1) Import rquired libraries

In [1]:
```python
#Import pandas, matplotlib.pyplot, and seaborn
import pandas as pd
import numpy as np
import math
import missingno as msno
import datetime as dt
import calendar
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```python
from IPython.display import Markdown, display
def printmd(string):
    display(Markdown(string))
```

2) Sourcing and loading

In [3]:
```python
#Load Accounts data from 'AllAccountReads.xlsx' file

#Load Accounts data for year 2017-2018
data1 = pd.read_excel('AllAccountReads.xlsx', sheet_name= 'Usage_17_18')
#Load Accounts data for year 2018-2019
data2 = pd.read_excel('AllAccountReads.xlsx', sheet_name= 'Usage_18_19')
#Load Accounts data for year 2019-2020
data3 = pd.read_excel('AllAccountReads.xlsx', sheet_name= 'Usage_19_20')
```

In [4]:
```python
df1 = data1.copy()
df2 = data2.copy()
df3 = data3.copy()
```

3) Overview DataFrames

In [5]:
```python
print('df1')
print(df1.head(3).T)
print('df2')
print(df2.head(3).T)
print('df3')
print(df3.head(3).T)
```

```
df1
                                  0                    1                    2
LOC ID                   1000000000           1000000001           1000000002
WTR_RATE                     W-RSFD               W-RSFD               W-RSFD
WTR_DWEL_UNIT                     1                    1                    1
WTR_USE1                         22                    9                   10
WTR_USE2                         22                    8                    7
WTR_USE3                         15                    7                    7
WTR_USE4                          9                    5                    8
WTR_USE5                         10                    4                    7
WTR_USE6                         10                    7                    8
WTR_USE7                         11                    5                   12
WTR_USE8                          9                    6                   10
WTR_USE9                         11                    6                   20
WTR_USE10                        13                    8                  NaN
WTR_USE11                        15                    8                  NaN
WTR_USE12                        15                    9                  NaN
WTR_READ_DT1    2018-07-11 00:00:00  2018-07-19 00:00:00  2018-07-16 00:00:00
WTR_READ_DT2    2018-06-11 00:00:00  2018-06-19 00:00:00  2018-06-14 00:00:00
WTR_READ_DT3    2018-05-10 00:00:00  2018-05-18 00:00:00  2018-05-15 00:00:00
WTR_READ_DT4    2018-04-11 00:00:00  2018-04-19 00:00:00  2018-04-16 00:00:00
WTR_READ_DT5    2018-03-13 00:00:00  2018-03-21 00:00:00  2018-03-16 00:00:00
WTR_READ_DT6    2018-02-09 00:00:00  2018-02-20 00:00:00  2018-02-14 00:00:00
WTR_READ_DT7    2018-01-09 00:00:00  2018-01-19 00:00:00  2018-01-16 00:00:00
WTR_READ_DT8    2017-12-08 00:00:00  2017-12-18 00:00:00  2017-12-13 00:00:00
WTR_READ_DT9    2017-11-07 00:00:00  2017-11-15 00:00:00  2017-11-10 00:00:00
WTR_READ_DT10   2017-10-09 00:00:00  2017-10-17 00:00:00                  NaT
WTR_READ_DT11   2017-09-08 00:00:00  2017-09-18 00:00:00                  NaT
WTR_READ_DT12   2017-08-09 00:00:00  2017-08-17 00:00:00                  NaT
WTR_READ_DAYS1                   30                   30                   32
WTR_READ_DAYS2                   32                   32                   30
WTR_READ_DAYS3                   29                   29                   29
WTR_READ_DAYS4                   29                   29                   31
WTR_READ_DAYS5                   32                   29                   30
WTR_READ_DAYS6                   31                   32                   29
WTR_READ_DAYS7                   32                   32                   34
WTR_READ_DAYS8                   31                   33                   33
WTR_READ_DAYS9                   29                   29                   25
WTR_READ_DAYS10                  31                   29                  NaN
WTR_READ_DAYS11                  30                   32                  NaN
WTR_READ_DAYS12                  29                   29                  NaN
df2
                                  0                    1                    2
LOC ID                   1000000000           1000000001           1000000002
WTR_RATE                     W-RSFD               W-RSFD               W-RSFD
WTR_DWEL_UNIT                     1                    1                    1
WTR_USE1                         20                    8                   15
WTR_USE2                         13                    6                   12
WTR_USE3                          6                   11                   13
WTR_USE4                          5                    7                   13
WTR_USE5                          5                    4                   14
WTR_USE6                          5                    5                   14
WTR_USE7                          7                    5                   15
WTR_USE8                         10                    5                   13
WTR_USE9                          8                    6                   10
WTR_USE10                        13                    7                   12
WTR_USE11                        19                    7                   12
WTR_USE12                        19                   10                   13
WTR_READ_DT1    2019-07-10 00:00:00  2019-07-19 00:00:00  2019-07-16 00:00:00
WTR_READ_DT2    2019-06-10 00:00:00  2019-06-19 00:00:00  2019-06-14 00:00:00
WTR_READ_DT3    2019-05-10 00:00:00  2019-05-20 00:00:00  2019-05-15 00:00:00
WTR_READ_DT4    2019-04-11 00:00:00  2019-04-19 00:00:00  2019-04-17 00:00:00
WTR_READ_DT5    2019-03-12 00:00:00  2019-03-21 00:00:00  2019-03-19 00:00:00
WTR_READ_DT6    2019-02-11 00:00:00  2019-02-20 00:00:00  2019-02-14 00:00:00
WTR_READ_DT7    2019-01-09 00:00:00  2019-01-18 00:00:00  2019-01-15 00:00:00
WTR_READ_DT8    2018-12-10 00:00:00  2018-12-18 00:00:00  2018-12-12 00:00:00
WTR_READ_DT9    2018-11-06 00:00:00  2018-11-15 00:00:00  2018-11-12 00:00:00
WTR_READ_DT10   2018-10-08 00:00:00  2018-10-17 00:00:00  2018-10-12 00:00:00
WTR_READ_DT11   2018-09-10 00:00:00  2018-09-18 00:00:00  2018-09-13 00:00:00
WTR_READ_DT12   2018-08-09 00:00:00  2018-08-17 00:00:00  2018-08-14 00:00:00
WTR_READ_DAYS1                   30                   30                   32
WTR_READ_DAYS2                   31                   30                   30
WTR_READ_DAYS3                   29                   31                   28
WTR_READ_DAYS4                   30                   29                   29
WTR_READ_DAYS5                   29                   29                   33
WTR_READ_DAYS6                   33                   33                   30
WTR_READ_DAYS7                   30                   31                   34
WTR_READ_DAYS8                   34                   33                   30
WTR_READ_DAYS9                   29                   29                   31
WTR_READ_DAYS10                  28                   29                   29
WTR_READ_DAYS11                  32                   32                   30
WTR_READ_DAYS12                  29                   29                   29
df3
                                  0                    1                    2
LOC ID                   1000000000           1000000001           1000000002
WTR_RATE                     W-RSFD               W-RSFD               W-RSFD
WTR_DWEL_UNIT                     1                    1                    1
WTR_USE1                         16                    9                   15
WTR_USE2                         13                   11                    8
WTR_USE3                         20                    9                    7
WTR_USE4                         10                    7                    7
WTR_USE5                          5                    7                    6
WTR_USE6                          6                    4                    6
WTR_USE7                          7                    4                    6
WTR_USE8                         10                    5                    9
WTR_USE9                          9                    5                   12
WTR_USE10                         8                    4                   13
WTR_USE11                        16                    7                   14
WTR_USE12                        15                    6                   12
WTR_READ_DT1    2020-07-10 00:00:00  2020-07-20 00:00:00  2020-07-15 00:00:00
WTR_READ_DT2    2020-06-09 00:00:00  2020-06-18 00:00:00  2020-06-15 00:00:00
WTR_READ_DT3    2020-05-11 00:00:00  2020-05-19 00:00:00  2020-05-14 00:00:00
WTR_READ_DT4    2020-04-10 00:00:00  2020-04-20 00:00:00  2020-04-15 00:00:00
WTR_READ_DT5    2020-03-11 00:00:00  2020-03-20 00:00:00  2020-03-17 00:00:00
WTR_READ_DT6    2020-02-11 00:00:00  2020-02-20 00:00:00  2020-02-14 00:00:00
WTR_READ_DT7    2020-01-10 00:00:00  2020-01-21 00:00:00  2020-01-15 00:00:00
WTR_READ_DT8    2019-12-09 00:00:00  2019-12-18 00:00:00  2019-12-13 00:00:00
WTR_READ_DT9    2019-11-06 00:00:00  2019-11-15 00:00:00  2019-11-12 00:00:00
WTR_READ_DT10   2019-10-08 00:00:00  2019-10-17 00:00:00  2019-10-14 00:00:00
WTR_READ_DT11   2019-09-09 00:00:00  2019-09-18 00:00:00  2019-09-13 00:00:00
WTR_READ_DT12   2019-08-09 00:00:00  2019-08-19 00:00:00  2019-08-14 00:00:00
WTR_READ_DAYS1                   31                   32                   30
WTR_READ_DAYS2                   29                   30                   32
WTR_READ_DAYS3                   31                   29                   29
WTR_READ_DAYS4                   30                   31                   29
WTR_READ_DAYS5                   29                   29                   32
WTR_READ_DAYS6                   32                   30                   30
WTR_READ_DAYS7                   32                   34                   33
WTR_READ_DAYS8                   33                   33                   31
WTR_READ_DAYS9                   29                   29                   29
WTR_READ_DAYS10                  29                   29                   31
WTR_READ_DAYS11                  31                   30                   30
WTR_READ_DAYS12                  30                   31                   29
```

Over the three years amount of water usage is recorded for each period for each unique LOC ID. The number of days between two consecutive read date might be more than 31 days, so each period of reading and recording water usage is not necessarily monthly. Each period is recognized with:

```
1) the number of days(WTR_READ_DAYS)

2) read date(WTR_READ_DT)

3) amount of water usage(WTR_USE)
```

The order of read dates is from read date12 to read date1. Consequently the order of water usage and water usage columns are from 12 to 1. For example, for the first and second users with location Id of 1000000000 and 1000000001: Read date12(WTR_READ_DT12) was in Augest then read date11(WTR_READ_DT11) was on September and so on.

In [6]:
```python
#Check the index column.
print('df1 Index:',df1.index)
print('df2 Index:',df2.index)
print('df3 Index:',df3.index)
```

```
df1 Index: RangeIndex(start=0, stop=78894, step=1)
df2 Index: RangeIndex(start=0, stop=78894, step=1)
df3 Index: RangeIndex(start=0, stop=78894, step=1)
```

In [7]:
```python
#Strip the 'WTR' form the name of columns, and change the 'LOC ID' to 'LOC_ID'.
col_labels = df1.columns.str.replace('WTR_','')
col_labels = col_labels.str.replace(' ','_')

#Changes in col labels of df1 is applicable for other two dateset.
df1.columns = col_labels
df2.columns = col_labels
df3.columns = col_labels
```

In [8]:
```python
#Call the info method on df1 to see a summary of data
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 78894 entries, 0 to 78893
Data columns (total 39 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   LOC_ID       78894 non-null  int64
 1   RATE         78894 non-null  object
 2   DWEL_UNIT    77632 non-null  float64
 3   USE1         78489 non-null  float64
 4   USE2         78053 non-null  float64
 5   USE3         77627 non-null  float64
 6   USE4         77228 non-null  float64
 7   USE5         76853 non-null  float64
 8   USE6         76535 non-null  float64
 9   USE7         76200 non-null  float64
 10  USE8         75845 non-null  float64
 11  USE9         75476 non-null  float64
 12  USE10        75112 non-null  float64
 13  USE11        74762 non-null  float64
 14  USE12        74363 non-null  float64
 15  READ_DT1     78488 non-null  datetime64[ns]
 16  READ_DT2     78052 non-null  datetime64[ns]
 17  READ_DT3     77626 non-null  datetime64[ns]
 18  READ_DT4     77227 non-null  datetime64[ns]
 19  READ_DT5     76852 non-null  datetime64[ns]
 20  READ_DT6     76534 non-null  datetime64[ns]
 21  READ_DT7     76199 non-null  datetime64[ns]
 22  READ_DT8     75844 non-null  datetime64[ns]
 23  READ_DT9     75475 non-null  datetime64[ns]
 24  READ_DT10    75111 non-null  datetime64[ns]
 25  READ_DT11    74761 non-null  datetime64[ns]
 26  READ_DT12    74362 non-null  datetime64[ns]
 27  READ_DAYS1   78488 non-null  float64
 28  READ_DAYS2   78052 non-null  float64
 29  READ_DAYS3   77626 non-null  float64
 30  READ_DAYS4   77227 non-null  float64
 31  READ_DAYS5   76852 non-null  float64
 32  READ_DAYS6   76534 non-null  float64
 33  READ_DAYS7   76199 non-null  float64
 34  READ_DAYS8   75844 non-null  float64
 35  READ_DAYS9   75475 non-null  float64
 36  READ_DAYS10  75111 non-null  float64
 37  READ_DAYS11  74761 non-null  float64
 38  READ_DAYS12  74362 non-null  float64
dtypes: datetime64[ns](12), float64(25), int64(1), object(1)
memory usage: 23.5+ MB
```

