Machine Learning File

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knitr::opts\_chunk$set(echo = TRUE)  
  
## This is my submission for the final for Machine Learning, Fall 2023. I will complete the analysis using theories we learned about in all modules of the class to try to summarize everything I have learned in the course, to try to synthesize a large amount of difficult information! This class has by far been the most challenging of my MBA, and actually made me realize my strengths are not inherently in coding! I have spent too much time in excel performing data analytics. ##

## Exectutive Summary

The findings of this report represent multiple different attempts to analyze over 600k lines of data. To begin, the data had to be understood, cleaned, and minimized for any meaningful output and analysis to be reached. Per the guidance provided, I started by omitting missing values, which reduced the data down to 76k observations. Then, a 2% sample was selected to proceed. I made many of my conclusions by reviewing the data in pudl, the interactive chart option was extremely useful. I started by learning that almost 100% of the contracts are type “C”, which means they have terms greater than one year. The vast majority of fuel received was natural gas, from two major plant IDs of Barry and Beluga. The two largest suppliers were the Bay gas line and Marathon Oil Company. I had hoped to understand gas consumption by geopraphic locatin, but was unable to find a data field representing this.

## Before I import the data and begin analysis, I will set-up a section to all all libraries I may want to use. As I add them throughout the data exploration and analysis, I will try to always put them up here at the top ##  
  
library(dplyr)

library(ISLR)

library(class)  
library(caret)

library(factoextra)

library(tidyverse)

library(ggplot2)  
library("gmodels")

## Next, I will bring in the dataset from PUDDL, and begin understanding what needs to be cleaned up. Right away in the global environment I see I have the complete data set with 663,572 obs. of 30 variables. I need to review some summary information, and understand what data is missing and should be excluded.

PowerGen.df <- read.csv("fuel\_receipts\_costs\_eia923.csv")  
summary(PowerGen.df)

## rowid plant\_id\_eia plant\_id\_eia\_label report\_date   
## Min. : 1 Min. : 3 Length:663572 Length:663572   
## 1st Qu.:165894 1st Qu.: 2720 Class :character Class :character   
## Median :331787 Median : 6178 Mode :character Mode :character   
## Mean :331787 Mean :18634   
## 3rd Qu.:497679 3rd Qu.:50835   
## Max. :663572 Max. :65978   
##   
## contract\_type\_code contract\_type\_code\_label contract\_expiration\_date  
## Length:663572 Length:663572 Length:663572   
## Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character   
##   
##   
##   
##   
## energy\_source\_code energy\_source\_code\_label fuel\_type\_code\_pudl  
## Length:663572 Length:663572 Length:663572   
## Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character   
##   
##   
##   
##   
## fuel\_group\_code mine\_id\_pudl mine\_id\_pudl\_label supplier\_name   
## Length:663572 Min. : 0 Min. : 0 Length:663572   
## Class :character 1st Qu.: 43 1st Qu.: 43 Class :character   
## Mode :character Median :1052 Median :1052 Mode :character   
## Mean :1642 Mean :1642   
## 3rd Qu.:3122 3rd Qu.:3122   
## Max. :4806 Max. :4806   
## NA's :432955 NA's :432955   
## fuel\_received\_units fuel\_mmbtu\_per\_unit sulfur\_content\_pct ash\_content\_pct   
## Min. : 1 Min. : 0.000 Min. : 0.0000 Min. : 0.000   
## 1st Qu.: 3880 1st Qu.: 1.026 1st Qu.: 0.0000 1st Qu.: 0.000   
## Median : 22585 Median : 1.060 Median : 0.0000 Median : 0.000   
## Mean : 255079 Mean : 8.636 Mean : 0.5022 Mean : 3.503   
## 3rd Qu.: 112321 3rd Qu.: 17.754 3rd Qu.: 0.4300 3rd Qu.: 5.600   
## Max. :48159765 Max. :1049.000 Max. :21.2400 Max. :72.200   
##   
## mercury\_content\_ppm fuel\_cost\_per\_mmbtu primary\_transportation\_mode\_code  
## Min. :0.00 Min. : -71.9 Length:663572   
## 1st Qu.:0.00 1st Qu.: 2.3 Class :character   
## Median :0.00 Median : 3.3 Mode :character   
## Mean :0.01 Mean : 14.0   
## 3rd Qu.:0.00 3rd Qu.: 5.1   
## Max. :6.25 Max. :562572.2   
## NA's :289482 NA's :214941   
## primary\_transportation\_mode\_code\_label secondary\_transportation\_mode\_code  
## Length:663572 Length:663572   
## Class :character Class :character   
## Mode :character Mode :character   
##   
##   
##   
##   
## secondary\_transportation\_mode\_code\_label natural\_gas\_transport\_code  
## Length:663572 Length:663572   
## Class :character Class :character   
## Mode :character Mode :character   
##   
##   
##   
##   
## natural\_gas\_delivery\_contract\_type\_code moisture\_content\_pct  
## Length:663572 Min. : 0.0   
## Class :character 1st Qu.: 6.7   
## Mode :character Median : 12.2   
## Mean : 15.9   
## 3rd Qu.: 26.9   
## Max. :247.0   
## NA's :557501   
## chlorine\_content\_ppm data\_maturity data\_maturity\_label  
## Min. : 0.0 Length:663572 Length:663572   
## 1st Qu.: 0.0 Class :character Class :character   
## Median : 0.0 Mode :character Mode :character   
## Mean : 57.9   
## 3rd Qu.: 0.0   
## Max. :3747.0   
## NA's :557501

dim(PowerGen.df)

## [1] 663572 30

t(t(names(PowerGen.df)))

