FUNDAMENTALS OF MACHINE LEARNING FINAL PROJECT

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```
import pandas as pd
file_path = "fuel_receipts_costs_eia923.csv"
#reading the csv file
df = pd.read_csv(file_path)

df.head()
```

```
   rowid  plant_id_eia plant_id_eia_label report_date
contract_type_code  \
0      1             3              Barry  2008-01-01
C
1      2             3              Barry  2008-01-01
C
2      3             3              Barry  2008-01-01
C
3      4             7            Gadsden  2008-01-01
C
4      5             7            Gadsden  2008-01-01
S

  contract_type_code_label contract_expiration_date energy_source_code
\
0                        C               2008-04-01                 BIT

1                        C               2008-04-01                 BIT

2                        C                      NaN                  NG

3                        C               2015-12-01                 BIT

4                        S               2008-11-01                 BIT


  energy_source_code_label fuel_type_code_pudl  ...  \
0                      BIT                coal  ...
1                      BIT                coal  ...
2                       NG                 gas  ...
3                      BIT                coal  ...
4                      BIT                coal  ...

  primary_transportation_mode_code
primary_transportation_mode_code_label  \
0                                 RV
RV
1                                 RV
RV
```

```
2                                   PL
PL
3                                   TR
TR
4                                   TR
TR

   secondary_transportation_mode_code  \
0                                 NaN
1                                 NaN
2                                 NaN
3                                 NaN
4                                 NaN

  secondary_transportation_mode_code_label  natural_gas_transport_code
\
0                                      NaN                          firm

1                                      NaN                          firm

2                                      NaN                          firm

3                                      NaN                          firm

4                                      NaN                          firm


   natural_gas_delivery_contract_type_code  moisture_content_pct  \
0                                      NaN                   NaN
1                                      NaN                   NaN
2                                      NaN                   NaN
3                                      NaN                   NaN
4                                      NaN                   NaN

   chlorine_content_ppm  data_maturity  data_maturity_label
0                   NaN          final                final
1                   NaN          final                final
2                   NaN          final                final
3                   NaN          final                final
4                   NaN          final                final

[5 rows x 30 columns]
```

```
df2 = df
#we need to get the copy of the data.
```

TASK

```
#getting important library
from sklearn.cluster import KMeans
```

```
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
import seaborn as sns

print(df.dtypes)
#seeing the datatype of the data
```

```
rowid                                      int64
plant_id_eia                               int64
plant_id_eia_label                        object
report_date                               object
contract_type_code                        object
contract_type_code_label                  object
contract_expiration_date                  object
energy_source_code                        object
energy_source_code_label                  object
fuel_type_code_pudl                       object
fuel_group_code                           object
mine_id_pudl                             float64
mine_id_pudl_label                       float64
supplier_name                             object
fuel_received_units                      float64
fuel_mmbtu_per_unit                      float64
sulfur_content_pct                       float64
ash_content_pct                          float64
mercury_content_ppm                      float64
fuel_cost_per_mmbtu                      float64
primary_transportation_mode_code          object
primary_transportation_mode_code_label    object
secondary_transportation_mode_code        object
secondary_transportation_mode_code_label  object
natural_gas_transport_code                object
natural_gas_delivery_contract_type_code  float64
moisture_content_pct                     float64
chlorine_content_ppm                     float64
data_maturity                             object
data_maturity_label                       object
dtype: object
```

```
df.info()
#getting the information of the data
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 30 columns):
 #   Column                                   Non-Null Count  Dtype
---  ------                                   --------------  -----
 0   rowid                                    1000 non-null   int64
 1   plant_id_eia                             1000 non-null   int64
 2   plant_id_eia_label                       1000 non-null   object
```

```
 3   report_date                                1000 non-null   object
 4   contract_type_code                         1000 non-null   object
 5   contract_type_code_label                   1000 non-null   object
 6   contract_expiration_date                   554 non-null    object
 7   energy_source_code                         1000 non-null   object
 8   energy_source_code_label                   1000 non-null   object
 9   fuel_type_code_pudl                        1000 non-null   object
 10  fuel_group_code                            1000 non-null   object
 11  mine_id_pudl                               533 non-null    float64
 12  mine_id_pudl_label                         533 non-null    float64
 13  supplier_name                              1000 non-null   object
 14  fuel_received_units                        1000 non-null   float64
 15  fuel_mmbtu_per_unit                        1000 non-null   float64
 16  sulfur_content_pct                         1000 non-null   float64
 17  ash_content_pct                            1000 non-null   float64
 18  mercury_content_ppm                        0 non-null      float64
 19  fuel_cost_per_mmbtu                        756 non-null    float64
 20  primary_transportation_mode_code           743 non-null    object
 21  primary_transportation_mode_code_label     743 non-null    object
 22  secondary_transportation_mode_code         123 non-null    object
 23  secondary_transportation_mode_code_label   123 non-null    object
 24  natural_gas_transport_code                 375 non-null    object
 25  natural_gas_delivery_contract_type_code    0 non-null      float64
 26  moisture_content_pct                       0 non-null      float64
 27  chlorine_content_ppm                       0 non-null      float64
 28  data_maturity                              1000 non-null   object
 29  data_maturity_label                        1000 non-null   object
dtypes: float64(11), int64(2), object(17)
memory usage: 234.5+ KB
```

```
print(df.dtypes)
#getting the infor about the data
```

```
rowid                                      int64
plant_id_eia                               int64
plant_id_eia_label                        object
report_date                               object
contract_type_code                        object
contract_type_code_label                  object
contract_expiration_date                  object
energy_source_code                        object
energy_source_code_label                  object
fuel_type_code_pudl                       object
fuel_group_code                           object
mine_id_pudl                             float64
mine_id_pudl_label                       float64
supplier_name                             object
fuel_received_units                      float64
fuel_mmbtu_per_unit                      float64
sulfur_content_pct                       float64
```

```
ash_content_pct                             float64
mercury_content_ppm                         float64
fuel_cost_per_mmbtu                         float64
primary_transportation_mode_code             object
primary_transportation_mode_code_label       object
secondary_transportation_mode_code           object
secondary_transportation_mode_code_label     object
natural_gas_transport_code                   object
natural_gas_delivery_contract_type_code     float64
moisture_content_pct                        float64
chlorine_content_ppm                        float64
data_maturity                                object
data_maturity_label                          object
dtype: object

df.describe()
#descripiton of the data.

              rowid  plant_id_eia  mine_id_pudl  mine_id_pudl_label  \
count  1000.000000   1000.000000    533.000000          533.000000
mean    500.500000    867.647000    110.797373          110.797373
std     288.819436    494.824251     83.889631           83.889631
min       1.000000      3.000000      0.000000            0.000000
25%     250.750000    535.000000     32.000000           32.000000
50%     500.500000    886.000000     97.000000           97.000000
75%     750.250000   1355.000000    185.000000          185.000000
max    1000.000000   1710.000000    263.000000          263.000000

       fuel_received_units  fuel_mmbtu_per_unit  sulfur_content_pct  \
count         1.000000e+03          1000.000000         1000.000000
mean          1.030101e+05            13.420019            0.685710
std           4.396658e+05            10.266133            0.973392
min           1.000000e+00             0.857000            0.000000
25%           1.431000e+03             1.030000            0.000000
50%           1.311650e+04            17.160000            0.300000
75%           4.381150e+04            23.814000            0.900000
max           6.067067e+06            29.400000            6.610000

       ash_content_pct  mercury_content_ppm  fuel_cost_per_mmbtu  \
count      1000.000000                  0.0           756.000000
mean          4.915780                  NaN             5.785993
std           5.063778                  NaN             5.332886
min           0.000000                  NaN             0.343000
25%           0.000000                  NaN             1.947250
50%           4.700000                  NaN             3.082000
75%           9.400000                  NaN             8.400000
max          20.900000                  NaN            29.514000

       natural_gas_delivery_contract_type_code
moisture_content_pct  \
```

```
count                                                0.0                    0.0

mean                                                 NaN                    NaN

std                                                  NaN                    NaN

min                                                  NaN                    NaN

25%                                                  NaN                    NaN

50%                                                  NaN                    NaN

75%                                                  NaN                    NaN

max                                                  NaN                    NaN
```

```
       chlorine_content_ppm
count                   0.0
mean                    NaN
std                     NaN
min                     NaN
25%                     NaN
50%                     NaN
75%                     NaN
max                     NaN
```

DATA CLEANING

