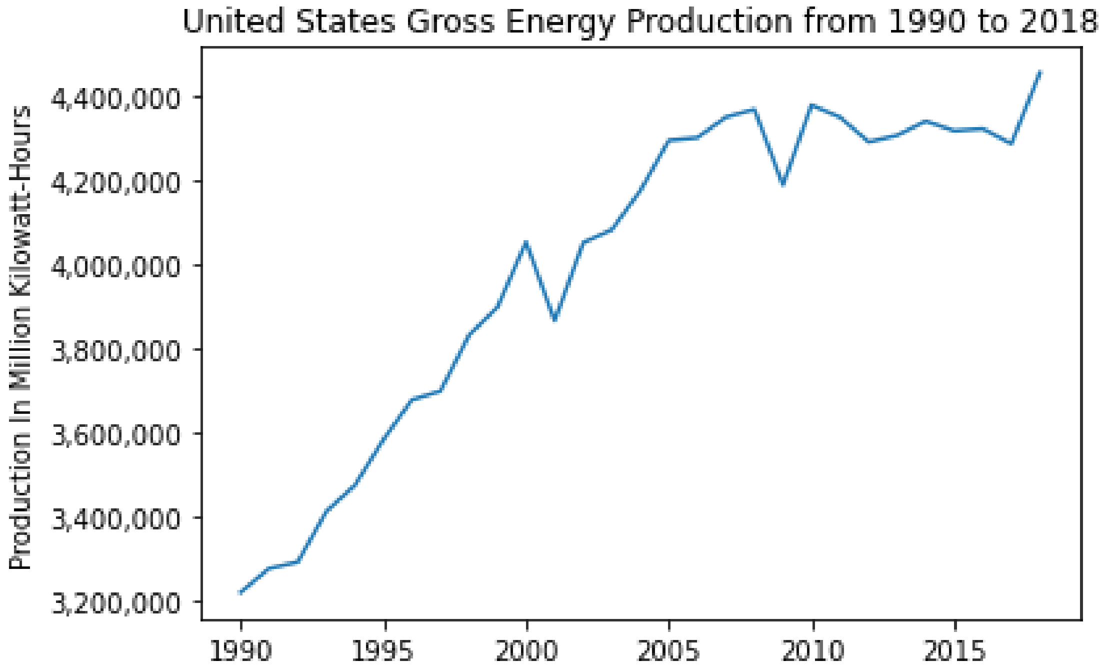

Solar Electricity Production in Percent of Nations Gross Production
Percent
25
20
15
10
5
0
Liechtenstein
Cook Islands
Tuvalu
Kiribati
State of Palestine
St. Helena and Depend.
Samoa
Namibia
Yemen
Niue

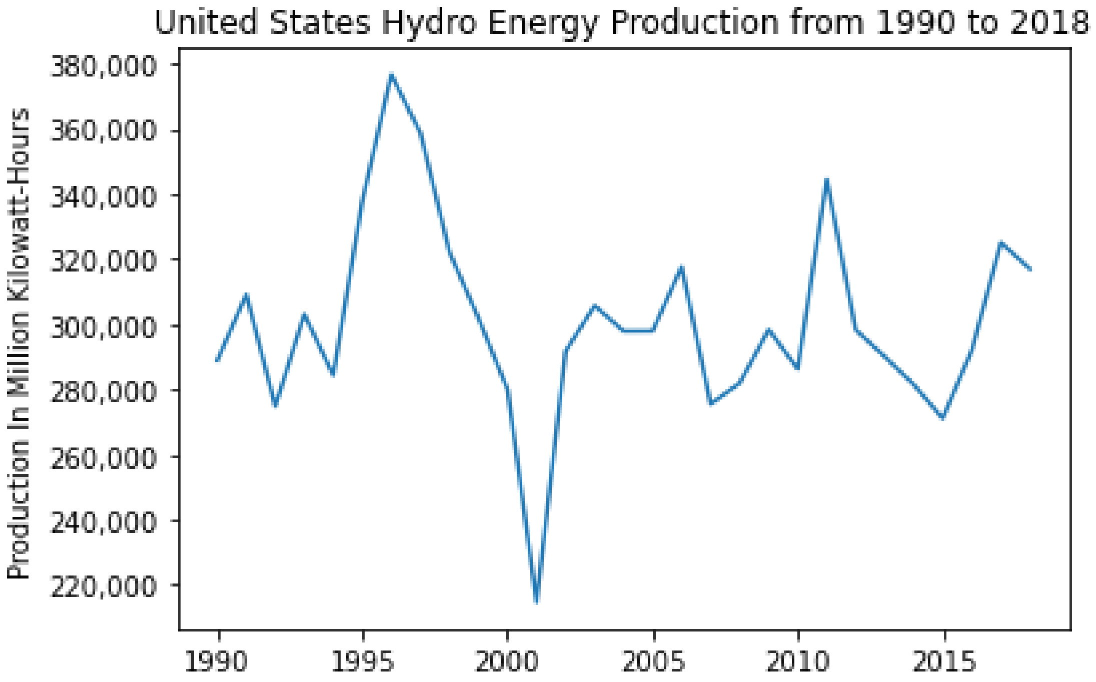

Wind Electricity Production in Percent of Nations Gross Production
Percent
40
30
20
10
0
Denmark
Lithuania
Uruguay
Bonaire, St Eustatius, Saba
Falkland Is. (Malvinas)
Ireland
Curaçao
Portugal
St. Helena and Depend.
Cabo Verde

