Coding Sample in R Program

Calculation Automation of Total Energy & Dollar Savings from Using Smart Battery Storage in R

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This R Markdown documents the steps for processing raw 15 minute Interval data from 'Inverter' Master dataset, and calculating Demand Savings (kW), Energy Savings (kWh) and Total Dollar Savings ($) generated from the Smart Battery Services for Residential Time-of-Use Rates on the E-19 Schedule invoiced by Pacific Gas and Electric (PG&E).

Calculation Flows for Total Dollar Savings Generated from Battery and Storage Services:

- Divide the "Inverter" Master Dataset into two subsets: Charge (kW > 0) and Discharge (kW < 0)
- Subset 'Charge' and 'Discharge' dataset by Time-of-Use Periods: Summer (On-peak, Partial-Peak, Off-Peak), Winter (On-Peak, Partial-Peak, Off-Peak)
- ***Calculate Demand Savings generated from Battery Discharging in each ToU*** period by:
    - Identifying Max_kW 15 minute Intervals discharged by the Battery system in the 'Discharge' dataset for each ToU Period
    - Multiplying the Max_kW 15 minute Interval with the corresponding Demand Rates for Winter_OnPeak, Winter_PartPeak, Winter_OffPeak, Summer_OnPeak, Summer_PartPeak, Summter_OffPeaks
- ***Calculate Net Energy Charge Savings generated from Battery operation in each ToU*** period:
    - Calculate **Total Charging_kW** in the Charge data set and **Total of Discharging_kW** in Charge and Discharge dataset for each ToU period
    - Calculate the Energy Consumption (kWh) over each ToU by:

      Energy (kWh) = Demand (kW) * Time/ Duration (hour)

      The duration for each interval is 15 minutes. Thus, *the Energy Consumption per each Interval* = ***Demand (kWh) * (15/60) minute = kW * 0.25***
    - Calculate the Energy Cost of Charging kWh for each ToU period:
        - Charging Cost = Energy Rate * Total Charging kWh)
    - Calculate the Energy Savings of Discharging kWh for each ToU period:
        - Discharging Savings = Energy Rate * Total Discharging kWh

- **Net Energy Savings = |Total Energy Savings of Discharging kWh| – Total Energy Cost of Charging kWh**

- Calculate Total Dollar Savings from the Smart Battery Services ***in each ToU*** period and for the whole year:

Total Savings = Total Demand Savings + Total Energy Savings

Codes and Output:

```
## Read in Master Data: Inverter

Inverter <- read.csv('C:/Battery/Inverter.csv')
ToU_Period <- read.csv('C:/Battery/ToU_Periods.csv')

# Rename Variables in the Master Inverter Dataset and ToU Period:

names(Inverter) <- c("Ending_Timestamp", 'Battery_kW')
names(ToU_Period) <- c("S_OnPeak", 'S_PartPeak', 'S_OffPeak', 'W_PartP
eak', "W_OffPeak")

head(Inverter)

##   Ending_Timestamp Battery_kW
## 1    1/1/2017 0:15    0.28393
## 2    1/1/2017 0:30    0.28387
## 3    1/1/2017 0:45    0.28548
## 4    1/1/2017 1:00    0.28636
## 5    1/1/2017 1:15     0.3745
## 6    1/1/2017 1:30    0.34713

head (ToU_Period)

##   S_OnPeak S_PartPeak S_OffPeak W_PartPeak W_OffPeak
## 1    12:00       8:00     23:15       8:00     21:15
## 2    12:15       8:15     23:30       8:15     21:30
## 3    12:30       8:30     23:45       8:30     21:45
## 4    12:45       8:45      0:00       8:45     22:00
## 5    13:00       9:00      0:15       9:00     22:15
## 6    13:15       9:15      0:30       9:15     22:30

## Subset Charging Data and Discharging data from the Master Dataset,
'Inverter', on the Condition of Battery_kW:

Charge <- sqldf("SELECT *
                FROM Inverter
                WHERE Battery_kW > 0
                OR Battery_kW = 0")
```

```
Discharge <- sqldf("SELECT *
                FROM Inverter
                WHERE Battery_kW < 0")

## Data manipulation to label ToU in the Discharge dataset:
## Separate the Ending Timestamp Interval Column into Date and Timesta
mp Variables:

Discharge_1 <- separate(Discharge, Ending_Timestamp, c('Date', 'ToU'),
sep = ' ')

# Create a 'Month' and Weekday column from Date Variable:
Discharge_2 <- Discharge_1 %>%
  mutate(Weekday = weekdays(Date),
         Month = months(Date))

head(Discharge_2)

##       Date  ToU Battery_kW Weekday Month
## 1 1/3/2017 8:30   -1.89569     Tue   Jan
## 2 1/3/2017 8:45   -0.76862     Tue   Jan
## 3 1/3/2017 9:00  -12.67053     Tue   Jan
## 4 1/3/2017 9:15  -13.80917     Tue   Jan
## 5 1/3/2017 9:30  -17.20109     Tue   Jan
## 6 1/3/2017 9:45   -13.9458     Tue   Jan

# Create a List of Season, Weekday, Weekend, Holiday to label Time_of_
Use Periods:

Winter_Months <- c ('Oct', 'Nov', 'Dec', 'Jan', 'Feb', 'Mar', 'Apr', '
May')
Summer_Months <- c('Jun', 'Jul', 'Aug', 'Sep')
Off_days <- c('Sat', 'Sun')
Holiday_2017 <- c('1/2/2017', '2/20/2017', '5/29/2017', '7/4/2017', '9
/4/2017', '11/11/2017', '11/23/2017', '12/25/2017')

# Create new columns for Winter months, Summer months, Working_Day, We
ekend, Holiday in the Discharge dataset:

Discharge_3 <- Discharge_2 %>%
  mutate(W_Month = ifelse(Month %in% Winter_Months, 'True', 'False'),
         S_Month = ifelse(Month %in% Summer_Months, 'True', 'False'),
         Weekend = ifelse(Weekday %in% Off_days, 'True', 'False'),
         Working_Day = ifelse(Weekday %in% Off_days, 'False', 'True'),
         Holiday = ifelse(Date %in% Holiday_2017, 'True', 'False'))
```

```r
# Change the "Battery_kW" into Numeric Variable:

Discharge_3$Battery_kW <- as.numeric(as.character(Discharge_3$Battery_
kW))

Discharge_4 <- na.omit(Discharge_3)
head(Discharge_4)
```

```
##       Date  ToU Battery_kW Weekday Month W_Month S_Month Weekend
## 1 1/3/2017 8:30   -1.89569     Tue   Jan    True   False   False
## 2 1/3/2017 8:45   -0.76862     Tue   Jan    True   False   False
## 3 1/3/2017 9:00  -12.67053     Tue   Jan    True   False   False
## 4 1/3/2017 9:15  -13.80917     Tue   Jan    True   False   False
## 5 1/3/2017 9:30  -17.20109     Tue   Jan    True   False   False
## 6 1/3/2017 9:45  -13.94580     Tue   Jan    True   False   False
##   Working_Day Holiday
## 1        True   False
## 2        True   False
## 3        True   False
## 4        True   False
## 5        True   False
## 6        True   False
```

```r
## Subset Summer and Winter Months in the Discharge dataset:

Discharge_S_ToU <- sqldf("SELECT *
                         FROM Discharge_4
                         WHERE S_Month = 'True'")

Discharge_W_ToU <- sqldf("SELECT *
                         FROM Discharge_4
                         WHERE W_Month = 'True'")

## Subset Summer ToU Period in Discharge dataset by range of hours:

#Summer on-Peak: 12:00 noon to 6:00 pm Monday through Friday (except
holiday)

Discharge_S_On <- sqldf("SELECT *
                         FROM Discharge_S_ToU
                         WHERE ToU BETWEEN '12:00' AND '18:00'
                         AND Working_Day = 'True'
                         AND Holiday = ‘False’