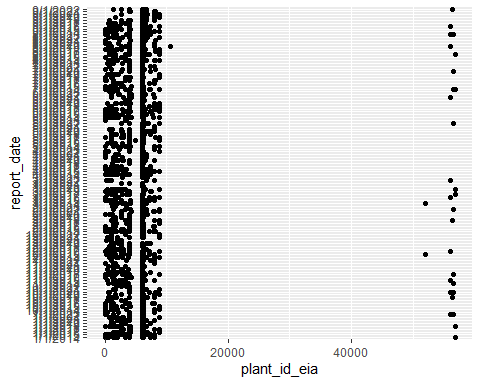
## [,1]   
## [1,] "rowid"   
## [2,] "plant\_id\_eia"   
## [3,] "plant\_id\_eia\_label"   
## [4,] "report\_date"   
## [5,] "contract\_type\_code"   
## [6,] "contract\_type\_code\_label"   
## [7,] "contract\_expiration\_date"   
## [8,] "energy\_source\_code"   
## [9,] "energy\_source\_code\_label"   
## [10,] "fuel\_type\_code\_pudl"   
## [11,] "fuel\_group\_code"   
## [12,] "mine\_id\_pudl"   
## [13,] "mine\_id\_pudl\_label"   
## [14,] "supplier\_name"   
## [15,] "fuel\_received\_units"   
## [16,] "fuel\_mmbtu\_per\_unit"   
## [17,] "sulfur\_content\_pct"   
## [18,] "ash\_content\_pct"   
## [19,] "mercury\_content\_ppm"   
## [20,] "fuel\_cost\_per\_mmbtu"   
## [21,] "primary\_transportation\_mode\_code"   
## [22,] "primary\_transportation\_mode\_code\_label"   
## [23,] "secondary\_transportation\_mode\_code"   
## [24,] "secondary\_transportation\_mode\_code\_label"  
## [25,] "natural\_gas\_transport\_code"   
## [26,] "natural\_gas\_delivery\_contract\_type\_code"   
## [27,] "moisture\_content\_pct"   
## [28,] "chlorine\_content\_ppm"   
## [29,] "data\_maturity"   
## [30,] "data\_maturity\_label"

## rowMeans(is.na(PowerGen.df)) I had to omit this line of code becuase it generated over 550 pages in the word document.  
PowerGen.df <- na.omit(PowerGen.df)  
PowerGen.df = PowerGen.df[,-c(3,6,12)] #remove useless variables

## Sample and partition the data  
set.seed(3268)  
##s <- sample(row.names(PowerGen.df), 1600) #1,600 samples is approximately 2% of the data  
train.rows <- sample(rownames(PowerGen.df), dim(PowerGen.df)[1]\*0.02) #2% for training, 98% for test  
train.data <- PowerGen.df[train.rows, ]  
valid.rows <- setdiff(rownames(PowerGen.df), train.rows)  
valid.data <- PowerGen.df[valid.rows, ]

##Now that I have set my sample data, and partitioned into training and validation data sets, I’ll start working through some analysis. At this point I am still working to understand the data to formulate my questions.

ggplot(data = train.data) + geom\_point(mapping = aes(x = plant\_id\_eia, y = report\_date)) #This plot is terrible, I will keep trying! Perhaps I need to normalize the data first? So I will try that next.



train.norm.df <- train.data  
valid.norm.df <- valid.data  
  
  
norm.values <- preProcess(train.data[, 16:20], method=c("center", "scale"))  
  
train.norm.df[, 16:20] <- predict(norm.values, train.data[, 16:20])  
valid.norm.df[, 16:20] <- predict(norm.values, valid.data[, 16:20])  
  
summary(train.norm.df)

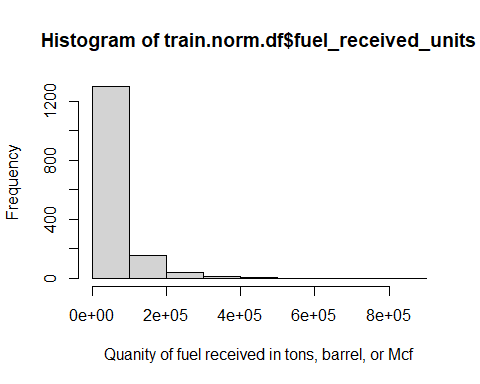
## rowid plant\_id\_eia report\_date contract\_type\_code  
## Min. :315828 Min. : 3 Length:1516 Length:1516   
## 1st Qu.:371222 1st Qu.: 1710 Class :character Class :character   
## Median :448174 Median : 3948 Mode :character Mode :character   
## Mean :462802 Mean : 5164   
## 3rd Qu.:545328 3rd Qu.: 6165   
## Max. :663363 Max. :56808   
## contract\_expiration\_date energy\_source\_code energy\_source\_code\_label  
## Length:1516 Length:1516 Length:1516   
## Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character   
##   
##   
##   
## fuel\_type\_code\_pudl fuel\_group\_code mine\_id\_pudl\_label supplier\_name   
## Length:1516 Length:1516 Min. : 16.0 Length:1516   
## Class :character Class :character 1st Qu.: 21.0 Class :character   
## Mode :character Mode :character Median : 300.5 Mode :character   
## Mean :1504.2   
## 3rd Qu.:2798.8   
## Max. :4778.0   
## fuel\_received\_units fuel\_mmbtu\_per\_unit sulfur\_content\_pct ash\_content\_pct   
## Min. : 11 Min. :10.04 Min. :0.120 Min. : 3.800   
## 1st Qu.: 12951 1st Qu.:17.63 1st Qu.:0.260 1st Qu.: 5.075   
## Median : 26652 Median :21.84 Median :0.720 Median : 7.790   
## Mean : 52130 Mean :20.78 Mean :1.275 Mean : 8.015   
## 3rd Qu.: 64514 3rd Qu.:23.96 3rd Qu.:2.570 3rd Qu.: 9.500   
## Max. :852907 Max. :27.29 Max. :5.520 Max. :50.100   
## mercury\_content\_ppm fuel\_cost\_per\_mmbtu primary\_transportation\_mode\_code  
## Min. :-0.4181 Min. :-1.0303 Length:1516   
## 1st Qu.:-0.4181 1st Qu.:-0.3522 Class :character   
## Median :-0.4181 Median :-0.1350 Mode :character   
## Mean : 0.0000 Mean : 0.0000   
## 3rd Qu.:-0.4181 3rd Qu.: 0.1859   
## Max. : 9.4816 Max. :24.9902   
## primary\_transportation\_mode\_code\_label secondary\_transportation\_mode\_code  
## Length:1516 Length:1516   
## Class :character Class :character   
## Mode :character Mode :character   
##   
##   
##   
## secondary\_transportation\_mode\_code\_label natural\_gas\_transport\_code  
## Length:1516 Length:1516   
## Class :character Class :character   
## Mode :character Mode :character   
##   
##   
##   
## natural\_gas\_delivery\_contract\_type\_code moisture\_content\_pct  
## Length:1516 Min. : 0.00   
## Class :character 1st Qu.: 6.96   
## Mode :character Median :12.99   
## Mean :16.47   
## 3rd Qu.:26.95   
## Max. :37.50   
## chlorine\_content\_ppm data\_maturity data\_maturity\_label  
## Min. : 0.0 Length:1516 Length:1516   
## 1st Qu.: 0.0 Class :character Class :character   
## Median : 0.0 Mode :character Mode :character   
## Mean : 37.5   
## 3rd Qu.: 0.0   
## Max. :2947.0