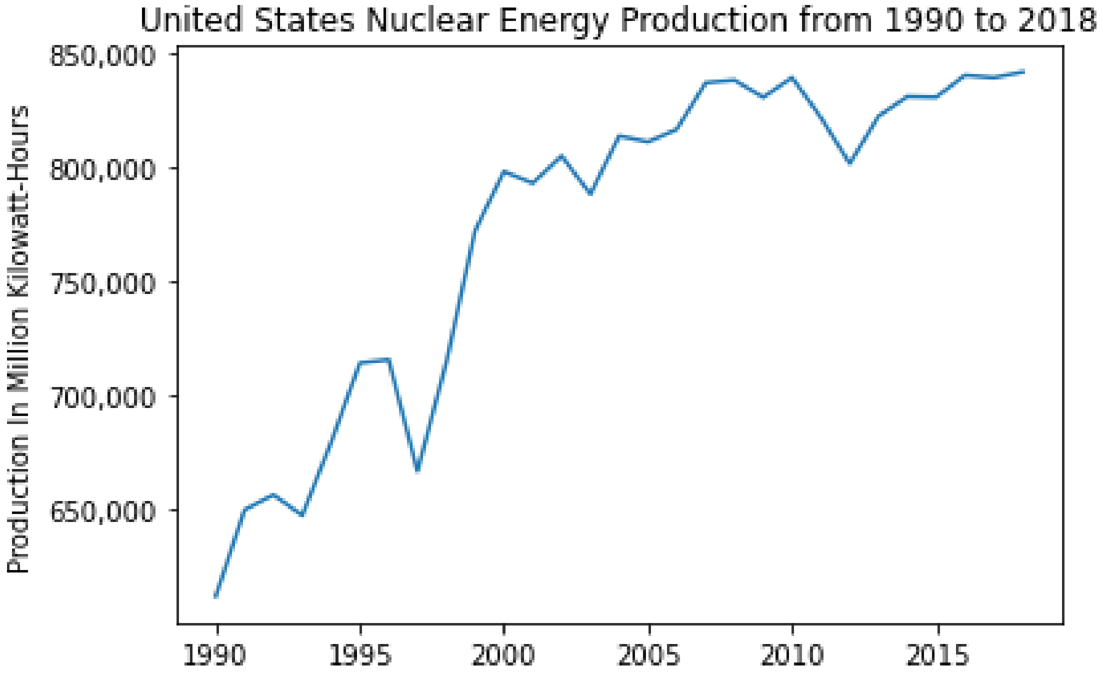
Graphing The United States Through Time

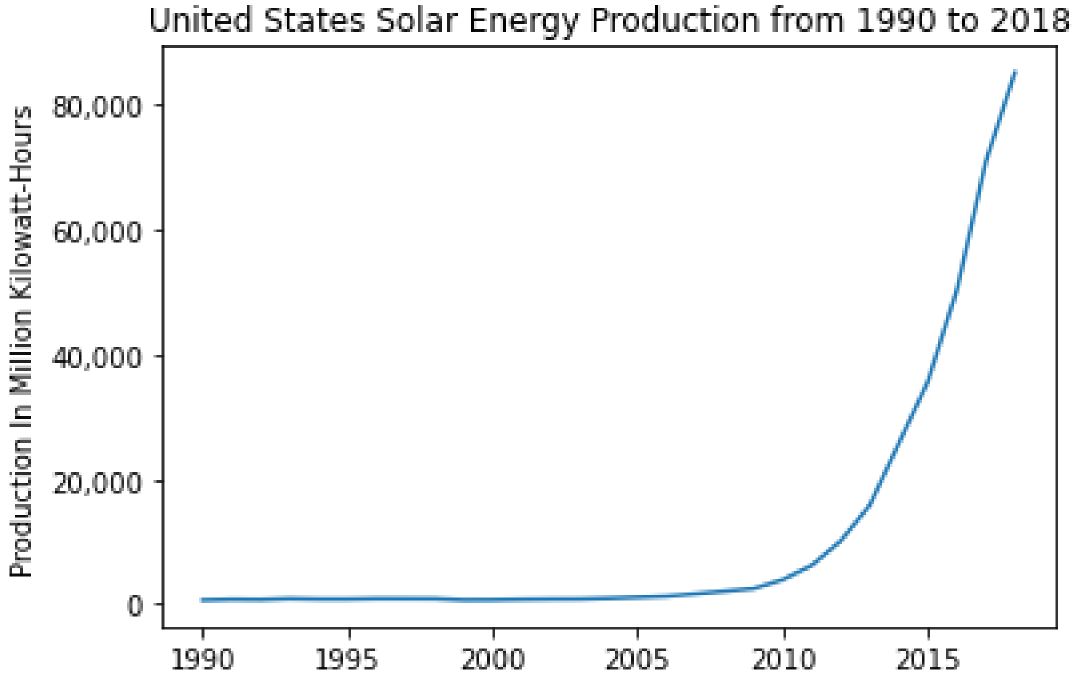
[14]:

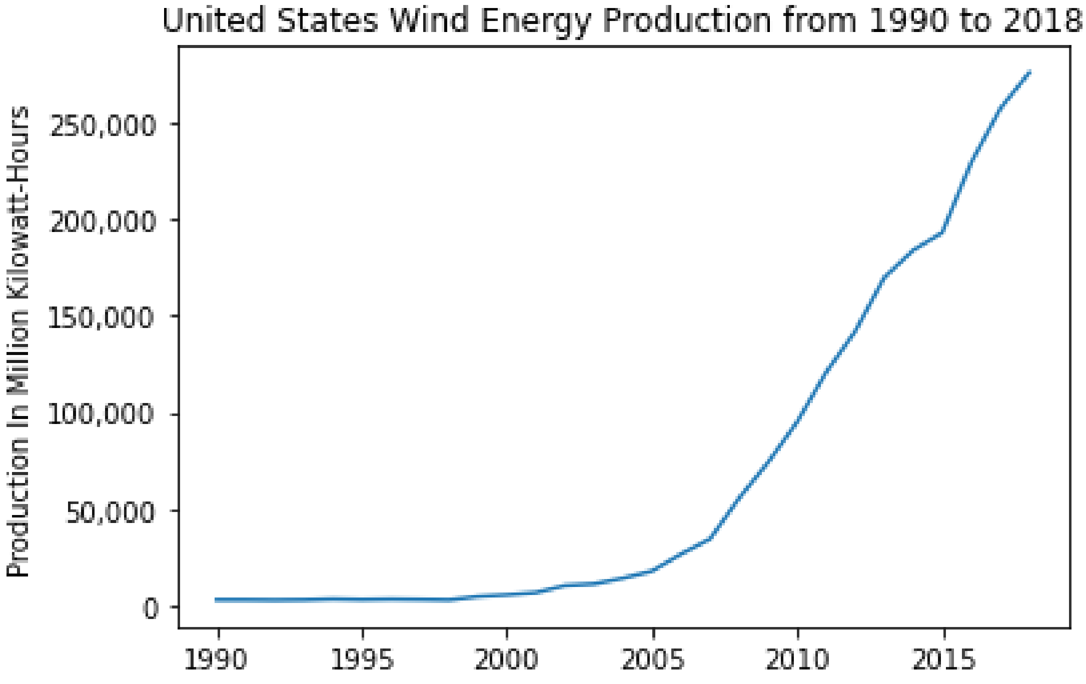
```
df_us = df_gross[df_gross['Country or Area'] == 'United States']

fig = plt.figure()

plt.title("United States Gross Energy Production from 1990 to 2018")
plt.plot(df_us['Year'], df_us['Gross Quantity'])
ax = plt.gca()
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")

fig = plt.figure()
plt.title("United States Hydro Energy Production from 1990 to 2018")
plt.plot(df_hydro[df_hydro['Country or Area'] == 'United States']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'United States']['Hydro␣
  ↪Quantity'])
ax = plt.gca()
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")

fig = plt.figure()
plt.title("United States Nuclear Energy Production from 1990 to 2018")
plt.plot(df_nuclear[df_nuclear['Country or Area'] == 'United States']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'United States']['Nuclear␣
  ↪Quantity'])
ax = plt.gca()
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")

fig = plt.figure()
plt.title("United States Solar Energy Production from 1990 to 2018")
plt.plot(df_solar[df_solar['Country or Area'] == 'United States']['Year'],
         df_solar[df_solar['Country or Area'] == 'United States']['Solar␣
  ↪Quantity'])
ax = plt.gca()
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours")

fig = plt.figure()
plt.title("United States Wind Energy Production from 1990 to 2018")
plt.plot(df_wind[df_wind['Country or Area'] == 'United States']['Year'],
         df_wind[df_wind['Country or Area'] == 'United States']['Wind␣
 ↪Quantity']);
ax = plt.gca()
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
ax.set_ylabel("Production In Million Kilowatt-Hours");
```




United States Hydro Energy Production from 1990 to 2018
Production In Million Kilowatt-Hours
380,000
360,000
340,000
320,000
300,000
280,000
260,000
240,000
220,000
1990
1995
2000
2005
2010
2015

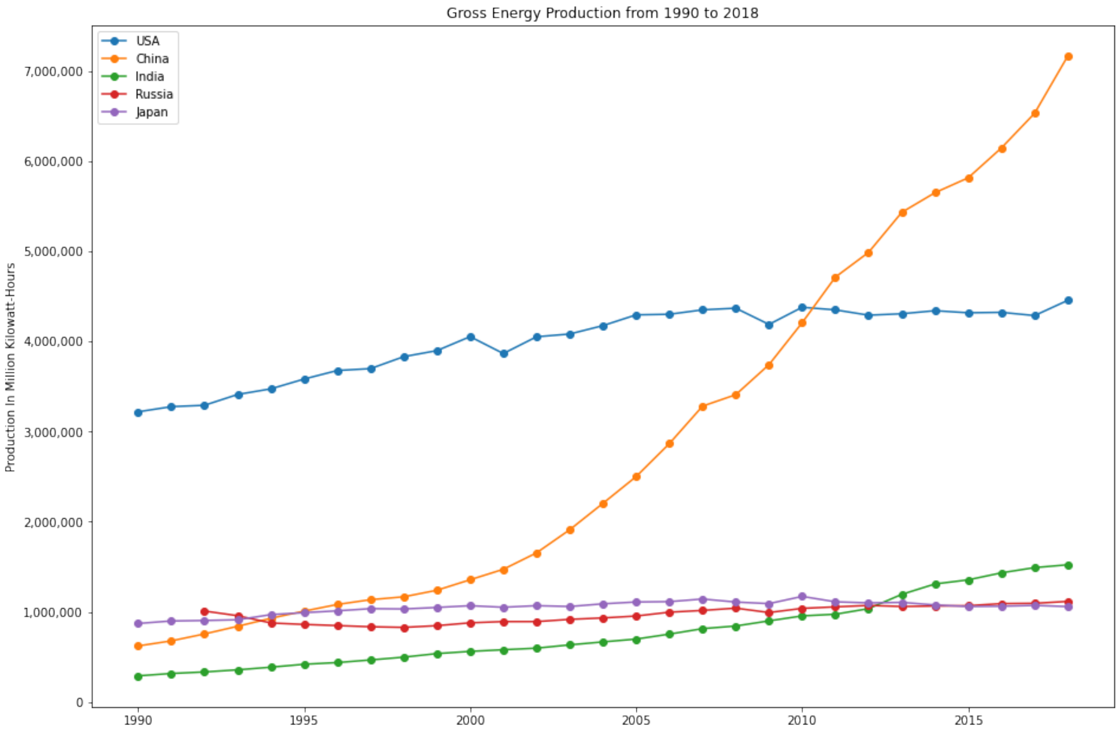

United States Nuclear Energy Production from 1990 to 2018
Production In Million Kilowatt-Hours
850,000
800,000
750,000
700,000
650,000
1990
1995
2000
2005
2010
2015