                         ORDER BY Date, ToU")


Discharge_W_Part <- sqldf("SELECT *
```

```
                        FROM Discharge_W_ToU
                        WHERE Working_Day = 'True'
                        AND Holiday = 'False'
                        AND ToU IN
                        (SELECT W_PartPeak
                        FROM ToU_Period)")

## Subset the Off_Peak Period for Summer and Winter in the Discharge
dataset:

# Label Weekend and Holiday in the Summer 2017:

Discharge_S_Weekend_Holiday <- sqldf("SELECT *
                        FROM Discharge_S_ToU
                        WHERE Weekend = 'True'
                        OR Holiday = 'True'")

Discharge_W_Weekend_Holiday <- sqldf("SELECT *
                        FROM Discharge_W_ToU
                        WHERE Weekend = 'True'
                        OR Holiday = 'True'")

Discharge_S_Off_1 <- sqldf("SELECT *
                        FROM Discharge_S_ToU
                        WHERE Working_Day = 'True'
                        AND Holiday = 'False'
                        AND ToU IN
                        (SELECT S_OffPeak
                        FROM ToU_Period)")

Discharge_W_Off_1 <- sqldf("SELECT *
                        FROM Discharge_W_ToU
                        WHERE Working_Day = 'True'
                        AND Holiday = 'False'
                        AND ToU IN
                        (SELECT W_OffPeak
                        FROM ToU_Period)")

Discharge_S_Off <- rbind(Discharge_S_Off_1, Discharge_S_Weekend_Holida
y)

Discharge_W_Off <- rbind(Discharge_W_Off_1, Discharge_W_Weekend_Holida
y)
```

```
### ??? How much was demand savings that the smart battery system gene
rated for the residential customer in 2017?


## Identify the Monthly Peak Discharging kW for the Summer ToU Period:

Discharge_S_OffPeak_Max_kW <- sqldf("SELECT Date, Month, ToU, Min(Batt
ery_kW) AS Max_Discharge_S_OffPeak
                                    FROM Discharge_S_Off
                                     GROUP BY Month
                                     ORDER BY Max_Discharge_S_OffPeak
")

Discharge_S_PartPeak_Max_kW <-  sqldf("SELECT Date, Month, ToU, Min(Ba
ttery_kW) AS Max_Discharge_S_PartPeak
                                     FROM Discharge_S_Part
                                     GROUP BY Month
                                     ORDER BY Max_Discharge_S_PartPea
k")



Discharge_S_OnPeak_Max_kW <- sqldf("SELECT Date, Month, ToU, Min(Batte
ry_kW) AS Max_Discharge_S_OnPeak
                                    FROM Discharge_S_On
                                    GROUP BY Month
                                    ORDER BY Max_Discharge_S_OnPeak")

## Calculate Monthly Demand Savings Generated by Battery System for Su
mmer   ToU Period:

S_OffPeak_DemandRate <- 15.89
S_PartPeak_DemandRate <- 3.88
S_OnPeak_DemandRate <- 19.89

S_OffPeak_DemandSavings <- Discharge_S_OffPeak_Max_kW %>%
                           mutate(S_OffPeak_DemandSavings = Max_Dischar
ge_S_OffPeak * S_OffPeak_DemandRate)

S_PartPeak_DemandSavings <- Discharge_S_PartPeak_Max_kW %>%
                           mutate(S_PartPeak_DemandSavings = Max_Discha
rge_S_PartPeak * S_PartPeak_DemandRate)

S_OnPeak_DemandSavings <- Discharge_S_OnPeak_Max_kW %>%
                           mutate(S_OnPeak_DemandSavings = Max_Dischar
e_S_OnPeak * S_OnPeak_DemandRate)
```

```
S_OffPeak_DemandSavings
```