In [9]:
```python
#Overview df2
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 78894 entries, 0 to 78893
Data columns (total 39 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   LOC_ID       78894 non-null  int64
 1   RATE         78894 non-null  object
 2   DWEL_UNIT    77626 non-null  float64
 3   USE1         78829 non-null  float64
 4   USE2         78783 non-null  float64
 5   USE3         78726 non-null  float64
 6   USE4         78683 non-null  float64
 7   USE5         78642 non-null  float64
 8   USE6         78610 non-null  float64
 9   USE7         78579 non-null  float64
 10  USE8         78544 non-null  float64
 11  USE9         78518 non-null  float64
 12  USE10        78483 non-null  float64
 13  USE11        78445 non-null  float64
 14  USE12        78379 non-null  float64
 15  READ_DT1     78829 non-null  datetime64[ns]
 16  READ_DT2     78784 non-null  datetime64[ns]
 17  READ_DT3     78726 non-null  datetime64[ns]
 18  READ_DT4     78683 non-null  datetime64[ns]
 19  READ_DT5     78642 non-null  datetime64[ns]
 20  READ_DT6     78610 non-null  datetime64[ns]
 21  READ_DT7     78579 non-null  datetime64[ns]
 22  READ_DT8     78544 non-null  datetime64[ns]
 23  READ_DT9     78518 non-null  datetime64[ns]
 24  READ_DT10    78483 non-null  datetime64[ns]
 25  READ_DT11    78445 non-null  datetime64[ns]
 26  READ_DT12    78379 non-null  datetime64[ns]
 27  READ_DAYS1   78830 non-null  float64
 28  READ_DAYS2   78784 non-null  float64
 29  READ_DAYS3   78726 non-null  float64
 30  READ_DAYS4   78683 non-null  float64
 31  READ_DAYS5   78642 non-null  float64
 32  READ_DAYS6   78610 non-null  float64
 33  READ_DAYS7   78579 non-null  float64
 34  READ_DAYS8   78544 non-null  float64
 35  READ_DAYS9   78518 non-null  float64
 36  READ_DAYS10  78483 non-null  float64
 37  READ_DAYS11  78445 non-null  float64
 38  READ_DAYS12  78379 non-null  float64
dtypes: datetime64[ns](12), float64(25), int64(1), object(1)
memory usage: 23.5+ MB
```

In [10]:
```python
#Overview df3
df3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 78894 entries, 0 to 78893
Data columns (total 39 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   LOC_ID       78894 non-null  int64
 1   RATE         78894 non-null  object
 2   DWEL_UNIT    77617 non-null  float64
 3   USE1         78842 non-null  float64
 4   USE2         78815 non-null  float64
 5   USE3         78779 non-null  float64
 6   USE4         78739 non-null  float64
 7   USE5         78681 non-null  float64
 8   USE6         78642 non-null  float64
 9   USE7         78591 non-null  float64
 10  USE8         78551 non-null  float64
 11  USE9         78510 non-null  float64
 12  USE10        78468 non-null  float64
 13  USE11        78423 non-null  float64
 14  USE12        78381 non-null  float64
 15  READ_DT1     78842 non-null  datetime64[ns]
 16  READ_DT2     78816 non-null  datetime64[ns]
 17  READ_DT3     78779 non-null  datetime64[ns]
 18  READ_DT4     78739 non-null  datetime64[ns]
 19  READ_DT5     78681 non-null  datetime64[ns]
 20  READ_DT6     78642 non-null  datetime64[ns]
 21  READ_DT7     78591 non-null  datetime64[ns]
 22  READ_DT8     78551 non-null  datetime64[ns]
 23  READ_DT9     78510 non-null  datetime64[ns]
 24  READ_DT10    78468 non-null  datetime64[ns]
 25  READ_DT11    78423 non-null  datetime64[ns]
 26  READ_DT12    78381 non-null  datetime64[ns]
 27  READ_DAYS1   78843 non-null  float64
 28  READ_DAYS2   78816 non-null  float64
 29  READ_DAYS3   78779 non-null  float64
 30  READ_DAYS4   78739 non-null  float64
 31  READ_DAYS5   78681 non-null  float64
 32  READ_DAYS6   78642 non-null  float64
 33  READ_DAYS7   78591 non-null  float64
 34  READ_DAYS8   78551 non-null  float64
 35  READ_DAYS9   78510 non-null  float64
 36  READ_DAYS10  78468 non-null  float64
 37  READ_DAYS11  78423 non-null  float64
 38  READ_DAYS12  78381 non-null  float64
dtypes: datetime64[ns](12), float64(25), int64(1), object(1)
memory usage: 23.5+ MB
```

DWEL_UNIT has more than one thousands missing values in each dataframe.

Rate determines the customer types, it is a categorical variable so I will also change its datatype to category.

In [11]:
```python
#Caculate the number and percentage of missing values in each column of three dataframes.
missing_values = pd.concat([df1.isna().sum(), round(100 * df1.isna().mean(), 2),
                            df2.isna().sum(), round(100 * df2.isna().mean(), 2),
                            df3.isna().sum(), round(100 * df3.isna().mean(), 2)], axis=1)

missing_values.columns = ['count_in_yr1','%_in_yr1','count_in_yr2','%_in_yr2','count_in_yr3','%_in_yr3'
]
missing_values = missing_values.sort_values(by= '%_in_yr1', ascending= False)
printmd("\n<span style='color:Blue'>**Missing Values over Three Years**\n</span>")
missing_values
```

Missing Values over Three Years

Out[11]:

	count_in_yr1	%_in_yr1	count_in_yr2	%_in_yr2	count_in_yr3	%_in_yr3
READ_DAYS12	4532	5.74	515	0.65	513	0.65
READ_DT12	4532	5.74	515	0.65	513	0.65
USE12	4531	5.74	515	0.65	513	0.65
READ_DAYS11	4133	5.24	449	0.57	471	0.60
READ_DT11	4133	5.24	449	0.57	471	0.60
USE11	4132	5.24	449	0.57	471	0.60
READ_DAYS10	3783	4.80	411	0.52	426	0.54
READ_DT10	3783	4.80	411	0.52	426	0.54
USE10	3782	4.79	411	0.52	426	0.54
READ_DT9	3419	4.33	376	0.48	384	0.49
USE9	3418	4.33	376	0.48	384	0.49
READ_DAYS9	3419	4.33	376	0.48	384	0.49
READ_DT8	3050	3.87	350	0.44	343	0.43
READ_DAYS8	3050	3.87	350	0.44	343	0.43
USE8	3049	3.86	350	0.44	343	0.43
READ_DAYS7	2695	3.42	315	0.40	303	0.38
READ_DT7	2695	3.42	315	0.40	303	0.38
USE7	2694	3.41	315	0.40	303	0.38
USE6	2359	2.99	284	0.36	252	0.32
READ_DAYS6	2360	2.99	284	0.36	252	0.32
READ_DT6	2360	2.99	284	0.36	252	0.32
READ_DAYS5	2042	2.59	252	0.32	213	0.27
READ_DT5	2042	2.59	252	0.32	213	0.27
USE5	2041	2.59	252	0.32	213	0.27
READ_DT4	1667	2.11	211	0.27	155	0.20
READ_DAYS4	1667	2.11	211	0.27	155	0.20
USE4	1666	2.11	211	0.27	155	0.20
READ_DT3	1268	1.61	168	0.21	115	0.15
READ_DAYS3	1268	1.61	168	0.21	115	0.15
USE3	1267	1.61	168	0.21	115	0.15
DWEL_UNIT	1262	1.60	1268	1.61	1277	1.62
READ_DT2	842	1.07	110	0.14	78	0.10
READ_DAYS2	842	1.07	110	0.14	78	0.10
USE2	841	1.07	111	0.14	79	0.10
READ_DAYS1	406	0.51	64	0.08	51	0.06
READ_DT1	406	0.51	65	0.08	52	0.07
USE1	405	0.51	65	0.08	52	0.07
RATE	0	0.00	0	0.00	0	0.00
LOC_ID	0	0.00	0	0.00	0	0.00

In all three years, data on the first period of reading accounts (READ_DAYS12, READ_DT12, USE12) has the most missing values. As moving forward the number of missing values for each period has decreased, so that the 12th period data (READ_DAYS1, READ_DT1, USE1) has least missing values.

The number of missing values in first year is significantly higher, except DWEL_UNIT.

LOC_ID and RATE don't have any missing values.

4) Checking missing values and validity of non numeric variables

4.1) LOC_ID variable

In [12]:
```python
#Check if the values in 'LOC_ID' column are unique
df1.LOC_ID.is_unique
```

Out[12]: `True`

In [13]:
```python
#Check if the values in 'LOC_ID' column are unique
df2.LOC_ID.is_unique
```

Out[13]: `True`

In [14]:
```python
#Check if the values in 'LOC_ID' column are unique
df3.LOC_ID.is_unique
```

Out[14]: `True`

In [15]:
```python
#Check if the LOC_ID colum in all three DataFrames are same.
((df1.LOC_ID != df2.LOC_ID) & (df2.LOC_ID != df3.LOC_ID)).sum()
```

Out[15]: `0`

Length of three DataFrames are eqaul and LOC_ID columns (with no missing value) are same in all three DataFrames

4.2) Check the RATE and DWEL_UNIT variables

In [16]:
```python
df1.RATE.unique()
```

Out[16]:
```
array(['W-RSFD', 'W-RMF', 'W-RDUPLX', 'W-COM', 'W-IRR', 'W-IND'],
      dtype=object)
```

In [17]:
```python
#Strip the 'W_' from all elements of RATE.
df1.RATE = df1.RATE.str.replace('W-','')
df2.RATE = df2.RATE.str.replace('W-','')
df3.RATE = df3.RATE.str.replace('W-','')
```

Question: Is there any changes in RATE for the fixed LOC_IDs?

In [18]:
```python
print('# LOC_ID that their RATE have been changed in 2019-2020 in comparison with year 2018-2018: ',
      (df2.RATE != df3.RATE).sum())
```

```
# LOC_ID that their RATE have been changed in 2019-2020 in comparison with year 2018-2018:  165
```

In [19]:
```python
#Check if the customer types (RATE column) has been changed over 3 years
print('# LOC_ID that their RATE have been changed in 2018-2019 in comparison with 2017-2018:',
      (df1.RATE != df2.RATE).sum())
```

```
# LOC_ID that their RATE have been changed in 2018-2019 in comparison with 2017-2018: 83
```

Rate of 84 accounts and 168 accounts has been changed in 2018-2019 and 2019-2020 respectively in comparison with their previous year.

4.2.1) DWEL_UNIT

In [20]:
```python
#Which type of Dwelling Units have missing values in df1?
temp = df1[df1. DWEL_UNIT.isna()]
temp = pd.DataFrame(temp)
temp.RATE.unique()
```

Out[20]:
```
array(['IRR', 'COM', 'RDUPLX', 'RSFD'], dtype=object)
```

In [21]:
```python
#Which type of Dwelling Units have missing values in df2?
temp = df2[df2. DWEL_UNIT.isna()]
temp = pd.DataFrame(temp)
temp.RATE.unique()
```

Out[21]:
```
array(['IRR', 'COM', 'RDUPLX', 'RSFD', 'RMF'], dtype=object)
```

In [22]:
```python
#Which type of Dwelling Units have missing values in df3?
temp = df3[df3. DWEL_UNIT.isna()]
temp = pd.DataFrame(temp)
temp.RATE.unique()
```

Out[22]:
```
array(['IRR', 'COM', 'RDUPLX', 'RSFD', 'RMF'], dtype=object)
```

There are missing values of dwelling unit in customer groups of irrigatin, commercial, residential duplex and single family in all three df1, df2 and df3.

There are also missing values of dwelling unit in customer group of residential multifamily in df2, df3.

Let's check these RATEs.

4.2.1.1) Fill Nan of dwelling unit colum for RATE of irrigation

In [23]:
```python
#Check the null value of dwelling unit for irrigation group in df1
df1[(df1.RATE == 'IRR') & (df1.DWEL_UNIT.isna())].head()
```

Out[23]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5	R
35	1000000035	IRR	NaN	3.0	2.0	2.0	1.0	1.0	0.0	2.0	...	29.0	31.0	29.0	
219	1000000219	IRR	NaN	10.0	8.0	9.0	9.0	8.0	8.0	9.0	...	30.0	31.0	29.0	
264	1000000264	IRR	NaN	0.0	0.0	0.0	0.0	1.0	1.0	0.0	...	29.0	31.0	29.0	
384	1000000384	IRR	NaN	262.0	140.0	142.0	154.0	82.0	103.0	42.0	...	29.0	29.0	31.0	
464	1000000464	IRR	NaN	49.0	24.0	19.0	28.0	12.0	23.0	13.0	...	30.0	29.0	31.0	

5 rows × 39 columns

In [24]:
```python
#Check whether all values of dwelling units for irrigation customers is null in df1.
print(df1[df1.RATE == 'IRR']['DWEL_UNIT'].isna().sum() == len(df1[df1.RATE == 'IRR']))

#Check whether all values of dwelling units for irrigation customers is null in df1.
print(df2[df2.RATE == 'IRR']['DWEL_UNIT'].isna().sum() == len(df2[df2.RATE == 'IRR']))

#Check whether all values of dwelling units for irrigation customers is null in df1.
print(df3[df3.RATE == 'IRR']['DWEL_UNIT'].isna().sum() == len(df3[df3.RATE == 'IRR']))
```

```
True
True
True
```

Number of dwelling units for irrigation customers is null. Let's Set the value one for dwelling units of irrigation customers.