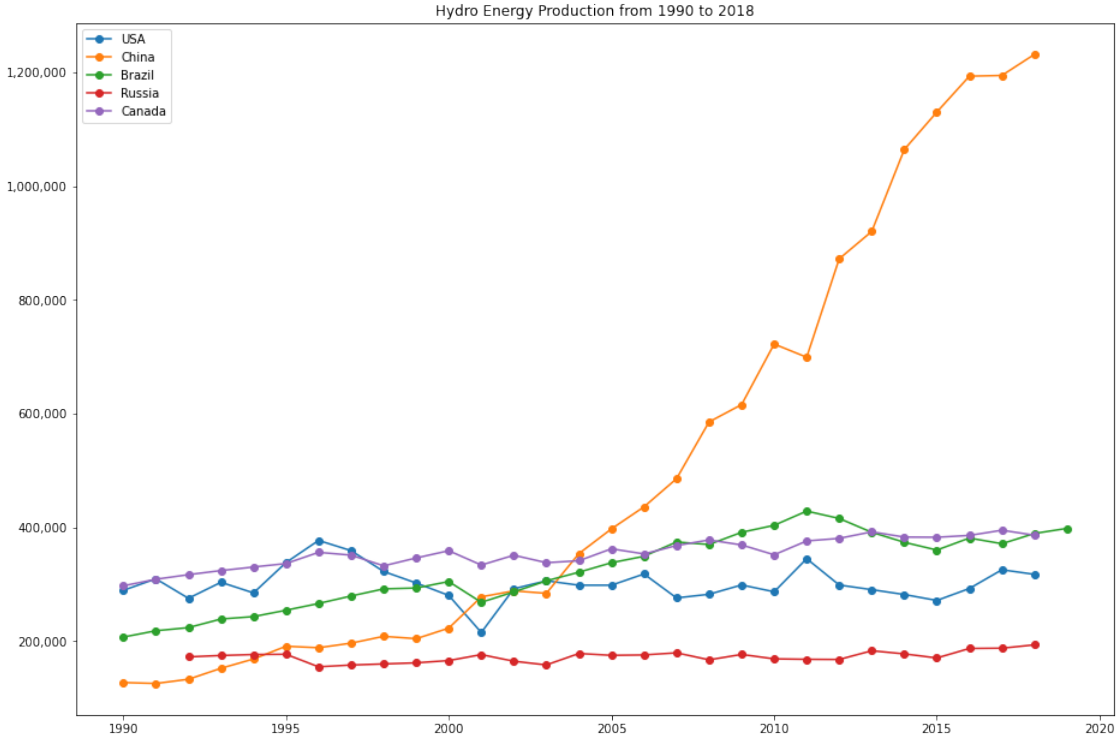
Graphing The Leading Energy Producers Through Time

```
[15]: fig = plt.figure()
      ax = fig.add_axes([0,0,2,2])
      ax.set_title("Gross Energy Production from 1990 to 2018")
      ax.plot(df_gross[df_gross['Country or Area'] == 'United States']['Year'],
               df_gross[df_gross['Country or Area'] == 'United States']['Gross␣
        ↪Quantity'], marker='o', label='USA')

      ax.plot(df_gross[df_gross['Country or Area'] == 'China']['Year'],
               df_gross[df_gross['Country or Area'] == 'China']['Gross Quantity'],␣
        ↪marker='o', label='China')

      ax.plot(df_gross[df_gross['Country or Area'] == 'India']['Year'],
               df_gross[df_gross['Country or Area'] == 'India']['Gross Quantity'],␣
        ↪marker='o', label='India')

      ax.plot(df_gross[df_gross['Country or Area'] == 'Russian Federation']['Year'],
               df_gross[df_gross['Country or Area'] == 'Russian Federation']['Gross␣
        ↪Quantity'], marker='o', label='Russia')

      ax.plot(df_gross[df_gross['Country or Area'] == 'Japan']['Year'],
               df_gross[df_gross['Country or Area'] == 'Japan']['Gross Quantity'],␣
        ↪marker='o', label='Japan')

      ax = plt.gca()
      handles, labels = ax.get_legend_handles_labels()
      ax.legend(handles, labels)

      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
      ax.set_ylabel("Production In Million Kilowatt-Hours");
```



Graphing Leading Nations in Hydro Power

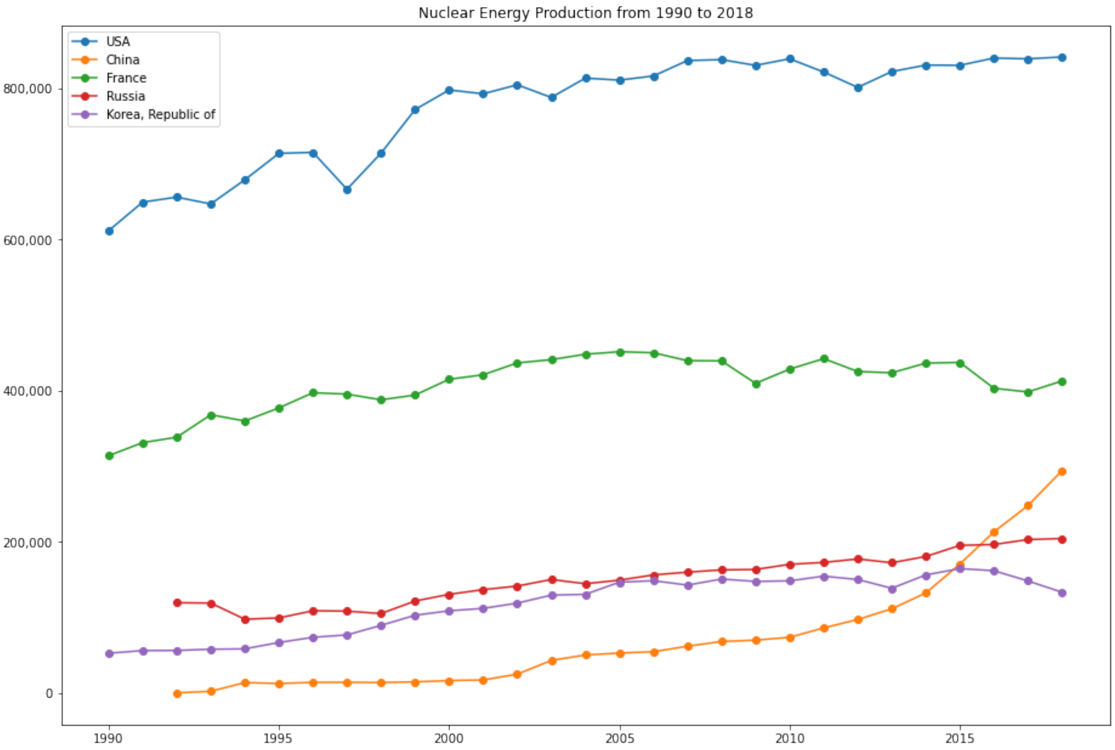
```
[16]: fig = plt.figure()
ax = fig.add_axes([0,0,2,2])
ax.set_title("Hydro Energy Production from 1990 to 2018")
ax.plot(df_hydro[df_hydro['Country or Area'] == 'United States']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'United States']['Hydro␣
 ↪Quantity'], marker='o', label='USA')

ax.plot(df_hydro[df_hydro['Country or Area'] == 'China']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'China']['Hydro Quantity'],␣
 ↪marker='o', label='China')

ax.plot(df_hydro[df_hydro['Country or Area'] == 'Brazil']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'Brazil']['Hydro Quantity'],␣
 ↪marker='o', label='Brazil')

ax.plot(df_hydro[df_hydro['Country or Area'] == 'Russian Federation']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'Russian Federation']['Hydro␣
 ↪Quantity'], marker='o', label='Russia')

ax.plot(df_hydro[df_hydro['Country or Area'] == 'Canada']['Year'],
         df_hydro[df_hydro['Country or Area'] == 'Canada']['Hydro Quantity'],␣
  ↪marker='o', label='Canada')

ax = plt.gca()
handles, labels = ax.get_legend_handles_labels()
ax.legend(handles, labels)

ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
```