var(train.norm.df[, 16:20])

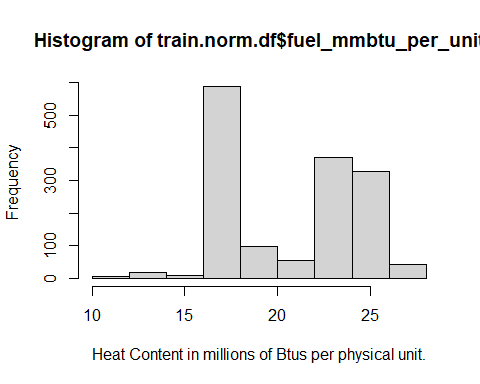
## Warning in var(train.norm.df[, 16:20]): NAs introduced by coercion

## mercury\_content\_ppm fuel\_cost\_per\_mmbtu  
## mercury\_content\_ppm 1.00000002 -0.01927469  
## fuel\_cost\_per\_mmbtu -0.01927469 1.00000010  
## primary\_transportation\_mode\_code NA NA  
## primary\_transportation\_mode\_code\_label NA NA  
## secondary\_transportation\_mode\_code NA NA  
## primary\_transportation\_mode\_code  
## mercury\_content\_ppm NA  
## fuel\_cost\_per\_mmbtu NA  
## primary\_transportation\_mode\_code NA  
## primary\_transportation\_mode\_code\_label NA  
## secondary\_transportation\_mode\_code NA  
## primary\_transportation\_mode\_code\_label  
## mercury\_content\_ppm NA  
## fuel\_cost\_per\_mmbtu NA  
## primary\_transportation\_mode\_code NA  
## primary\_transportation\_mode\_code\_label NA  
## secondary\_transportation\_mode\_code NA  
## secondary\_transportation\_mode\_code  
## mercury\_content\_ppm NA  
## fuel\_cost\_per\_mmbtu NA  
## primary\_transportation\_mode\_code NA  
## primary\_transportation\_mode\_code\_label NA  
## secondary\_transportation\_mode\_code NA

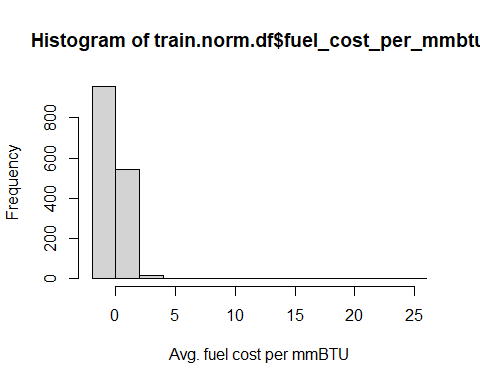
hist(train.norm.df$fuel\_received\_units, xlab = "Quanity of fuel received in tons, barrel, or Mcf")



hist(train.norm.df$fuel\_mmbtu\_per\_unit, xlab = "Heat Content in millions of Btus per physical unit.")



hist(train.norm.df$fuel\_cost\_per\_mmbtu, xlab = "Avg. fuel cost per mmBTU")



##With the normalized data, I will now apply k means.

##This code chunk did now work, trying again.  
## numeric\_Power <- PowerGen.df[,c(16:20,27)]  
## distance <- dist(numeric\_Power)

t(t(names(train.norm.df)))

## [,1]   
## [1,] "rowid"   
## [2,] "plant\_id\_eia"   
## [3,] "report\_date"   
## [4,] "contract\_type\_code"   
## [5,] "contract\_expiration\_date"   
## [6,] "energy\_source\_code"   
## [7,] "energy\_source\_code\_label"   
## [8,] "fuel\_type\_code\_pudl"   
## [9,] "fuel\_group\_code"   
## [10,] "mine\_id\_pudl\_label"   
## [11,] "supplier\_name"   
## [12,] "fuel\_received\_units"   
## [13,] "fuel\_mmbtu\_per\_unit"   
## [14,] "sulfur\_content\_pct"   
## [15,] "ash\_content\_pct"   
## [16,] "mercury\_content\_ppm"   
## [17,] "fuel\_cost\_per\_mmbtu"   
## [18,] "primary\_transportation\_mode\_code"   
## [19,] "primary\_transportation\_mode\_code\_label"   
## [20,] "secondary\_transportation\_mode\_code"   
## [21,] "secondary\_transportation\_mode\_code\_label"  
## [22,] "natural\_gas\_transport\_code"   
## [23,] "natural\_gas\_delivery\_contract\_type\_code"   
## [24,] "moisture\_content\_pct"   
## [25,] "chlorine\_content\_ppm"   
## [26,] "data\_maturity"   
## [27,] "data\_maturity\_label"

numeric\_Power <- train.norm.df[,c(13,17)]

