FML Final Exam

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#IMPORTING OF DATASET

```
PUDL<- read.csv("~/Downloads/fuel_receipts_costs_eia923.csv")

#importing the dataset PUDL(Fuel receipts)
```

#IMPORTING THE LIBRARY

```
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✔ dplyr     1.1.0     ✔ readr     2.1.4
## ✔ forcats   1.0.0     ✔ stringr   1.5.0
## ✔ ggplot2   3.4.1     ✔ tibble    3.1.8
## ✔ lubridate 1.9.2     ✔ tidyr     1.3.0
## ✔ purrr     1.0.1
## ── Conflicts ────────────────────────────────────────
tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the ]8;;http://conflicted.r-lib.org/conflicted package]8;; to force
all conflicts to become errors
```

```
library(dplyr)
library(tidyr)
library(ggplot2)
library(ggthemes)
library(caret)
```

```
## Loading required package: lattice
##
## Attaching package: 'caret'
##
## The following object is masked from 'package:purrr':
##
##     lift
```

```
#Recalling the istalled packages.
```

#CHECKING OF THE DATA

```
str(PUDL)

## 'data.frame':    608564 obs. of  30 variables:
##  $ rowid                                 : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ plant_id_eia                          : int  3 3 3 7 7 7 7 8 8 8 ...
##  $ plant_id_eia_label                    : chr  "Barry" "Barry" "Barry"
"Gadsden" ...
##  $ report_date                           : chr  "2008-01-01" "2008-01-
01" "2008-01-01" "2008-01-01" ...
##  $ contract_type_code                    : chr  "C" "C" "C" "C" ...
##  $ contract_type_code_label              : chr  "C" "C" "C" "C" ...
##  $ contract_expiration_date              : chr  "2008-04-01" "2008-04-
01" "" "2015-12-01" ...
##  $ energy_source_code                    : chr  "BIT" "BIT" "NG" "BIT"
...
##  $ energy_source_code_label              : chr  "BIT" "BIT" "NG" "BIT"
...
##  $ fuel_type_code_pudl                   : chr  "coal" "coal" "gas"
"coal" ...
##  $ fuel_group_code                       : chr  "coal" "coal"
"natural_gas" "coal" ...
##  $ mine_id_pudl                          : int  0 0 NA 1 2 3 NA 4 4 1
...
##  $ mine_id_pudl_label                    : int  0 0 NA 1 2 3 NA 4 4 1
...
##  $ supplier_name                         : chr  "interocean coal"
"interocean coal" "bay gas pipeline" "alabama coal" ...
##  $ fuel_received_units                   : num  259412 52241 2783619
25397 764 ...
##  $ fuel_mmbtu_per_unit                   : num  23.1 22.8 1.04 24.61
24.45 ...
##  $ sulfur_content_pct                    : num  0.49 0.48 0 1.69 0.84
1.54 0 2.16 1.24 1.9 ...
##  $ ash_content_pct                       : num  5.4 5.7 0 14.7 15.5 14.6
0 15.4 11.9 15.4 ...
##  $ mercury_content_ppm                   : num  NA NA NA NA NA NA NA NA
NA NA ...
##  $ fuel_cost_per_mmbtu                   : num  2.13 2.12 8.63 2.78 3.38
...
##  $ primary_transportation_mode_code      : chr  "RV" "RV" "PL" "TR" ...
##  $ primary_transportation_mode_code_label  : chr  "RV" "RV" "PL" "TR" ...
##  $ secondary_transportation_mode_code    : chr  "" "" "" "" ...
##  $ secondary_transportation_mode_code_label: chr  "" "" "" "" ...
##  $ natural_gas_transport_code            : chr  "firm" "firm" "firm"
"firm" ...
##  $ natural_gas_delivery_contract_type_code : chr  "" "" "" "" ...
##  $ moisture_content_pct                  : num  NA NA NA NA NA NA NA NA
NA NA ...
##  $ chlorine_content_ppm                  : num  NA NA NA NA NA NA NA NA
NA NA ...
```

```
##  $ data_maturity                          : chr  "final" "final" "final"
"final" ...
##  $ data_maturity_label                    : chr  "final" "final" "final"
"final" ...