Graphing Nuclear Power

```
[17]: fig = plt.figure()
ax = fig.add_axes([0,0,2,2])
ax.set_title("Nuclear Energy Production from 1990 to 2018")
ax.plot(df_nuclear[df_nuclear['Country or Area'] == 'United States']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'United States']['Nuclear␣
  ↪Quantity'], marker='o', label='USA')

ax.plot(df_nuclear[df_nuclear['Country or Area'] == 'China']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'China']['Nuclear␣
  ↪Quantity'], marker='o', label='China')
```

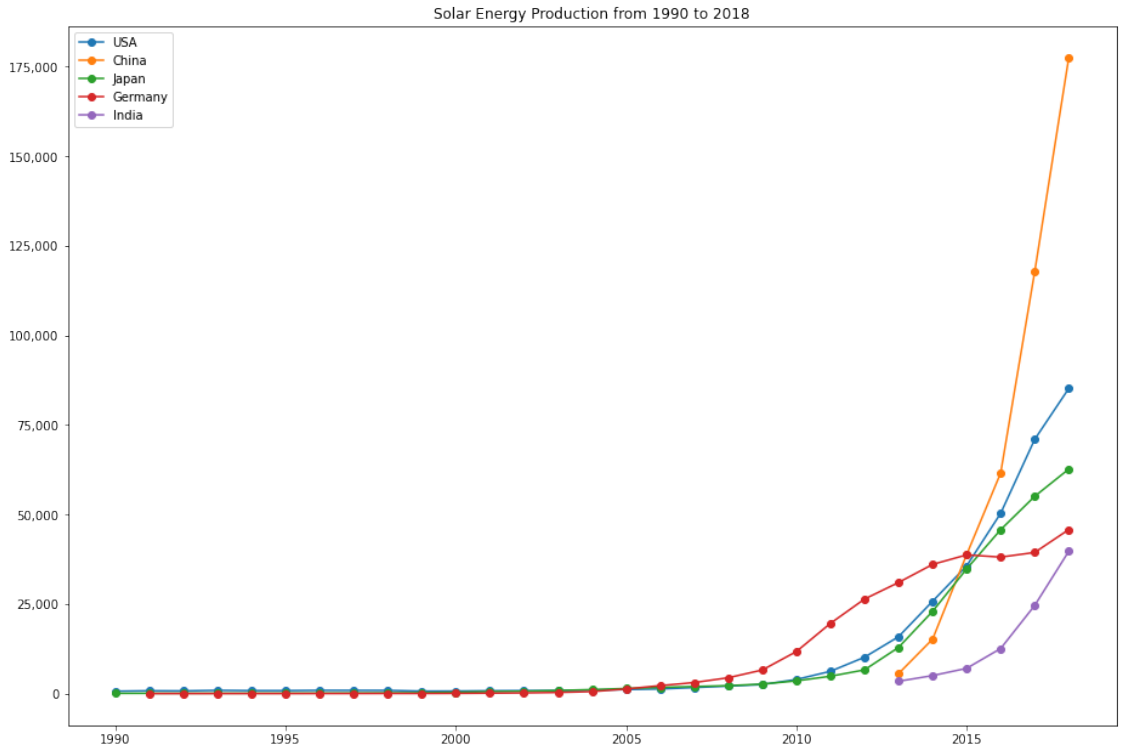
```
ax.plot(df_nuclear[df_nuclear['Country or Area'] == 'France']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'France']['Nuclear␣
 ↪Quantity'], marker='o', label='France')

ax.plot(df_nuclear[df_nuclear['Country or Area'] == 'Russian␣
 ↪Federation']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'Russian␣
 ↪Federation']['Nuclear Quantity'], marker='o', label='Russia')

ax.plot(df_nuclear[df_nuclear['Country or Area'] == 'Korea, Republic␣
 ↪of']['Year'],
         df_nuclear[df_nuclear['Country or Area'] == 'Korea, Republic␣
 ↪of']['Nuclear Quantity'], marker='o', label='Korea, Republic of')

ax = plt.gca()
handles, labels = ax.get_legend_handles_labels()
ax.legend(handles, labels)
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
```