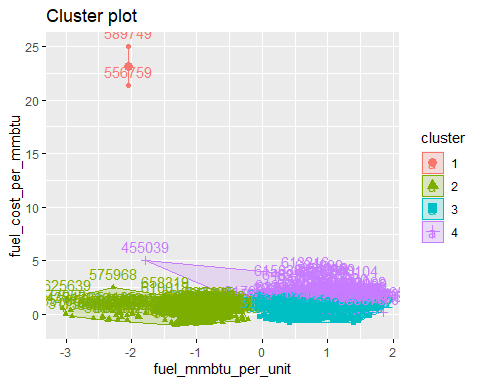
df <- scale(numeric\_Power)  
k4 <- kmeans(df, centers = 4, nstart = 25)  
k4$centers

## fuel\_mmbtu\_per\_unit fuel\_cost\_per\_mmbtu  
## 1 -2.0498589 23.1646735  
## 2 -0.9769213 -0.2820254  
## 3 0.7969080 -0.1079430  
## 4 1.0676983 0.7704470

k4$size

## [1] 2 720 518 276

fviz\_cluster(k4, data = df) #visualize to see if this makes sense, it does not!



set.seed(3268)  
library(flexclust)

## Warning: package 'flexclust' was built under R version 4.3.1

## Loading required package: grid

## Loading required package: modeltools

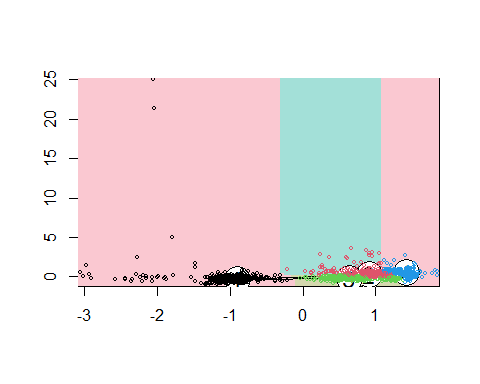
## Warning: package 'modeltools' was built under R version 4.3.1

## Loading required package: stats4

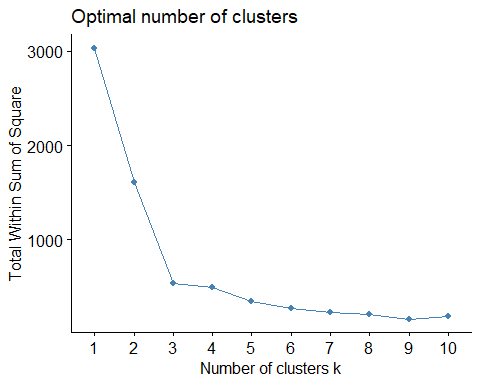
k4 = kcca(df, k=4, kccaFamily("kmedians"))  
clusters\_index <- predict(k4)  
dist(k4@centers)

## 1 2 3  
## 2 1.9260558   
## 3 1.5403005 0.6540618   
## 4 2.4511403 0.5258655 1.0747711

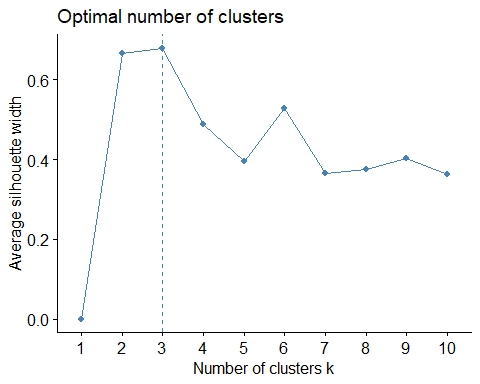
image(k4)  
points(df, col=clusters\_index, pch=21, cex=0.6)

 ##I will now make determine what K should ideally be.

library(tidyverse)  
library(factoextra)  
library(ISLR)  
set.seed(3268)  
  
df <- scale(df)  
fviz\_nbclust(df, kmeans, method = "wss")



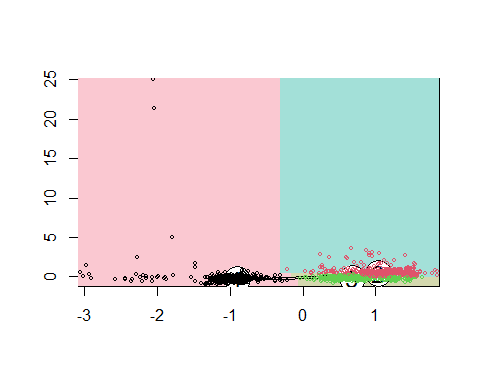
fviz\_nbclust(df, kmeans, method = "silhouette")

 ##I Can easily see that 3 is the optimal number of clusters for this partitioned and scaled data.

set.seed(3268)  
library(flexclust)  
k3 = kcca(df, k=3, kccaFamily("kmedians"))  
clusters\_index <- predict(k3)  
dist(k3@centers)

## 1 2  
## 2 2.0732882   
## 3 1.5811906 0.7590253

image(k3)  
points(df, col=clusters\_index, pch=21, cex=0.6)



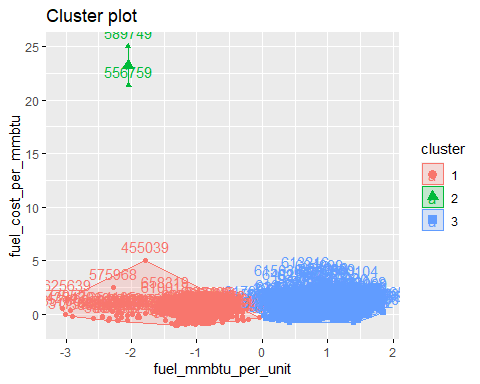
k3 <- kmeans(df, centers = 3, nstart = 25)  
k3$centers