```

#EXPLORING THE GIVEN DATA

```
glimpse(PUDL)

## Rows: 608,564
## Columns: 30
## $ rowid                                  <int> 1, 2, 3, 4, 5, 6, 7, 8,
9, 10…
## $ plant_id_eia                           <int> 3, 3, 3, 7, 7, 7, 7, 8,
8, 8,…
## $ plant_id_eia_label                     <chr> "Barry", "Barry",
"Barry", "G…
## $ report_date                            <chr> "2008-01-01", "2008-01-
01", "…
## $ contract_type_code                     <chr> "C", "C", "C", "C", "S",
"S",…
## $ contract_type_code_label               <chr> "C", "C", "C", "C", "S",
"S",…
## $ contract_expiration_date               <chr> "2008-04-01", "2008-04-
01", "…
## $ energy_source_code                     <chr> "BIT", "BIT", "NG",
"BIT", "B…
## $ energy_source_code_label               <chr> "BIT", "BIT", "NG",
"BIT", "B…
## $ fuel_type_code_pudl                    <chr> "coal", "coal", "gas",
"coal"…
## $ fuel_group_code                        <chr> "coal", "coal",
"natural_gas"…
## $ mine_id_pudl                           <int> 0, 0, NA, 1, 2, 3, NA, 4,
4, …
## $ mine_id_pudl_label                     <int> 0, 0, NA, 1, 2, 3, NA, 4,
4, …
## $ supplier_name                          <chr> "interocean coal",
"interocea…
## $ fuel_received_units                    <dbl> 259412, 52241, 2783619,
25397…
## $ fuel_mmbtu_per_unit                    <dbl> 23.100, 22.800, 1.039,
24.610…
## $ sulfur_content_pct                     <dbl> 0.49, 0.48, 0.00, 1.69,
0.84,…
## $ ash_content_pct                        <dbl> 5.4, 5.7, 0.0, 14.7,
15.5, 14…
## $ mercury_content_ppm                    <dbl> NA, NA, NA, NA, NA, NA,
NA, N…
## $ fuel_cost_per_mmbtu                    <dbl> 2.135, 2.115, 8.631,
```

```
2.776, 3…
## $ primary_transportation_mode_code         <chr> "RV", "RV", "PL", "TR",
"TR",…
## $ primary_transportation_mode_code_label   <chr> "RV", "RV", "PL", "TR",
"TR",…
## $ secondary_transportation_mode_code       <chr> "", "", "", "", "", "",
"", "…
## $ secondary_transportation_mode_code_label <chr> "", "", "", "", "", "",
"", "…
## $ natural_gas_transport_code               <chr> "firm", "firm", "firm",
"firm…
## $ natural_gas_delivery_contract_type_code  <chr> "", "", "", "", "", "",
"", "…
## $ moisture_content_pct                     <dbl> NA, NA, NA, NA, NA, NA,
NA, N…
## $ chlorine_content_ppm                     <dbl> NA, NA, NA, NA, NA, NA,
NA, N…
## $ data_maturity                            <chr> "final", "final",
"final", "f…
## $ data_maturity_label                      <chr> "final", "final",
"final", "f…

#Investigating The given Information.
```

#CLEANING THE GIVEN DATA While the data itself is clean, the dataset contains several variables that have significant missing values. Follows these steps:

```
#1. Identify all variables that have significant missing values.
# col names with missing values
colnames(PUDL)[colSums(is.na(PUDL)) > 0]

## [1] "mine_id_pudl"         "mine_id_pudl_label"   "mercury_content_ppm"
## [4] "fuel_cost_per_mmbtu"  "moisture_content_pct" "chlorine_content_ppm"

# all missing values
all <- PUDL %>%
  summarise_all(funs(sum(is.na(.)))) %>%
  gather(key = "variable", value = "missing_values") %>%
  filter(missing_values > 0) %>%
  arrange(desc(missing_values))

## Warning: `funs()` was deprecated in dplyr 0.8.0.
## ℹ Please use a list of either functions or lambdas:
##
## # Simple named list: list(mean = mean, median = median)
##
## # Auto named with `tibble::lst()`: tibble::lst(mean, median)
##
## # Using lambdas list(~ mean(., trim = .2), ~ median(., na.rm = TRUE))
```

```r
# Remove variables with significant missing values
PUDL <- PUDL %>%
  select(-all$variable)
```

CHECKING THE DATA

```r
 str(PUDL)
```

```
## 'data.frame':    608564 obs. of  24 variables:
##  $ rowid                                  : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ plant_id_eia                           : int  3 3 3 7 7 7 7 8 8 8 ...