```
df.isnull().sum()
#seeing the null value.
```

```
rowid                                      0
plant_id_eia                               0
plant_id_eia_label                         0
report_date                                0
contract_type_code                         0
contract_type_code_label                   0
contract_expiration_date                 446
energy_source_code                         0
energy_source_code_label                   0
fuel_type_code_pudl                        0
fuel_group_code                            0
mine_id_pudl                             467
mine_id_pudl_label                       467
supplier_name                              0
fuel_received_units                        0
fuel_mmbtu_per_unit                        0
sulfur_content_pct                         0
ash_content_pct                            0
```

```
mercury_content_ppm                          1000
fuel_cost_per_mmbtu                           244
primary_transportation_mode_code              257
primary_transportation_mode_code_label        257
secondary_transportation_mode_code            877
secondary_transportation_mode_code_label      877
natural_gas_transport_code                    625
natural_gas_delivery_contract_type_code      1000
moisture_content_pct                         1000
chlorine_content_ppm                         1000
data_maturity                                   0
data_maturity_label                             0
dtype: int64
```

```
null_percentage = (df.isnull().sum() / len(df)) * 100
null_percentage
#seeing the null value using the percentage
```

```
rowid                                         0.0
plant_id_eia                                  0.0
plant_id_eia_label                            0.0
report_date                                   0.0
contract_type_code                            0.0
contract_type_code_label                      0.0
contract_expiration_date                     44.6
energy_source_code                            0.0
energy_source_code_label                      0.0
fuel_type_code_pudl                           0.0
fuel_group_code                               0.0
mine_id_pudl                                 46.7
mine_id_pudl_label                           46.7
supplier_name                                 0.0
fuel_received_units                           0.0
fuel_mmbtu_per_unit                           0.0
sulfur_content_pct                            0.0
ash_content_pct                               0.0
mercury_content_ppm                         100.0
fuel_cost_per_mmbtu                          24.4
primary_transportation_mode_code             25.7
primary_transportation_mode_code_label       25.7
secondary_transportation_mode_code           87.7
secondary_transportation_mode_code_label     87.7
natural_gas_transport_code                   62.5
natural_gas_delivery_contract_type_code     100.0
moisture_content_pct                        100.0
chlorine_content_ppm                        100.0
data_maturity                                 0.0
data_maturity_label                           0.0
dtype: float64
```

```
columns_to_drop = null_percentage[null_percentage > 35].index

#droping the null value column having the null percentage more than 35
percentage.
df = df.drop(columns=columns_to_drop)
df.isnull().sum()
```

```
rowid                                   0
plant_id_eia                            0
plant_id_eia_label                      0
report_date                             0
contract_type_code                      0
contract_type_code_label                0
energy_source_code                      0
energy_source_code_label                0
fuel_type_code_pudl                     0
fuel_group_code                         0
supplier_name                           0
fuel_received_units                     0
fuel_mmbtu_per_unit                     0
sulfur_content_pct                      0
ash_content_pct                         0
fuel_cost_per_mmbtu                   244
primary_transportation_mode_code      257
primary_transportation_mode_code_label    257
data_maturity                           0
data_maturity_label                     0
dtype: int64
```

```
import numpy as np
# Filling of the null value
numerical_columns = df.select_dtypes(include=[np.number]).columns
df[numerical_columns] =
df[numerical_columns].fillna(df[numerical_columns].mean())

# Filling of null value categorical
categorical_columns = df.select_dtypes(include=[np.object]).columns
df[categorical_columns] =
df[categorical_columns].fillna(df[categorical_columns].mode().iloc[0])
```

```
<ipython-input-18-063e6773f86e>:7: DeprecationWarning: `np.object` is
a deprecated alias for the builtin `object`. To silence this warning,
use `object` by itself. Doing this will not modify any behavior and is
safe.
Deprecated in NumPy 1.20; for more details and guidance:
https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  categorical_columns = df.select_dtypes(include=[np.object]).columns
```

```
df.isnull().sum()
#checking the data is null or not.
```

```
rowid                                   0
plant_id_eia                            0
plant_id_eia_label                      0
report_date                             0
contract_type_code                      0
contract_type_code_label                0
energy_source_code                      0
energy_source_code_label                0
fuel_type_code_pudl                     0
fuel_group_code                         0
supplier_name                           0
fuel_received_units                     0
fuel_mmbtu_per_unit                     0
sulfur_content_pct                      0
ash_content_pct                         0
fuel_cost_per_mmbtu                     0
primary_transportation_mode_code        0
primary_transportation_mode_code_label  0
data_maturity                           0
data_maturity_label                     0
dtype: int64
```

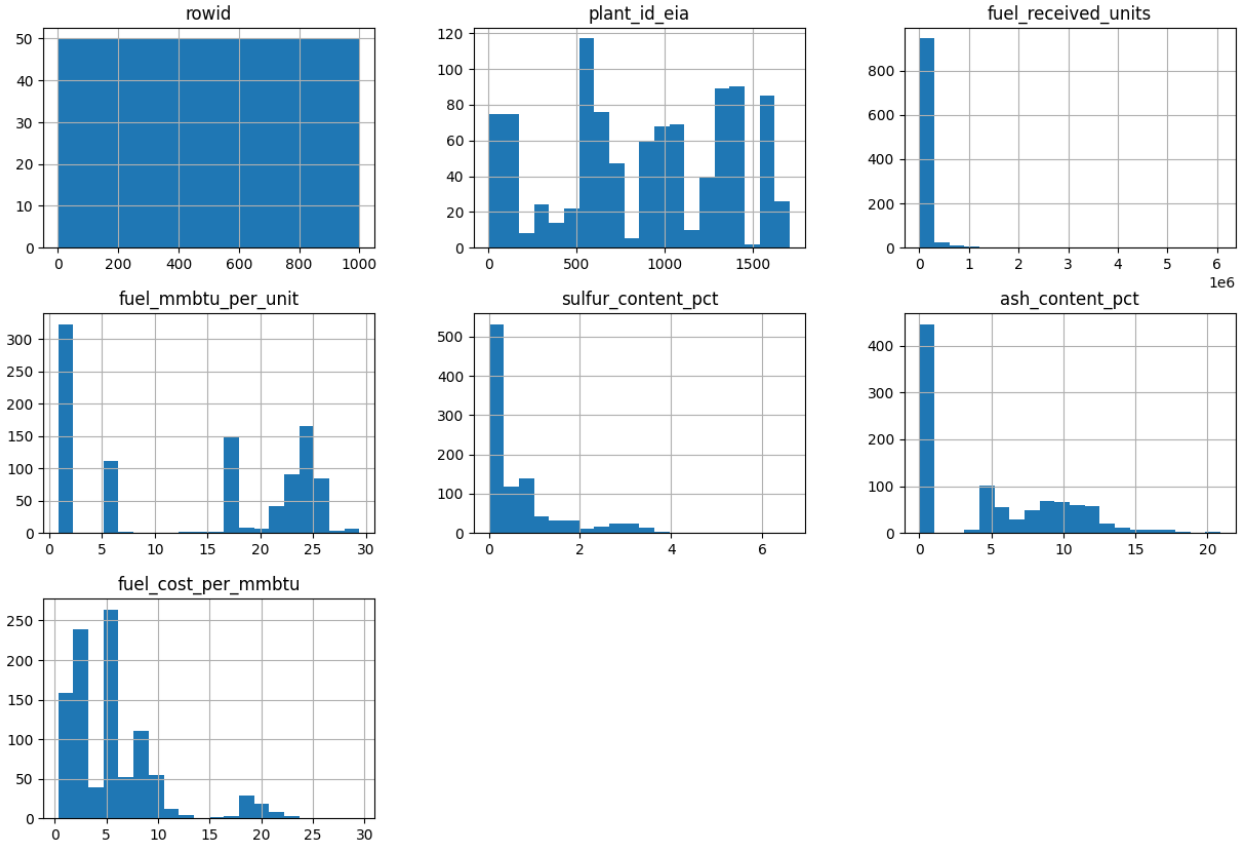
```
df.head()
```

```
   rowid  plant_id_eia plant_id_eia_label report_date
contract_type_code  \
0      1             3              Barry  2008-01-01
C
1      2             3              Barry  2008-01-01
C
2      3             3              Barry  2008-01-01
C
3      4             7            Gadsden  2008-01-01
C
4      5             7            Gadsden  2008-01-01
S

  contract_type_code_label energy_source_code energy_source_code_label
\
0                        C                BIT                        BIT