In [25]:
```python
#Set the value one for dwelling units of irrigation customers.
df1.loc[df1.RATE == 'IRR','DWEL_UNIT']= 1
df2.loc[df2.RATE == 'IRR','DWEL_UNIT']= 1
df3.loc[df3.RATE == 'IRR','DWEL_UNIT']= 1
```

In [26]:
```python
#Is there still any null value for dewelling unit of irriagation RATE.
len(df1[(df1.RATE == 'IRR') & (df1.DWEL_UNIT.isna())])
```

Out[26]: `0`

4.2.1.2) Fill Nan of dwelling unit colum for RATE of commercial

In [27]:
```python
#Filter the null value of dwelling unit for commercial group
df1[(df1.RATE == 'COM') & (df1.DWEL_UNIT.isna())].head()
```

Out[27]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
1093	1000001093	COM	NaN	3.0	2.0	3.0	2.0	1.0	2.0	NaN	...	29.0	31.0	29.0
1515	1000001515	COM	NaN	33.0	44.0	21.0	NaN	NaN	NaN	NaN	...	13.0	NaN	NaN
1651	1000001651	COM	NaN	19.0	22.0	19.0	18.0	19.0	23.0	20.0	...	30.0	31.0	29.0
2320	1000002320	COM	NaN	6.0	4.0	5.0	5.0	5.0	5.0	6.0	...	30.0	29.0	31.0
3109	1000003109	COM	NaN	45.0	56.0	56.0	56.0	48.0	56.0	84.0	...	29.0	29.0	29.0

5 rows × 39 columns

In [28]:
```python
#What is the range of dwelling unit for commercial group in df1
temp = df1[(df1.RATE == 'COM')]
round(temp.DWEL_UNIT.value_counts(dropna=False, normalize= True),4).head()
```

Out[28]:
```
0.0    0.9290
NaN    0.0246
1.0    0.0176
2.0    0.0092
4.0    0.0058
Name: DWEL_UNIT, dtype: float64
```

In [29]:
```python
#What is the range of dwelling unit for commercial group in df1
temp = df2[(df1.RATE == 'COM')]
round(temp.DWEL_UNIT.value_counts(dropna=False, normalize= True),4).head()
```

Out[29]:
```
0.0    0.9283
NaN    0.0250
1.0    0.0179
2.0    0.0092
4.0    0.0058
Name: DWEL_UNIT, dtype: float64
```

In [30]:
```python
#What is the range of dwelling unit for commercial group in df1
temp = df3[(df1.RATE == 'COM')]
round(temp.DWEL_UNIT.value_counts(dropna=False, normalize= True),4).head()
```

Out[30]:
```
0.0    0.9269
NaN    0.0253
1.0    0.0186
2.0    0.0091
4.0    0.0060
Name: DWEL_UNIT, dtype: float64
```

More than 92% of commericial group in all three dataframes has only zero dwelling unit. Based on data dictionary, commercial customers with 0 dwelling unit are pure commercial account. There are about 2.5% dewelling unit with null value in this group, So it totally makes sense to fill them with 0.

In [31]:
```python
##Fillna with zero for dwelling units of COM customers.
df1.loc[(df1.RATE == 'COM') & (df1.DWEL_UNIT.isna()), 'DWEL_UNIT'] = 0
print(len(df1[(df1.RATE == 'COM') & (df1.DWEL_UNIT.isna())]))

df2.loc[(df2.RATE == 'COM') & (df2.DWEL_UNIT.isna()), 'DWEL_UNIT'] = 0
print(len(df1[(df1.RATE == 'COM') & (df1.DWEL_UNIT.isna())]))

df3.loc[(df3.RATE == 'COM') & (df3.DWEL_UNIT.isna()), 'DWEL_UNIT'] = 0
print(len(df1[(df1.RATE == 'COM') & (df1.DWEL_UNIT.isna())]))
```

```
0
0
0
```

There is no dwelling unit with null value in commercial group.

Question: How many pure commercial customers are there in each dataframe?

In [32]:
```python
#"commercial" accounts with non-zero dwelling units are mixed-use properties that have both commercial
 and residential
#units using water from the same water account.

#find pure commercial customers in df1.
print('# pure commercial customers in df1:', df1[(df1.RATE == 'COM') & (df1.DWEL_UNIT== 0)].shape[0])

#find pure commercial customers in df1.
print('# pure commercial customers in df2:',df2[(df2.RATE == 'COM') & (df2.DWEL_UNIT== 0)].shape[0])

#find pure commercial customers in df1.
print('# pure commercial customers in df3:',df3[(df3.RATE == 'COM') & (df2.DWEL_UNIT== 0)].shape[0])
```

```
# pure commercial customers in df1: 5268
# pure commercial customers in df2: 5269
# pure commercial customers in df3: 5261
```

Significant number of customers are pure commercial. Let's separate pure commercial from mixed commercial and residential units.

In [33]:
```python
#Define a new category of COM&RES for commercial accounts that don't use water for pure commercial prup
ose.
boolean1 = (df1.RATE == 'COM') & (df1.DWEL_UNIT > 0)
df1.loc[boolean1,'RATE'] = 'COM&RES'

boolean2 = (df2.RATE == 'COM') & (df2.DWEL_UNIT > 0)
df2.loc[boolean2,'RATE'] = 'COM&RES'

boolean3 = (df3.RATE == 'COM') & (df3.DWEL_UNIT > 0)
df3.loc[boolean3,'RATE'] = 'COM&RES'
```

In [34]:
```python
#Set the value one for dwelling units of pure commercial customers.
df1.loc[df1.RATE == 'COM','DWEL_UNIT']= 1
df2.loc[df2.RATE == 'COM','DWEL_UNIT']= 1
df3.loc[df3.RATE == 'COM','DWEL_UNIT']= 1
```

In [35]:
```python
print(len(df1[(df1.RATE == 'COM&RES') & (df1.DWEL_UNIT.isna())]))
print(len(df1[(df1.RATE == 'COM&RES') & (df1.DWEL_UNIT.isna())]))
print(len(df1[(df1.RATE == 'COM&RES') & (df1.DWEL_UNIT.isna())]))
```

```
0
0
0
```

There is no dwelling unit with null value in mix of commercial and residential group.

In [36]:
```python
#Convert the datatype of object to category for column of RATE.
df1.RATE = df1.RATE.astype('category')
df2.RATE = df2.RATE.astype('category')
df3.RATE = df3.RATE.astype('category')
```

In [37]:
```python
df1.RATE.unique()
```

Out[37]:
```
[RSFD, RMF, RDUPLX, COM, IRR, IND, COM&RES]
Categories (7, object): [RSFD, RMF, RDUPLX, COM, IRR, IND, COM&RES]
```

Now, RATE is a categorical variable with 7 unique values.

4.2.1.3) Fill Nan of dwelling unit colum for RATE of residential duplex

In [38]:
```python
#Check the value of Dwelling units for Duplex houses
temp = df1[(df1.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

Out[38]:
```
2.0    0.856434
1.0    0.143153
NaN    0.000276
3.0    0.000138
Name: DWEL_UNIT, dtype: float64
```

In [39]:
```python
#For duplex group with number of dwelling unit of 3, set the number of dwelling unit to 2
df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 3),'DWEL_UNIT']= 2
```

In [40]:
```python
#For duplex group with number of dwelling unit of 1, set the number of dwelling unit to 2 and double th
e amount of usage.
df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE1'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE1']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE2'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE2']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE3'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE3']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE4'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE4']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE5'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE5']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE6'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE6']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE7'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE7']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE8'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE8']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE9'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE9']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE10'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE10']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE11'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE11']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE12'] = 2*\
    df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'USE12']

df1.loc[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT == 1),'DWEL_UNIT'] = 2
```

In [41]:
```python
#Check the value of Dwelling units for Duplex houses
temp = df1[(df1.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

Out[41]:
```
2.0    0.999724
NaN    0.000276
Name: DWEL_UNIT, dtype: float64
```

In [42]:
```
#Filter the null value of dwelling unit for residential duplex group in df1
df1[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT.isna())].T
```
Out[42]:

	12743	65066
LOC_ID	1000012743	1000065066
RATE	RDUPLX	RDUPLX
DWEL_UNIT	NaN	NaN
USE1	NaN	NaN
USE2	NaN	NaN
USE3	NaN	NaN
USE4	NaN	NaN
USE5	NaN	NaN
USE6	NaN	NaN
USE7	NaN	NaN
USE8	NaN	NaN
USE9	NaN	NaN
USE10	NaN	NaN
USE11	NaN	NaN
USE12	NaN	NaN
READ_DT1	NaT	NaT
READ_DT2	NaT	NaT
READ_DT3	NaT	NaT
READ_DT4	NaT	NaT
READ_DT5	NaT	NaT
READ_DT6	NaT	NaT
READ_DT7	NaT	NaT
READ_DT8	NaT	NaT
READ_DT9	NaT	NaT
READ_DT10	NaT	NaT
READ_DT11	NaT	NaT
READ_DT12	NaT	NaT
READ_DAYS1	NaN	NaN
READ_DAYS2	NaN	NaN
READ_DAYS3	NaN	NaN
READ_DAYS4	NaN	NaN
READ_DAYS5	NaN	NaN
READ_DAYS6	NaN	NaN
READ_DAYS7	NaN	NaN
READ_DAYS8	NaN	NaN
READ_DAYS9	NaN	NaN
READ_DAYS10	NaN	NaN
READ_DAYS11	NaN	NaN
READ_DAYS12	NaN	NaN

In [43]:
```
#check the customer with LOC_ID of 1000012743 and 1000065066 in df2 and df3.
temp = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000065066], df2[df2.LOC_ID == 1000065066],
                                    df3[df3.LOC_ID == 1000065066],df1[df1.LOC_ID == 1000012743],
                                    df2[df2.LOC_ID == 1000012743], df3[df3.LOC_ID == 1000012743]],ax
is=0).T)

temp.columns = ['df1', 'df2','df3','df1', 'df2','df3']
temp['label'] = df2.columns
temp = temp[['label','df1', 'df2','df3']]
temp
```
Out[43]:

	label	df1	df1	df2	df2	df3	df3
0	LOC_ID	1000065066	1000012743	1000065066	1000012743	1000065066	1000012743
1	RATE	RDUPLX	RDUPLX	RDUPLX	RDUPLX	RDUPLX	RDUPLX
2	DWEL_UNIT	NaN	NaN	NaN	NaN	NaN	NaN
3	USE1	NaN	NaN	NaN	NaN	NaN	NaN
4	USE2	NaN	NaN	NaN	NaN	NaN	NaN
5	USE3	NaN	NaN	NaN	NaN	NaN	NaN
6	USE4	NaN	NaN	NaN	NaN	NaN	NaN
7	USE5	NaN	NaN	NaN	NaN	NaN	NaN
8	USE6	NaN	NaN	NaN	NaN	NaN	NaN
9	USE7	NaN	NaN	NaN	NaN	NaN	NaN
10	USE8	NaN	NaN	NaN	NaN	NaN	NaN
11	USE9	NaN	NaN	NaN	NaN	NaN	NaN
12	USE10	NaN	NaN	NaN	NaN	NaN	NaN
13	USE11	NaN	NaN	NaN	NaN	NaN	NaN
14	USE12	NaN	NaN	NaN	NaN	NaN	NaN
15	READ_DT1	NaT	NaT	NaT	NaT	NaT	NaT
16	READ_DT2	NaT	NaT	NaT	NaT	NaT	NaT
17	READ_DT3	NaT	NaT	NaT	NaT	NaT	NaT
18	READ_DT4	NaT	NaT	NaT	NaT	NaT	NaT
19	READ_DT5	NaT	NaT	NaT	NaT	NaT	NaT
20	READ_DT6	NaT	NaT	NaT	NaT	NaT	NaT
21	READ_DT7	NaT	NaT	NaT	NaT	NaT	NaT
22	READ_DT8	NaT	NaT	NaT	NaT	NaT	NaT
23	READ_DT9	NaT	NaT	NaT	NaT	NaT	NaT
24	READ_DT10	NaT	NaT	NaT	NaT	NaT	NaT
25	READ_DT11	NaT	NaT	NaT	NaT	NaT	NaT
26	READ_DT12	NaT	NaT	NaT	NaT	NaT	NaT
27	READ_DAYS1	NaN	NaN	NaN	NaN	NaN	NaN
28	READ_DAYS2	NaN	NaN	NaN	NaN	NaN	NaN
29	READ_DAYS3	NaN	NaN	NaN	NaN	NaN	NaN
30	READ_DAYS4	NaN	NaN	NaN	NaN	NaN	NaN
31	READ_DAYS5	NaN	NaN	NaN	NaN	NaN	NaN
32	READ_DAYS6	NaN	NaN	NaN	NaN	NaN	NaN
33	READ_DAYS7	NaN	NaN	NaN	NaN	NaN	NaN
34	READ_DAYS8	NaN	NaN	NaN	NaN	NaN	NaN
35	READ_DAYS9	NaN	NaN	NaN	NaN	NaN	NaN
36	READ_DAYS10	NaN	NaN	NaN	NaN	NaN	NaN
37	READ_DAYS11	NaN	NaN	NaN	NaN	NaN	NaN
38	READ_DAYS12	NaN	NaN	NaN	NaN	NaN	NaN

These two account of duplex group don't have any data in any dataframes, so let's drop them.