##  $ plant_id_eia_label                     : chr  "Barry" "Barry" "Barry"
"Gadsden" ...
##  $ report_date                            : chr  "2008-01-01" "2008-01-
01" "2008-01-01" "2008-01-01" ...
##  $ contract_type_code                     : chr  "C" "C" "C" "C" ...
##  $ contract_type_code_label               : chr  "C" "C" "C" "C" ...
##  $ contract_expiration_date               : chr  "2008-04-01" "2008-04-
01" "" "2015-12-01" ...
##  $ energy_source_code                     : chr  "BIT" "BIT" "NG" "BIT"
...
##  $ energy_source_code_label               : chr  "BIT" "BIT" "NG" "BIT"
...
##  $ fuel_type_code_pudl                    : chr  "coal" "coal" "gas"
"coal" ...
##  $ fuel_group_code                        : chr  "coal" "coal"
"natural_gas" "coal" ...
##  $ supplier_name                          : chr  "interocean coal"
"interocean coal" "bay gas pipeline" "alabama coal" ...
##  $ fuel_received_units                    : num  259412 52241 2783619
25397 764 ...
##  $ fuel_mmbtu_per_unit                    : num  23.1 22.8 1.04 24.61
24.45 ...
##  $ sulfur_content_pct                     : num  0.49 0.48 0 1.69 0.84
1.54 0 2.16 1.24 1.9 ...
##  $ ash_content_pct                        : num  5.4 5.7 0 14.7 15.5 14.6
0 15.4 11.9 15.4 ...
##  $ primary_transportation_mode_code       : chr  "RV" "RV" "PL" "TR" ...
##  $ primary_transportation_mode_code_label : chr  "RV" "RV" "PL" "TR" ...
##  $ secondary_transportation_mode_code     : chr  "" "" "" "" ...
##  $ secondary_transportation_mode_code_label: chr  "" "" "" "" ...
##  $ natural_gas_transport_code             : chr  "firm" "firm" "firm"
"firm" ...
##  $ natural_gas_delivery_contract_type_code : chr  "" "" "" "" ...
##  $ data_maturity                          : chr  "final" "final" "final"
"final" ...
##  $ data_maturity_label                    : chr  "final" "final" "final"
"final" ...
```

2. Ensure that the variables have the right attributes. For example, numerical or categorical.

```
# attributes
sapply(PUDL, class)
```

```
##                                     rowid
##                                 "integer"
##                               plant_id_eia
##                                  "integer"
##                           plant_id_eia_label
##                                  "character"
##                                  report_date
##                                  "character"
##                           contract_type_code
##                                  "character"
##                      contract_type_code_label
##                                  "character"
##                      contract_expiration_date
##                                  "character"
##                            energy_source_code
##                                  "character"
##                      energy_source_code_label
##                                  "character"
##                           fuel_type_code_pudl
##                                  "character"
##                               fuel_group_code
##                                  "character"
##                                 supplier_name
##                                  "character"
##                           fuel_received_units
##                                    "numeric"
##                           fuel_mmbtu_per_unit
##                                    "numeric"
##                            sulfur_content_pct
##                                    "numeric"
##                               ash_content_pct
##                                    "numeric"
##            primary_transportation_mode_code
##                                  "character"
##     primary_transportation_mode_code_label
##                                  "character"
##          secondary_transportation_mode_code
##                                  "character"
## secondary_transportation_mode_code_label
##                                  "character"
##                  natural_gas_transport_code
##                                  "character"
##    natural_gas_delivery_contract_type_code
##                                  "character"
##                                data_maturity
```

```
##                               "character"
##                       data_maturity_label
##                               "character"

#It determines the data types of each variable in the "PUDL" dataset and
returns the information as a vector using the class() function and sapply().