Graphing Solar Power

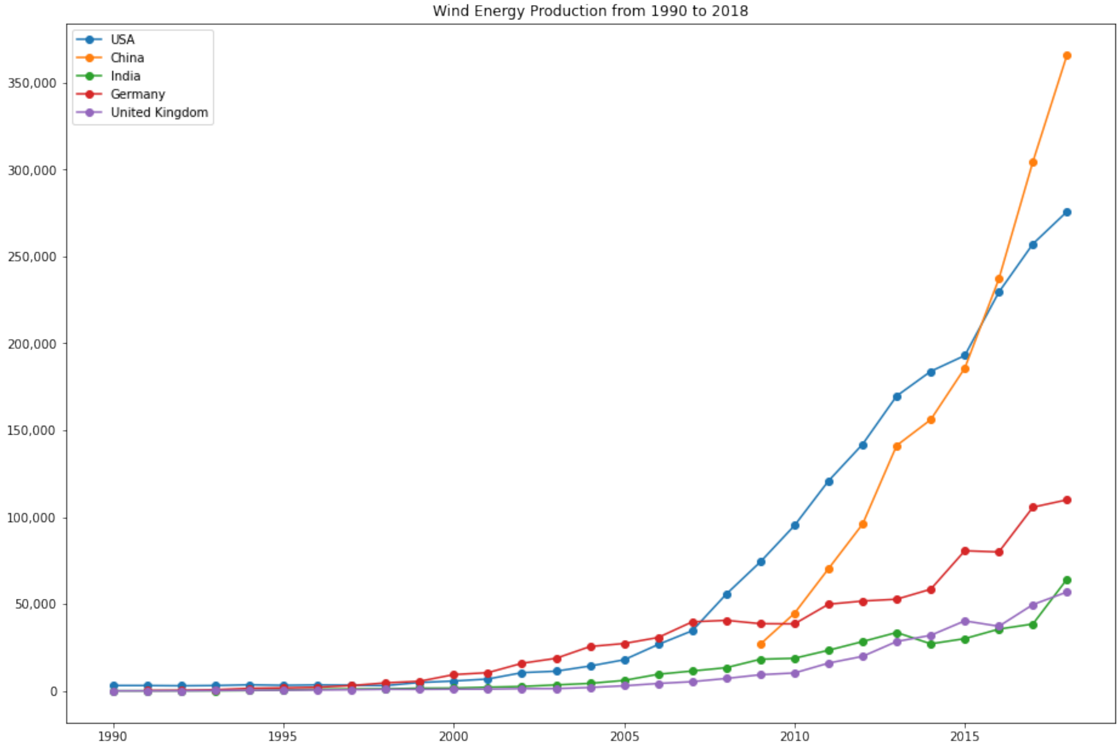
[18]:

```
fig = plt.figure()
ax = fig.add_axes([0,0,2,2])
ax.set_title("Solar Energy Production from 1990 to 2018")
ax.plot(df_solar[df_solar['Country or Area'] == 'United States']['Year'],
         df_solar[df_solar['Country or Area'] == 'United States']['Solar␣
 ↪Quantity'], marker='o', label='USA')

ax.plot(df_solar[df_solar['Country or Area'] == 'China']['Year'],
         df_solar[df_solar['Country or Area'] == 'China']['Solar Quantity'],␣
 ↪marker='o', label='China')

ax.plot(df_solar[df_solar['Country or Area'] == 'Japan']['Year'],
         df_solar[df_solar['Country or Area'] == 'Japan']['Solar Quantity'],␣
 ↪marker='o', label='Japan')

ax.plot(df_solar[df_solar['Country or Area'] == 'Germany']['Year'],
         df_solar[df_solar['Country or Area'] == 'Germany']['Solar Quantity'],␣
 ↪marker='o', label='Germany')

ax.plot(df_solar[df_solar['Country or Area'] == 'India']['Year'],
         df_solar[df_solar['Country or Area'] == 'India']['Solar Quantity'],␣
 ↪marker='o', label='India')

ax = plt.gca()
handles, labels = ax.get_legend_handles_labels()
ax.legend(handles, labels)
ax.get_yaxis().set_major_formatter(
    matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
```



Graphing Wind

```
[19]: fig = plt.figure()
      ax = fig.add_axes([0,0,2,2])
      ax.set_title("Wind Energy Production from 1990 to 2018")
      ax.plot(df_wind[df_wind['Country or Area'] == 'United States']['Year'],
               df_wind[df_wind['Country or Area'] == 'United States']['Wind␣
        ↪Quantity'], marker='o', label='USA')

      ax.plot(df_wind[df_wind['Country or Area'] == 'China']['Year'],
               df_wind[df_wind['Country or Area'] == 'China']['Wind Quantity'],␣
        ↪marker='o', label='China')

      ax.plot(df_wind[df_wind['Country or Area'] == 'India']['Year'],
               df_wind[df_wind['Country or Area'] == 'India']['Wind Quantity'],␣
        ↪marker='o', label='India')

      ax.plot(df_wind[df_wind['Country or Area'] == 'Germany']['Year'],
               df_wind[df_wind['Country or Area'] == 'Germany']['Wind Quantity'],␣
        ↪marker='o', label='Germany')

      ax.plot(df_wind[df_wind['Country or Area'] == 'United Kingdom']['Year'],
               df_wind[df_wind['Country or Area'] == 'United Kingdom']['Wind␣
        ↪Quantity'], marker='o', label='United Kingdom')

      ax = plt.gca()
      handles, labels = ax.get_legend_handles_labels()
      ax.legend(handles, labels)
      ax.get_yaxis().set_major_formatter(
          matplotlib.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
```