## fuel\_mmbtu\_per\_unit fuel\_cost\_per\_mmbtu  
## 1 -0.9767477 -0.2745913  
## 2 -2.0498589 23.1646735  
## 3 0.8955954 0.1918252

k3$size

## [1] 722 2 792

fviz\_cluster(k3, data = df)



library("dbscan")

## Warning: package 'dbscan' was built under R version 4.3.2

##   
## Attaching package: 'dbscan'

## The following object is masked from 'package:stats':  
##   
## as.dendrogram

db <- dbscan::dbscan(numeric\_Power, eps = 0.5, minPts = 5)  
print(db)

## DBSCAN clustering for 1516 objects.  
## Parameters: eps = 0.5, minPts = 5  
## Using euclidean distances and borderpoints = TRUE  
## The clustering contains 4 cluster(s) and 23 noise points.  
##   
## 0 1 2 3 4   
## 23 690 776 21 6   
##   
## Available fields: cluster, eps, minPts, dist, borderPoints

library(reshape2)

## Warning: package 'reshape2' was built under R version 4.3.1

##   
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':  
##   
## smiths

melted.power <- melt(train.data, id.vars = c("fuel\_received\_units","fuel\_cost\_per\_mmbtu"), measure.vars = "energy\_source\_code", value.name = "Type")  
pivot.power1 <- dcast(melted.power, fuel\_received\_units + fuel\_cost\_per\_mmbtu ~ Type, fun.aggregate = length, value.var = "Type")  
pivot.power1