```

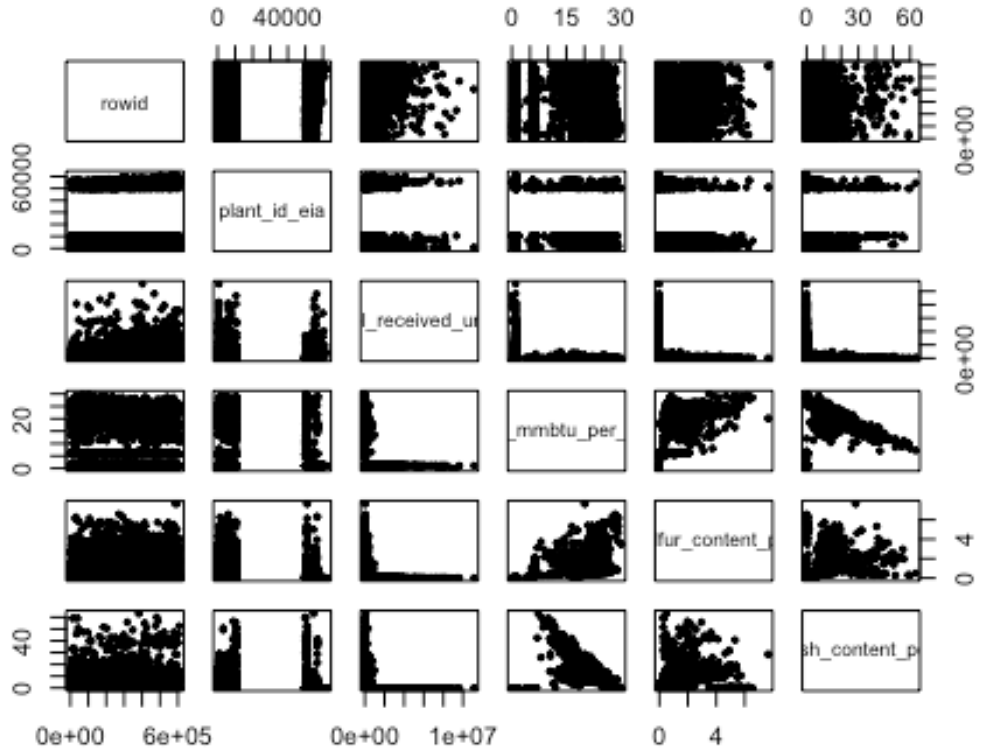
3. To ensure that both the data, and the analysis are unique to each student, randomly sample about 2% of your data using a random 4-digit number as the seed to sample the data. Use 75% of the sampled data as the training set, and the rest as the test set (if needed). This should yield a training set of about 9000 and a test of about 3000.

```
# Set a random seed for reproducibility
set.seed(1234)

# Randomly sample about 2% of the rows from the dataset
sampled <- PUDL %>%
  sample_frac(0.02)

# Split the sampled data into training and test sets

train<- sampled %>%
  sample_frac(0.75)

test<- sampled %>%
    anti_join(train)

## Joining with `by = join_by(rowid, plant_id_eia, plant_id_eia_label,
## report_date, contract_type_code, contract_type_code_label,
## contract_expiration_date, energy_source_code, energy_source_code_label,
## fuel_type_code_pudl, fuel_group_code, supplier_name, fuel_received_units,
## fuel_mmbtu_per_unit, sulfur_content_pct, ash_content_pct,
## primary_transportation_mode_code, primary_transportation_mode_code_label,
## secondary_transportation_mode_code,
secondary_transportation_mode_code_label,
## natural_gas_transport_code, natural_gas_delivery_contract_type_code,
## data_maturity, data_maturity_label)`

# Print the number of rows in the training and test sets
nrow(train)

## [1] 9128

nrow(test)

## [1] 3043

#This code randomly samples 2% of the "PUDL" dataset, splits it into training
and test sets, and prints the number of rows in each set. It is a common data
preparation step before building and evaluating predictive models.
```

#CHECKING THE DATA

```
str(train)

## 'data.frame':    9128 obs. of  24 variables:
##  $ rowid                                  : int  87571 142756 9625 146942
26617 579028 539024 412250 382869 133924 ...
##  $ plant_id_eia                           : int  666 2964 55380 1393 2866
7916 57664 50481 2963 4041 ...
##  $ plant_id_eia_label                     : chr  "J D Kennedy"
"Southwestern" "Union Power Station" "R S Nelson" ...