Wind Energy Production from 1990 to 2018

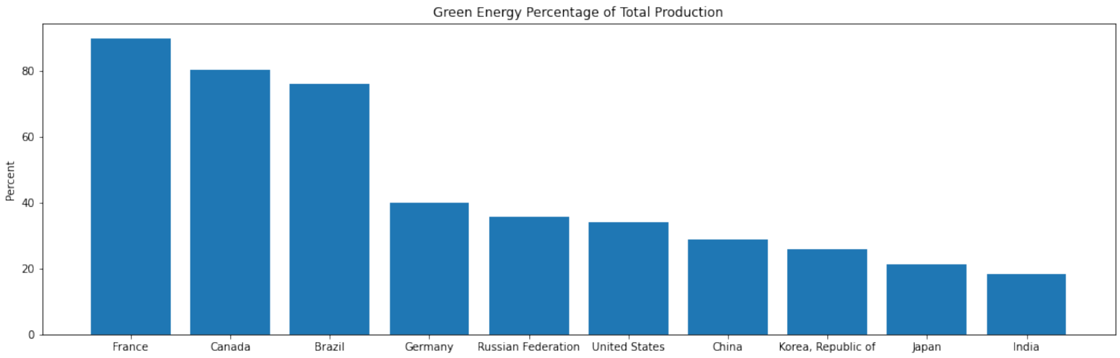
Greenest Countries

[20]:

```
df_green = df_gross[df_gross['Year'] == 2018].filter(['Country or Area',␣
 ↪'Year', 'Gross Quantity'])
df_green = pd.merge(df_green,
                    df_hydro[df_hydro['Year'] == 2018].filter(['Country or␣
 ↪Area', 'Year', 'Hydro Quantity']), how='outer')
df_green = pd.merge(df_green,
                    df_nuclear[df_nuclear['Year'] == 2018].filter(['Country or␣
 ↪Area', 'Year', 'Nuclear Quantity']), how='outer')
df_green = pd.merge(df_green,
                    df_solar[df_solar['Year'] == 2018].filter(['Country or␣
 ↪Area', 'Year', 'Solar Quantity']), how='outer')
df_green = pd.merge(df_green,
                    df_wind[df_wind['Year'] == 2018].filter(['Country or Area',␣
 ↪'Year', 'Wind Quantity']), how='outer')
display(df_green)

df_green = df_green.fillna(0)
df_green['Total Green'] = (df_green['Hydro Quantity'] + df_green['Nuclear␣
 ↪Quantity'] +
                           df_green['Solar Quantity'] + df_green['Wind␣
 ↪Quantity'])
df_green= df_green.filter(['Country or Area', 'Year', 'Gross Quantity', 'Total␣
 ↪Green'])
df_green['Green Percent'] = (df_green['Total Green'] / df_green['Gross␣
 ↪Quantity'] * 100).round(2)

display(df_green.sort_values(
    'Green Percent', ascending=False).reset_index(drop=True).head(20))

df_green = df_green.sort_values(
    'Green Percent', ascending=False).reset_index(drop=True)
df_green_top_10 = df_green[df_green['Country or Area'].
 ↪isin(df_gross_leaders['Country or Area'])].reset_index(drop=True)

display(df_green_top_10)
fig = plt.figure()
countries = df_green_top_10['Country or Area']
production = df_green_top_10['Green Percent']
ax = fig.add_axes([0,0,2.3,1])
ax.bar(countries, production)
ax.set_title("Green Energy Percentage of Total Production")
ax.set_ylabel("Percent");
```

```
           Country or Area  Year  Gross Quantity  Hydro Quantity  \
0              Afghanistan  2018         1265.72         1065.79
1                  Albania  2018         8552.15         8552.15
2                  Algeria  2018        76664.00          638.00
3           American Samoa  2018          168.03             NaN
4                  Andorra  2018          139.45          118.20
..                       …     …               …               …
220               Viet Nam  2018       213121.00        84205.00
221    Wallis and Futuna Is.  2018           20.27            0.34
222                  Yemen  2018         3609.00             NaN
223                 Zambia  2018        16190.90        12666.00
224               Zimbabwe  2018         9418.00         5049.00

     Nuclear Quantity  Solar Quantity  Wind Quantity
0                 NaN             NaN            NaN
1                 NaN             NaN            NaN
```

```
2                 NaN           62.00           84.0
3                 NaN            4.83            NaN
4                 NaN            0.90            NaN
..                …             …            …
220               NaN           23.00          317.0
221               NaN            0.16            NaN
222               NaN          458.00            NaN
223               NaN            0.93            NaN
224               NaN             NaN            NaN

[225 rows x 7 columns]
           Country or Area  Year  Gross Quantity  Total Green  Green Percent
0                   Bhutan  2018         6960.47      6960.43         100.00
1                  Albania  2018         8552.15      8552.15         100.00
2                    Nepal  2018         4913.12      4913.00         100.00
3                 Paraguay  2018        59212.45     59210.90         100.00
4                  Lesotho  2018          517.27       516.66          99.88
5                 Ethiopia  2018        13612.00     13571.00          99.70
6     Central African Rep.  2018          147.43       146.43          99.32
7                  Namibia  2018         1363.10      1342.10          98.46
8            Liechtenstein  2018           89.00        87.10          97.87
9                   Norway  2018       146889.00    143387.00          97.62
10             Switzerland  2018        69107.00     65382.00          94.61
11              Tajikistan  2018        19742.40     18394.40          93.17
12  Dem. Rep. of the Congo  2018        12066.68     11090.68          91.91
13                  Malawi  2018         2265.66      2080.66          91.83
14              Kyrgyzstan  2018        15728.00     14318.00          91.04
15                  Sweden  2018       163400.00    147829.00          90.47
16                  Uganda  2018         4039.50      3634.10          89.96
17                  France  2018       581943.00    522701.00          89.82
18              Costa Rica  2018        11497.90     10197.12          88.69
19                 Andorra  2018          139.45       119.10          85.41
      Country or Area  Year  Gross Quantity  Total Green  Green Percent
0              France  2018       581943.00    522701.00          89.82
1              Canada  2018       654399.00    523661.00          80.02
2              Brazil  2018       601396.00    456581.00          75.92
3             Germany  2018       643159.00    255883.00          39.79
4  Russian Federation  2018      1115093.19    398548.27          35.74
5       United States  2018      4455439.00   1519351.00          34.10
6               China  2018      7166133.00   2069634.00          28.88
7  Korea, Republic of  2018       590108.00    152448.00          25.83
8               Japan  2018      1057755.00    223426.00          21.12
9               India  2018      1521785.00    276826.00          18.19
```



