First Name:

Last Name:

In [1]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import scipy
import matplotlib.pyplot as plt
```

In [2]:

Using a lambda function to round numeric values to 2 decimals.

```
pd.set_option('display.float_format', lambda x:'%.2f'%x)

gapminder = pd.read_csv('gapminder.csv', low_memory=False)
gapminder.head()
```

Out[2]:

Showing the first 5 rows of dataset.

	country	incomeperperson	alcconsumption	armedforcesrate	breastcancerper100th	c
0	Afghanistan		.03	.5696534	26.8	
1	Albania	1914.99655094922	7.29	1.0247361	57.4	22374
2	Algeria	2231.99333515006	.69	2.306817	23.5	29321
3	Andorra	21943.3398976022	10.17			
4	Angola	1381.00426770244	5.57	1.4613288	23.1	

In [3]:

```
#setting variables you will be working with to numeric
gapminder['oilperperson'] = pd.to_numeric(gapminder['oilperperson'],errors='coerce')
gapminder['relectricperperson'] = pd.to_numeric(gapminder['relectricperperson'],errors='coe
gapminder['co2emissions'] = pd.to_numeric(gapminder['co2emissions'],errors='coerce')
```

In [4]:

Turning columns into numeric and drop Non number values.

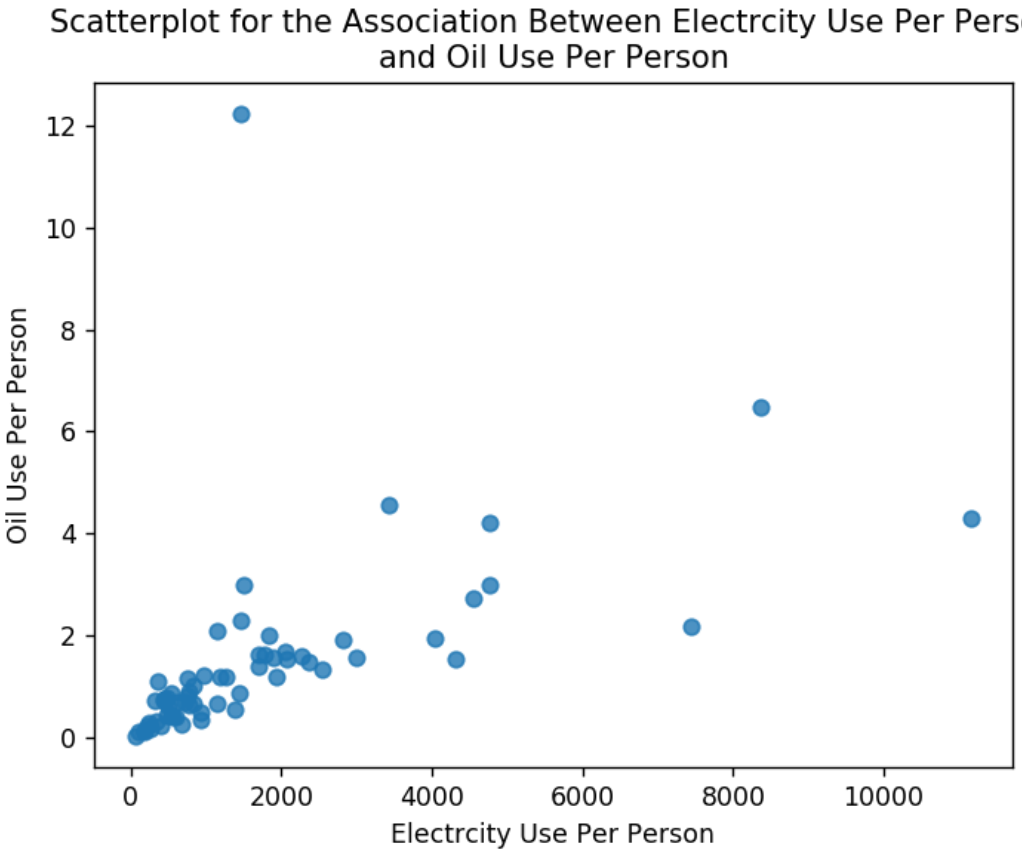
```
gapminder_clean=gapminder.dropna()
```

Correlation - Scenario 1

Scatter plot to show association between relectricperperson (x) and oilperperson (y)

In [28]:

```
%matplotlib notebook
scat1 = sns.regplot(x="electricperperson", y="oilperperson", fit_reg=False, data=gapminder
plt.xlabel('Electrcity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association Between Electrcity Use Per Person' + '\n' + 'and
```



The scatterplot shows a strong positive correlation between electricity and oil usage, but the relationship is weakened after electricity use surpass 5000.

Out[28]:

```
Text(0.5,1,'Scatterplot for the Association Between Electrcity Use Per Perso
n\nand Oil Use Per Person')
```

Pearson correlation - relectricperperson (x) and oilperperson (y)

In [6]:

```
print ('association between relectricperperson and oilperperson')
print (scipy.stats.pearsonr(gapminder_clean['relectricperperson'], gapminder_clean['oilperp
```

```
association between relectricperperson and oilperperson
(0.52493737791598849, 1.0020621767836594e-05)
```

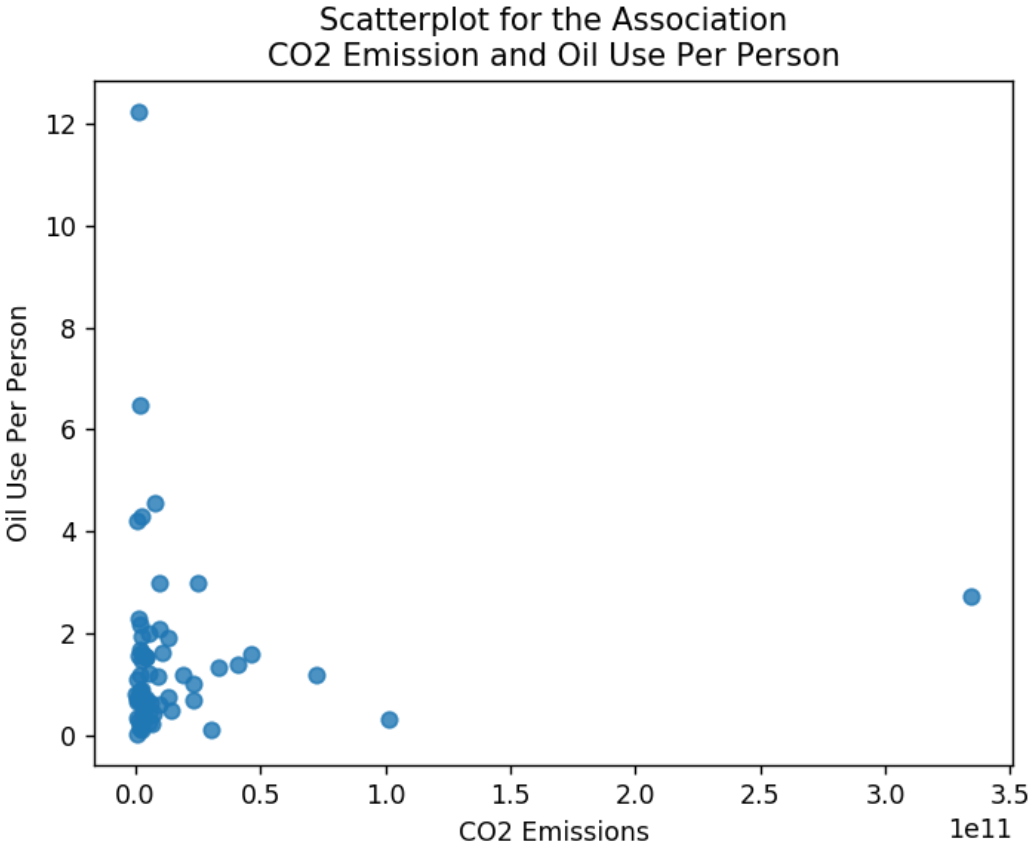
Using scipy to calculate linear regression correlation coefficient and p-value for null hypothesis.

Correlation - Scenario 2

Scatter plot to show association between co2emissions (x) and oilperperson (y)

In [29]:

```
%matplotlib notebook
plt.figure()
scat2 = sns.regplot(x="co2emissions", y="oilperperson", fit_reg=False, data=gapminder)
plt.xlabel('CO2 Emissions')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association' + '\n' + 'CO2 Emission and Oil Use Per Person')
```



The scatterplot shows there isn't much correlation between CO2 emission and oil usage.

Out[29]:

```
Text(0.5,1,'Scatterplot for the Association\nCO2 Emission and Oil Use Per Pe
rson')
```

Pearson correlation - co2emissions (x) and oilperperson (y)

In [8]:

```
print ('association between co2emissions and oilperperson')
print (scipy.stats.pearsonr(gapminder_clean['co2emissions'], gapminder_clean['oilperperson'
```

```
association between co2emissions and oilperperson
(0.044442012312287921, 0.72945188401230332)
```

Using scipy to calculate linear regression correlation coefficient and p-value for null hypothesis.

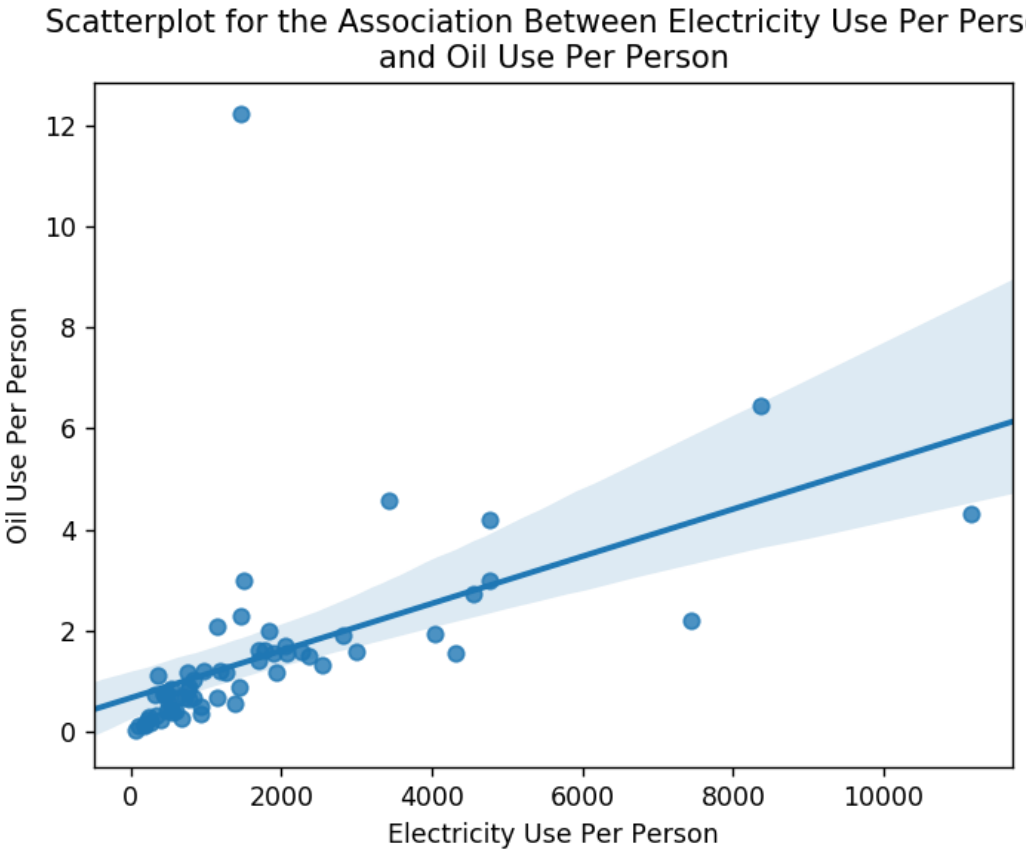
Regression - Scenario 3

Scatter plot with regression to show relationship

between relectricperperson (x) and oilperperson (y)

In [30]:

```
%matplotlib notebook
scat1 = sns.regplot(x="relectricperperson", y="oilperperson", fit_reg=True, data=gapminder_
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association Between Electricity Use Per Person' + '\n' + 'ar
```



We can see most data fit into regression model, with few outliers.

Out[30]:

```
Text(0.5,1,'Scatterplot for the Association Between Electricity Use Per Pers
on\nand Oil Use Per Person')
```

Regression analysis to show association between relectricperperson (x) and oilperperson (y)

In [10]:

```
import statsmodels.formula.api as smf

print ("OLS regression model for the association between Electric Use Per Person and Oil Pe
reg1 = smf.ols('oilperperson ~ relectricperperson', data=gapminder_clean).fit()
print (reg1.summary())
```

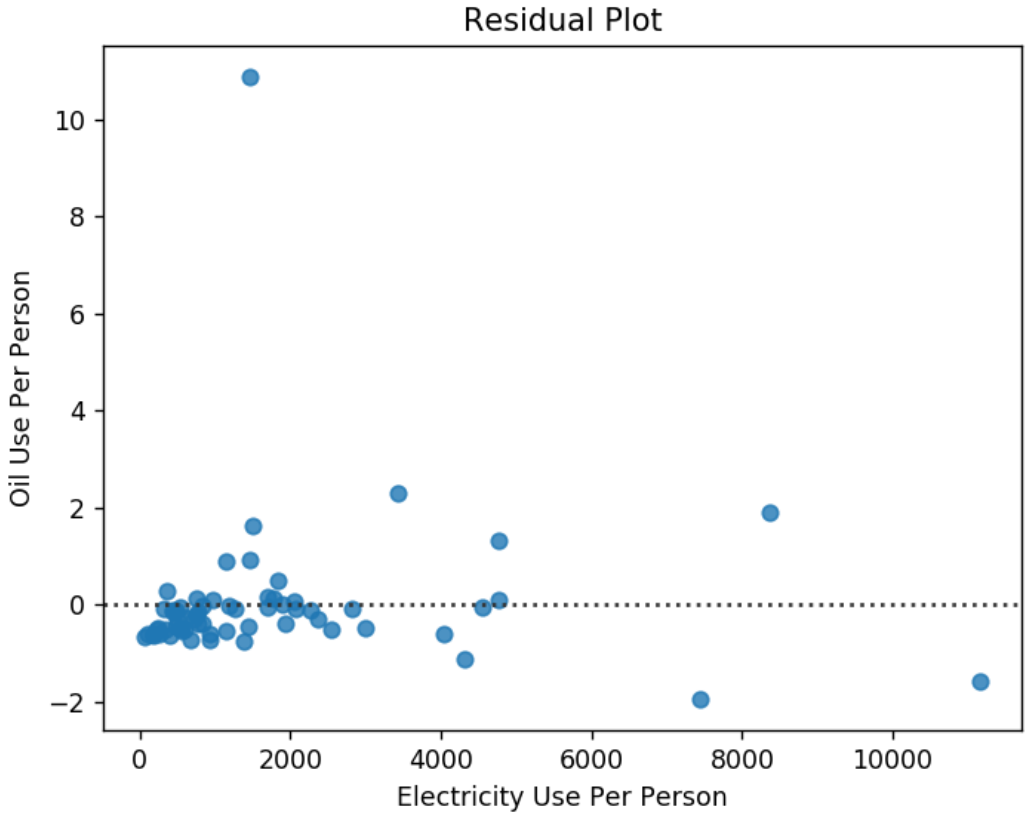
```
OLS regression model for the association between Electric Use Per Person and
Oil Per Person
                            OLS Regression Results

==============================================================================
==
Dep. Variable:           oilperperson   R-squared:                       0.2
76
Model:                            OLS   Adj. R-squared:                  0.2
64
Method:                 Least Squares   F-statistic:                     23.
20
Date:                Fri, 27 Apr 2018   Prob (F-statistic):           1.00e-
05
Time:                        15:02:25   Log-Likelihood:                -116.
64
No. Observations:                  63   AIC:                             23
7.3
Df Residuals:                      61   BIC:                             24
1.6
Df Model:                           1

Covariance Type:            nonrobust

==============================================================================
==========
                          coef    std err          t      P>|t|      [0.025
    0.975]
------------------------------------------------------------------------------
----------
Intercept              0.6736      0.259      2.598      0.012       0.155
     1.192
relectricperperson     0.0005   9.69e-05      4.817      0.000       0.000
     0.001
==============================================================================
==
Omnibus:                      112.807   Durbin-Watson:                   1.6
27
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             3834.0
05
Skew:                           5.613   Prob(JB):                         0.
00
Kurtosis:                      39.531   Cond. No.                     3.52e+
03
==============================================================================
==

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is corre
ctly specified.
[2] The condition number is large, 3.52e+03. This might indicate that there
are
strong multicollinearity or other numerical problems.
```

R-squared shows only 20% variables are explained with our model, a low Prob(f-statistic) indicates we should reject null hypothesis

Residual plot - regression analysis between relectricperperson (x) and oilperperson (y) - if required

In [31]:

```
%matplotlib notebook
scat1 = sns.residplot(x="relectricperperson", y="oilperperson",  data=gapminder_clean)

plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Residual Plot')
```



From the residual plot, as most variables are close to the line at 0, we know the variance is relatively low.

Out[31]:

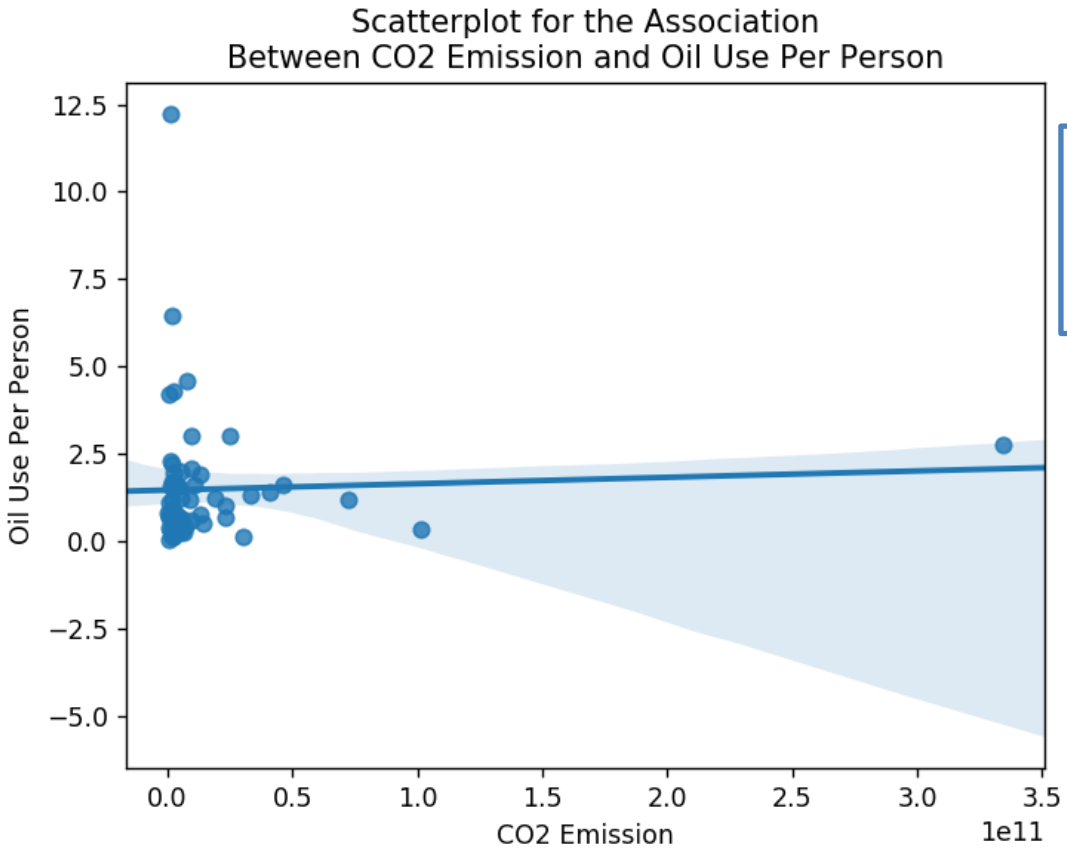
```
Text(0.5,1,'Residual Plot')
```

Regression - Scenario 4

Scatter plot with regression to show association between co2emissions (x) and oilperperson (y)

In [32]:

```
plt.figure()
scat2 = sns.regplot(x="co2emissions", y="oilperperson", fit_reg=True, data=gapminder)
plt.xlabel('CO2 Emission')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association' + '\n' + 'Between CO2 Emission and Oil Use Per
```



We can see most data does not fit into regression model, with few outliers.

Out[32]:

```
Text(0.5,1,'Scatterplot for the Association\nBetween CO2 Emission and Oil Us
e Per Person')
```

Regression analysis to show association between co2emissions (x) and oilperperson (y)

In [13]:

```
print ("OLS regression model for the association between CO2 emission and Oil Use Per Persc
reg1 = smf.ols('oilperperson ~ co2emissions', data=gapminder_clean).fit()
print (reg1.summary())
```

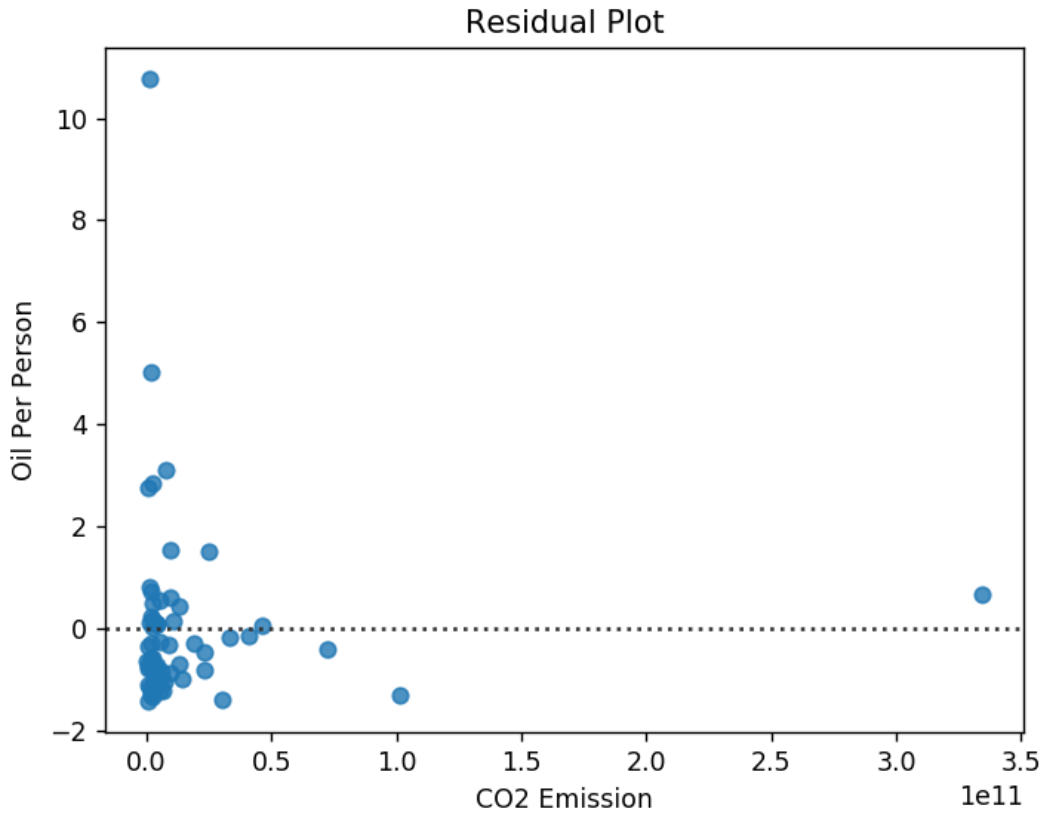
```
OLS regression model for the association between CO2 emission and Oil Use Pe
r Person
                            OLS Regression Results

==============================================================================
==
Dep. Variable:           oilperperson   R-squared:                       0.0
02
Model:                            OLS   Adj. R-squared:                 -0.0
14
Method:                 Least Squares   F-statistic:                    0.12
07
Date:                Fri, 27 Apr 2018   Prob (F-statistic):              0.7
29
Time:                        15:02:25   Log-Likelihood:                -126.
73
No. Observations:                  63   AIC:                             25
7.5
Df Residuals:                      61   BIC:                             26
1.7
Df Model:                           1

Covariance Type:            nonrobust

==============================================================================
====
                   coef    std err          t      P>|t|      [0.025      0.
975]
------------------------------------------------------------------------------
------------------
Intercept        1.4561      0.245      5.939      0.000       0.966
1.946
co2emissions  1.829e-12   5.26e-12      0.347      0.729    -8.7e-12    1.24
e-11
==============================================================================
==
Omnibus:                       82.847   Durbin-Watson:                   1.7
27
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1029.8
53
Skew:                           3.814   Prob(JB):                    2.35e-2
24
Kurtosis:                      21.279   Cond. No.                     4.93e+
10
==============================================================================
==

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is corre
ctly specified.
[2] The condition number is large, 4.93e+10. This might indicate that there
are
strong multicollinearity or other numerical problems.
```

R-squared shows the model does not explain any variables (0%), a high Prob(f-statistic) indicates we should accept null hypothesis

Residual plot - regression analysis between co2emissions (x) and oilperperson (y) - if required

In [33]:

```
%matplotlib notebook
scat1 = sns.residplot(x="co2emissions", y="oilperperson",  data=gapminder_clean)

plt.xlabel('CO2 Emission')
plt.ylabel('Oil Per Person')
plt.title('Residual Plot')
```



Residual plot further depicts how most data are not align with line at 0.

Out[33]:

```
Text(0.5,1,'Residual Plot')
```

Regression with 3 variables

Use co2emissionsgrp function to divide/group data into 3 groups

Low co2emission (1): min - 1846084167

Medium co2emission (2): 1846084168 - 7993752800

High co2emission (3): 7993752801 - max

In [15]:

```
def co2emissionsgrp  (row):
   if row['co2emissions'] <= 1846084167:
      return 1
   elif row['co2emissions'] <= 7993752800:
      return 2
   elif row['co2emissions'] > 7993752800:
      return 3
```

Dividing CO2 emissions into three groups, as low, mid, and high.

In [16]:

```
gapminder_clean['co2emissionsgrp'] = gapminder_clean.apply (lambda row: co2emissionsgrp (rc
```

```
C:\Users\jc443343\AppData\Local\Continuum\anaconda3\lib\site-packages\ipyker
nel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/s
table/indexing.html#indexing-view-versus-copy (http://pandas.pydata.org/pand
as-docs/stable/indexing.html#indexing-view-versus-copy)
  """Entry point for launching an IPython kernel.
```

Print the number of countries in each group of CO2 emission

In [17]:

```
chk1 = gapminder_clean['co2emissionsgrp'].value_counts(sort=False, dropna=False)
print(chk1)
```

```
1    17
2    27
3    19
Name: co2emissionsgrp, dtype: int64
```

Mid CO2 emission group has the highest count: 27

Divide gapminder_clean into 3 dataframes, each dataframe representing rows of data in low, medium and high CO2 Emission

In [18]:

```
sub1=gapminder_clean[(gapminder_clean['co2emissionsgrp']== 1)]
sub2=gapminder_clean[(gapminder_clean['co2emissionsgrp']== 2)]
sub3=gapminder_clean[(gapminder_clean['co2emissionsgrp']== 3)]
```

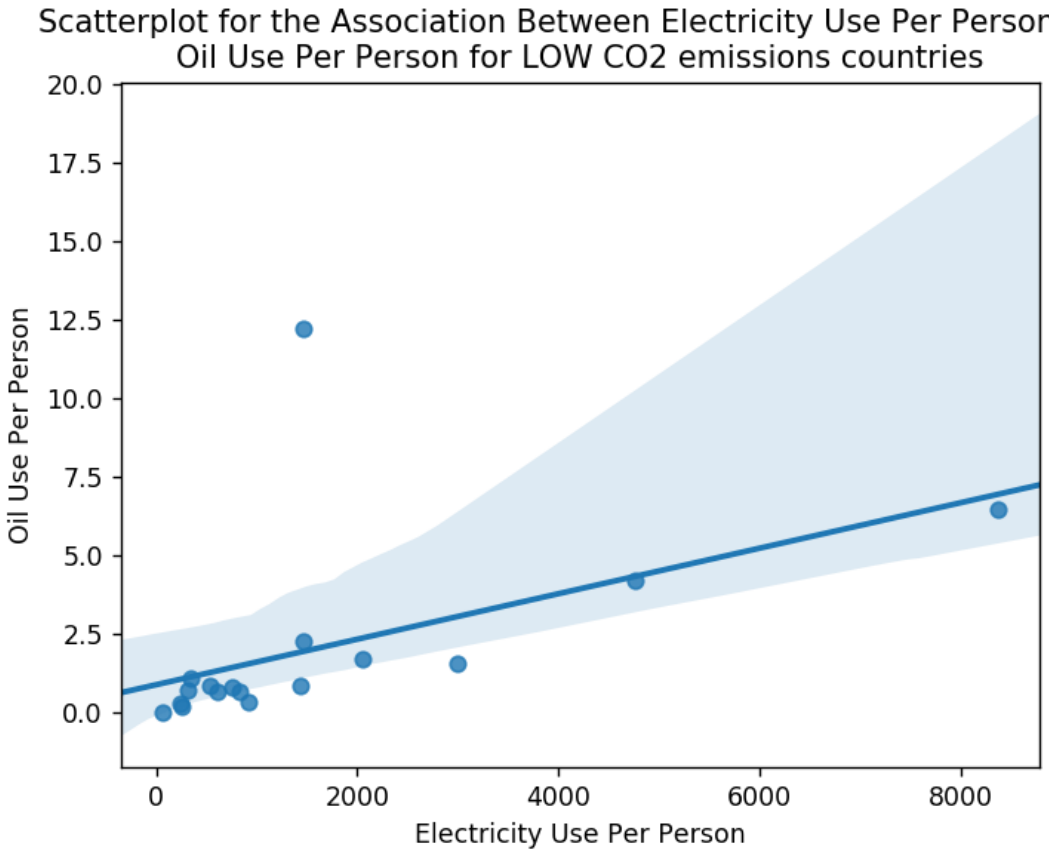
Regression - Scenario 5

Scatter plot with regression analysis to show association between electricity use per person (x) and

oilperperson (y) for low CO2 emission countries

In [34]:

```
%matplotlib notebook
scat1 = sns.regplot(x="relectricperperson", y="oilperperson", data=sub1)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association Between Electricity Use Per Person and' + '\n'
print (scat1)
```



We can see most data does not fit into regression model, with only one significant outlier.

```
AxesSubplot(0.125,0.11;0.775x0.77)
```

Regression analysis to show association between electricity use per person (x) and oilperperson (y) for low CO2 emission countries

In [20]:

```
print ('OLS regression model for the association between Electricty Use Per Person and Oil
reg1 = smf.ols('oilperperson ~ relectricperperson', data=sub1).fit()
print (reg1.summary())
```

```
OLS regression model for the association between Electricty Use Per Person a
nd Oil Use Per Person for
LOW CO2 Emission countries
                            OLS Regression Results

==============================================================================
==
Dep. Variable:           oilperperson   R-squared:                       0.2
44
Model:                            OLS   Adj. R-squared:                  0.1
94
Method:                 Least Squares   F-statistic:                     4.8
40
Date:                Fri, 27 Apr 2018   Prob (F-statistic):             0.04
39
Time:                        15:02:26   Log-Likelihood:                -40.3
87
No. Observations:                  17   AIC:                             84.
77
Df Residuals:                      15   BIC:                             86.
44
Df Model:                           1

Covariance Type:            nonrobust

==============================================================================
==========
                          coef    std err          t      P>|t|      [0.025
    0.975]
------------------------------------------------------------------------------
----------
Intercept              0.8962      0.856      1.046      0.312      -0.929
     2.722
relectricperperson     0.0007      0.000      2.200      0.044    2.25e-05
     0.001
==============================================================================
==
Omnibus:                       43.166   Durbin-Watson:                   2.0
57
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              126.4
42
Skew:                           3.582   Prob(JB):                     3.50e-
28
Kurtosis:                      14.278   Cond. No.                     3.32e+
03
==============================================================================
==