1                        C                BIT                        BIT

2                        C                 NG                         NG

3                        C                BIT                        BIT

4                        S                BIT                        BIT
```

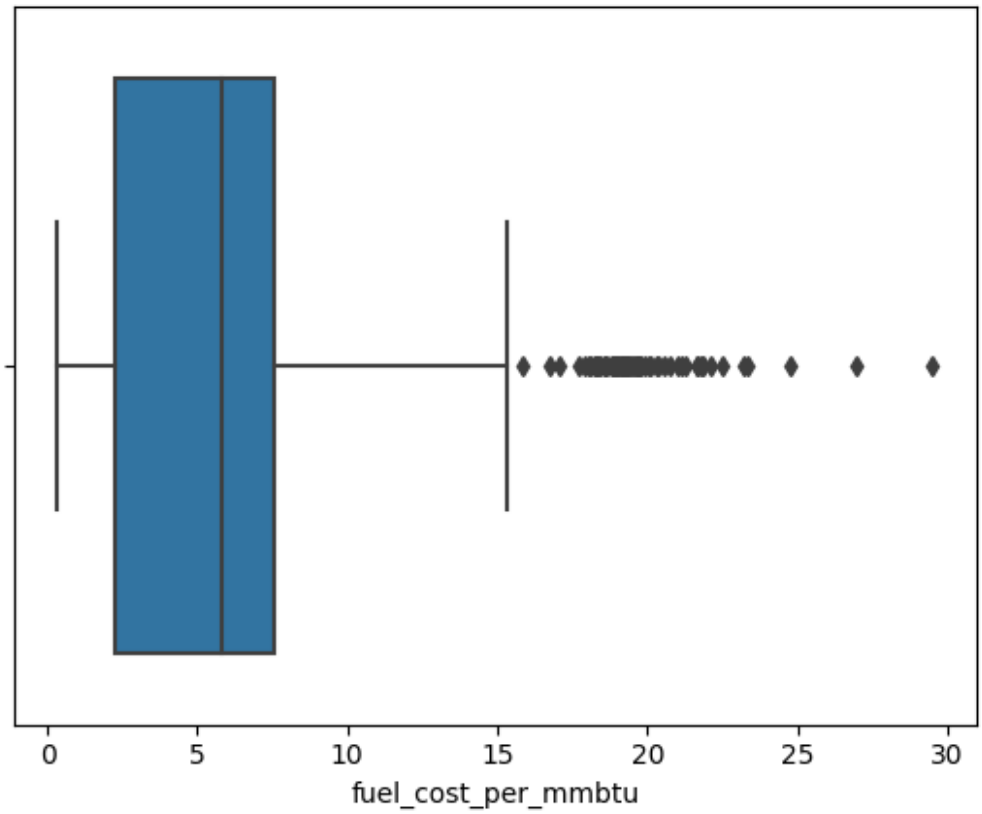
```
  fuel_type_code_pudl fuel_group_code     supplier_name
fuel_received_units  \
0                coal            coal   interocean coal
259412.0
1                coal            coal   interocean coal
52241.0
2                 gas     natural_gas  bay gas pipeline
2783619.0
3                coal            coal      alabama coal
25397.0
4                coal            coal      d & e mining
764.0

   fuel_mmbtu_per_unit  sulfur_content_pct  ash_content_pct  \
0               23.100                0.49             5.4
1               22.800                0.48             5.7
2                1.039                0.00             0.0
3               24.610                1.69            14.7
4               24.446                0.84            15.5

   fuel_cost_per_mmbtu primary_transportation_mode_code  \
0                2.135                                RV
1                2.115                                RV
2                8.631                                PL
3                2.776                                TR
4                3.381                                TR

  primary_transportation_mode_code_label data_maturity
data_maturity_label
0                                     RV         final
final
1                                     RV         final
final
2                                     PL         final
final
3                                     TR         final
final
4                                     TR         final
final
```

plotting some graphics from the data.

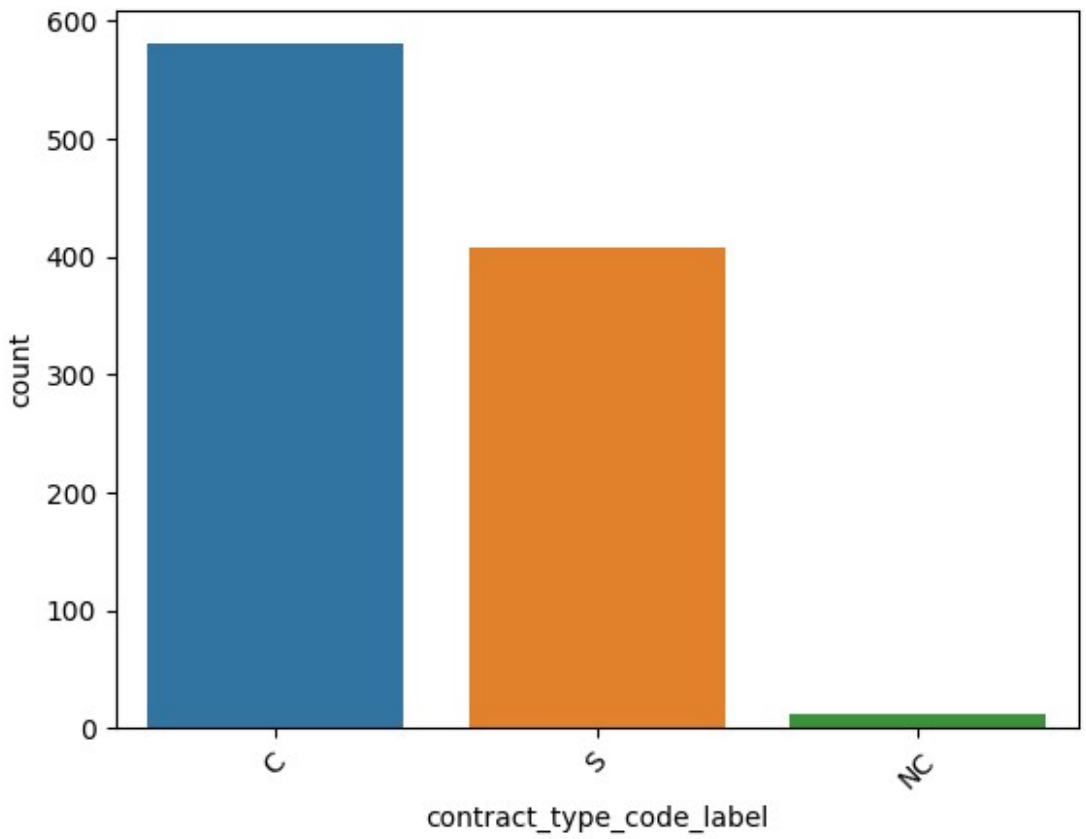
```
import matplotlib.pyplot as plt
import seaborn as sns
#seeing the distribution of all the numeric data.
numerical_columns = df.select_dtypes(include=[np.number]).columns
df[numerical_columns].hist(bins=20, figsize=(15, 10))
plt.show()
```



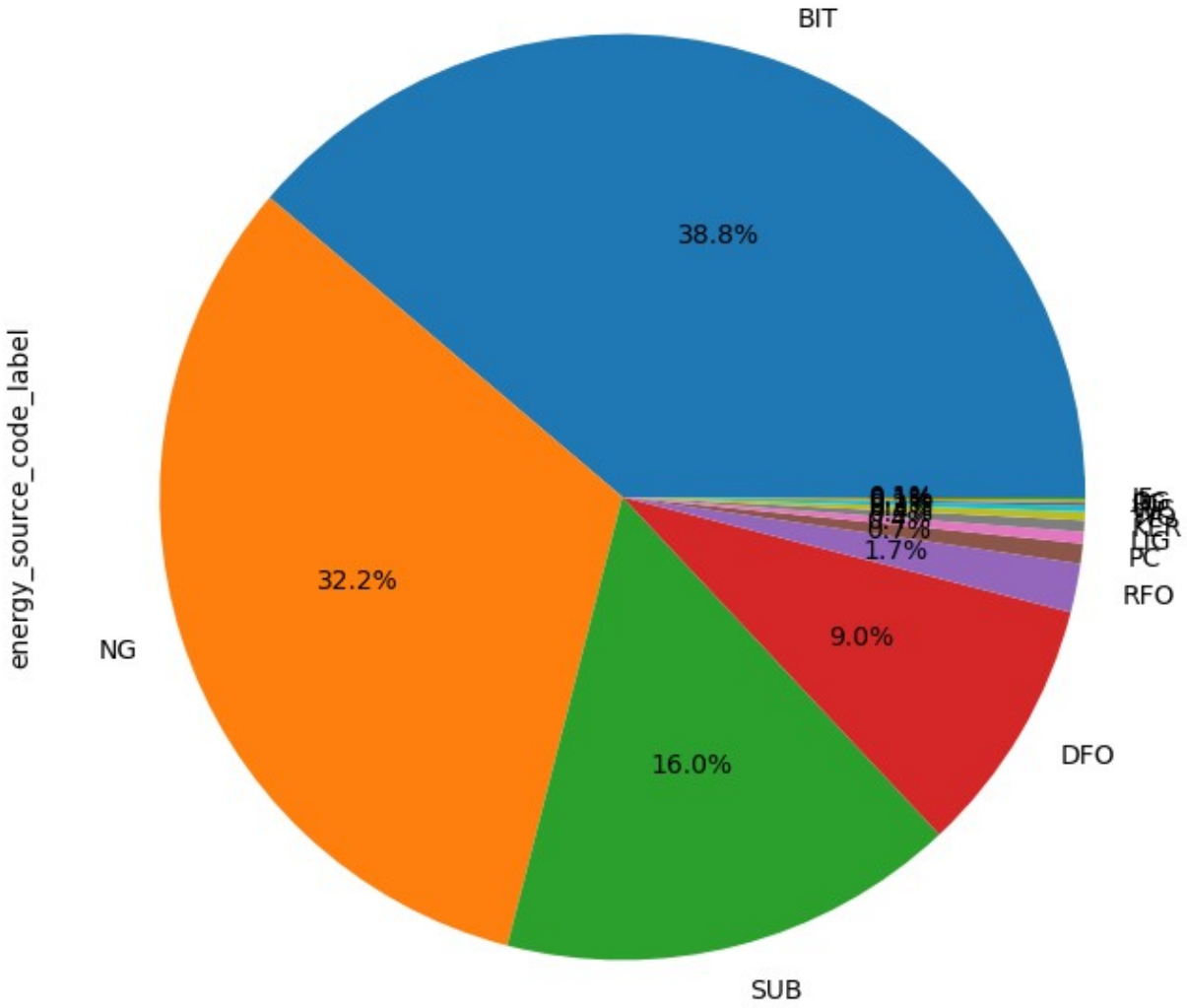