```
##        Date Month   ToU Max_Discharge_S_OffPeak S_OffPeak_DemandSav
ings
## 1  8/4/2017   Aug 23:45               -25.37321               -403.
1803
## 2  6/1/2017   Jun  0:30               -22.32829               -354.
7965
## 3  9/1/2017   Sep  6:30               -22.31732               -354.
6222
## 4 7/29/2017   Jul 22:15               -20.78428               -330.
2622
```

```
S_PartPeak_DemandSavings
```

```
##        Date Month   ToU Max_Discharge_S_PartPeak S_PartPeak_DemandS
avings
## 1 7/12/2017   Jul  8:45                -22.56961                -87
.57009
## 2 8/24/2017   Aug 19:00                -17.37424                -67
.41205
## 3 6/23/2017   Jun 10:15                -14.79566                -57
.40716
## 4 9/28/2017   Sep  8:00                 -8.90168                -34
.53852
```

```
S_OnPeak_DemandSavings
```

```
##        Date Month   ToU Max_Discharge_S_OnPeak S_OnPeak_DemandSavin
gs
## 1 6/23/2017   Jun 13:30              -20.77046              -413.12
44
## 2  8/3/2017   Aug 13:30              -18.72287              -372.39
79
## 3 7/27/2017   Jul 13:15              -14.72424              -292.86
51
```

```
## Identify the Monthly Peak Discharging kW for the Winter ToU Period:

Discharge_W_OffPeak_Max_kW <- sqldf("SELECT Date, Month, ToU, Min(Batt
ery_kW) AS Max_Discharge_W_OffPeak
                                    FROM Discharge_W_Off
                                     GROUP BY Month
                                     ORDER BY Max_Discharge_W_OffPeak
")
```

```
Discharge_W_PartPeak_Max_kW <-  sqldf("SELECT Date, Month, ToU, Min(Ba
ttery_kW) AS Max_Discharge_W_PartPeak
                                      FROM Discharge_W_Part
                                      GROUP BY Month
                                      ORDER BY Max_Discharge_W_PartPea
k")

## Calculate Monthly Demand Savings Generated by the Battery system fo
r the  Winter ToU Period:

W_OffPeak_DemandRate <- 15.89
W_PartPeak_DemandRate <- 0

W_OffPeak_DemandSavings <- Discharge_W_OffPeak_Max_kW %>%
                           mutate(W_OffPeak_DemandSavings = Max_Dischar
ge_W_OffPeak * W_OffPeak_DemandRate)

W_PartPeak_DemandSavings <- Discharge_W_PartPeak_Max_kW %>%
                           mutate(W_PartPeak_DemandSavings = Max_Discha
rge_W_PartPeak * W_PartPeak_DemandRate)

W_OffPeak_DemandSavings

##         Date  Month   ToU Max_Discharge_W_OffPeak W_OffPeak_DemandSa
vings
## 1 10/29/2017   Oct 19:15               -30.65717               -487
.1424
## 2  5/24/2017   May 21:45               -22.93991               -364
.5152
## 3  2/22/2017   Feb 22:30               -19.93954               -316
.8393
## 4 11/26/2017   Nov  2:00               -15.22970               -241
.9999
## 5  3/25/2017   Mar  6:30               -15.13168               -240
.4424
## 6 12/11/2017   Dec  1:15               -11.02745               -175
.2262
## 7  4/29/2017   Apr 17:15               -10.45252               -166
.0905
## 8  1/20/2017   Jan 21:30               -10.27472               -163
.2653

W_PartPeak_DemandSavings

##         Date Month   ToU Max_Discharge_W_PartPeak W_PartPeak_Demand
Savings
```

```
## 1   1/3/2017   Jan 10:15                -22.15351
0