## fuel\_received\_units fuel\_cost\_per\_mmbtu BIT LIG SUB WC  
## 1 11 1.176 1 0 0 0  
## 2 15 2.801 1 0 0 0  
## 3 21 2.589 0 0 1 0  
## 4 34 3.227 1 0 0 0  
## 5 42 2.896 1 0 0 0  
## 6 52 1.822 1 0 0 0  
## 7 107 3.858 1 0 0 0  
## 8 114 3.194 1 0 0 0  
## 9 115 3.307 1 0 0 0  
## 10 116 3.961 1 0 0 0  
## 11 118 2.816 1 0 0 0  
## 12 119 2.045 0 0 1 0  
## 13 119 2.164 0 0 1 0  
## 14 119 3.504 1 0 0 0  
## 15 121 2.461 0 0 1 0  
## 16 122 3.013 1 0 0 0  
## 17 194 2.831 1 0 0 0  
## 18 227 1.999 0 0 1 0  
## 19 229 2.403 1 0 0 0  
## 20 239 1.638 0 0 1 0  
## 21 262 1.759 1 0 0 0  
## 22 364 1.998 0 0 1 0  
## 23 365 2.242 0 0 1 0  
## 24 398 1.920 0 1 0 0  
## 25 487 2.430 0 0 1 0  
## 26 488 2.505 0 0 1 0  
## 27 717 2.712 1 0 0 0  
## 28 726 2.618 1 0 0 0  
## 29 727 2.467 1 0 0 0  
## 30 732 2.246 0 0 1 0  
## 31 763 1.958 1 0 0 0  
## 32 765 3.425 1 0 0 0  
## 33 879 2.902 1 0 0 0  
## 34 974 2.555 1 0 0 0  
## 35 1087 4.619 1 0 0 0  
## 36 1094 1.669 0 0 1 0  
## 37 1167 4.248 1 0 0 0  
## 38 1305 2.480 1 0 0 0  
## 39 1321 1.244 1 0 0 0  
## 40 1373 3.044 1 0 0 0  
## 41 1431 2.276 1 0 0 0  
## 42 1431 3.230 1 0 0 0  
## 43 1522 2.744 1 0 0 0  
## 44 1542 2.923 1 0 0 0  
## 45 1552 1.607 1 0 0 0  
## 46 1561 2.872 1 0 0 0  
## 47 1563 2.427 1 0 0 0  
## 48 1579 1.851 1 0 0 0  
## 49 1606 2.152 1 0 0 0  
## 50 1618 2.585 1 0 0 0  
## 51 1618 6.197 1 0 0 0  
## 52 1688 1.367 0 0 1 0  
## 53 1712 1.821 1 0 0 0  
## 54 1765 1.705 1 0 0 0  
## 55 1790 1.519 1 0 0 0  
## 56 1845 1.855 1 0 0 0  
## 57 1913 2.536 1 0 0 0  
## 58 1932 1.788 1 0 0 0  
## 59 1985 2.236 1 0 0 0  
## 60 2008 2.263 1 0 0 0  
## 61 2011 2.113 1 0 0 0  
## 62 2068 2.027 1 0 0 0  
## 63 2269 2.427 1 0 0 0  
## 64 2301 3.308 1 0 0 0  
## 65 2338 2.381 1 0 0 0  
## 66 2401 2.663 1 0 0 0  
## 67 2475 1.882 1 0 0 0  
## 68 2535 3.039 1 0 0 0  
## 69 2561 3.390 1 0 0 0  
## 70 2795 3.332 1 0 0 0  
## 71 2805 2.835 1 0 0 0  
## 72 2850 1.612 0 0 1 0  
## 73 2900 2.699 1 0 0 0  
## 74 2915 2.666 1 0 0 0  
## 75 2948 2.643 1 0 0 0  
## 76 2958 3.714 1 0 0 0  
## 77 2964 2.203 0 0 1 0  
## 78 3091 2.104 1 0 0 0  
## 79 3104 2.671 1 0 0 0  
## 80 3106 3.030 1 0 0 0  
## 81 3149 2.470 1 0 0 0  
## 82 3151 1.834 1 0 0 0  
## 83 3188 1.842 1 0 0 0  
## 84 3191 4.131 1 0 0 0  
## 85 3200 2.091 1 0 0 0  
## 86 3216 1.842 1 0 0 0  
## 87 3219 2.122 1 0 0 0  
## 88 3228 1.660 0 0 1 0  
## 89 3234 1.643 1 0 0 0  
## 90 3250 1.482 1 0 0 0  
## 91 3299 2.078 0 0 1 0  
## 92 3302 2.719 1 0 0 0  
## 93 3302 2.847 1 0 0 0  
## 94 3322 2.560 1 0 0 0  
## 95 3330 2.087 1 0 0 0  
## 96 3376 2.462 1 0 0 0  
## 97 3404 1.954 1 0 0 0  
## 98 3446 2.833 1 0 0 0  
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## 1207 77168 2.235 1 0 0 0  
## 1208 77565 2.060 0 0 1 0  
## 1209 77906 3.028 1 0 0 0  
## 1210 78091 3.445 1 0 0 0  
## 1211 78386 4.295 1 0 0 0  
## 1212 78394 1.848 0 0 1 0  
## 1213 78507 3.439 1 0 0 0  
## 1214 78721 2.295 0 0 1 0  
## 1215 78885 1.683 0 0 1 0  
## 1216 79096 2.495 0 0 1 0  
## 1217 79413 2.135 0 0 1 0  
## 1218 79427 2.029 0 0 1 0  
## 1219 79618 1.591 1 0 0 0  
## 1220 79733 1.684 0 0 1 0  
## 1221 79961 1.696 1 0 0 0  
## 1222 79980 1.842 0 0 1 0  
## 1223 80387 1.823 0 0 1 0  
## 1224 80778 2.649 1 0 0 0  
## 1225 81098 2.167 1 0 0 0  
## 1226 81101 3.051 1 0 0 0  
## 1227 81509 1.508 0 0 1 0  
## 1228 81614 1.786 0 0 1 0  
## 1229 82085 1.321 0 0 1 0  
## 1230 82710 2.556 1 0 0 0  
## 1231 82803 2.471 1 0 0 0  
## 1232 82816 1.498 0 0 1 0  
## 1233 83024 2.037 0 0 1 0  
## 1234 83573 1.999 0 0 1 0  
## 1235 83786 2.004 1 0 0 0  
## 1236 83943 2.054 1 0 0 0  
## 1237 84430 2.920 0 0 1 0  
## 1238 84589 2.269 0 0 1 0  
## 1239 84720 2.000 0 0 1 0  
## 1240 84988 1.456 0 0 1 0  
## 1241 85177 2.312 0 0 1 0  
## 1242 85457 1.230 0 0 1 0  
## 1243 85525 2.598 1 0 0 0  
## 1244 85646 1.223 0 0 1 0  
## 1245 85739 2.562 1 0 0 0  
## 1246 86513 1.624 0 0 1 0  
## 1247 86646 2.681 1 0 0 0  
## 1248 87047 2.922 0 0 1 0  
## 1249 87160 2.724 1 0 0 0  
## 1250 87336 3.182 1 0 0 0  
## 1251 87417 2.106 1 0 0 0  
## 1252 87521 2.047 0 0 1 0  
## 1253 87740 1.874 0 0 1 0  
## 1254 87858 1.844 1 0 0 0  
## 1255 88243 2.620 1 0 0 0  
## 1256 88421 2.367 1 0 0 0  
## 1257 88674 2.709 0 0 1 0  
## 1258 89154 3.243 1 0 0 0  
## 1259 89211 3.455 0 0 1 0  
## 1260 