```
sns.boxplot(x='fuel_cost_per_mmbtu', data=df)
plt.show()
#seeing the distribution of the costper per mmbtu
```




```
sns.countplot(x='contract_type_code_label', data=df)
plt.xticks(rotation=45)
plt.show()
#seeing the contract type code label.
```




```
df['energy_source_code_label'].value_counts().plot.pie(autopct='%1.1f%
%', figsize=(8, 8))
plt.show()
df['energy_source_code_label'].value_counts()

#seeing the energy_source_doce label.
```




```
BIT    388
NG     322
SUB    160
DFO     90
RFO     17
PC       7
LIG      4
KER      4
WO       3
WC       2
PG       1
OG       1
```

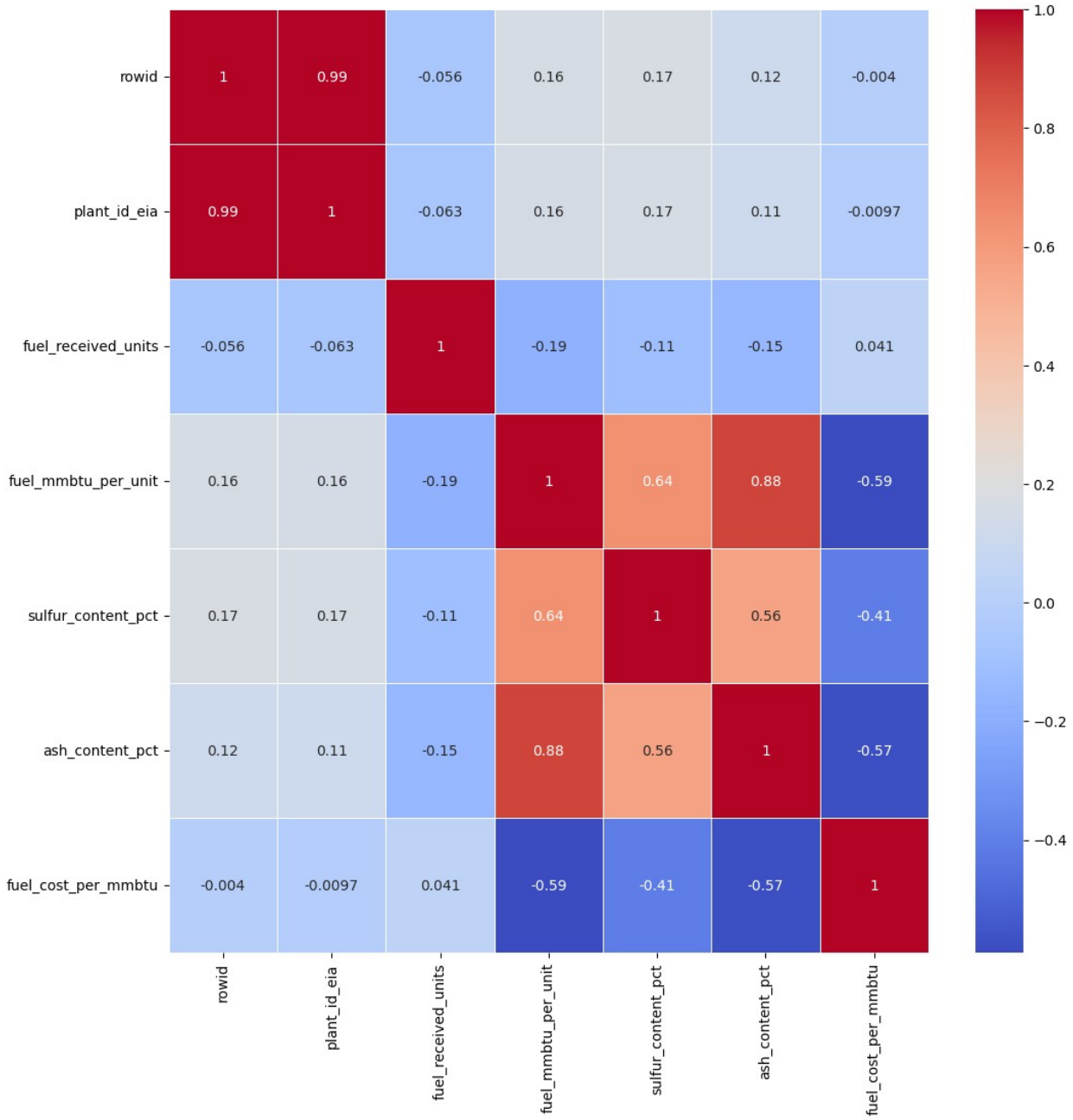
```
JF       1
Name: energy_source_code_label, dtype: int64
```

```
print(df.describe())
#seeing the description fo the clean data.
```

```
             rowid  plant_id_eia  fuel_received_units
fuel_mmbtu_per_unit  \
count  1000.000000   1000.000000         1.000000e+03
1000.000000
mean    500.500000    867.647000         1.030101e+05
13.420019
std     288.819436    494.824251         4.396658e+05
10.266133
min       1.000000      3.000000         1.000000e+00
0.857000
25%     250.750000    535.000000         1.431000e+03
1.030000
50%     500.500000    886.000000         1.311650e+04
17.160000
75%     750.250000   1355.000000         4.381150e+04
23.814000
max    1000.000000   1710.000000         6.067067e+06
29.400000

       sulfur_content_pct  ash_content_pct  fuel_cost_per_mmbtu
count         1000.000000      1000.000000          1000.000000
mean             0.685710         4.915780             5.785993
std              0.973392         5.063778             4.636103
min              0.000000         0.000000             0.343000
25%              0.000000         0.000000             2.260000
50%              0.300000         4.700000             5.785993
75%              0.900000         9.400000             7.563000
max              6.610000        20.900000            29.514000
```

```
import matplotlib.pyplot as plt
plt.figure(figsize=(12,12))
correlation_matrix = df.corr()
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm',
linewidths=.5)
plt.show()
df.corr()
#seeing the heatmap for the relation.
```