## 2 10/27/2017   Oct 20:30                -20.46500
0
## 3  3/28/2017   Mar 11:30                -19.66640
0
## 4 11/24/2017   Nov 20:00                -18.17849
0
## 5  5/24/2017   May 20:15                -16.25294
0
## 6  4/21/2017   Apr 15:15                -14.94967
0
## 7 12/18/2017   Dec 11:30                -12.16475
0
## 8   2/2/2017   Feb 18:30                -10.27345
0

## Calculate Total Demand Savings generated by the battery system for
the    whole year 2017:

Total_S_OffPeak_DemandSavings <- sum(S_OffPeak_DemandSavings$S_OffPeak
_DemandSavings)
Total_S_OnPeak_DemandSavings <- sum(S_OnPeak_DemandSavings$S_OnPeak_De
mandSavings)
Total_S_PartPeak_DemandSavings <- sum(S_PartPeak_DemandSavings$S_PartP
eak_DemandSavings)

Total_W_OffPeak_DemandSavings <- sum(W_OffPeak_DemandSavings$W_OffPeak
_DemandSavings)
Total_W_PartPeak_DemandSavings <- 0

### Total Demand Savings for 2017:

Total_2017DemandSavings <- sum(Total_S_OnPeak_DemandSavings, Total_S_P
artPeak_DemandSavings, Total_S_OffPeak_DemandSavings, Total_W_OffPeak_
DemandSavings, Total_W_PartPeak_DemandSavings )

Total_2017DemandSavings

## [1] -4923.698

### ??? Question: How much total dollar savings did the battery system
generated for the customer in 2017?

## Calculate total kW that the Battery system DISCHARGED for the Summe
r ToU  Period:
```

```r
Total_Discharge_S_OffPeak <- sum(Discharge_S_Off$Battery_kW)
Total_Discharge_S_PartPeak <- sum(Discharge_S_Part$Battery_kW)
Total_Discharge_S_OnPeak <- sum(Discharge_S_On$Battery_kW)

## Calculate total kW that Battery discharged for the Winter ToU Perio
d:

Total_Discharge_W_OffPeak <- sum(Discharge_W_Off$Battery_kW)
Total_Discharge_W_PartPeak <- sum(Discharge_W_Part$Battery_kW)

## Calculate total energy consumption kWh that Battery system DISCHARG
ED in  2017 with 15 minute interval data:

## kWh = kW * 0.25

Total_Discharge_S_OnPeak_kwh <- 0.25*Total_Discharge_S_OnPeak
Total_Discharge_S_PartPeak_kwh<- 0.25*Total_Discharge_S_PartPeak
Total_Discharge_S_OffPeak_kwh <- 0.25*Total_Discharge_S_OffPeak
Total_Discharge_W_PartPeak_kwh <- 0.25* Total_Discharge_W_PartPeak
Total_Discharge_W_OffPeak_kwh <- 0.25 * Total_Discharge_W_OffPeak

Total_Discharge_S_OnPeak_kwh

## [1] -208.3935

Total_Discharge_S_PartPeak_kwh

## [1] -319.3843

Total_Discharge_S_OffPeak_kwh

## [1] -1167.445

Total_Discharge_W_PartPeak_kwh

## [1] -864.5874

Total_Discharge_W_OffPeak_kwh

## [1] -843.6629

## Calculate the Total Energy Charge Savings from the kW that Battery
system Discharged for each ToU and total 2017:

S_OnPeak_EnergyRate <- 0.12
S_PartPeak_EnergyRate <- 0.08
S_OffPeak_EnergyRate <- 0.06
```

```r
W_PartPeak_EnergyRate <- 0.08
W_OffPeak_EnergyRate <- 0.06

Total_2017Discharge_EnergySavings = sum(S_OnPeak_EnergyRate*Total_Disc
harge_S_OnPeak_kwh, S_PartPeak_EnergyRate*Total_Discharge_S_PartPeak_k
wh, S_OffPeak_EnergyRate*Total_Discharge_S_OffPeak_kwh, W_PartPeak_Ene
rgyRate * Total_Discharge_W_PartPeak_kwh, W_OffPeak_EnergyRate*Total_D
ischarge_W_OffPeak_kwh)

Total_2017Discharge_EnergySavings
```

```
## [1] -240.3914
```

```r
### ???? Question: How much total dollar savings did the battery syste
m generated   for the customer in 2017?