In [44]:
```
#Filter the null value of dwelling unit for residential duplex group in df2
df2[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT.isna())]
```
Out[44]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS
12743	1000012743	RDUPLX	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
65066	1000065066	RDUPLX	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na

2 rows × 39 columns

In [45]:
```
#check the customer with LOC_ID of 1000012743 and 1000065066 in df1 and df3.
temp = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000012743], df2[df2.LOC_ID == 1000012743],
                                    df3[df3.LOC_ID == 1000012743],
                                df1[df1.LOC_ID == 1000065066], df2[df2.LOC_ID == 1000065066],
                                    df3[df3.LOC_ID == 1000065066]],axis=0).T)

temp.columns = ['df1', 'df2','df3','df1', 'df2','df3']
temp['label'] = df2.columns
temp = temp[['label','df1', 'df2','df3']]
temp
```
Out[45]:

	label	df1	df1	df2	df2	df3	df3
0	LOC_ID	1000012743	1000065066	1000012743	1000065066	1000012743	1000065066
1	RATE	RDUPLX	RDUPLX	RDUPLX	RDUPLX	RDUPLX	RDUPLX
2	DWEL_UNIT	NaN	NaN	NaN	NaN	NaN	NaN
3	USE1	NaN	NaN	NaN	NaN	NaN	NaN
4	USE2	NaN	NaN	NaN	NaN	NaN	NaN
5	USE3	NaN	NaN	NaN	NaN	NaN	NaN
6	USE4	NaN	NaN	NaN	NaN	NaN	NaN
7	USE5	NaN	NaN	NaN	NaN	NaN	NaN
8	USE6	NaN	NaN	NaN	NaN	NaN	NaN
9	USE7	NaN	NaN	NaN	NaN	NaN	NaN
10	USE8	NaN	NaN	NaN	NaN	NaN	NaN
11	USE9	NaN	NaN	NaN	NaN	NaN	NaN
12	USE10	NaN	NaN	NaN	NaN	NaN	NaN
13	USE11	NaN	NaN	NaN	NaN	NaN	NaN
14	USE12	NaN	NaN	NaN	NaN	NaN	NaN
15	READ_DT1	NaT	NaT	NaT	NaT	NaT	NaT
16	READ_DT2	NaT	NaT	NaT	NaT	NaT	NaT
17	READ_DT3	NaT	NaT	NaT	NaT	NaT	NaT
18	READ_DT4	NaT	NaT	NaT	NaT	NaT	NaT
19	READ_DT5	NaT	NaT	NaT	NaT	NaT	NaT
20	READ_DT6	NaT	NaT	NaT	NaT	NaT	NaT
21	READ_DT7	NaT	NaT	NaT	NaT	NaT	NaT
22	READ_DT8	NaT	NaT	NaT	NaT	NaT	NaT
23	READ_DT9	NaT	NaT	NaT	NaT	NaT	NaT
24	READ_DT10	NaT	NaT	NaT	NaT	NaT	NaT
25	READ_DT11	NaT	NaT	NaT	NaT	NaT	NaT
26	READ_DT12	NaT	NaT	NaT	NaT	NaT	NaT
27	READ_DAYS1	NaN	NaN	NaN	NaN	NaN	NaN
28	READ_DAYS2	NaN	NaN	NaN	NaN	NaN	NaN
29	READ_DAYS3	NaN	NaN	NaN	NaN	NaN	NaN
30	READ_DAYS4	NaN	NaN	NaN	NaN	NaN	NaN
31	READ_DAYS5	NaN	NaN	NaN	NaN	NaN	NaN
32	READ_DAYS6	NaN	NaN	NaN	NaN	NaN	NaN
33	READ_DAYS7	NaN	NaN	NaN	NaN	NaN	NaN
34	READ_DAYS8	NaN	NaN	NaN	NaN	NaN	NaN
35	READ_DAYS9	NaN	NaN	NaN	NaN	NaN	NaN
36	READ_DAYS10	NaN	NaN	NaN	NaN	NaN	NaN
37	READ_DAYS11	NaN	NaN	NaN	NaN	NaN	NaN
38	READ_DAYS12	NaN	NaN	NaN	NaN	NaN	NaN

These two account of duplex group don't have any data in any dataframes, so let's drop them.

In [46]:
```
df3[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT.isna())]
```
Out[46]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS
12743	1000012743	RDUPLX	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
63905	1000063905	RDUPLX	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
65066	1000065066	RDUPLX	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na

3 rows × 39 columns

In [47]:
```
#check the customer with LOC_ID of 1000012743,1000063905 and 1000065066 in df1 and df2.
temp = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000012743], df2[df2.LOC_ID == 1000012743],
                                    df3[df3.LOC_ID == 1000012743],
                                  df1[df1.LOC_ID == 1000063905], df2[df2.LOC_ID == 1000063905],
                                    df3[df3.LOC_ID == 1000063905],
                                 df1[df1.LOC_ID == 1000065066], df2[df2.LOC_ID == 1000065066],
                                    df3[df3.LOC_ID == 1000065066]],axis=0).T)

temp.columns = ['df1', 'df2','df3','df1', 'df2','df3','df1', 'df2','df3']
temp['label'] = df2.columns
temp = temp[['label','df1', 'df2','df3']]
temp
```
Out[47]:

	label	df1	df1	df1	df2	df2	df2	df3	df3	df3
0	LOC_ID	1000012743	1000063905	1000065066	1000012743	1000063905	1000065066	1000012743	1000063905	1000065066
1	RATE	RDUPLX	RSFD	RDUPLX	RDUPLX	RSFD	RDUPLX	RDUPLX	RDUPLX	RDUPLX
2	DWEL_UNIT	NaN	1	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	USE1	NaN	11	NaN	NaN	NaN	NaN	NaN	NaN	NaN
4	USE2	NaN	12	NaN	NaN	NaN	NaN	NaN	NaN	NaN
5	USE3	NaN	10	NaN	NaN	NaN	NaN	NaN	NaN	NaN
6	USE4	NaN	9	NaN	NaN	NaN	NaN	NaN	NaN	NaN
7	USE5	NaN	9	NaN	NaN	NaN	NaN	NaN	NaN	NaN
8	USE6	NaN	8	NaN	NaN	NaN	NaN	NaN	NaN	NaN
9	USE7	NaN	10	NaN	NaN	NaN	NaN	NaN	NaN	NaN
10	USE8	NaN	8	NaN	NaN	NaN	NaN	NaN	NaN	NaN
11	USE9	NaN	10	NaN	NaN	NaN	NaN	NaN	NaN	NaN
12	USE10	NaN	8	NaN	NaN	NaN	NaN	NaN	NaN	NaN
13	USE11	NaN	9	NaN	NaN	NaN	NaN	NaN	NaN	NaN
14	USE12	NaN	8	NaN	NaN	NaN	NaN	NaN	NaN	NaN
15	READ_DT1	NaT	2018-07-30 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
16	READ_DT2	NaT	2018-06-27 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
17	READ_DT3	NaT	2018-05-30 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
18	READ_DT4	NaT	2018-04-30 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
19	READ_DT5	NaT	2018-03-30 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
20	READ_DT6	NaT	2018-03-01 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
21	READ_DT7	NaT	2018-01-30 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
22	READ_DT8	NaT	2017-12-28 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
23	READ_DT9	NaT	2017-11-28 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
24	READ_DT10	NaT	2017-10-26 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
25	READ_DT11	NaT	2017-09-27 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
26	READ_DT12	NaT	2017-08-28 00:00:00	NaT	NaT	NaT	NaT	NaT	NaT	NaT
27	READ_DAYS1	NaN	33	NaN	NaN	NaN	NaN	NaN	NaN	NaN
28	READ_DAYS2	NaN	28	NaN	NaN	NaN	NaN	NaN	NaN	NaN
29	READ_DAYS3	NaN	30	NaN	NaN	NaN	NaN	NaN	NaN	NaN
30	READ_DAYS4	NaN	31	NaN	NaN	NaN	NaN	NaN	NaN	NaN
31	READ_DAYS5	NaN	29	NaN	NaN	NaN	NaN	NaN	NaN	NaN
32	READ_DAYS6	NaN	30	NaN	NaN	NaN	NaN	NaN	NaN	NaN
33	READ_DAYS7	NaN	33	NaN	NaN	NaN	NaN	NaN	NaN	NaN
34	READ_DAYS8	NaN	30	NaN	NaN	NaN	NaN	NaN	NaN	NaN
35	READ_DAYS9	NaN	33	NaN	NaN	NaN	NaN	NaN	NaN	NaN
36	READ_DAYS10	NaN	29	NaN	NaN	NaN	NaN	NaN	NaN	NaN
37	READ_DAYS11	NaN	30	NaN	NaN	NaN	NaN	NaN	NaN	NaN
38	READ_DAYS12	NaN	31	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Let's drop all these accounts since they are not informative

In [48]:
```
df1 = df1[(df1.LOC_ID  != 1000065066) & (df1.LOC_ID  != 1000012743) &
          (df1.LOC_ID  != 1000012743) & (df1.LOC_ID  != 1000065066) &
          (df1.LOC_ID  != 1000012743) & (df1.LOC_ID  != 1000063905) & (df1.LOC_ID  != 1000065066)]


df2 = df2[(df2.LOC_ID  != 1000065066) & (df2.LOC_ID  != 1000012743) &
          (df2.LOC_ID  != 1000012743) & (df2.LOC_ID  != 1000065066) &
          (df2.LOC_ID  != 1000012743) & (df2.LOC_ID  != 1000063905) & (df2.LOC_ID  != 1000065066)]

df3 = df3[(df3.LOC_ID  != 1000065066) & (df3.LOC_ID  != 1000012743) &
          (df3.LOC_ID  != 1000012743) & (df3.LOC_ID  != 1000065066) &
          (df3.LOC_ID  != 1000012743) & (df3.LOC_ID  != 1000063905) & (df3.LOC_ID  != 1000065066)]
```

In [49]:
```
#Check the value of Dwelling units for Duplex houses
temp = df1[(df1.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[49]:
```
2.0    1.0
Name: DWEL_UNIT, dtype: float64
```

In [50]:
```
#Check the value of Dwelling units for Duplex houses
temp = df2[(df2.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[50]:
```
2.0    0.854485
1.0    0.145377
3.0    0.000138
Name: DWEL_UNIT, dtype: float64
```

In [51]:
```
#For duplex group with number of dwelling unit of 3, set the number of dwelling unit to 2
df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 3),'DWEL_UNIT']= 2
```

In [52]:
```
#For duplex group with number of dwelling unit of 1, set the number of dwelling unit to 2 and double th
e amount of usage.
df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE1'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE1']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE2'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE2']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE3'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE3']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE4'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE4']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE5'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE5']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE6'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE6']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE7'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE7']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE8'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE8']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE9'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE9']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE10'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE10']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE11'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE11']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE12'] = 2*\
    df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'USE12']

df2.loc[(df2.RATE == 'RDUPLX') & (df2.DWEL_UNIT == 1),'DWEL_UNIT'] = 2
```

In [53]:
```
#Check the value of Dwelling units for Duplex houses
temp = df2[(df2.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[53]:
```
2.0    1.0
Name: DWEL_UNIT, dtype: float64
```

In [54]:
```
#Check the value of Dwelling units for Duplex houses
temp = df3[(df3.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[54]:
```
2.0    0.850899
1.0    0.148829
3.0    0.000272
Name: DWEL_UNIT, dtype: float64
```

In [55]:
```
#For duplex group with number of dwelling unit of 3, set the number of dwelling unit to 2
df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 3),'DWEL_UNIT']= 2
```

In [56]:
```
#For duplex group with number of dwelling unit of 1, set the number of dwelling unit to 2 and double th
e amount of usage.
df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE1'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE1']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE2'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE2']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE3'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE3']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE4'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE4']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE5'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE5']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE6'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE6']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE7'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE7']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE8'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE8']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE9'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE9']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE10'] = 2*\
    df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE10']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE11'] = 2*\
    df3.loc[(df2.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE11']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE12'] = 2*\
    df3.loc[(df2.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'USE12']

df3.loc[(df3.RATE == 'RDUPLX') & (df3.DWEL_UNIT == 1),'DWEL_UNIT'] = 2
```

In [57]:
```
#Check the value of Dwelling units for Duplex houses
temp = df3[(df3.RATE == 'RDUPLX')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[57]:
```
2.0    1.0
Name: DWEL_UNIT, dtype: float64
```

Now all dwelling units in Duplex group are 2.

4.2.1.4) Fill Nan of dwelling unit colum for RATE of residential single family

In [58]:
```
temp = df1[(df1.RATE == 'RSFD')]
temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```
Out[58]:
```
1.0    0.999610
2.0    0.000279
0.0    0.000056
NaN    0.000037
3.0    0.000019
Name: DWEL_UNIT, dtype: float64
```

In [59]:
```
#Check the single family house with zero dwelling unit
df1[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 0)]
```
Out[59]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
2168	1000002168	RSFD	0.0	1.0	1.0	2.0	2.0	1.0	1.0	2.0	...	32.0	29.0	29.0
2901	1000002901	RSFD	0.0	110.0	52.0	29.0	38.0	36.0	41.0	36.0	...	29.0	29.0	29.0
31101	1000031101	RSFD	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	...	29.0	29.0	29.0

3 rows × 39 columns

In [60]:
```
df2[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 0)]
```
Out[60]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
2168	1000002168	RSFD	0.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	...	32.0	30.0	29.0
2901	1000002901	RSFD	0.0	48.0	25.0	39.0	81.0	29.0	39.0	47.0	...	30.0	29.0	28.0
31101	1000031101	RSFD	0.0	5.0	1.0	1.0	0.0	1.0	0.0	0.0	...	29.0	30.0	28.0

3 rows × 39 columns

In [61]:
```
df3[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 0)]
```
Out[61]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
2168	1000002168	RSFD	0.0	3.0	3.0	4.0	5.0	2.0	2.0	2.0	...	29.0	31.0	29.0
2901	1000002901	RSFD	0.0	33.0	24.0	26.0	31.0	31.0	15.0	45.0	...	30.0	32.0	28.0
31101	1000031101	RSFD	0.0	6.0	7.0	3.0	1.0	1.0	0.0	0.0	...	32.0	30.0	29.0

3 rows × 39 columns

LOC_ID of '1000002168', '1000002901' and '1000031101' have data and they are informative. Also, these accounts belong to single family group, so I can set the value of their dwelling unit one.