```
<ipython-input-26-88b35f80d076>:3: FutureWarning: The default value of
numeric_only in DataFrame.corr is deprecated. In a future version, it
will default to False. Select only valid columns or specify the value
of numeric_only to silence this warning.
  correlation_matrix = df.corr()
```



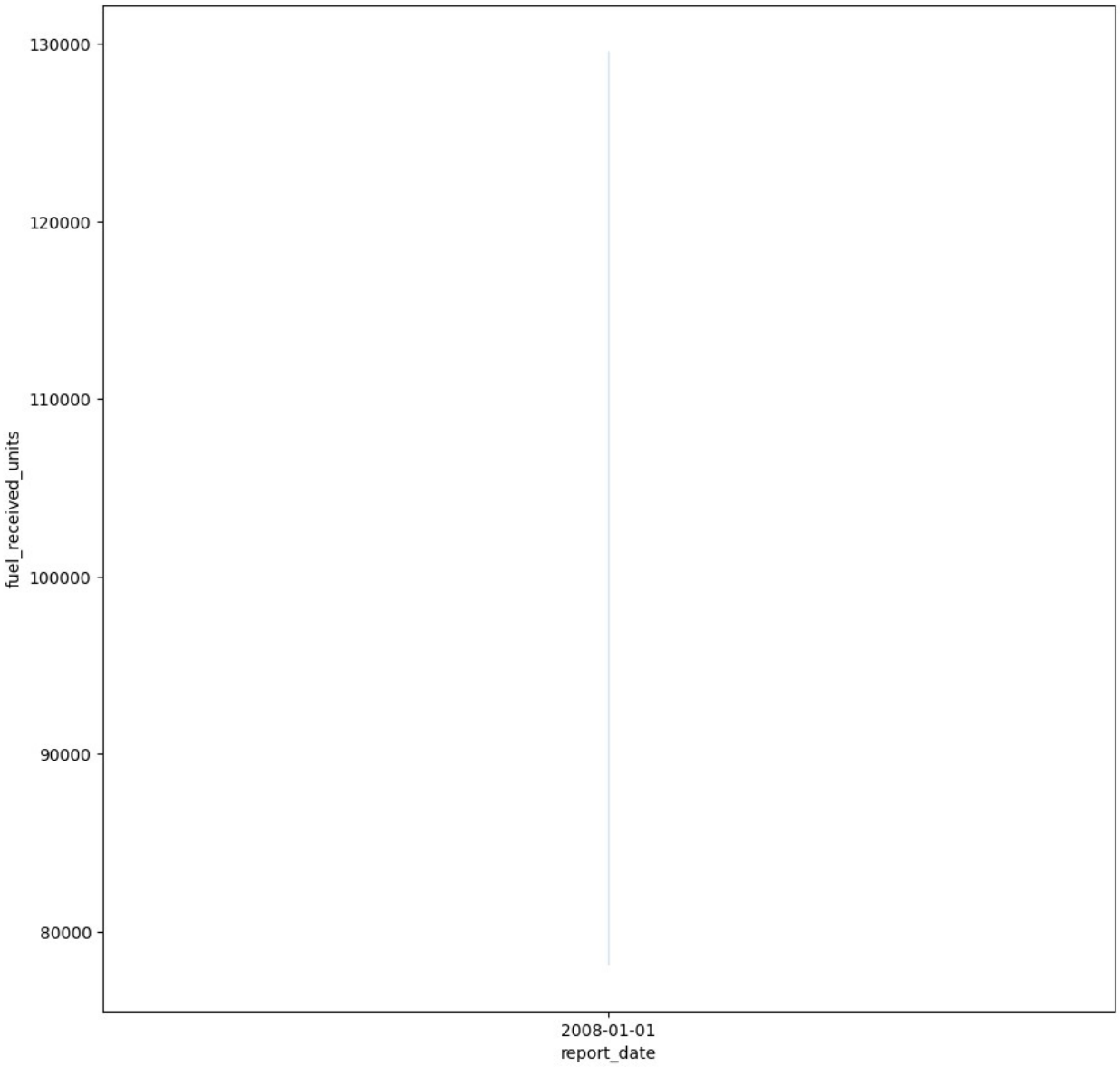

```
<ipython-input-26-88b35f80d076>:6: FutureWarning: The default value of
numeric_only in DataFrame.corr is deprecated. In a future version, it
will default to False. Select only valid columns or specify the value
of numeric_only to silence this warning.
  df.corr()
```

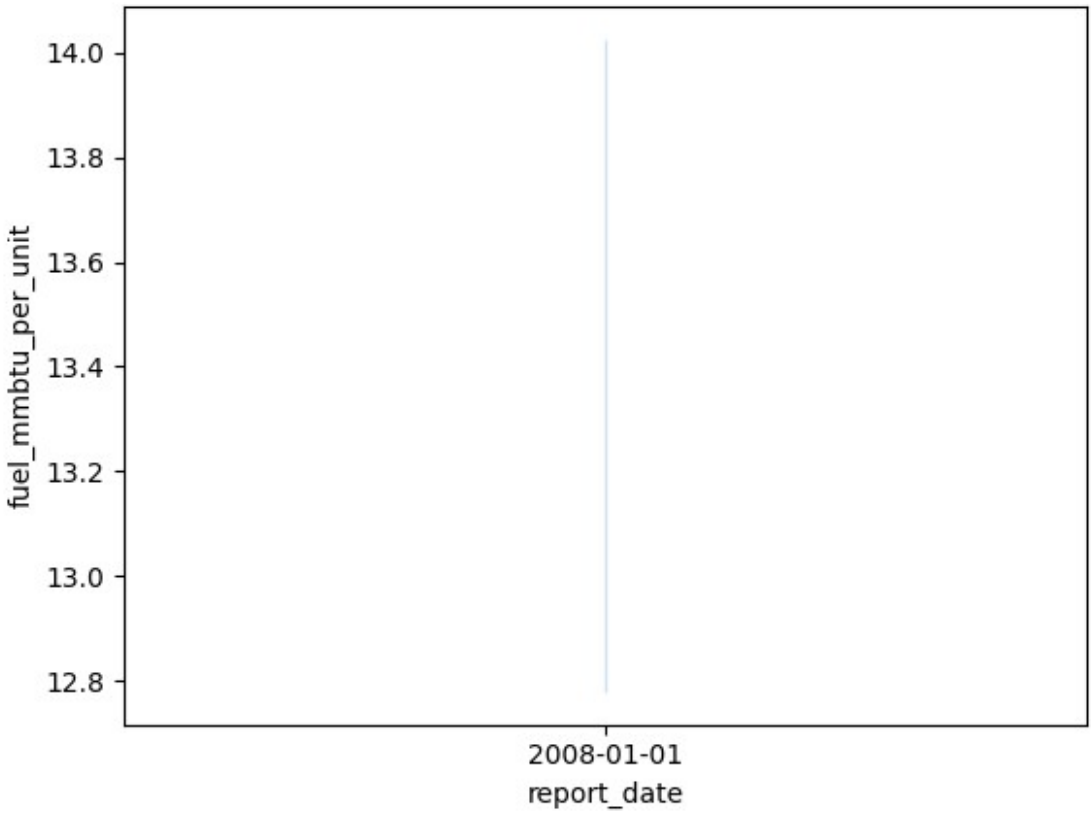
	rowid	plant_id_eia	fuel_received_units	\
rowid	1.000000	0.993835	-0.056134	
plant_id_eia	0.993835	1.000000	-0.063403	
fuel_received_units	-0.056134	-0.063403	1.000000	
fuel_mmbtu_per_unit	0.163386	0.157575	-0.185860	

```
sulfur_content_pct   0.173547      0.167000            -0.110104
ash_content_pct      0.116184      0.113713            -0.147567
fuel_cost_per_mmbtu -0.004044     -0.009697             0.040935

                     fuel_mmbtu_per_unit  sulfur_content_pct
ash_content_pct  \
rowid                           0.163386            0.173547
0.116184
plant_id_eia                    0.157575            0.167000
0.113713
fuel_received_units            -0.185860           -0.110104        -
0.147567
fuel_mmbtu_per_unit             1.000000            0.636903
0.880177
sulfur_content_pct              0.636903            1.000000
0.560380
ash_content_pct                 0.880177            0.560380
1.000000
fuel_cost_per_mmbtu            -0.590312           -0.407959        -
0.572700

