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))

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

# CHECKING THE DATA

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" ...

1. 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().

1. 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

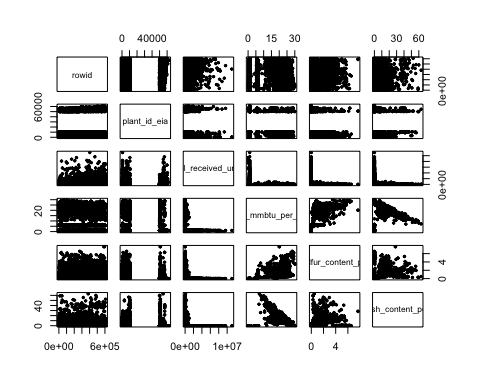
str(train)

## '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 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 1 3 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 1 3 3 3 3 1 3 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 1 1 3 3 3 3 3 3 3 3 3  
## [260] 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 1 3 3 3  
## [297] 3 3 3 3 3 3 3 3 3 1 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 1 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 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  
## [408] 3 3 3 3 3 3 3 3 3 3 2 3 2 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 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 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  
## [556] 3 3 3 3 3 3 3 3 2 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 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 1 3 3 3 3 3 3 3 2  
## [630] 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 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 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 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  
## [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  
## [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 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 3 2 3 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 1 3 3 3 3 3 3 3 1 3 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 3 1 3  
## [1000] 1 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 1 3 3 3 3 3 3 3 3  
## [1037] 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 1 3 3 3 3 3 3 3 3 1 1 3 3 3 3 3 3 3 3 3 3  
## [1074] 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 1 1 3 3 3  
## [1111] 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 3 1 3 3 3 3 3 3 3 3 3  
## [1148] 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 1 3 3 3 3 3 3 3 3 3 3 3 2 3  
## [1185] 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 3 3 3 1 3 3  
## [1222] 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 2 3 3 3 3  
## [1259] 3 3 3 3 3 3 1 3 3 3 1 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3  
## [1296] 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  
## [1333] 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 1 3 3 3 3 3 3 3 3 3 3 3  
## [1370] 3 3 3 3 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 3 3 3 1 3  
## [1407] 3 3 2 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  
## [1444] 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  
## [1481] 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 3 3 3 3 3 3 3 3 3 3  
## [1518] 3 3 3 3 3 3 3 1 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  
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## [9103] 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  
##   
## 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)

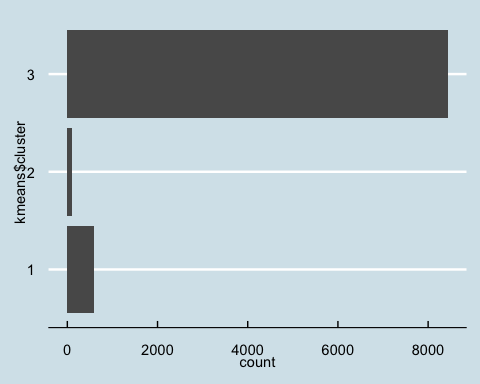
## Group.1 rowid plant\_id\_eia fuel\_received\_units fuel\_mmbtu\_per\_unit  
## 1 1 353664.9 37772.14 1734967.04 1.0507136  
## 2 2 382242.5 28576.76 5018917.32 0.9681261  
## 3 3 301395.7 16623.99 81635.17 9.4080154  
## sulfur\_content\_pct ash\_content\_pct  
## 1 0.002521441 0.02504288  
## 2 0.000000000 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 3  
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## [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 2 3 2 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 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 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 2 3 2 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 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"

#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

# Step 2: Get the length of the kNN classifications  
knn\_length <- length(knn)  
knn\_length

## [1] 3043

# 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.