In [62]:
```
df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 0),'DWEL_UNIT'] = 1
df2.loc[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 0),'DWEL_UNIT'] = 1
df3.loc[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 0),'DWEL_UNIT'] = 1
```

In [63]:
```
#Check the single family house with 2 dwellings
df1[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 2)]
```
Out[63]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
1959	1000001959	RSFD	2.0	22.0	26.0	23.0	22.0	23.0	27.0	29.0	...	29.0	29.0	32.0
5070	1000005070	RSFD	2.0	5.0	9.0	10.0	13.0	5.0	22.0	7.0	...	29.0	29.0	32.0
5946	1000005946	RSFD	2.0	22.0	21.0	18.0	19.0	18.0	21.0	15.0	...	32.0	29.0	29.0
7298	1000007298	RSFD	2.0	18.0	30.0	21.0	21.0	17.0	16.0	15.0	...	32.0	29.0	29.0
7835	1000007835	RSFD	2.0	5.0	11.0	6.0	6.0	3.0	5.0	5.0	...	30.0	29.0	31.0
25927	1000025927	RSFD	2.0	9.0	9.0	9.0	7.0	8.0	9.0	7.0	...	32.0	29.0	29.0
29443	1000029443	RSFD	2.0	19.0	15.0	17.0	15.0	11.0	11.0	12.0	...	32.0	29.0	29.0
31848	1000031848	RSFD	2.0	14.0	14.0	18.0	15.0	15.0	14.0	18.0	...	30.0	29.0	31.0
35104	1000035104	RSFD	2.0	10.0	9.0	9.0	10.0	12.0	16.0	14.0	...	32.0	29.0	29.0
46745	1000046745	RSFD	2.0	15.0	15.0	15.0	14.0	15.0	17.0	10.0	...	32.0	29.0	29.0
50331	1000050331	RSFD	2.0	5.0	5.0	4.0	4.0	6.0	5.0	5.0	...	29.0	29.0	32.0
51160	1000051160	RSFD	2.0	25.0	35.0	36.0	31.0	9.0	8.0	10.0	...	29.0	29.0	29.0
66500	1000066500	RSFD	2.0	10.0	8.0	10.0	8.0	10.0	10.0	12.0	...	31.0	29.0	29.0
68845	1000068845	RSFD	2.0	6.0	9.0	9.0	8.0	10.0	8.0	10.0	...	29.0	29.0	32.0
70919	1000070919	RSFD	2.0	6.0	6.0	5.0	4.0	4.0	5.0	5.0	...	32.0	29.0	29.0

15 rows × 39 columns

It seems the number of dwelling units are incorrectly recorded and they have 1 dwelling, since the amount of usage is similar to the one dwelling's usage.

In [64]:
```
df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 2) ,'DWEL_UNIT'] = 1
```

In [65]:
```
df1[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3)]
```
Out[65]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
9349	1000009349	RSFD	3.0	46.0	65.0	70.0	39.0	38.0	42.0	35.0	...	29.0	29.0	30.0

1 rows × 39 columns

In [66]:
```
#For single family group with number of dwelling unit of 3, set the number of dwelling unit to 1
#and divide the amount of usage by 3.
df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE1'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE1'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE2'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE2'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE2'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE2'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE3'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE3'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE4'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE4'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE5'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE5'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE6'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE6'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE7'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE7'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE8'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE8'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE9'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE9'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE10'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE10'] /3


df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE11'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE11'] /3

df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE12'] = \
    df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3),'USE12'] /3


df1.loc[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT == 3) ,'DWEL_UNIT'] = 1
```

In [67]:
```
#Filter the null value of dwelling unit for residential duplex group
df1[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT.isna())]
```
Out[67]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
17509	1000017509	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
35946	1000035946	RSFD	NaN	365.0	25.0	26.0	20.0	16.0	20.0	25.0	...	NaN	NaN	NaN

2 rows × 39 columns

In [68]:
```
#check the customer with LOC_ID of 1000017509 and 1000035946 in df2 and df3.
temp = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000017509], df2[df2.LOC_ID == 1000017509],
                                    df3[df3.LOC_ID == 1000017509],df1[df1.LOC_ID == 1000035946],
                                    df2[df2.LOC_ID == 1000035946], df3[df3.LOC_ID == 1000035946]],ax
is=0).T)

temp.columns = ['df1', 'df2','df3','df1','df2','df3']
temp['label'] = df2.columns
temp = temp[['label','df1','df2','df3']]
temp
```
Out[68]:

	label	df1	df1	df2	df2	df3	df3
0	LOC_ID	1000017509	1000035946	1000017509	1000035946	1000017509	1000035946
1	RATE	RSFD	RSFD	RSFD	RSFD	RSFD	RSFD
2	DWEL_UNIT	NaN	NaN	NaN	NaN	NaN	NaN
3	USE1	NaN	365	NaN	NaN	NaN	NaN
4	USE2	NaN	25	NaN	NaN	NaN	NaN
5	USE3	NaN	26	NaN	0	NaN	0
6	USE4	NaN	20	NaN	1	NaN	0
7	USE5	NaN	16	NaN	2	NaN	0
8	USE6	NaN	20	NaN	0	NaN	2
9	USE7	NaN	25	NaN	0	NaN	1
10	USE8	NaN	21	NaN	0	NaN	6
11	USE9	NaN	20	NaN	0	NaN	10
12	USE10	NaN	19	NaN	1	NaN	4
13	USE11	NaN	24	NaN	3	NaN	4
14	USE12	NaN	23	NaN	4	NaN	1
15	READ_DT1	NaT	NaT	NaT	NaT	NaT	NaT
16	READ_DT2	NaT	NaT	NaT	2019-07-10 00:00:00	NaT	2020-07-12 00:00:00
17	READ_DT3	NaT	NaT	NaT	2019-06-11 00:00:00	NaT	2020-06-10 00:00:00
18	READ_DT4	NaT	NaT	NaT	2019-05-10 00:00:00	NaT	2020-05-11 00:00:00
19	READ_DT5	NaT	NaT	NaT	2019-04-11 00:00:00	NaT	2020-04-12 00:00:00
20	READ_DT6	NaT	NaT	NaT	2019-03-13 00:00:00	NaT	2020-03-12 00:00:00
21	READ_DT7	NaT	NaT	NaT	2019-02-11 00:00:00	NaT	2020-02-10 00:00:00
22	READ_DT8	NaT	NaT	NaT	2019-01-10 00:00:00	NaT	2020-01-10 00:00:00
23	READ_DT9	NaT	NaT	NaT	2018-12-10 00:00:00	NaT	2019-12-10 00:00:00
24	READ_DT10	NaT	NaT	NaT	2018-11-06 00:00:00	NaT	2019-11-06 00:00:00
25	READ_DT11	NaT	NaT	NaT	2018-10-09 00:00:00	NaT	2019-10-08 00:00:00
26	READ_DT12	NaT	NaT	NaT	2018-09-10 00:00:00	NaT	2019-09-11 00:00:00
27	READ_DAYS1	NaN	NaN	NaN	1	NaN	1
28	READ_DAYS2	NaN	NaN	NaN	29	NaN	32
29	READ_DAYS3	NaN	NaN	NaN	32	NaN	30
30	READ_DAYS4	NaN	NaN	NaN	29	NaN	29
31	READ_DAYS5	NaN	NaN	NaN	29	NaN	31
32	READ_DAYS6	NaN	NaN	NaN	30	NaN	31
33	READ_DAYS7	NaN	NaN	NaN	32	NaN	31
34	READ_DAYS8	NaN	NaN	NaN	31	NaN	31
35	READ_DAYS9	NaN	NaN	NaN	34	NaN	34
36	READ_DAYS10	NaN	NaN	NaN	28	NaN	29
37	READ_DAYS11	NaN	NaN	NaN	29	NaN	27
38	READ_DAYS12	NaN	NaN	NaN	33	NaN	33

There is no data for LOC_ID of '1000017509', and account '1000035946' mostly has no value or value of zero. Let' drop them since they are informative'

In [69]:
```
#Filter the null value of dwelling unit for residential duplex group in df2
df2[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT.isna())]
```
Out[69]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
17509	1000017509	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
35946	1000035946	RSFD	NaN	NaN	NaN	0.0	1.0	2.0	0.0	0.0	...	32.0	29.0	29.0

2 rows × 39 columns

Again LOC_ID '1000017509', and '1000035946', I will drop them.

In [70]:
```
#Filter the null value of dwelling unit for residential duplex group in df3
df3[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT.isna())]
```
Out[70]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
17509	1000017509	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
24304	1000024304	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
35946	1000035946	RSFD	NaN	NaN	NaN	0.0	0.0	0.0	2.0	1.0	...	30.0	29.0	31.0
54741	1000054741	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
62574	1000062574	RSFD	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN

5 rows × 39 columns

In [71]:
```
#check the customer with LOC_ID of 1000024304, 1000054741 and 1000062574 in df1 and df2.
temp = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000024304], df2[df2.LOC_ID == 1000024304],
                                    df3[df3.LOC_ID == 1000024304],df1[df1.LOC_ID == 1000054741],
                                    df2[df2.LOC_ID == 1000054741], df3[df3.LOC_ID == 1000054741],
                                    df1[df1.LOC_ID == 1000062574], df2[df2.LOC_ID == 1000062574],
                                    df3[df3.LOC_ID == 1000062574]],axis=0).T)

temp.columns = ['df1', 'df2','df3','df1','df2','df3','df1','df2','df3']
temp['label'] = df2.columns
temp = temp[['label','df1','df2','df3']]
temp
```
Out[71]:

	label	df1	df1	df1	df2	df2	df2	df3	df3	df3
0	LOC_ID	1000024304	1000054741	1000062574	1000024304	1000054741	1000062574	1000024304	1000054741	1000062574
1	RATE	RSFD	RSFD	RSFD	RSFD	RSFD	RSFD	RSFD	RSFD	RSFD
2	DWEL_UNIT	1	1	1	1	1	1	NaN	NaN	NaN
3	USE1	18	24	6	8	9	6	NaN	NaN	NaN
4	USE2	25	21	6	11	7	6	NaN	NaN	NaN
5	USE3	17	8	6	8	15	5	NaN	NaN	NaN
6	USE4	13	7	4	9	7	5	NaN	NaN	NaN
7	USE5	16	9	6	34	5	6	NaN	NaN	NaN
8	USE6	17	14	5	12	4	6	NaN	NaN	NaN
9	USE7	14	10	6	16	8	6	NaN	NaN	NaN
10	USE8	12	15	6	17	6	5	NaN	NaN	NaN
11	USE9	18	8	6	16	8	6	NaN	NaN	NaN
12	USE10	NaN	7	5	17	8	5	NaN	NaN	NaN
13	USE11	NaN	12	5	15	7	6	NaN	NaN	NaN
14	USE12	NaN	8	5	14	12	5	NaN	NaN	NaN
15	READ_DT1	2018-07-17 00:00:00	2018-07-17 00:00:00	2018-07-17 00:00:00	2019-07-16 00:00:00	2019-07-17 00:00:00	2019-07-17 00:00:00	NaT	NaT	NaT
16	READ_DT2	2018-06-15 00:00:00	2018-06-15 00:00:00	2018-06-15 00:00:00	2019-06-17 00:00:00	2019-06-17 00:00:00	2019-06-17 00:00:00	NaT	NaT	NaT
17	READ_DT3	2018-05-16 00:00:00	2018-05-16 00:00:00	2018-05-16 00:00:00	2019-05-15 00:00:00	2019-05-16 00:00:00	2019-05-16 00:00:00	NaT	NaT	NaT
18	READ_DT4	2018-04-17 00:00:00	2018-04-17 00:00:00	2018-04-17 00:00:00	2019-04-16 00:00:00	2019-04-17 00:00:00	2019-04-17 00:00:00	NaT	NaT	NaT
19	READ_DT5	2018-03-19 00:00:00	2018-03-19 00:00:00	2018-03-19 00:00:00	2019-03-18 00:00:00	2019-03-19 00:00:00	2019-03-19 00:00:00	NaT	NaT	NaT
20	READ_DT6	2018-02-15 00:00:00	2018-02-15 00:00:00	2018-02-15 00:00:00	2019-02-15 00:00:00	2019-02-15 00:00:00	2019-02-15 00:00:00	NaT	NaT	NaT
21	READ_DT7	2018-01-17 00:00:00	2018-01-17 00:00:00	2018-01-17 00:00:00	2019-01-16 00:00:00	2019-01-16 00:00:00	2019-01-16 00:00:00	NaT	NaT	NaT
22	READ_DT8	2017-12-14 00:00:00	2017-12-14 00:00:00	2017-12-14 00:00:00	2018-12-14 00:00:00	2018-12-14 00:00:00	2018-12-14 00:00:00	NaT	NaT	NaT
23	READ_DT9	2017-11-13 00:00:00	2017-11-13 00:00:00	2017-11-13 00:00:00	2018-11-13 00:00:00	2018-11-13 00:00:00	2018-11-13 00:00:00	NaT	NaT	NaT
24	READ_DT10	NaT	2017-10-13 00:00:00	2017-10-13 00:00:00	2018-10-15 00:00:00	2018-10-15 00:00:00	2018-10-15 00:00:00	NaT	NaT	NaT
25	READ_DT11	NaT	2017-09-14 00:00:00	2017-09-14 00:00:00	2018-09-14 00:00:00	2018-09-14 00:00:00	2018-09-14 00:00:00	NaT	NaT	NaT
26	READ_DT12	NaT	2017-08-15 00:00:00	2017-08-15 00:00:00	2018-08-15 00:00:00	2018-08-15 00:00:00	2018-08-15 00:00:00	NaT	NaT	NaT
27	READ_DAYS1	32	32	32	29	30	30	NaN	NaN	NaN
28	READ_DAYS2	30	30	30	33	32	32	NaN	NaN	NaN
29	READ_DAYS3	29	29	29	29	29	29	NaN	NaN	NaN
30	READ_DAYS4	29	29	29	29	29	29	NaN	NaN	NaN
31	READ_DAYS5	32	32	32	31	32	32	NaN	NaN	NaN
32	READ_DAYS6	29	29	29	30	30	30	NaN	NaN	NaN
33	READ_DAYS7	34	34	34	33	33	33	NaN	NaN	NaN
34	READ_DAYS8	31	31	31	31	31	31	NaN	NaN	NaN
35	READ_DAYS9	38	31	31	29	29	29	NaN	NaN	NaN
36	READ_DAYS10	NaN	29	29	31	31	31	NaN	NaN	NaN
37	READ_DAYS11	NaN	30	30	30	30	30	NaN	NaN	NaN
38	READ_DAYS12	NaN	29	29	29	29	29	NaN	NaN	NaN

In [72]:
```
df1 = df1[(df1.LOC_ID  != 1000017509) & (df1.LOC_ID  != 1000035946) &
          (df1.LOC_ID  != 1000024304) & (df1.LOC_ID  != 1000054741) &
          (df1.LOC_ID  != 1000062574)]

df2 = df2[(df2.LOC_ID  != 1000017509) & (df2.LOC_ID  != 1000035946) &
          (df2.LOC_ID  != 1000024304) & (df2.LOC_ID  != 1000054741) &
          (df2.LOC_ID  != 1000062574)]

df3 = df3[(df3.LOC_ID  != 1000017509) & (df3.LOC_ID  != 1000035946) &
          (df3.LOC_ID  != 1000024304) & (df3.LOC_ID  != 1000054741) &
          (df3.LOC_ID  != 1000062574)]
```

```
In [73]: temp = df1[(df1.RATE == 'RSFD')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[73]: 1.0    1.0
         Name: DWEL_UNIT, dtype: float64
```

```
In [74]: temp = df2[(df2.RATE == 'RSFD')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[74]: 1.0    0.999703
         2.0    0.000279
         4.0    0.000019
         Name: DWEL_UNIT, dtype: float64
```

```
In [75]: df2[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 2)]
```

Out[75]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
1959	1000001959	RSFD	2.0	26.0	30.0	27.0	22.0	9.0	11.0	24.0	...	28.0	30.0	31.0
5070	1000005070	RSFD	2.0	7.0	7.0	6.0	6.0	6.0	6.0	5.0	...	28.0	30.0	31.0
5946	1000005946	RSFD	2.0	41.0	29.0	14.0	16.0	13.0	19.0	19.0	...	32.0	29.0	29.0
7298	1000007298	RSFD	2.0	23.0	18.0	17.0	18.0	7.0	8.0	12.0	...	30.0	31.0	29.0
7835	1000007835	RSFD	2.0	5.0	5.0	5.0	3.0	3.0	6.0	5.0	...	31.0	28.0	29.0
25927	1000025927	RSFD	2.0	12.0	11.0	11.0	9.0	7.0	8.0	9.0	...	32.0	29.0	29.0
29443	1000029443	RSFD	2.0	17.0	14.0	13.0	13.0	10.0	8.0	12.0	...	32.0	29.0	29.0
31848	1000031848	RSFD	2.0	29.0	38.0	33.0	47.0	36.0	106.0	100.0	...	30.0	29.0	26.0
35104	1000035104	RSFD	2.0	8.0	9.0	10.0	9.0	6.0	7.0	10.0	...	30.0	31.0	30.0
46745	1000046745	RSFD	2.0	11.0	10.0	13.0	11.0	10.0	12.0	10.0	...	32.0	29.0	29.0
50331	1000050331	RSFD	2.0	7.0	6.0	6.0	6.0	5.0	5.0	8.0	...	30.0	29.0	31.0
51160	1000051160	RSFD	2.0	29.0	26.0	24.0	25.0	9.0	21.0	20.0	...	31.0	29.0	29.0
66500	1000066500	RSFD	2.0	11.0	10.0	8.0	9.0	8.0	10.0	11.0	...	29.0	31.0	29.0
68845	1000068845	RSFD	2.0	8.0	10.0	8.0	8.0	8.0	24.0	30.0	...	29.0	29.0	29.0
70919	1000070919	RSFD	2.0	6.0	8.0	5.0	4.0	5.0	5.0	5.0	...	29.0	31.0	30.0

15 rows × 39 columns

It seems the number of dwelling units are incorrectly recorded and they have 1 dwelling, since the amount of usage is similar to the one dwelling's usage.

```
In [76]: df2.loc[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 2) ,'DWEL_UNIT'] = 1
```

```
In [77]: df2[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 4)]
```

Out[77]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
9349	1000009349	RSFD	4.0	19.0	31.0	29.0	31.0	31.0	37.0	37.0	...	31.0	30.0	29.0

1 rows × 39 columns

```
In [78]: df2.loc[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT == 4) ,'DWEL_UNIT'] = 1
```

```
In [79]: temp = df2[(df2.RATE == 'RSFD')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[79]: 1.0    1.0
         Name: DWEL_UNIT, dtype: float64
```

```
In [80]: temp = df3[(df3.RATE == 'RSFD')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[80]: 1.0    0.999702
         2.0    0.000279
         4.0    0.000019
         Name: DWEL_UNIT, dtype: float64
```

```
In [81]: df3[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 4)]
```

Out[81]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
9349	1000009349	RSFD	4.0	30.0	29.0	29.0	28.0	21.0	21.0	26.0	...	29.0	31.0	30.0

1 rows × 39 columns

```
In [82]: df3.loc[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 4) ,'DWEL_UNIT'] = 1
```

```
In [83]: df3[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 2)]
```

Out[83]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
1959	1000001959	RSFD	2.0	24.0	25.0	22.0	14.0	19.0	26.0	18.0	...	29.0	29.0	29.0
5070	1000005070	RSFD	2.0	3.0	1.0	8.0	6.0	8.0	9.0	7.0	...	29.0	29.0	29.0
5946	1000005946	RSFD	2.0	24.0	31.0	23.0	17.0	11.0	10.0	11.0	...	30.0	31.0	29.0
7298	1000007298	RSFD	2.0	19.0	19.0	19.0	16.0	14.0	13.0	8.0	...	30.0	29.0	31.0
7835	1000007835	RSFD	2.0	5.0	5.0	4.0	3.0	2.0	2.0	2.0	...	32.0	29.0	29.0
25927	1000025927	RSFD	2.0	12.0	12.0	13.0	14.0	14.0	12.0	13.0	...	30.0	31.0	29.0
29443	1000029443	RSFD	2.0	21.0	21.0	19.0	15.0	11.0	11.0	12.0	...	30.0	31.0	29.0
31848	1000031848	RSFD	2.0	14.0	19.0	19.0	17.0	15.0	14.0	17.0	...	32.0	29.0	29.0
35104	1000035104	RSFD	2.0	10.0	9.0	9.0	7.0	7.0	6.0	9.0	...	30.0	28.0	31.0
46745	1000046745	RSFD	2.0	12.0	10.0	9.0	8.0	12.0	12.0	19.0	...	30.0	29.0	31.0
50331	1000050331	RSFD	2.0	6.0	5.0	6.0	3.0	5.0	8.0	5.0	...	29.0	29.0	29.0
51160	1000051160	RSFD	2.0	20.0	22.0	17.0	20.0	8.0	16.0	12.0	...	29.0	28.0	32.0
66500	1000066500	RSFD	2.0	15.0	14.0	14.0	13.0	13.0	11.0	14.0	...	29.0	29.0	31.0
68845	1000068845	RSFD	2.0	9.0	10.0	13.0	11.0	11.0	11.0	12.0	...	29.0	31.0	29.0
70919	1000070919	RSFD	2.0	3.0	5.0	4.0	5.0	5.0	4.0	7.0	...	30.0	28.0	31.0

15 rows × 39 columns

It seems the number of dwelling units are incorrectly recorded and they have 1 dwelling, since the amount of usage is similar to the one dwelling's usage.

```
In [84]: df3.loc[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT == 2) ,'DWEL_UNIT'] = 1
```

```
In [85]: temp = df3[(df3.RATE == 'RSFD')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[85]: 1.0    1.0
         Name: DWEL_UNIT, dtype: float64
```

Now all dwelling units in single family group have value of 1.

4.2.2) Filter the accounts in multifamily group with dwelling unit with null value.

```
In [86]: temp = df1[(df1.RATE == 'RMF')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[86]: 4.0      0.240540
         3.0      0.169509
         1.0      0.103219
         8.0      0.082885
         6.0      0.067566
                    ...
         92.0     0.000091
         120.0    0.000091
         201.0    0.000091
         91.0     0.000091
         183.0    0.000091
         Name: DWEL_UNIT, Length: 126, dtype: float64
```

```
In [87]: df2[(df2.RATE == 'RMF') & (df2.DWEL_UNIT.isna())]
```

Out[87]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
52668	1000052668	RMF	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN

1 rows × 39 columns

```
In [88]: df3[(df3.RATE == 'RMF') & (df3.DWEL_UNIT.isna())]
```

Out[88]:

	LOC_ID	RATE	DWEL_UNIT	USE1	USE2	USE3	USE4	USE5	USE6	USE7	...	READ_DAYS3	READ_DAYS4	READ_DAYS5
52668	1000052668	RMF	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN

1 rows × 39 columns

```
In [89]: df1 = df1[(df1.LOC_ID  != 1000052668)]
         df2 = df2[(df2.LOC_ID  != 1000052668)]
         df3 = df3[(df3.LOC_ID  != 1000052668)]
```

```
In [90]: temp = df1[(df1.RATE == 'RMF')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[90]: 4.0      0.240562
         3.0      0.169433
         1.0      0.103228
         8.0      0.082893
         6.0      0.067572
                    ...
         92.0     0.000091
         120.0    0.000091
         201.0    0.000091
         91.0     0.000091
         183.0    0.000091
         Name: DWEL_UNIT, Length: 126, dtype: float64
```

```
In [91]: temp = df2[(df1.RATE == 'RMF')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[91]: 4.0      0.240744
         3.0      0.169524
         1.0      0.103411
         8.0      0.082801
         6.0      0.067572
                    ...
         92.0     0.000091
         120.0    0.000091
         201.0    0.000091
         91.0     0.000091
         183.0    0.000091
         Name: DWEL_UNIT, Length: 126, dtype: float64
```

```
In [92]: temp = df2[(df1.RATE == 'RMF')]
         temp.DWEL_UNIT.value_counts(dropna= False, normalize= True)
```

```
Out[92]: 4.0      0.240744
         3.0      0.169524
         1.0      0.103411
         8.0      0.082801
         6.0      0.067572
                    ...
         92.0     0.000091
         120.0    0.000091
         201.0    0.000091
         91.0     0.000091
         183.0    0.000091
         Name: DWEL_UNIT, Length: 126, dtype: float64
```

There is no Null value in dwelling unit column of multifamily group in all 3 dataframes.