##  $ report_date                            : chr  "2009-06-01" "2010-05-
01" "2008-02-01" "2010-06-01" ...
##  $ contract_type_code                     : chr  "S" "S" "S" "S" ...
##  $ contract_type_code_label               : chr  "S" "S" "S" "S" ...
##  $ contract_expiration_date               : chr  "" "" "" "" ...
##  $ energy_source_code                     : chr  "NG" "NG" "NG" "NG" ...
##  $ energy_source_code_label               : chr  "NG" "NG" "NG" "NG" ...
##  $ fuel_type_code_pudl                    : chr  "gas" "gas" "gas" "gas"
...
##  $ fuel_group_code                        : chr  "natural_gas"
"natural_gas" "natural_gas" "natural_gas" ...
##  $ supplier_name                          : chr  "florida gas"
"chesapeake" "andarko" "florida gas" ...
##  $ fuel_received_units                    : num  249079 607 409008 467564
30780 ...
##  $ fuel_mmbtu_per_unit                    : num  1.06 1.04 1.05 1.03 24.8
...
##  $ sulfur_content_pct                     : num  0 0 0 0 0.79 0 0 0.95 0
0 ...
##  $ ash_content_pct                        : num  0 0 0 0 12 0 0 8.7 0 0
...
##  $ primary_transportation_mode_code       : chr  "" "" "" "" ...
##  $ primary_transportation_mode_code_label : chr  "" "" "" "" ...
##  $ secondary_transportation_mode_code     : chr  "" "" "" "" ...
##  $ secondary_transportation_mode_code_label: chr  "" "" "" "" ...
##  $ natural_gas_transport_code             : chr  "interruptible"
"interruptible" "interruptible" "interruptible" ...
##  $ natural_gas_delivery_contract_type_code : chr  "" "" "" "" ...
##  $ data_maturity                          : chr  "final" "final" "final"
"final" ...
##  $ data_maturity_label                    : chr  "final" "final" "final"
"final" ...

str(test)

## 'data.frame':    3043 obs. of  24 variables:
##  $ rowid                                  : int  126055 382554 345167
199608 279106 237360 330424 131974 166742 413590 ...
##  $ plant_id_eia                           : int  50978 1733 3399 55192 96
6061 8102 535 8 2723 ...
##  $ plant_id_eia_label                     : chr  "Carr Street" "Monroe"
```

```
"Cumberland" "Osceola" ...
##  $ report_date                              : chr  "2010-01-01" "2015-11-
01" "2014-10-01" "2011-04-01" ...
##  $ contract_type_code                       : chr  "S" "C" "S" "S" ...
##  $ contract_type_code_label                 : chr  "S" "C" "S" "S" ...
##  $ contract_expiration_date                 : chr  "" "2015-11-01" "" ""
...
##  $ energy_source_code                       : chr  "NG" "BIT" "DFO" "NG"
...
##  $ energy_source_code_label                 : chr  "NG" "BIT" "DFO" "NG"
...
##  $ fuel_type_code_pudl                      : chr  "gas" "coal" "oil" "gas"
...
##  $ fuel_group_code                          : chr  "natural_gas" "coal"
"petroleum" "natural_gas" ...
##  $ supplier_name                            : chr  "sprague energy corp"
"blackhawk mining llc" "jat oil" "seminole" ...
##  $ fuel_received_units                      : num  11537 12883 170 163405
875779 ...
##  $ fuel_mmbtu_per_unit                      : num  1.03 25.1 5.76 1.03 1
...
##  $ sulfur_content_pct                       : num  0 0.76 0 0 0 0.84 3.8 0
0.99 0 ...
##  $ ash_content_pct                          : num  0 8.2 0 0 0 ...
##  $ primary_transportation_mode_code         : chr  "PL" "RR" "TR" "PL" ...
##  $ primary_transportation_mode_code_label   : chr  "PL" "RR" "TR" "PL" ...
##  $ secondary_transportation_mode_code       : chr  "" "" "" "" ...
##  $ secondary_transportation_mode_code_label: chr  "" "" "" "" ...
##  $ natural_gas_transport_code               : chr  "interruptible" "" ""
"firm" ...
##  $ natural_gas_delivery_contract_type_code : chr  "" "" "" "" ...
##  $ data_maturity                            : chr  "final" "final" "final"
"final" ...