                     fuel_cost_per_mmbtu
rowid                          -0.004044
plant_id_eia                   -0.009697
fuel_received_units             0.040935
fuel_mmbtu_per_unit            -0.590312
sulfur_content_pct             -0.407959
ash_content_pct                -0.572700
fuel_cost_per_mmbtu             1.000000
```

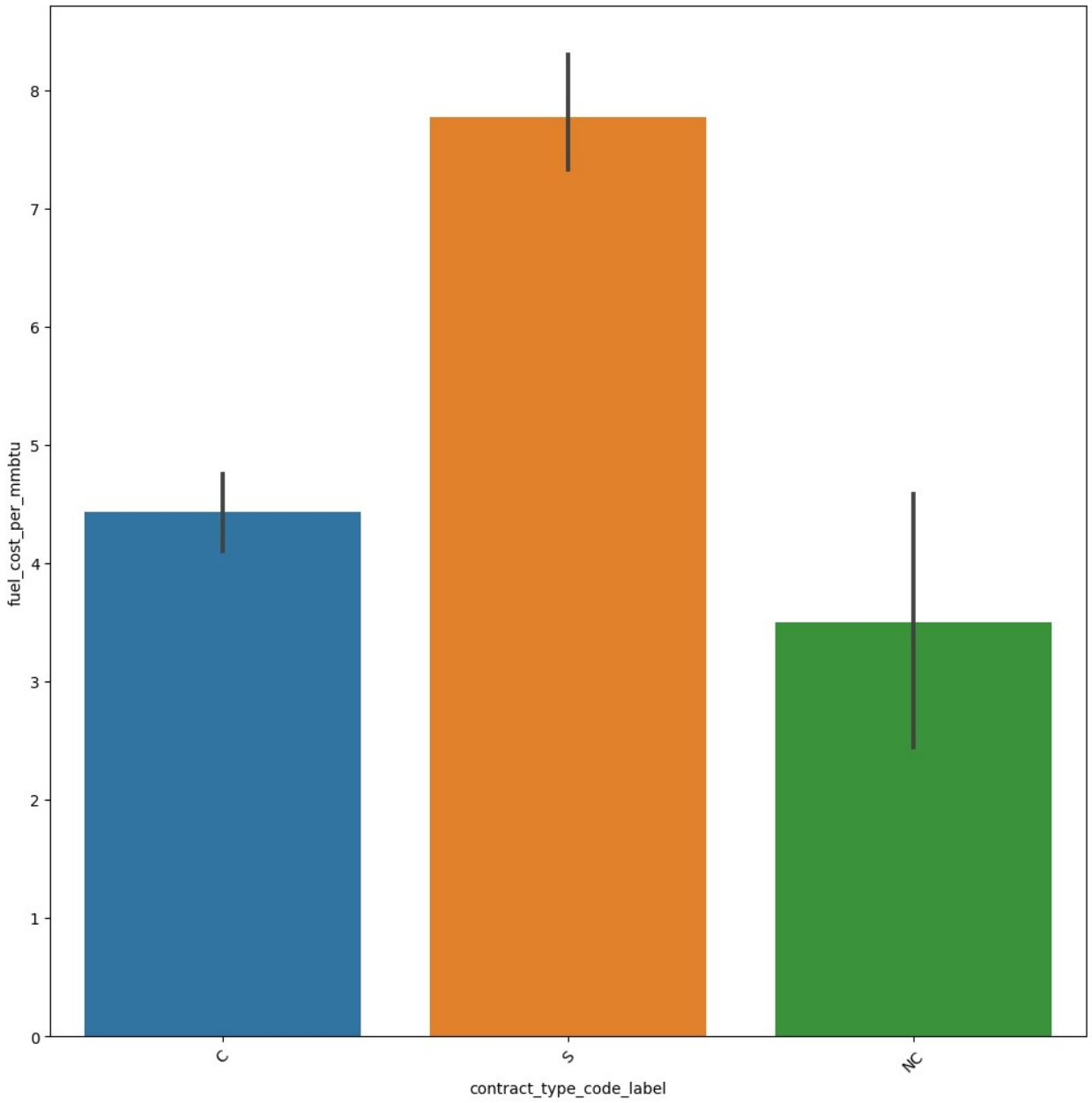
PERFORMING MORE ANALYSIS

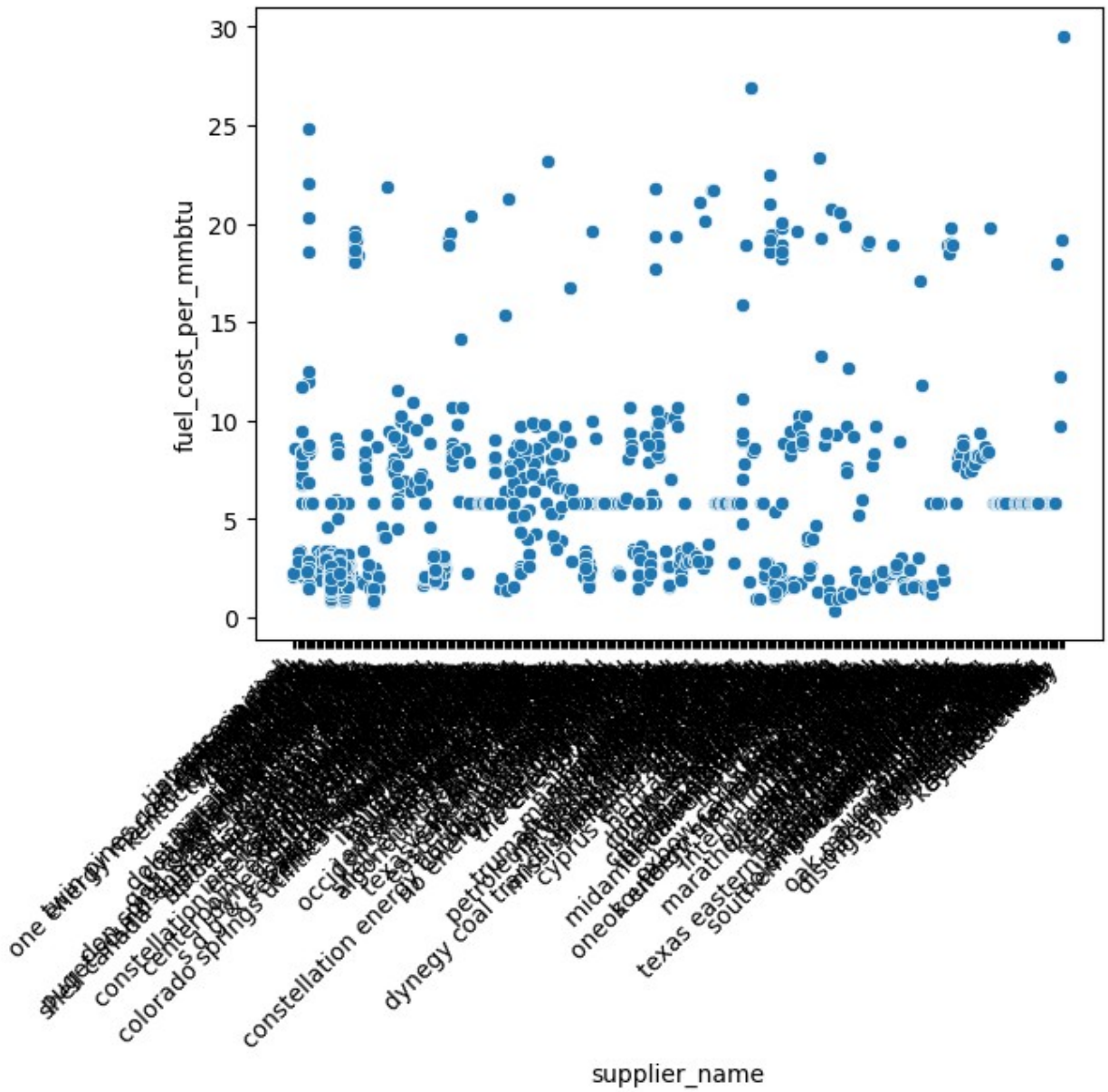
```
plt.figure(figsize=(11,11))
# Distribution of the fuel received over units over time
sns.lineplot(x='report_date', y='fuel_received_units', data=df)
plt.show()