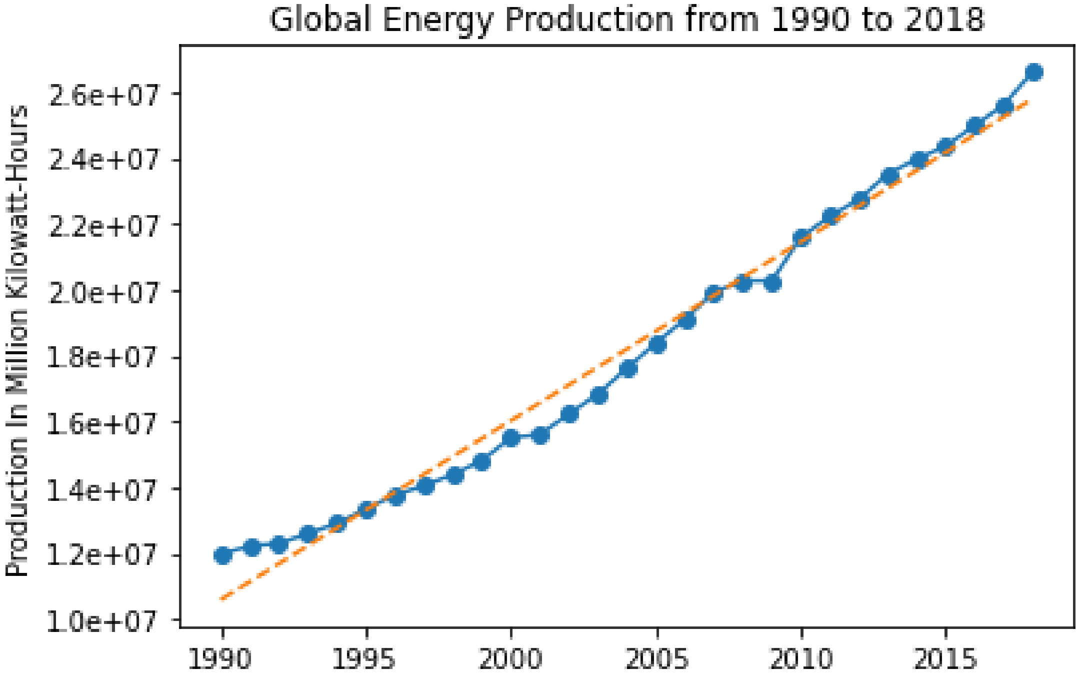
Predicting Future Global Energy Production

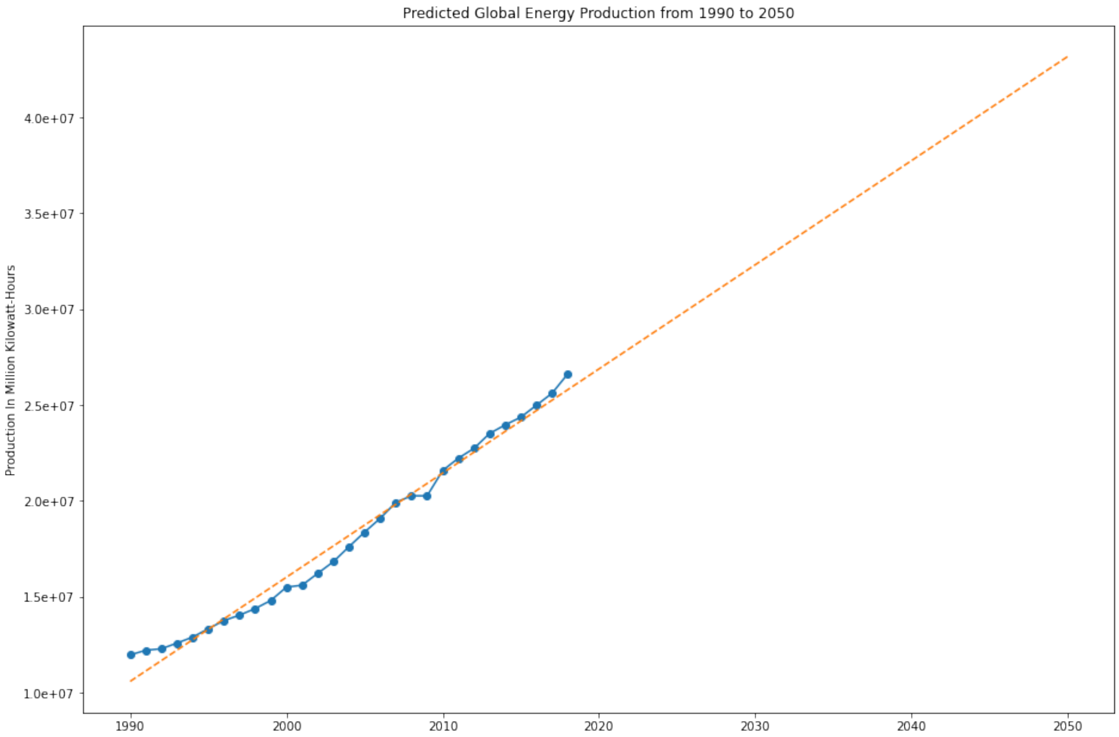
[21]:

```
import statsmodels.formula.api as smf

df_global = df_gross.filter(['Year', 'Gross Quantity']).groupby('Year').sum().reset_index()
df_global = df_global.rename(columns={'Gross Quantity' : 'Gross_Quantity'})
df_global = df_global.head(df_global.shape[0] - 1)

df_global

smresults = smf.ols('Gross_Quantity ~ Year', df_global).fit()
df = pd.DataFrame()
df['Year'] = range(1990, 2051)


display(df_global)
fig = plt.figure()
plt.title("Global Energy Production from 1990 to 2018")
plt.plot(df_global['Year'], df_global['Gross_Quantity'], marker='o')
plt.plot(df_global['Year'], smresults.predict(df_global), linestyle='dashed')
ax = plt.gca()
ax.yaxis.set_major_formatter(mtick.FormatStrFormatter('%.1e'))
ax.set_ylabel("Production In Million Kilowatt-Hours");


fig = plt.figure()
ax = fig.add_axes([0,0,2,2])
ax.plot(df_global['Year'], df_global['Gross_Quantity'], marker='o')
ax.plot(df['Year'], smresults.predict(df), linestyle='dashed')
ax.yaxis.set_major_formatter(mtick.FormatStrFormatter('%.1e'));
ax.set_ylabel("Production In Million Kilowatt-Hours");
ax.set_title("Predicted Global Energy Production from 1990 to 2050");
```

```
    Year  Gross_Quantity
```

```
0    1990      11973610.53
1    1991      12216053.82
2    1992      12293445.51
3    1993      12591066.90
4    1994      12902732.49
..    …              …
24   2014      23971263.22
25   2015      24370885.11
26   2016      24995882.08
27   2017      25621699.50
28   2018      26626090.62

[29 rows x 2 columns]
```




Predicted Global Energy Production from 1990 to 2050
Production In Million Kilowatt-Hours
4.0e+07
3.5e+07
3.0e+07
2.5e+07
2.0e+07
1.5e+07
1.0e+07
1990
2000
2010
2020
2030
2040
2050

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