## Calculate total kW that the Battery CHARGED for the Summer ToU Peri
od:

## Data manipulation to label ToU in the CHARGING dataset:
## Separate the Ending Timestamp Interval Column into Date and Timesta
mp Variables:

Charge_1 <- separate(Charge, Ending_Timestamp, c('Date', 'ToU'), sep =
' ')

# Create a 'Month' and Weekday column from Date Variable:
Charge_2 <- Charge_1 %>%
  mutate(Weekday = weekdays(Date),
         Month = months(Date))

# Create new columns for Winter months, Summer months, Working_Day, We
ekend, Holiday in the Charging dataset:

Charge_3 <- Charge_2 %>%
  mutate(W_Month = ifelse(Month %in% Winter_Months, 'True', 'False'),
         S_Month = ifelse(Month %in% Summer_Months, 'True', 'False'),
         Weekend = ifelse(Weekday %in% Off_days, 'True', 'False'),
         Working_Day = ifelse(Weekday %in% Off_days, 'False', 'True'),
         Holiday = ifelse(Date %in% Holiday_2017, 'True', 'False'))

# Change the "Battery_kW" into Numeric Variable:

Charge_3$Battery_kW <- as.numeric(as.character(Charge_3$Battery_kW))
Charge_4 <- na.omit(Charge_3)
head(Charge_4)
```

```
##       Date  ToU Battery_kW Weekday Month W_Month S_Month Weekend
## 1 1/1/2017 0:15    0.28393     Sun   Jan    True   False    True
## 2 1/1/2017 0:30    0.28387     Sun   Jan    True   False    True
## 3 1/1/2017 0:45    0.28548     Sun   Jan    True   False    True
## 4 1/1/2017 1:00    0.28636     Sun   Jan    True   False    True
## 5 1/1/2017 1:15    0.37450     Sun   Jan    True   False    True
## 6 1/1/2017 1:30    0.34713     Sun   Jan    True   False    True
##   Working_Day Holiday
## 1       False   False
## 2       False   False
## 3       False   False
## 4       False   False
## 5       False   False
## 6       False   False
```

```
## Subset Summer and Summer Months in the Charge dataset:

Charge_S_ToU <- sqldf("SELECT *
                      FROM Charge_4
                      WHERE S_Month = 'True'")
Charge_W_ToU <- sqldf("SELECT *
                      FROM Charge_4
                      WHERE W_Month = 'True'")

## Subset the ToU Period in the Charge dataset:

Charge_S_Part <- sqldf("SELECT *
                      FROM Charge_S_ToU
                      WHERE Working_Day = 'True'
                      AND Holiday = 'False'
                      AND ToU IN
                      (SELECT S_PartPeak
                      FROM ToU_Period)")

Charge_S_On <- sqldf("SELECT *
                      FROM Charge_S_ToU
                      WHERE Working_Day = 'True'
                      AND Holiday = 'False'
                      AND ToU IN
                      (SELECT S_OnPeak
                      FROM ToU_Period)")

Charge_W_Part <- sqldf("SELECT *
                      FROM Charge_W_ToU
                      WHERE Working_Day = 'True'
                      AND Holiday = 'False'
```

```
                        AND ToU IN
                        (SELECT W_PartPeak
                        FROM ToU_Period)")

## Subset the Off_Peak Period for Summer and Winter in the CHARGE data
set:
# Label Weekend and Holiday in the Summer 2017 in the Charge dataset

Charge_S_Weekend_Holiday <- sqldf("SELECT *
                        FROM Charge_S_ToU
                        WHERE Weekend = 'True'