# Trends in the fuel MMBTU over unit over the years
sns.lineplot(x='report_date', y='fuel_mmbtu_per_unit', data=df)
plt.show()
```


130000
120000
110000
100000
90000
80000
fuel_received_units
2008-01-01
report_date

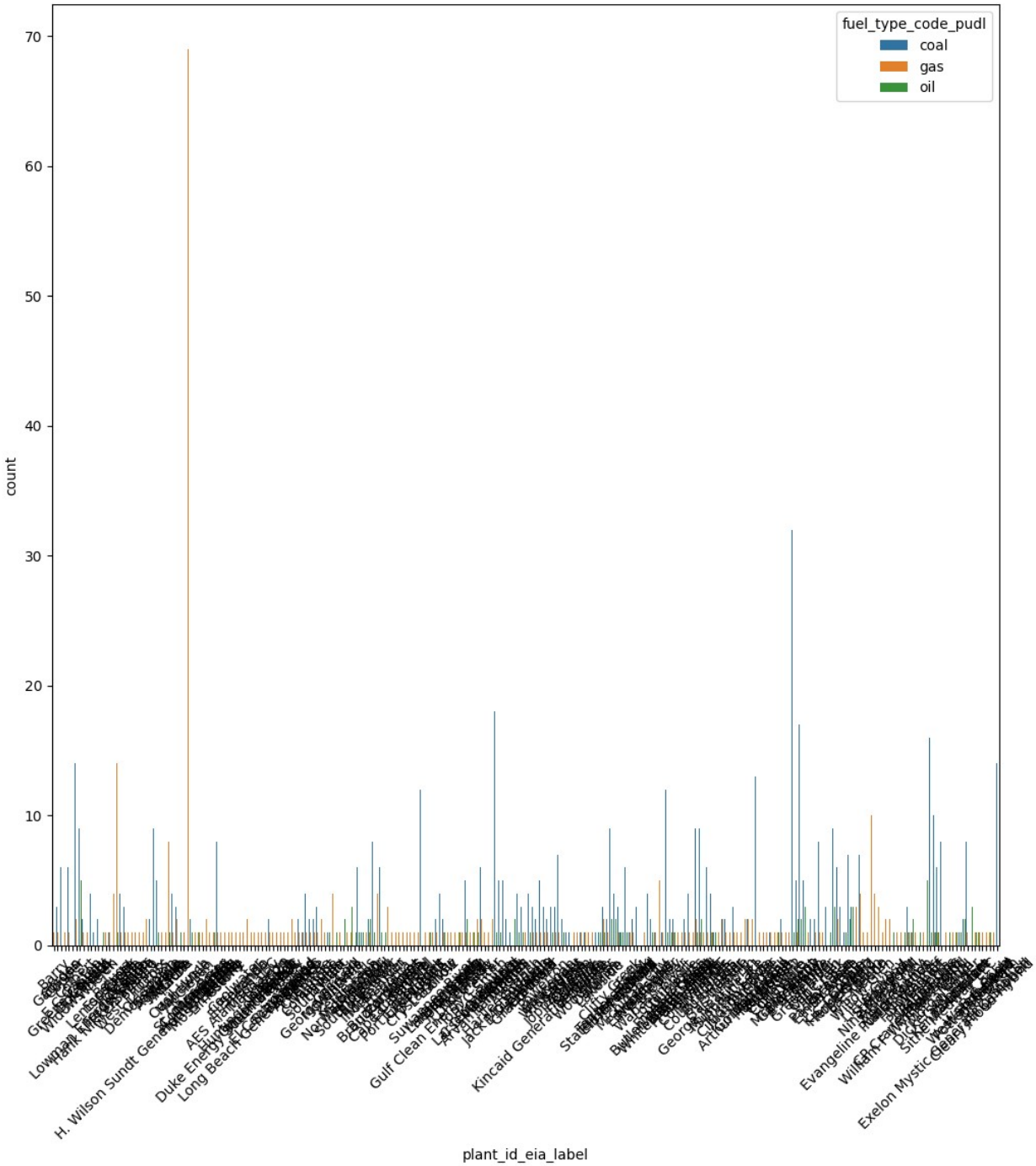


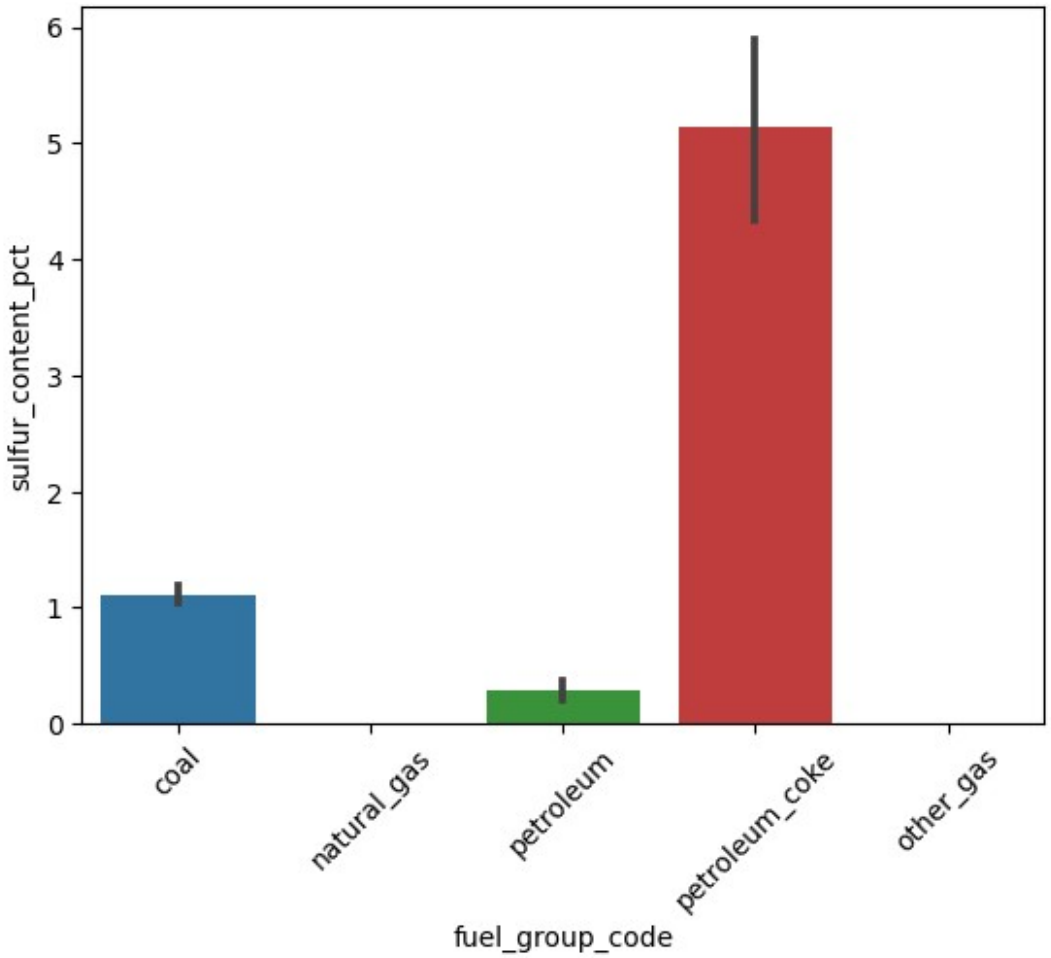

```
plt.figure(figsize=(12,12))
# Aveg fuel cost per MMBTU for different of contract types

sns.barplot(x='contract_type_code_label', y='fuel_cost_per_mmbtu',
data=df)
plt.xticks(rotation=45)
plt.show()

# Correlation between fuel cost over MMBTU and supplier names
sns.scatterplot(x='supplier_name', y='fuel_cost_per_mmbtu', data=df)
plt.xticks(rotation=45, ha='right')
plt.show()
```


fuel_cost_per_mmbtu
0
1
2
3
4
5
6
7
8
C
S
NC
contract_type_code_label




```
plt.figure(figsize=(12,12))
# Distribution of the fuel over diferent plant_id_eia label.
sns.countplot(x='plant_id_eia_label', hue='fuel_type_code_pudl',
data=df)
plt.xticks(rotation=45)
plt.show()

# fuel group code over sulfur content pct.
sns.barplot(x='fuel_group_code', y='sulfur_content_pct', data=df)
plt.xticks(rotation=45)
plt.show()
```


fuel_type_code_pudl
coal
gas
oil
count
0
10
20
30
40
50
60
70
plant_id_eia_label



Train test split of the data

```
import pandas as pd
from sklearn.model_selection import train_test_split
# Seting a random seed for reproducibility
random_seed = 1234  # Useing of the 4-digit number as the seed
# Randomly sampleing of the about 2% of the data
sampled_data = df.sample(frac=0.02, random_state=random_seed)
# Split the data into the training set of (75%) and a test set of
(25%)
train_data, test_data = train_test_split(sampled_data, test_size=0.25,
random_state=random_seed)
test_data.head()
#test data.
```

```
     rowid  plant_id_eia plant_id_eia_label report_date
contract_type_code  \
768    769          1356               Ghent  2008-01-01
S
89      90            99        Frederickson  2008-01-01
```