89236 1.168 0 0 1 0  
## 1261 89569 1.307 0 0 1 0  
## 1262 90016 3.385 1 0 0 0  
## 1263 90153 2.910 1 0 0 0  
## 1264 90231 1.597 0 0 1 0  
## 1265 90267 1.728 1 0 0 0  
## 1266 90510 3.104 1 0 0 0  
## 1267 90793 1.275 0 0 1 0  
## 1268 90869 1.547 0 0 1 0  
## 1269 90926 1.272 0 0 1 0  
## 1270 90992 1.611 0 0 1 0  
## 1271 92233 1.322 0 0 1 0  
## 1272 92467 2.276 0 0 1 0  
## 1273 92506 41.656 0 1 0 0  
## 1274 92512 4.105 1 0 0 0  
## 1275 92662 2.218 1 0 0 0  
## 1276 93326 2.152 1 0 0 0  
## 1277 93466 1.669 0 0 1 0  
## 1278 93710 2.329 1 0 0 0  
## 1279 94222 2.041 0 0 1 0  
## 1280 94467 2.247 0 0 1 0  
## 1281 94534 3.246 1 0 0 0  
## 1282 94755 2.039 0 0 1 0  
## 1283 94838 2.054 0 0 1 0  
## 1284 95058 1.890 1 0 0 0  
## 1285 95130 2.499 0 0 1 0  
## 1286 95504 1.449 0 0 1 0  
## 1287 95736 1.900 0 0 1 0  
## 1288 95746 1.405 0 0 1 0  
## 1289 95784 3.241 0 0 1 0  
## 1290 95866 2.322 0 0 1 0  
## 1291 95908 2.240 1 0 0 0  
## 1292 97060 1.439 0 0 1 0  
## 1293 97423 1.161 0 0 1 0  
## 1294 97670 2.020 0 0 1 0  
## 1295 97929 2.640 1 0 0 0  
## 1296 98023 1.380 0 0 1 0  
## 1297 98326 1.305 0 0 1 0  
## 1298 98353 2.290 0 0 1 0  
## 1299 98513 2.561 1 0 0 0  
## 1300 99540 1.867 0 0 1 0  
## 1301 100966 3.039 1 0 0 0  
## 1302 101653 2.317 0 0 1 0  
## 1303 101654 3.200 0 0 1 0  
## 1304 101783 2.367 1 0 0 0  
## 1305 101880 2.170 0 0 1 0  
## 1306 102040 2.339 0 0 1 0  
## 1307 102253 2.804 1 0 0 0  
## 1308 103100 2.038 0 0 1 0  
## 1309 103445 1.626 0 0 1 0  
## 1310 104021 2.663 0 0 1 0  
## 1311 104104 2.450 1 0 0 0  
## 1312 104603 1.975 0 0 1 0  
## 1313 104635 2.028 0 0 1 0  
## 1314 104964 4.124 1 0 0 0  
## 1315 105375 1.638 0 0 1 0  
## 1316 105406 3.696 0 0 1 0  
## 1317 105526 1.076 0 0 1 0  
## 1318 105647 1.537 0 1 0 0  
## 1319 105782 1.722 0 0 1 0  
## 1320 105923 2.219 0 0 1 0  
## 1321 105939 2.056 1 0 0 0  
## 1322 106658 1.070 0 0 1 0  
## 1323 106760 1.559 0 0 1 0  
## 1324 106868 1.112 0 0 1 0  
## 1325 107184 2.092 1 0 0 0  
## 1326 107423 2.595 0 0 1 0  
## 1327 107848 2.558 0 0 1 0  
## 1328 108150 2.447 0 0 1 0  
## 1329 108198 2.401 1 0 0 0  
## 1330 109090 1.793 1 0 0 0  
## 1331 109120 1.990 0 0 1 0  
## 1332 109853 1.985 0 0 1 0  
## 1333 110591 2.585 1 0 0 0  
## 1334 110892 1.389 0 0 1 0  
## 1335 111195 1.882 0 0 1 0  
## 1336 111354 1.663 0 0 1 0  
## 1337 111659 1.694 0 0 1 0  
## 1338 111959 1.696 0 0 1 0  
## 1339 112540 3.585 1 0 0 0  
## 1340 113480 2.078 1 0 0 0  
## 1341 113557 1.453 0 0 1 0  
## 1342 113630 2.073 0 0 1 0  
## 1343 113730 2.139 0 0 1 0  
## 1344 114170 2.480 0 0 1 0  
## 1345 114601 1.269 0 0 1 0  
## 1346 115282 2.057 0 0 1 0  
## 1347 116178 2.011 1 0 0 0  
## 1348 116744 1.978 1 0 0 0  
## 1349 117269 2.128 0 0 1 0  
## 1350 117802 1.463 0 0 1 0  
## 1351 118665 1.904 0 0 1 0  
## 1352 119113 2.232 1 0 0 0  
## 1353 119877 1.031 0 0 1 0  
## 1354 120103 1.792 0 0 1 0  
## 1355 120659 2.440 1 0 0 0  
## 1356 120833 2.287 1 0 0 0  
## 1357 121308 2.268 1 0 0 0  
## 1358 121464 1.130 0 0 1 0  
## 1359 121497 1.326 0 0 1 0  
## 1360 121520 1.347 0 0 1 0  
## 1361 121728 2.140 0 0 1 0  
## 1362 122415 3.232 1 0 0 0  
## 1363 122944 1.582 1 0 0 0  
## 1364 123051 2.075 1 0 0 0  
## 1365 124882 2.497 0 0 1 0  
## 1366 125626 1.710 0 0 1 0  
## 1367 126153 1.737 0 0 1 0  
## 1368 126518 1.837 0 0 1 0  
## 1369 126708 3.701 1 0 0 0  
## 1370 127102 2.483 0 0 1 0  
## 1371 127182 2.273 0 0 1 0  
## 1372 127930 3.659 1 0 0 0  
## 1373 128323 2.296 0 1 0 0  
## 1374 128579 1.930 0 0 1 0  
## 1375 128681 1.700 0 0 1 0  
## 1376 129341 1.753 0 0 1 0  
## 1377 129561 2.376 0 0 1 0  
## 1378 129826 2.344 0 0 1 0  
## 1379 129871 2.351 0 0 1 0  
## 1380 130615 3.306 1 0 0 0  
## 1381 131005 2.468 0 0 1 0  
## 1382 131752 3.121 1 0 0 0  
## 1383 132485 3.020 1 0 0 0  
## 1384 132537 1.365 0 0 1 0  
## 1385 133476 2.240 0 0 1 0  
## 1386 134730 1.118 0 0 1 0  
## 1387 134915 1.911 1 0 0 0  
## 1388 135404 2.893 1 0 0 0  
## 1389 136060 3.388 1 0 0 0  
## 1390 136993 1.502 0 0 1 0  
## 1391 138389 1.593 1 0 0 0  
## 1392 138619 1.067 0 0 1 0  
## 1393 139365 2.106 1 0 0 0  
## 1394 140267 2.321 1 0 0 0  
## 1395 140869 4.049 1 0 0 0  
## 1396 141030 1.802 0 0 1 0  
## 1397 141096 2.014 0 0 1 0  
## 1398 141383 2.445 0 0 1 0  
## 1399 143887 1.644 0 0 1 0  
## 1400 143992 1.885 0 