4.2.2) Filter the dwelling unit with zero value

```
In [93]: #Filter the RATEs that their dwelling units are zero.
         print(df1[df1.DWEL_UNIT == 0]['RATE'].unique())
         print(df2[df2.DWEL_UNIT == 0]['RATE'].unique())
         print(df3[df3.DWEL_UNIT == 0]['RATE'].unique())

         [IND]
         Categories (1, object): [IND]
         [IND]
         Categories (1, object): [IND]
         [IND]
         Categories (1, object): [IND]
```

Industrial group has some accounts with dwelling unit of zero. Let's look at them.

4.2.2.1) Accounts in Industrial group with zero dwelling

```
In [94]: #Check the number of null in DWEL_UNIT column with the RATE of Industrial in df1.
         print(df1[df1.RATE == 'IND']['DWEL_UNIT'].isna().sum())

         #Caculate sum of DWEL_UNIT with the RATE of Industrial.
         print(df1[df1.RATE == 'IND']['DWEL_UNIT'].sum())

         0
         0.0
```

```
In [95]: #Check the number of null in DWEL_UNIT column with the RATE of Industrial in df2.
         print(df2[df2.RATE == 'IND']['DWEL_UNIT'].isna().sum())

         #Caculate sum of DWEL_UNIT with the RATE of Industrial.
         print(df2[df2.RATE == 'IND']['DWEL_UNIT'].sum())

         0
         0.0
```

```
In [96]: #Check the number of null in DWEL_UNIT column with the RATE of Industrial in df3.
         print(df3[df3.RATE == 'IND']['DWEL_UNIT'].isna().sum())

         #Caculate sum of DWEL_UNIT with the RATE of Industrial.
         print(df3[df3.RATE == 'IND']['DWEL_UNIT'].sum())

         0
         0.0
```

Number of dwelling units for industrial customers in all three dataframes is zero. Let's set the value one for dwelling units of industrial customers.

```
In [97]: #Set the value one for dwelling units of industrial customers.
         df1.loc[df1.RATE == 'IND','DWEL_UNIT']= 1
         df2.loc[df2.RATE == 'IND','DWEL_UNIT']= 1
         df3.loc[df3.RATE == 'IND','DWEL_UNIT']= 1
```

```
In [98]: #Filter the RATEs that their dwelling units are zero.
         print(len(df1[df1.DWEL_UNIT == 0]))
         print(len(df2[df2.DWEL_UNIT == 0]))
         print(len(df3[df3.DWEL_UNIT == 0]))

         0
         0
         0
```

There is no zero value in dwelling unit column in all 3 dataframes.

5) What is the market share of different RATE?

```
In [99]: def count(data,rate:str):
             '''this function takes the type of customer and returns the
              number of customer, number and percentage of missing values associated to.'''

             temp = data[data.RATE == rate]

             number = temp['DWEL_UNIT'].sum()
             missing_num = temp['DWEL_UNIT'].isna().sum()
             missing_per = round(100* temp['DWEL_UNIT'].isna().sum()/len(df1), 2)

             return(number, missing_num, missing_per )
```

df1

```
In [100]: #Calculate the market share of each Rate in first year, the number of Rate based on the number of Dwel
          lling unit
          #and % of related missing values.
          dict1= {rate:count(df1,rate) for rate in df1.RATE.unique()}
          customer1 = pd.DataFrame(dict1)
          customer1.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial',
                               'Commercial and Residential']
          customer1 = customer1.T
          customer1.columns = ['count', '# missing_value', '% missing_value']
          customer1['market_share'] = list(round(100* df1.RATE.value_counts()/len(df1),2))


          customer1 = customer1[['market_share','count', '# missing_value', '% missing_value']]
          printmd("\n<span style='color:Blue'>**Information about RATE(customer types) over the Year 2017-2018**
          </span>")
          customer1
```

Information about RATE(customer types) over the Year 2017-2018

Out[100]:

	market_share	count	# missing_value	% missing_value
Singel_family	68.23	53827.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.19	14498.0	0.0	0.0
Commercial	6.68	5268.0	0.0	0.0
Irrigation	1.42	1122.0	0.0	0.0
Industrial	0.32	197.0	0.0	0.0
Commercial and Residential	0.25	1578.0	0.0	0.0

df2

```
In [101]: #Calculate the market share of each Ratein second year, the number of Rate based on the number of Dwel
          lling unit
          #and % of related missing values.
          dict2= {rate:count(df2,rate) for rate in df2.RATE.unique()}
          customer2 = pd.DataFrame(dict1)
          customer2.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial',
                               'Commercial and Residential']
          customer2 = customer2.T
          customer2.columns = ['count', '# missing_value', '% missing_value']
          customer2['market_share'] = list(round(100* df2.RATE.value_counts()/len(df2),2))


          customer2 = customer2[['market_share','count', '# missing_value', '% missing_value']]
          printmd("\n<span style='color:Blue'>**Information about RATE(customer types) over the Year 2018-2019**
          </span>")
          customer2
```

Information about RATE(customer types) over the Year 2018-2019

Out[101]:

	market_share	count	# missing_value	% missing_value
Singel_family	68.23	53827.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.20	14498.0	0.0	0.0
Commercial	6.68	5268.0	0.0	0.0
Irrigation	1.42	1122.0	0.0	0.0
Industrial	0.33	197.0	0.0	0.0
Commercial and Residential	0.25	1578.0	0.0	0.0

df3

```
In [102]: #Calculate the market share of each Ratein second year, the number of Rate based on the number of Dwel
          lling unit
          #and % of related missing values.
          dict3= {rate:count(df3,rate) for rate in df3.RATE.unique()}
          customer3 = pd.DataFrame(dict1)
          customer3.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial',
                               'Commercial and Residential']
          customer3 = customer3.T
          customer3.columns = ['count', '# missing_value', '% missing_value']
          customer3['market_share'] = list(round(100* df3.RATE.value_counts()/len(df3),2))


          customer3 = customer3[['market_share','count', '# missing_value', '% missing_value']]
          printmd("\n<span style='color:Blue'>**Information about RATE(customer types) over the Year 2019-2020**
          </span>")
          customer3
```

Information about RATE(customer types) over the Year 2019-2020

Out[102]:

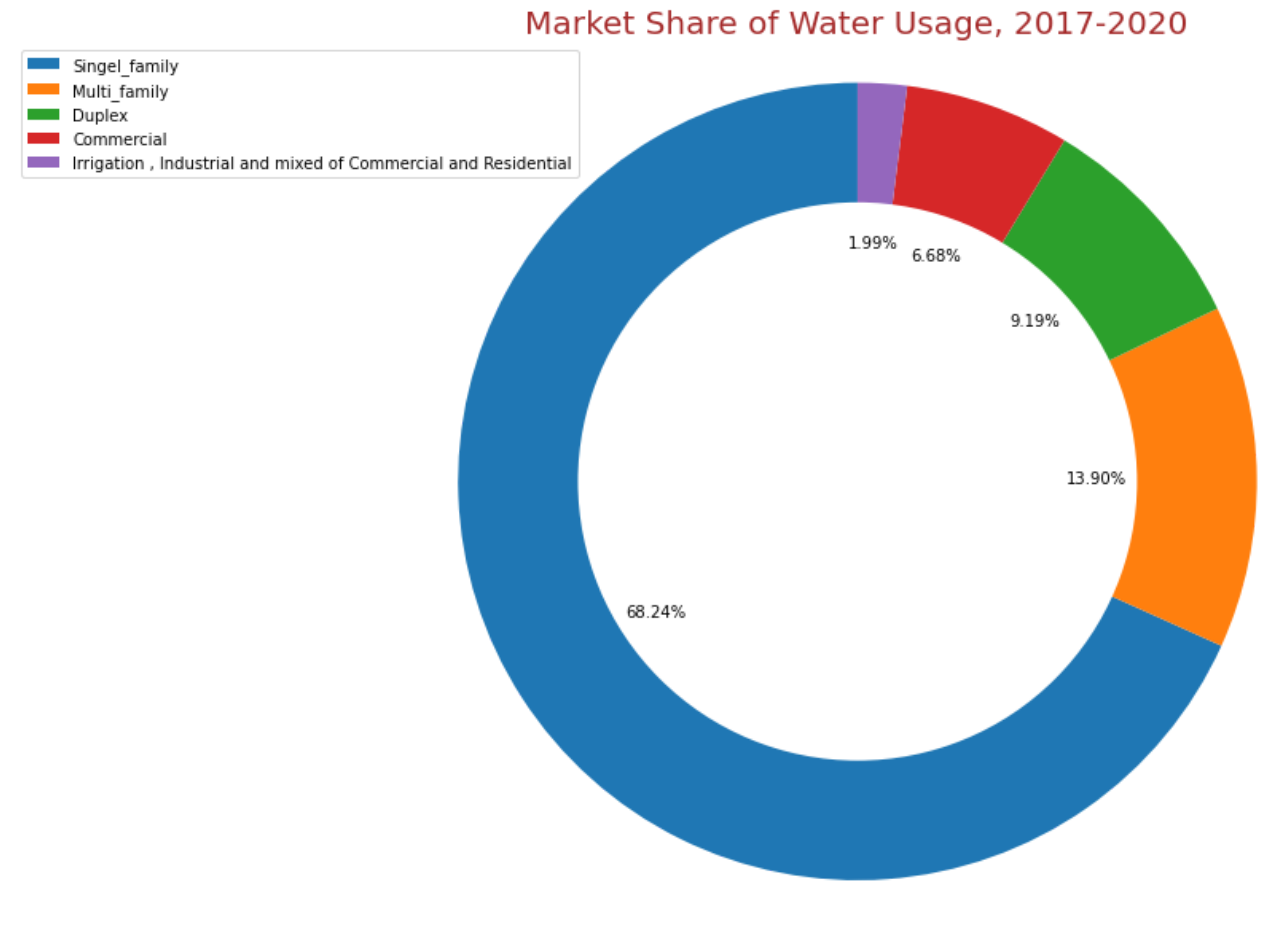
	market_share	count	# missing_value	% missing_value
Singel_family	68.11	53827.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.31	14498.0	0.0	0.0
Commercial	6.68	5268.0	0.0	0.0
Irrigation	1.43	1122.0	0.0	0.0
Industrial	0.33	197.0	0.0	0.0
Commercial and Residential	0.25	1578.0	0.0	0.0

```
In [103]: # Pie chart
          plt.figure(figsize=(15,8))
          data = [68.24, 13.9 ,  9.19,  6.68, 1.99]
          labels = ['Singel_family', 'Multi_family', 'Duplex', 'Commercial',
                    'Irrigation , Industrial and mixed of Commercial and Residential']

          plt.pie(data, autopct='%1.2f%%', startangle=90)


          #draw circle
          centre_circle = plt.Circle((0,0),0.70,fc='white')
          fig = plt.gcf()
          fig.gca().add_artist(centre_circle)

          # Equal aspect ratio ensures that pie is drawn as a circle
          plt.axis('equal')
          plt.tight_layout()
          plt.title('Market Share of Water Usage, 2017-2020',fontsize= 20, color= 'brown')
          plt.legend(labels, loc='best')
          plt.show()
```



Now,there is no missing value in Dwelling unit column of dataframes.

And about market share:

1) There is very small changes in the market share of Singel_family and Duplex.