```
S
155    156           246       Humboldt Bay  2008-01-01
S
29      30            26         E C Gaston  2008-01-01
C
982    983          1695           B C Cobb  2008-01-01
S

    contract_type_code_label energy_source_code
energy_source_code_label  \
768                         S                BIT
BIT
89                          S                 NG
NG
155                         S                 NG
NG
29                          C                BIT
BIT
982                         S                 NG
NG

    fuel_type_code_pudl fuel_group_code         supplier_name  \
768                coal            coal  pleasant view mining
89                  gas     natural_gas                avista
155                 gas     natural_gas                  pg&e
29                 coal            coal          perry county
982                 gas     natural_gas            b p canada

     fuel_received_units  fuel_mmbtu_per_unit  sulfur_content_pct  \
768               4392.0               23.568                3.26
89                 680.0                1.030                0.00
155             641364.0                1.021                0.00
29               20358.0               25.723                0.92
982              26465.0                1.015                0.00

     ash_content_pct  fuel_cost_per_mmbtu
primary_transportation_mode_code  \
768             10.8                1.544
RV
89               0.0                9.760
RR
155              0.0                7.857
RR
29               7.7                3.057
RR
982              0.0                8.936
RR

    primary_transportation_mode_code_label data_maturity
data_maturity_label
```

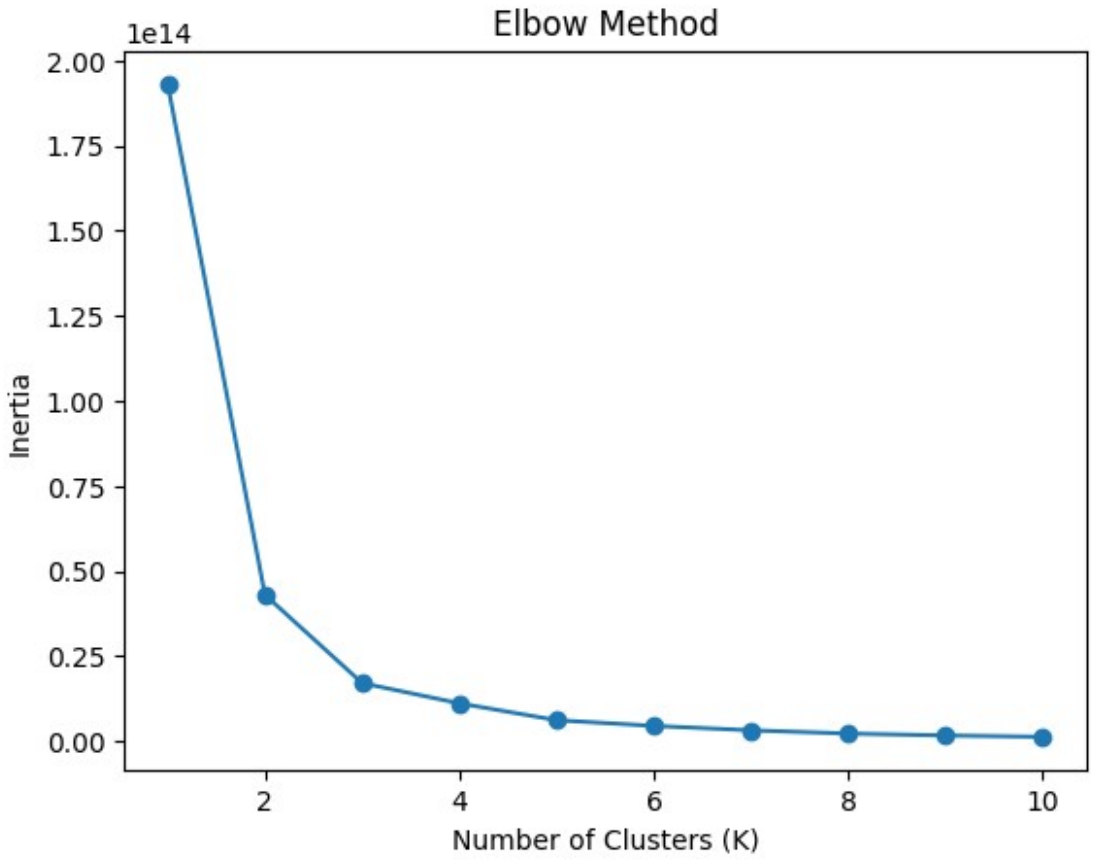
```
768                                          RV         final
final
89                                           RR         final
final
155                                          RR         final
final
29                                           RR         final
final
982                                          RR         final
final

train_data.head()
#training data.

     rowid  plant_id_eia plant_id_eia_label report_date
contract_type_code  \
363    364           628      Crystal River  2008-01-01
C
438    439           708            Hammond  2008-01-01
C
681    682          1239           Riverton  2008-01-01
C
620    621          1077         Sutherland  2008-01-01
C
466    467           861            Coffeen  2008-01-01
C

    contract_type_code_label energy_source_code
energy_source_code_label  \
363                        C                BIT
BIT
438                        C                BIT
BIT
681                        C                SUB
SUB
620                        C                SUB
SUB
466                        C                SUB
SUB

    fuel_type_code_pudl fuel_group_code supplier_name
fuel_received_units  \
363                coal            coal      icg, llc
34648.0
438                coal            coal   delta coals
37157.0
681                coal            coal          arch
30643.0
620                coal            coal     rio tinto
14510.0
```

```
466                 coal             coal  peabody coal
206612.0

     fuel_mmbtu_per_unit  sulfur_content_pct  ash_content_pct  \
363               24.260                1.16             11.7
438               25.201                1.49             11.3
681               17.656                0.30              5.2
620               17.530                0.46              4.9
466               17.520                0.20              4.6

     fuel_cost_per_mmbtu primary_transportation_mode_code  \
363             3.192000                                RR
438             2.826000                                RR
681             1.691000                                RR
620             1.373000                                RR
466             5.785993                                RR

    primary_transportation_mode_code_label data_maturity
data_maturity_label
363                                     RR         final
final
438                                     RR         final
final
681                                     RR         final
final
620                                     RR         final
final
466                                     RR         final
final
```

```python
from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
#feature matrix.
X = df[['fuel_received_units', 'fuel_mmbtu_per_unit',
'sulfur_content_pct', 'ash_content_pct']]

inertia = []
for k in range(1, 11):
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(X)
    inertia.append(kmeans.inertia_)

# seeing of the Elbow Method
plt.plot(range(1, 11), inertia, marker='o')
plt.xlabel('Number of Clusters (K)')
plt.ylabel('Inertia')
plt.title('Elbow Method')
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/
_kmeans.py:870: FutureWarning: The default value of `n_init` will
change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly
to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
```

```
warning
  warnings.warn(
```




```
from sklearn.cluster import KMeans

k = 3 #k value
kmeans = KMeans(n_clusters=k, random_state=42)
clusters = kmeans.fit_predict(X)
cluster_data = pd.concat([df, pd.Series(clusters, name='cluster')],
axis=1)
cluster_analysis = cluster_data.groupby('cluster').mean()
print(cluster_analysis)
#cluster of the data.

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/
_kmeans.py:870: FutureWarning: The default value of `n_init` will
change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly
to suppress the warning
  warnings.warn(

                rowid  plant_id_eia  fuel_received_units
fuel_mmbtu_per_unit  \
cluster
```

```
0        502.298958    872.069792         3.700990e+04
13.906707
1        321.777778    563.888889         4.167994e+06
1.029000
2        496.677419    818.870968         9.667301e+05
1.945774

         sulfur_content_pct  ash_content_pct  fuel_cost_per_mmbtu
cluster
0                  0.713240         5.097583             5.716472
1                  0.000000         0.000000             7.883331
2                  0.032258         0.712903             7.329997

<ipython-input-34-f45f319067e3>:7: FutureWarning: The default value of
numeric_only in DataFrameGroupBy.mean is deprecated. In a future
version, numeric_only will default to False. Either specify
numeric_only or select only columns which should be valid for the
function.
  cluster_analysis = cluster_data.groupby('cluster').mean()
```

EXTRA CREDIT QUESTION

```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error
# target variable and dependent variable.
features = ['fuel_received_units', 'fuel_mmbtu_per_unit',
'sulfur_content_pct', 'ash_content_pct']
target = 'fuel_cost_per_mmbtu'
# doing train test split.
X_train, X_test, y_train, y_test =
train_test_split(train_data[features], train_data[target],
test_size=0.2, random_state=42)
# implemtning linear regression.
model = LinearRegression()
model.fit(X_train, y_train)

LinearRegression()

# predicting the model.
y_pred = model.predict(X_test)

# evaluating the mode.
mse_without_cluster = mean_squared_error(y_test, y_pred)
print(f'Mean Squared Error without Cluster Information:
{mse_without_cluster}')

Mean Squared Error without Cluster Information: 4.5090686910783475
```