0 1 0  
## 1401 144153 2.041 0 0 1 0  
## 1402 144517 1.753 0 0 1 0  
## 1403 145913 2.025 1 0 0 0  
## 1404 146014 1.614 0 0 1 0  
## 1405 146099 2.174 1 0 0 0  
## 1406 146580 2.154 0 0 1 0  
## 1407 146587 2.129 0 0 1 0  
## 1408 147244 1.453 0 0 1 0  
## 1409 147594 1.899 0 0 1 0  
## 1410 147989 1.913 1 0 0 0  
## 1411 150036 1.978 0 0 1 0  
## 1412 151385 2.293 1 0 0 0  
## 1413 151476 6.363 0 1 0 0  
## 1414 155944 2.053 0 0 1 0  
## 1415 156518 3.803 1 0 0 0  
## 1416 159228 1.921 0 0 1 0  
## 1417 159981 1.467 0 0 1 0  
## 1418 160977 1.885 0 0 1 0  
## 1419 162342 2.291 1 0 0 0  
## 1420 162387 2.006 0 1 0 0  
## 1421 163844 1.963 1 0 0 0  
## 1422 165255 2.927 1 0 0 0  
## 1423 166404 2.167 0 0 1 0  
## 1424 167273 2.380 1 0 0 0  
## 1425 167541 1.884 0 0 1 0  
## 1426 167759 3.546 1 0 0 0  
## 1427 167784 3.397 1 0 0 0  
## 1428 167972 2.179 1 0 0 0  
## 1429 172270 1.994 0 0 1 0  
## 1430 172404 2.411 0 0 1 0  
## 1431 173285 2.206 0 0 1 0  
## 1432 174628 2.544 1 0 0 0  
## 1433 174803 2.448 0 0 1 0  
## 1434 175932 1.154 0 0 1 0  
## 1435 177550 2.087 1 0 0 0  
## 1436 178451 2.470 0 1 0 0  
## 1437 178821 1.982 1 0 0 0  
## 1438 178908 1.928 0 0 1 0  
## 1439 180749 2.187 0 0 1 0  
## 1440 181363 1.709 0 0 1 0  
## 1441 181672 1.287 0 0 1 0  
## 1442 183363 2.065 0 0 1 0  
## 1443 184050 1.922 1 0 0 0  
## 1444 185008 2.940 0 1 0 0  
## 1445 186571 0.790 0 0 1 0  
## 1446 186772 1.505 0 1 0 0  
## 1447 189291 1.900 0 0 1 0  
## 1448 192164 1.777 0 0 1 0  
## 1449 193413 2.074 0 0 1 0  
## 1450 193736 2.195 0 0 1 0  
## 1451 194299 2.296 1 0 0 0  
## 1452 194700 1.934 1 0 0 0  
## 1453 195327 2.460 1 0 0 0  
## 1454 195728 2.226 0 0 1 0  
## 1455 196779 1.643 0 0 1 0  
## 1456 199161 1.986 0 0 1 0  
## 1457 199334 2.101 0 0 1 0  
## 1458 200602 4.700 0 1 0 0  
## 1459 200611 1.969 1 0 0 0  
## 1460 201308 2.451 0 0 1 0  
## 1461 202883 1.843 0 0 1 0  
## 1462 203857 2.258 0 0 1 0  
## 1463 204985 2.441 1 0 0 0  
## 1464 205465 1.357 0 0 1 0  
## 1465 206238 1.030 0 0 1 0  
## 1466 209289 2.081 0 0 1 0  
## 1467 209837 1.473 0 0 1 0  
## 1468 210012 2.039 0 0 1 0  
## 1469 213026 3.123 0 0 1 0  
## 1470 218497 2.924 0 0 1 0  
## 1471 220581 3.641 1 0 0 0  
## 1472 226267 2.386 0 1 0 0  
## 1473 228042 1.483 0 1 0 0  
## 1474 231422 2.216 0 0 1 0  
## 1475 231661 2.380 1 0 0 0  
## 1476 231872 1.793 0 0 1 0  
## 1477 234438 3.557 1 0 0 0  
## 1478 235021 2.383 0 0 1 0  
## 1479 236633 2.085 0 0 1 0  
## 1480 242383 1.028 0 0 1 0  
## 1481 251847 1.923 0 0 1 0  
## 1482 252514 2.110 0 1 0 0  
## 1483 255715 1.681 0 0 1 0  
## 1484 257589 2.220 0 0 1 0  
## 1485 257618 2.689 0 0 1 0  
## 1486 262726 2.208 0 0 1 0  
## 1487 269712 2.271 1 0 0 0  
## 1488 275483 2.015 0 0 1 0  
## 1489 276036 1.446 0 0 1 0  
## 1490 286981 1.655 0 0 1 0  
## 1491 287737 2.057 0 0 1 0  
## 1492 291534 1.879 0 0 1 0  
## 1493 292570 1.506 0 0 1 0  
## 1494 293204 1.428 0 0 1 0  
## 1495 311508 3.240 0 1 0 0  
## 1496 319072 2.366 1 0 0 0  
## 1497 322796 2.516 0 0 1 0  
## 1498 329518 2.908 0 1 0 0  
## 1499 333469 1.777 1 0 0 0  
## 1500 346226 1.831 0 0 1 0  
## 1501 354885 2.753 0 1 0 0  
## 1502 362279 2.565 0 1 0 0  
## 1503 384222 2.687 0 0 1 0  
## 1504 385095 2.553 0 0 1 0  
## 1505 389397 1.464 0 0 1 0  
## 1506 410467 2.143 0 0 1 0  
## 1507 419753 2.340 1 0 0 0  
## 1508 437454 1.828 0 0 1 0  
## 1509 445186 2.172 1 0 0 0  
## 1510 447098 1.767 0 0 1 0  
## 1511 452899 1.493 0 0 1 0  
## 1512 460913 1.967 0 0 1 0  
## 1513 491029 2.349 0 0 1 0  
## 1514 666770 1.869 0 1 0 0  
## 1515 707037 1.503 0 1 0 0  
## 1516 852907 1.669 0 0 1 0

##I Want to attempt the extra credit for multiple-linear regression to predict fuel cost per mmbtu. I will try to use the example in our text book, page 159, to apply this model.

PowerGen.df <- PowerGen.df[1:5000, ] #use first 5,000 rows  
selected.var <- c(2:3,6,8,13:17)  
set.seed(499)  
train.index <-sample(c(1:5000), 1000)  
trainregression.df <- PowerGen.df[train.index, selected.var]  
validregression.df <- PowerGen.df[-train.index, selected.var]  
## I could not get this lm chunk to work! I really thought I had it. I had to emit as comment only so that I could knit my flie.  
## power.lm <- lm(fuel\_cost\_per\_mmbtu ~., data = trainregression.df)  
## options(scipen = 999)  
## summary(power.lm)