##  $ data_maturity_label                      : chr  "final" "final" "final"
"final" ...

# Identify the numeric variables in the training set
numVars <- names(train)[sapply(train, is.numeric)]

# Create the scatterplot matrix using the pairs() function
pairs(train[,numVars], pch = 19, cex = 0.5,)
```




```
#The code selects the numeric variables from the train dataframe and stores
them in numVars. It then creates a scatterplot matrix using the pairs()
function to visualize the pairwise relationships between the numeric
variables in the train dataset.

# k-means clustering
set.seed(1234)
# Select numeric columns from the train data
numValues <- train %>% select_if(is.numeric)

# Perform k-means clustering with 3 clusters
kmeans <- kmeans(numValues, centers = 3)
kmeans

## K-means clustering with 3 clusters of sizes 583, 111, 8434
##
## Cluster means:
##      rowid plant_id_eia fuel_received_units fuel_mmbtu_per_unit
## 1 353664.9     37772.14          1734967.04           1.0507136
## 2 382242.5     28576.76          5018917.32           0.9681261
## 3 301395.7     16623.99            81635.17           9.4080154
##   sulfur_content_pct ash_content_pct
## 1        0.002521441      0.02504288
```

```
## 2        0.000000000      0.00000000
## 3        0.558086317      3.79857482
##
## Clustering vector:
##    [1] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3 3 3 1 1 3 3 1 3 3 3 3 3 3
3 1 3
##   [38] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3
3 3 1
##   [75] 3 3 3 3 3 3 3 3 3 2 3 3 3 1 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3 3 3 3
3 3 3
##  [112] 3 3 3 3 3 3 3 3 3 3 3 1 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3
3 3 3
##  [149] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [186] 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3 1 3 3 3 3 3 3 3 3 3
3 3 3
##  [223] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 1 3 3 3 3 3 3
3 3 3
##  [260] 3 3 3 3 3 3 3 3 3 3 1 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1
3 3 3
##  [297] 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [334] 1 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3 1 3 3 3 3 3 3 3 3 3 3 3
1 3 3
##  [371] 3 1 3 3 3 2 3 3 3 3 1 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [408] 3 3 3 3 3 3 3 3 3 3 3 2 3 2 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [445] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3
3 3 3
##  [482] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3
3 3 3
##  [519] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [556] 3 3 3 3 3 3 3 3 3 2 1 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [593] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3
3 3 2
##  [630] 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [667] 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [704] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 1 1
3 3 3
##  [741] 3 3 3 1 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 1 3 3 3 1 3 3 3 3
3 3 3
##  [778] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##  [815] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
```

```
##  [852] 3 3 3 3 3 3 1 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
##  [889] 3 3 3 3 3 3 3 3 1 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3 3
##  [926] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3
##  [963] 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3 3 3 3 3 3 3 1 3
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3 3 3
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## [8696] 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 1
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3 3 3
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3 3 3
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3 3 3
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3 3 3
## [9103] 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3
##
## Within cluster sum of squares by cluster:
## [1] 2.670057e+14 3.078375e+14 4.634426e+14
```

```
##  (between_SS / total_SS =  79.6 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"
"tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"

#It performs k-means clustering with 3 clusters on the numeric columns of the
training data. The resulting clusters will be stored in the kmeans object.

# aggregate the data
aggregate(train[,numVars], by = list (kmeans $ cluster), mean)

##   Group.1    rowid plant_id_eia fuel_received_units fuel_mmbtu_per_unit
## 1       1 353664.9     37772.14          1734967.04           1.0507136
## 2       2 382242.5     28576.76          5018917.32           0.9681261
## 3       3 301395.7     16623.99            81635.17           9.4080154
##   sulfur_content_pct ash_content_pct
## 1        0.002521441      0.02504288
## 2        0.000000000      0.00000000
## 3        0.558086317      3.79857482

#This code aggregates the numeric variables in the training set by the k-
means cluster labels and computes the mean for each variable within each
cluster.