                        OR Holiday = 'True'")

Charge_W_Weekend_Holiday <- sqldf("SELECT *
                        FROM Charge_W_ToU
                        WHERE Weekend = 'True'
                        OR Holiday = 'True'")

Charge_S_Off_1 <- sqldf("SELECT *
                        FROM Charge_S_ToU
                        WHERE Working_Day = 'True'
                        AND Holiday = 'False'
                        AND ToU IN
                        (SELECT S_OffPeak
                        FROM ToU_Period)")

Charge_W_Off_1 <- sqldf("SELECT *
                        FROM Charge_W_ToU
                        WHERE Working_Day = 'True'
                        AND Holiday = 'False'
                        AND ToU IN
                        (SELECT W_OffPeak
                        FROM ToU_Period)")

Charge_S_Off <- rbind(Charge_S_Off_1, Charge_S_Weekend_Holiday)

Charge_W_Off <- rbind(Charge_W_Off_1, Charge_W_Weekend_Holiday)

## Calculate total kW that Battery CHARGED for the Summer ToU Period:

Total_Charge_S_OffPeak <- sum(Charge_S_Off$Battery_kW)
Total_Charge_S_PartPeak <- sum(Charge_S_Part$Battery_kW)
Total_Charge_S_OnPeak <- sum(Charge_S_On$Battery_kW)

## Calculate total kW that the Battery Charged for the Winter ToU Peri
od:
```

```
Total_Charge_W_OffPeak <- sum(Charge_W_Off$Battery_kW)
Total_Charge_W_PartPeak <- sum(Charge_W_Part$Battery_kW)

### Caculate Total Energy Consumpton kWh that the Battery system charg
ed in  2017 with the 15 minute interval data:

## kWh = kW * 0.25

Total_Charge_S_OnPeak_kwh <- Total_Charge_S_OnPeak*0.25
Total_Charge_S_PartPeak_kwh <- Total_Charge_S_PartPeak*0.25
Total_Charge_S_OffPeak_kwh <- Total_Charge_S_OffPeak*0.25
Total_Charge_W_PartPeak_kwh <- Total_Charge_W_PartPeak*0.25
Total_Charge_W_OffPeak_kwh <- Total_Charge_W_OffPeak*0.25

Total_Charge_S_OnPeak_kwh

## [1] 398.2857

Total_Charge_S_PartPeak_kwh

## [1] 593.015

Total_Charge_S_OffPeak_kwh

## [1] 1874.239

Total_Charge_W_PartPeak_kwh

## [1] 1331.128

Total_Charge_W_OffPeak_kwh

## [1] 2202.452

## Calculate the Total Cost of Energy Charge that the Battery system C
harged for each ToU and total 2017 (Energy Rate * kWh)

Total_2017Charge_EnergyCost = sum(S_OnPeak_EnergyRate*Total_Charge_S_O
nPeak_kwh, S_PartPeak_EnergyRate*Total_Charge_S_PartPeak_kwh, S_OffPea
k_EnergyRate*Total_Charge_S_OffPeak_kwh, W_PartPeak_EnergyRate * Total
_Charge_W_PartPeak_kwh, W_OffPeak_EnergyRate*Total_Charge_W_OffPeak_kw
h)

Total_2017Charge_EnergyCost

## [1] 446.3272
```

```
### ??? Question: How much total savings did the Battery system genera
te for the residential customer in 2017?
## Calculate The Net Dollar Savings in 2017 that the smart Battery gen
erated for the customer: Energy Savings of Discharging kWh - Energy Co
st of Charging kWh:

Total_2017EnergySavings = Total_2017Discharge_EnergySavings * (-1) - T
otal_2017Charge_EnergyCost

Total_2017EnergySavings
```

```
## [1] -205.9358
```

```
### ??? Question: How much total dollar savings did the smart Battery
system generate for the residential customer in 2017?

## Total Savings = Demand Savings + Energy Savings

Total_2017_Savings = Total_2017DemandSavings*(-1) + Total_2017EnergySa
vings
Total_2017_Savings
```

```
## [1] 4717.762
```