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is corre
ctly specified.
[2] The condition number is large, 3.32e+03. This might indicate that there
are
strong multicollinearity or other numerical problems.
```

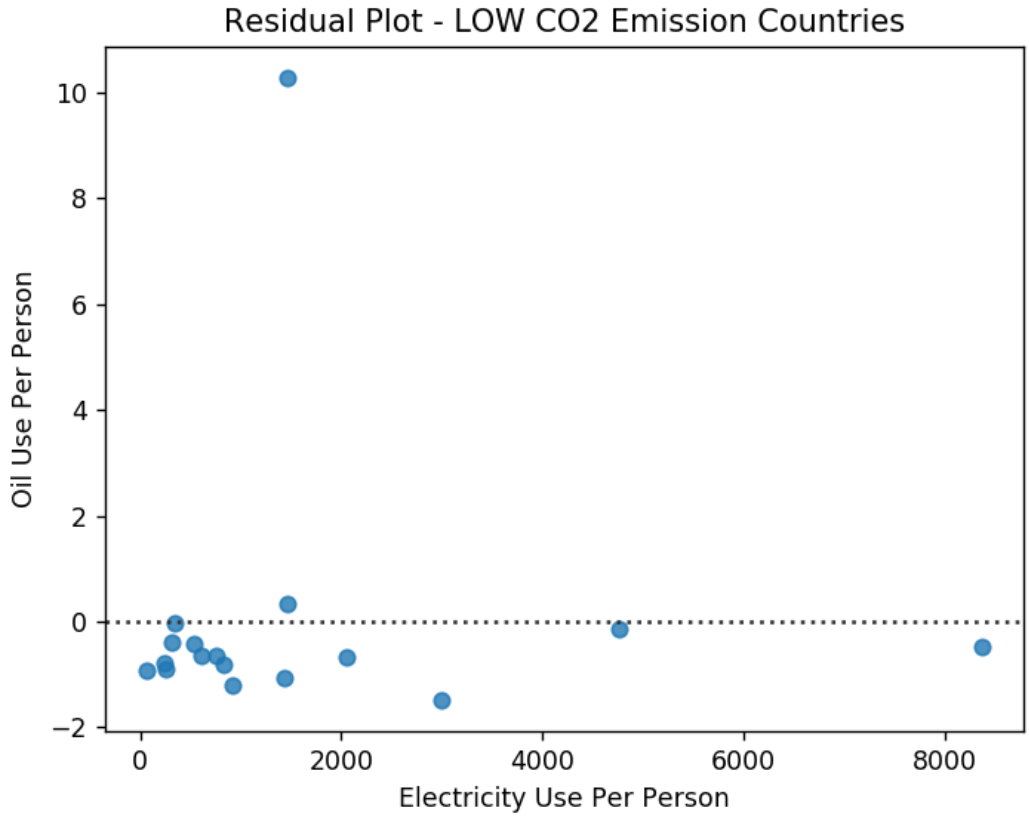
R-squared shows the model only explains 20% variables, Prob(f-statistic) barely pass the test of below 0.05, and we should still reject null hypothesis

```
C:\Users\jc443343\AppData\Local\Continuum\anaconda3\lib\site-packages\scipy
\stats\stats.py:1334: UserWarning: kurtosistest only valid for n>=20 ... con
tinuing anyway, n=17
  "anyway, n=%i" % int(n))
```

Residual plot - regression analysis between relectricperperson (x) and oilperperson (y) for Low CO2 emission countries

In [35]:

```
%matplotlib notebook
scat1 = sns.residplot(x="relectricperperson", y="oilperperson", data=sub1)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Residual Plot - LOW CO2 Emission Countries')
```



Residual plot shows most data are close to line 0, with one noticeable outlier.

Out[35]:

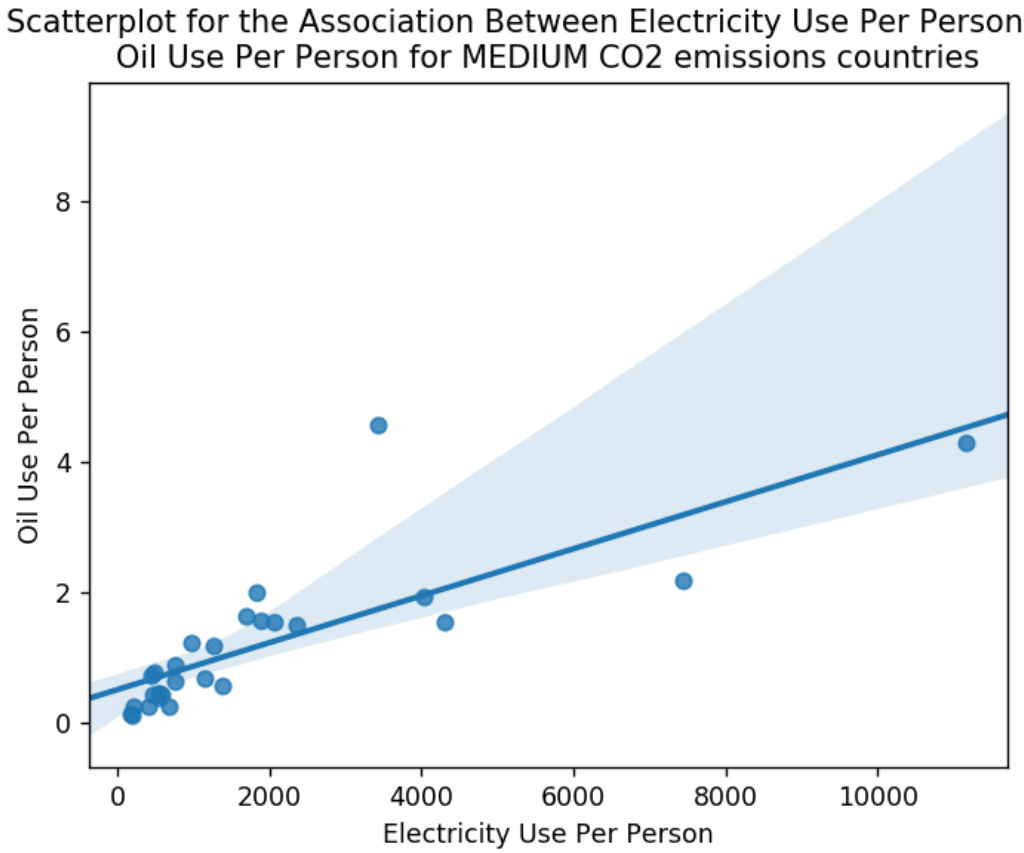
```
Text(0.5,1,'Residual Plot - LOW CO2 Emission Countries')
```

Regression - Scenario 6

Scatter plot with regression analysis to show association between electricity use per person (x) and oilperperson (y) for medium CO2 emission countries

In [36]:

```
%matplotlib notebook
scat1 = sns.regplot(x="relectricperperson", y="oilperperson", data=sub2)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association Between Electricity Use Per Person and' + '\n'
print (scat1)
```



We can see most data fit into regression model, with only one significant outlier.

```
AxesSubplot(0.125,0.11;0.775x0.77)
```

In [23]:

```
print ('OLS regression model for the association between Electricty Use Per Person and Oil
reg1 = smf.ols('oilperperson ~ relectricperperson', data=sub2).fit()
print (reg1.summary())
```

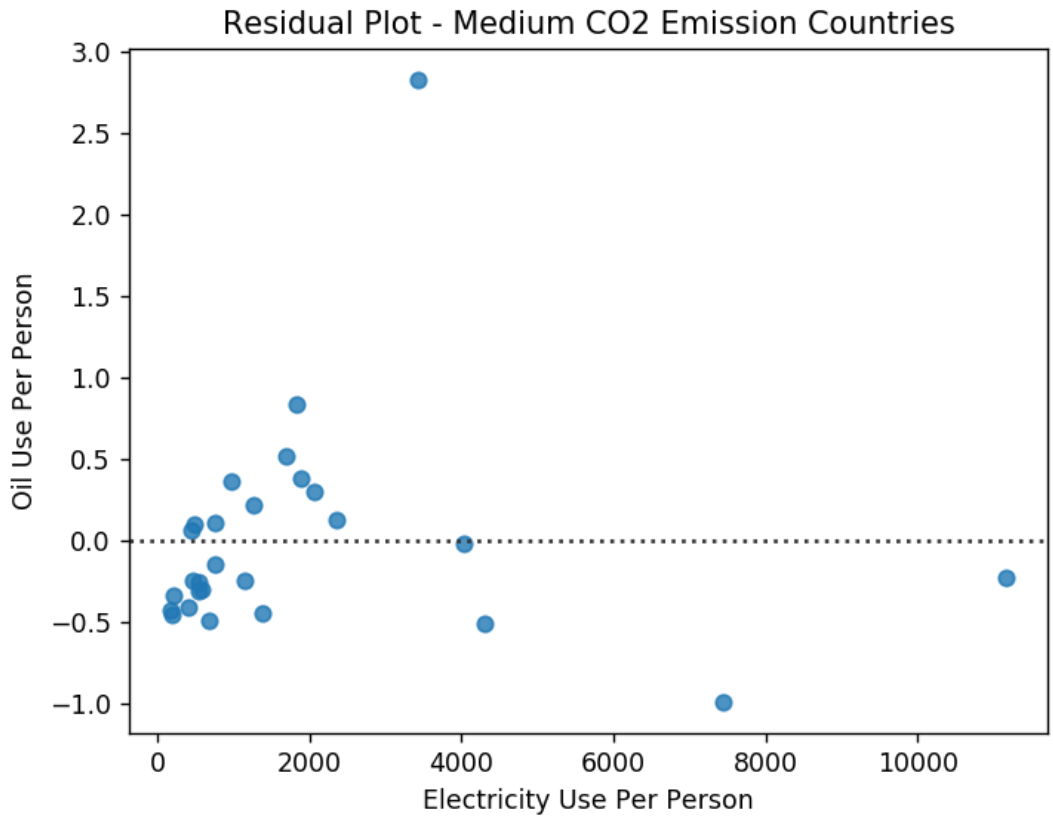
```
OLS regression model for the association between Electricty Use Per Person a
nd Oil Use Per Person for
MEDIUM CO2 Emission countries
                            OLS Regression Results

==============================================================================
==
Dep. Variable:           oilperperson   R-squared:                       0.6
26
Model:                            OLS   Adj. R-squared:                  0.6
11
Method:                 Least Squares   F-statistic:                     41.
89
Date:                Fri, 27 Apr 2018   Prob (F-statistic):           8.88e-
07
Time:                        15:02:26   Log-Likelihood:                -27.6
31
No. Observations:                  27   AIC:                             59.
26
Df Residuals:                      25   BIC:                             61.
85
Df Model:                           1

Covariance Type:            nonrobust

==============================================================================
==========
                         coef    std err          t      P>|t|      [0.025
    0.975]
------------------------------------------------------------------------------
----------
Intercept              0.5063      0.171      2.958      0.007       0.154
     0.859
relectricperperson     0.0004   5.57e-05      6.472      0.000       0.000
     0.000
==============================================================================
==
Omnibus:                       37.330   Durbin-Watson:                   2.2
73
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              120.1
41
Skew:                           2.643   Prob(JB):                     8.16e-
27
Kurtosis:                      11.880   Cond. No.                     3.91e+
03
==============================================================================
==

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is corre
ctly specified.
[2] The condition number is large, 3.91e+03. This might indicate that there
are
strong multicollinearity or other numerical problems.
```

R-squared shows the model explains 60% variables, a very small Prob(f-statistic) tells us we should still reject null hypothesis

Residual plot - regression analysis between relectricperperson (x) and oilperperson (y) for Medium CO2 emission countries

In [37]:

```
%matplotlib notebook
scat1 = sns.residplot(x="relectricperperson", y="oilperperson", data=sub2)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Residual Plot - Medium CO2 Emission Countries')
```



Residual plot shows most data are close to line 0, with one noticeable outlier.

Out[37]:

```
Text(0.5,1,'Residual Plot - Medium CO2 Emission Countries')
```

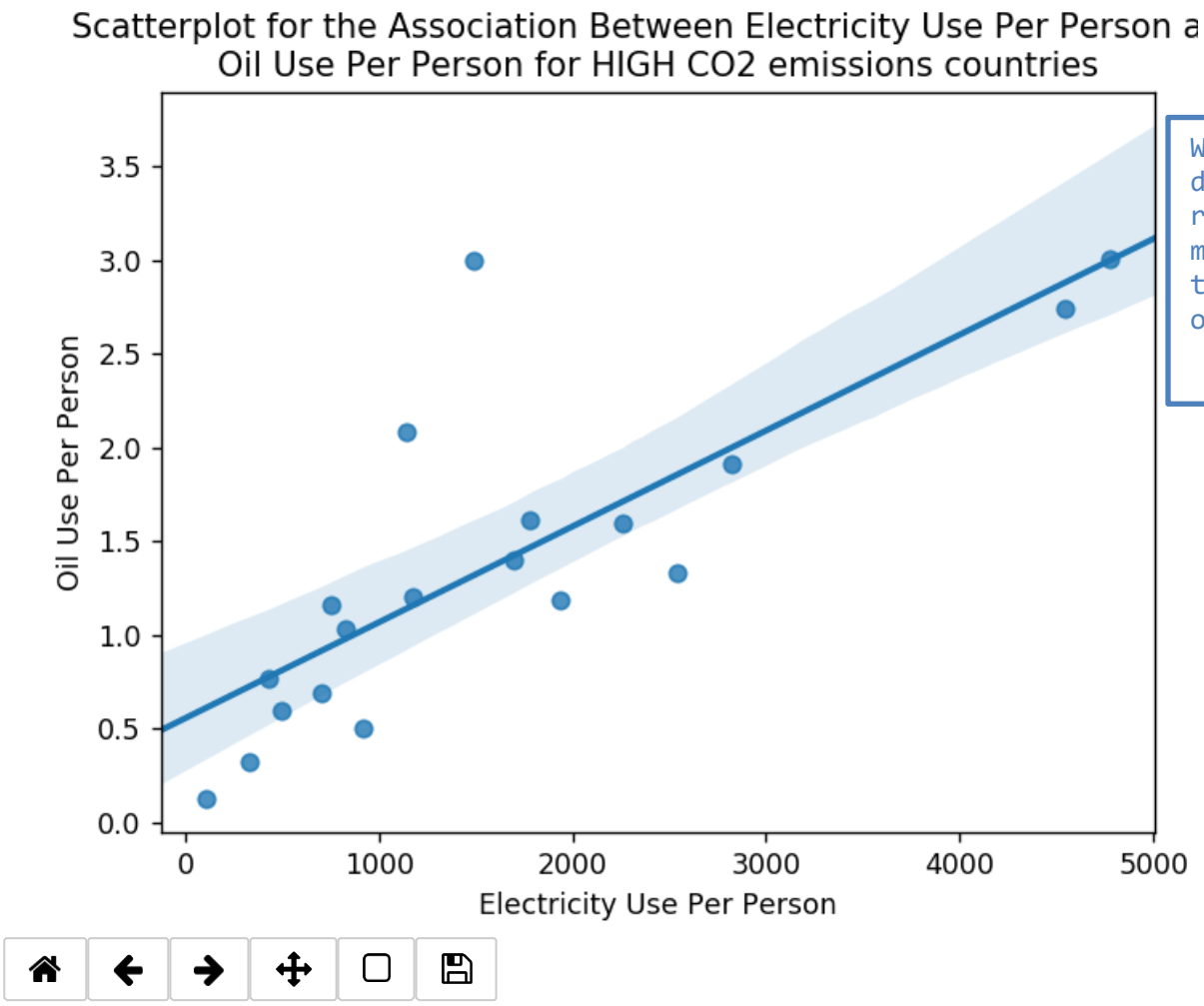
Regression - Scenario 7

Scatter plot with regression analysis to show association between electricity use per person (x) and oilperperson (y) for high CO2 emission countries

In [38]:

```
%matplotlib notebook
scat1 = sns.regplot(x="relectricperperson", y="oilperperson", data=sub3)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Scatterplot for the Association Between Electricity Use Per Person and' + '\n'
print (scat1)
```

Figure 1



We can see most data fit into regression model, with only two significant outliers.

```
AxesSubplot(0.125,0.11;0.775x0.77)
```

In [26]:

```
print ('OLS regression model for the association between Electricty Use Per Person and Oil

reg1 = smf.ols('oilperperson ~ relectricperperson', data=sub3).fit()
print (reg1.summary())
```

```
OLS regression model for the association between Electricty Use Per Person
and Oil Use Per Person for
HIGH CO2 Emission countries
                            OLS Regression Results

==============================================================================
====
Dep. Variable:           oilperperson   R-squared:
0.619
Model:                            OLS   Adj. R-squared:
0.597
Method:                 Least Squares   F-statistic:                      2
7.61
Date:                Fri, 27 Apr 2018   Prob (F-statistic):           6.45
e-05
Time:                        15:02:26   Log-Likelihood:                 -1
4.302
No. Observations:                  19   AIC:                              3
2.60
Df Residuals:                      17   BIC:                              3
4.49
Df Model:                           1

Covariance Type:            nonrobust

==============================================================================
============
                         coef    std err          t      P>|t|      [0.025
      0.975]
------------------------------------------------------------------------------
------------
Intercept              0.5552      0.201      2.764      0.013       0.131
       0.979
relectricperperson     0.0005   9.74e-05      5.255      0.000       0.000
       0.001
==============================================================================
====
Omnibus:                       20.501   Durbin-Watson:
2.188
Prob(Omnibus):                  0.000   Jarque-Bera (JB):                2
3.814
Skew:                           1.966   Prob(JB):                     6.74
e-06
Kurtosis:                       6.823   Cond. No.                     3.32
e+03
==============================================================================
====

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is cor
rectly specified.
[2] The condition number is large, 3.32e+03. This might indicate that ther
```

R-squared shows the model explains 62% variables, a very small Prob(f-statistic) tells us we should still reject null hypothesis

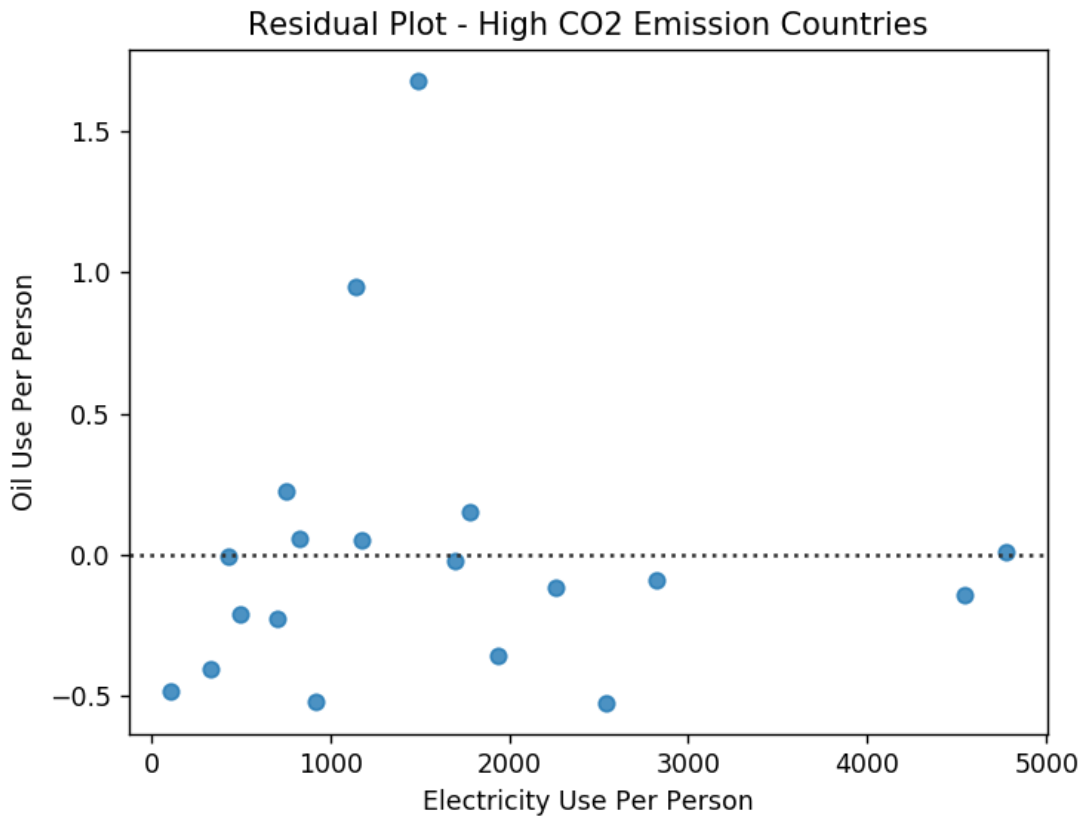
```
e are
strong multicollinearity or other numerical problems.
```

```
C:\Users\jc443343\AppData\Local\Continuum\anaconda3\lib\site-packages\scipy
\stats\stats.py:1334: UserWarning: kurtosistest only valid for n>=20 ... con
tinuing anyway, n=19
  "anyway, n=%i" % int(n))
```

Residual plot - regression analysis between relectricperperson (x) and oilperperson (y) for High CO2 emission countries

In [27]:

```
%matplotlib notebook
scat1 = sns.residplot(x="relectricperperson", y="oilperperson", data=sub3)
plt.xlabel('Electricity Use Per Person')
plt.ylabel('Oil Use Per Person')
plt.title('Residual Plot - High CO2 Emission Countries')
```



Residual plot shows most data are far away from the line 0, indicates the there are large variances for this regression model.

Out[27]:

```
Text(0.5,1,'Residual Plot - High CO2 Emission Countries')
```