```

#visualizing the given data

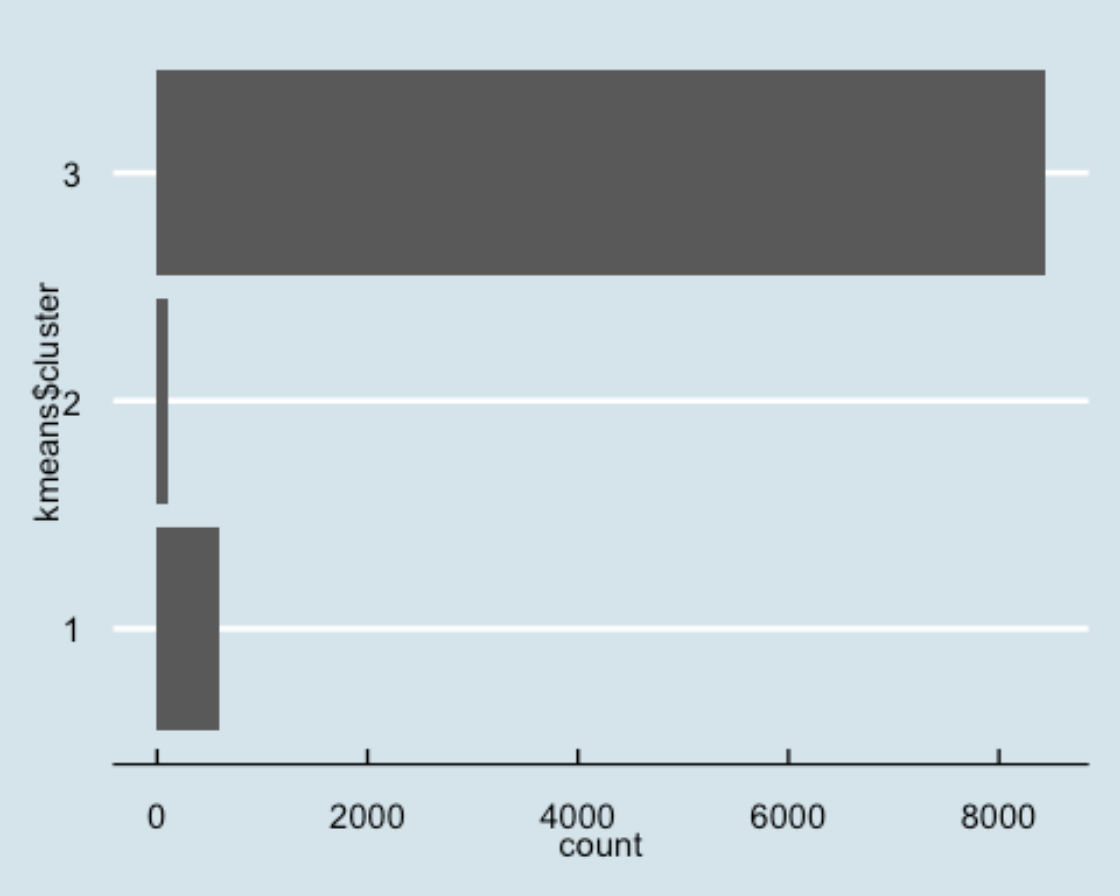
```
#  Create a ggplot object with the train data and cluster assignments on the
y-axis
ggplot(train, aes(y = kmeans$cluster)) +

# Add a bar layer to the plot, with fill color based on cluster assignments
  geom_bar(aes(fill = kmeans$cluster), position = "dodge") +

#  Apply the economist theme to the plot
  theme_economist() +

# Adjust the title alignment
  theme(plot.title = element_text(hjust = 0.5))

## Warning: The following aesthetics were dropped during statistical
transformation: fill
## ℹ This can happen when ggplot fails to infer the correct grouping
structure in
##   the data.
## ℹ Did you forget to specify a `group` aesthetic or to convert a numerical
##   variable into a factor?
```




```
#This creates a bar plot using ggplot, with the cluster assignments on the y-axis and the fill color based on the cluster assignments. The economist theme is applied to the plot, and the title alignment is adjusted.
```

#KNN

```
# Set the seed for reproducibility
set.seed(1234)

# Identify numeric columns in the train data
numValues <- sapply(train, is.numeric)

# Load the 'class' package for kNN classification
library(class)

#Subset the train and test data to only include numeric columns
train1 <- train[, numValues]
test1 <- test[, numValues]

# Perform kNN classification on the numeric train and test data
# using the cluster assignments from the k-means model as the class labels
knn <- knn(train1, test1, cl = kmeans$cluster, k = 3)
knn
```

```
##    [1] 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3
##   [38] 3 3 3 3 3 3 3 3 1 3 3 3 3 1 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1
3 3 3
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3 3 2
##  [112] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3
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3 2 3
##  [889] 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 1 3
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1 3 3
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3 3 3
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3 3 3
## [1185] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 2 3 3 3 3
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3 3 3
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3 3 3
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3 3 3
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3 3 3
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3 3 2
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```
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3 3 3
3 1 3
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3 3 3
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3 3 3
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3 3 3
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```
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## [2813] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3
1 3 3
## [2850] 3 3 3 3 2 3 3 3 1 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 1 1
## [2887] 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 1 3 3 3 3 3 3
3 3 3
## [2924] 3 3 1 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 1 3 3 3
3 1 3
## [2961] 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3
3 3 3
## [2998] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 1
3 3 3
## [3035] 3 3 3 3 3 3 3 3 3
## Levels: 1 2 3
```

```
#It perform k-Nearest Neighbors classification on the numeric columns of the
train and test data, using the cluster assignments obtained from k-means
clustering with 3 clusters on the train data as the class labels. The
resulting classification is stored in the knn object.
```

#SEGMENTATION

```
#Identify numeric columns in the train data
numValues <- sapply(train, is.numeric)

# Step 2: Perform k-means clustering on the numeric train data, with 3
clusters
kmeans <- kmeans(train[, numValues], centers = 3)

kmeans

## K-means clustering with 3 clusters of sizes 583, 8434, 111
##
## Cluster means:
##      rowid plant_id_eia fuel_received_units fuel_mmbtu_per_unit
## 1 353664.9     37772.14          1734967.04           1.0507136
## 2 301395.7     16623.99            81635.17           9.4080154
## 3 382242.5     28576.76          5018917.32           0.9681261
##   sulfur_content_pct ash_content_pct
## 1        0.002521441      0.02504288
## 2        0.558086317      3.79857482
## 3        0.000000000      0.00000000
##
## Clustering vector:
##    [1] 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2 2 2 2 2 1 1 2 2 1 2 2 2 2 2 2
2 1 2
##   [38] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2
2 2 1
##   [75] 2 2 2 2 2 2 2 2 2 3 2 2 2 1 2 2 2 2 2 2 2 2 2 3 2 2 2 2 2 2 2 2 2
```

```
2 2 2
##  [112] 2 2 2 2 2 2 2 2 2 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2 2 2
2 2 2
##  [149] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [186] 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 1 2 2 2 2 1 2 2 2 2 2 2 2 2 2
2 2 2
##  [223] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1 2 2 2 2 2
2 2 2
##  [260] 2 2 2 2 2 2 2 2 2 2 1 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1
2 2 2
##  [297] 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [334] 1 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 1 2 1 2 2 2 2 2 2 2 2 2 2 2
1 2 2
##  [371] 2 1 2 2 2 3 2 2 2 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [408] 2 2 2 2 2 2 2 2 2 2 3 2 3 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [445] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2
2 2 2
##  [482] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2
2 2 2
##  [519] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [556] 2 2 2 2 2 2 2 2 2 3 1 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
##  [593] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2
2 2 3
##  [630] 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2
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2 2 2
##  [704] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 1 1
2 2 2
##  [741] 2 2 2 1 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 1 2 2 2 1 2 2 2 2
2 2 2
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## [9103] 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2
##
## Within cluster sum of squares by cluster:
## [1] 2.670057e+14 4.634426e+14 3.078375e+14
##  (between_SS / total_SS =  79.6 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"
"tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
#This code performs k-means clustering on the numeric columns of the training data with 3 clusters. The resulting object is saved as kmeans.

# Step 1: Get the length of the k-means cluster assignments
kmeans_length <- length(kmeans$cluster)
kmeans_length
```

```
## [1] 9128
```

```r
# Step 2: Get the length of the kNN classifications
knn_length <- length(knn)
knn_length
```

```
## [1] 3043
```

```r
# It calculates the length of the k-means cluster assignments and the length of the kNN classifications, stored in the variables kmeans_length and knn_length, respectively.
```