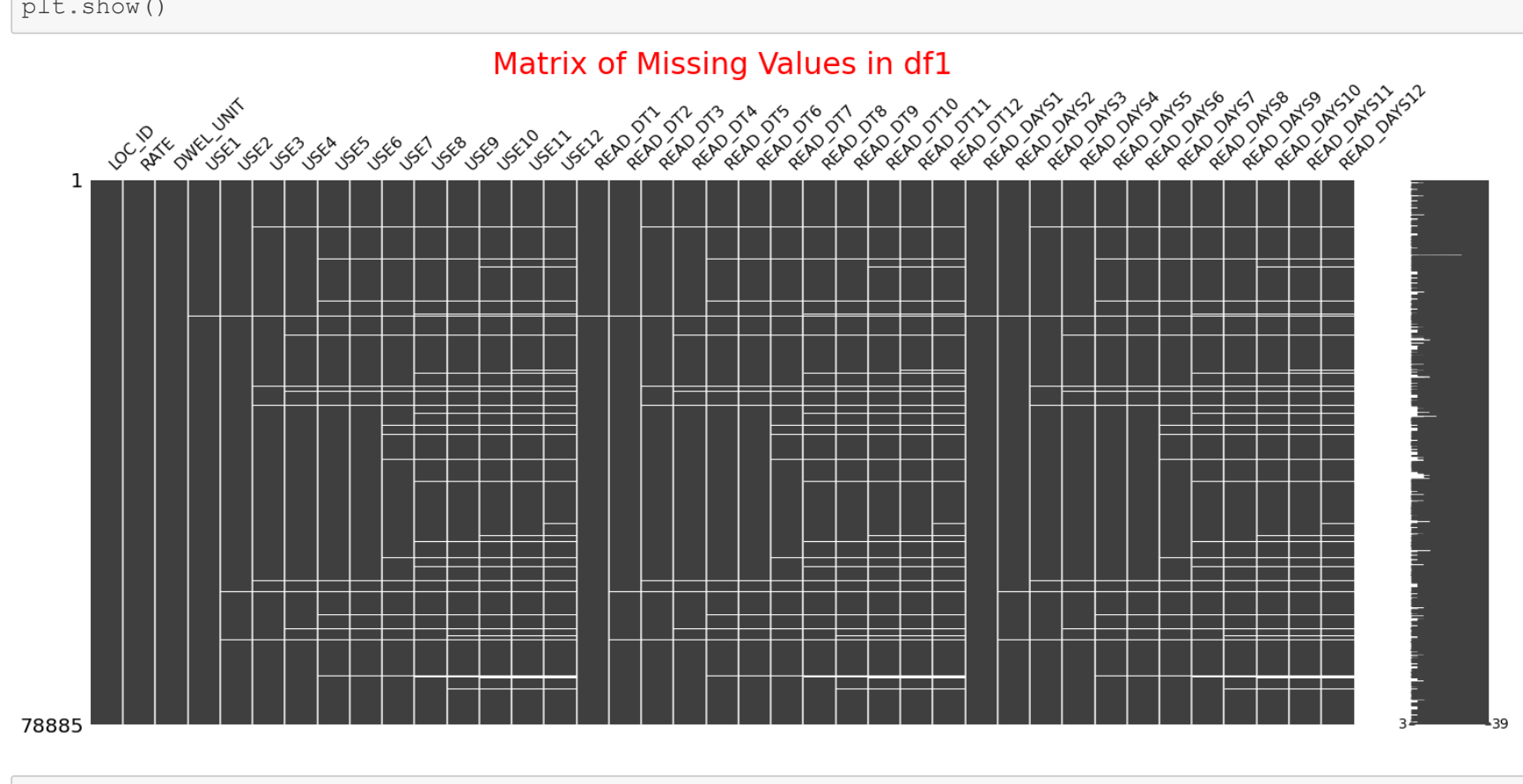
2) The majority of customers (more than 91%) are Residential including single family dwelling, multi-family and duplex houses.

3) There are 6.68% commercial customers. Only 2% of customers used water for commercial and residential, irrigation and industrial usage.

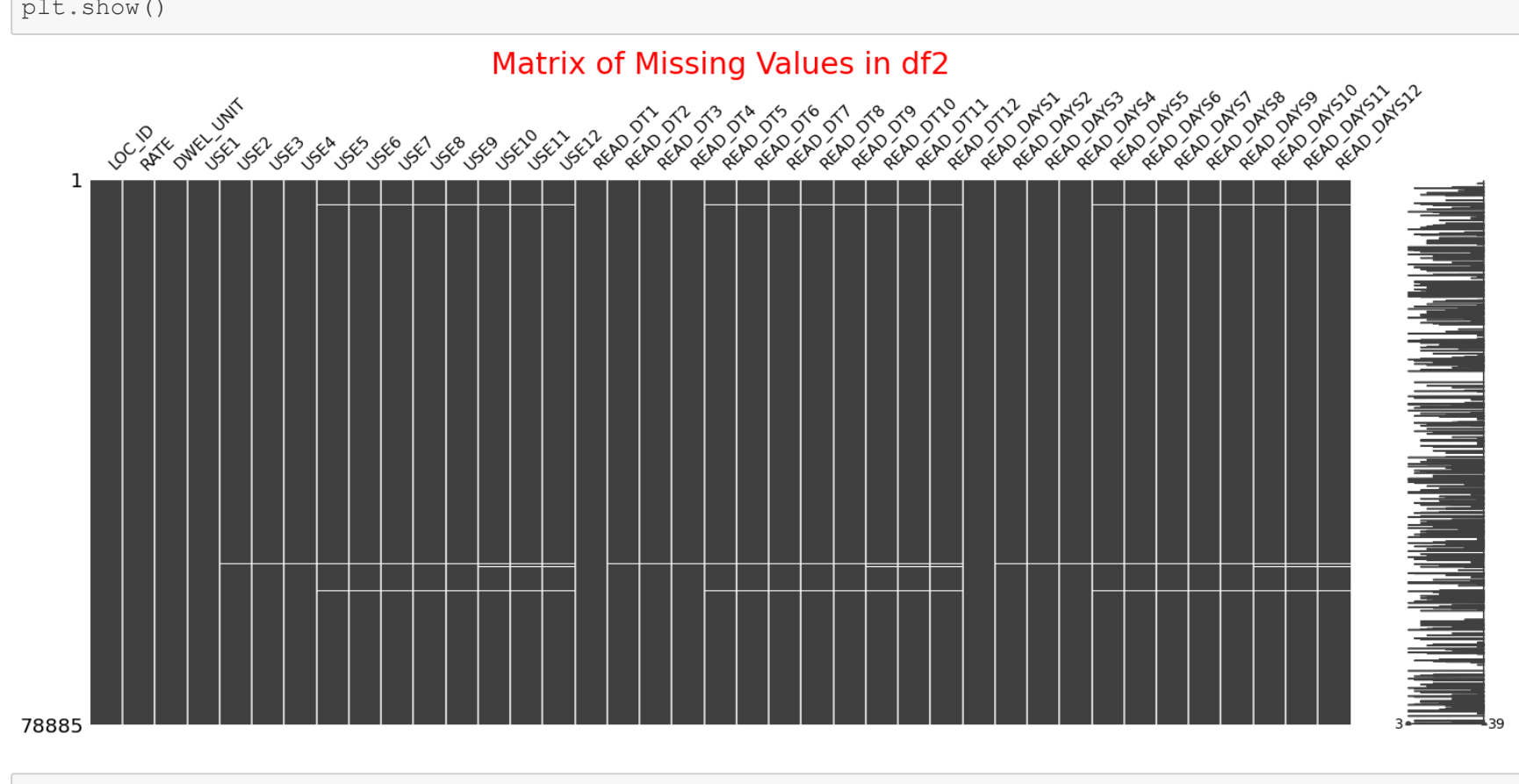
6) Visualizing missing values of numeric variables

df1

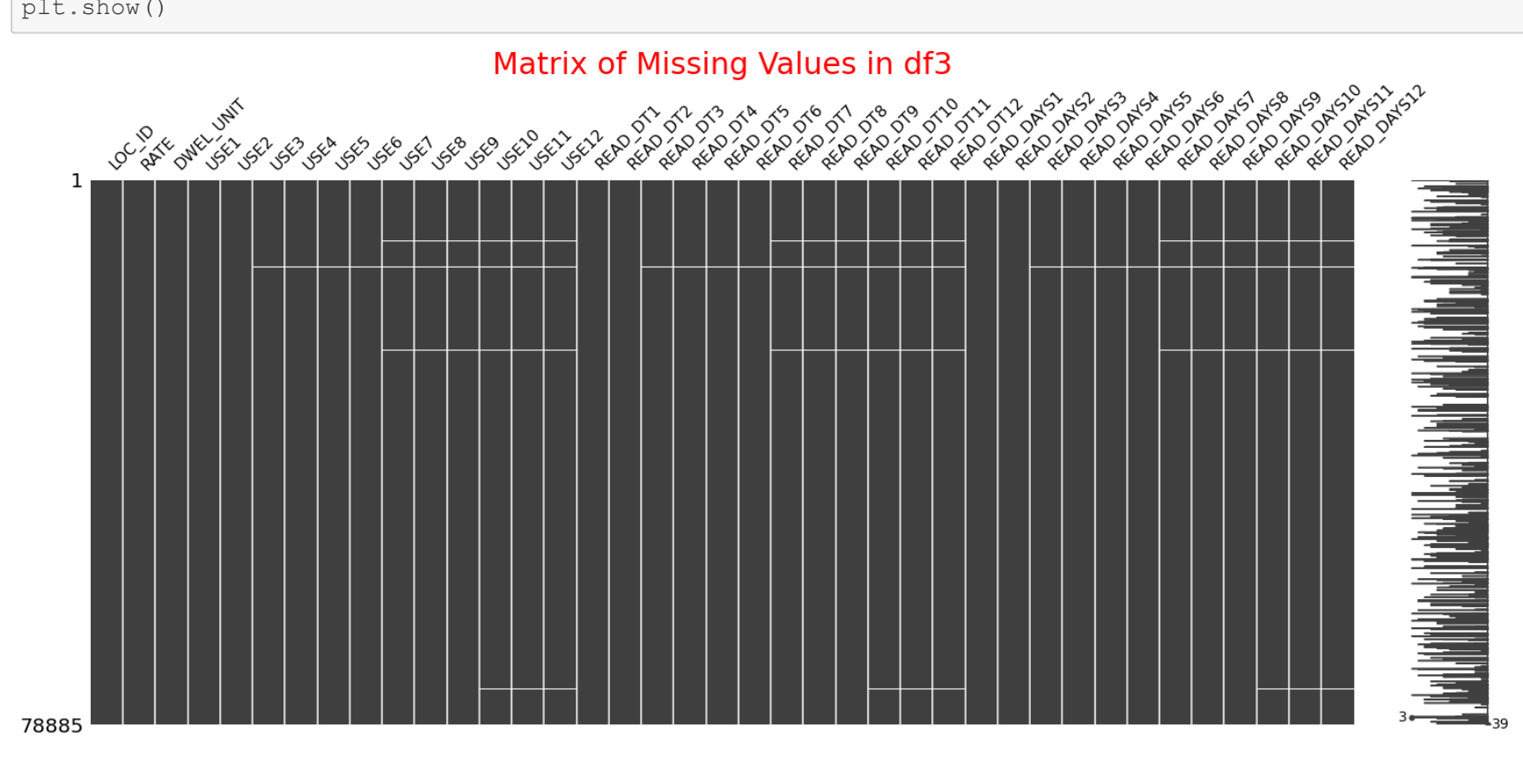
```
In [104]: #Find matrix of missing values and plot it
          msno.matrix(df1)
          plt.title('Matrix of Missing Values in df1', fontsize=30, color='red')
          plt.show()
```




```
In [105]: #Find matrix of missing values and plot it
          msno.matrix(df2)
          plt.title('Matrix of Missing Values in df2', fontsize=30, color='red')
          plt.show()
```




```
In [106]: #Find matrix of missing values and plot it
          msno.matrix(df3)
          plt.title('Matrix of Missing Values in df3', fontsize=30, color='red')
          plt.show()
```



There are plenty missing values of usage and read date in df1 than df2 and df3.

7) Find previous read date of each read date

7.1) Find previous read date of each read date

df1

```
In [107]: #Create a new dataframe that each row has an unique LOC_ID and RATE, and a group of columns of usage,
           read date and
          #read days which include all values of related columns in main df1. Remaining column(DWEL_UNIT) of df1
           is in left intact.

          long_df1 =pd.wide_to_long(df1, stubnames= ['USE','READ_DT', 'READ_DAYS'],
                            i= ['LOC_ID','RATE'],
                           j='period').reset_index()


          print(long_df1.shape)
          long_df1.head()

          (946620, 7)
```

Out[107]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS
0	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0
1	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0
2	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0
3	1000000000	RSFD	4	1.0	9.0	2018-04-11	29.0
4	1000000000	RSFD	5	1.0	10.0	2018-03-13	32.0

```
In [108]: #Find the previous read date for each read date based on its associated read days.
          long_df1['Previous_READ_DT'] = long_df1['READ_DT'] - pd.to_timedelta(long_df1['READ_DAYS'], unit='D')
          long_df1.Previous_READ_DT = pd.to_datetime(long_df1.Previous_READ_DT)
          long_df1.head()
```

Out[108]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11
1	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10
2	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0	2018-04-11
3	1000000000	RSFD	4	1.0	9.0	2018-04-11	29.0	2018-03-13
4	1000000000	RSFD	5	1.0	10.0	2018-03-13	32.0	2018-02-09

```
In [109]: #Dropping the rows that their Read date and previous read date are null
          missing_read_date1 = long_df1[long_df1['READ_DT'].isna()]
          long_df1 = long_df1[~long_df1['READ_DT'].isna()]
          print(long_df1.shape)
          long_df1.head()

          (916474, 8)
```

Out[109]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11
1	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10
2	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0	2018-04-11
3	1000000000	RSFD	4	1.0	9.0	2018-04-11	29.0	2018-03-13
4	1000000000	RSFD	5	1.0	10.0	2018-03-13	32.0	2018-02-09

```
In [110]: long_df1.info()

          <class 'pandas.core.frame.DataFrame'>
          Int64Index: 916474 entries, 0 to 946619
          Data columns (total 8 columns):
           #   Column            Non-Null Count   Dtype
          ---  ------            --------------   -----
           0   LOC_ID            916474 non-null  int64
           1   RATE              916474 non-null  category
           2   period            916474 non-null  int64
           3   DWEL_UNIT         916474 non-null  float64
           4   USE               916474 non-null  float64
           5   READ_DT           916474 non-null  datetime64[ns]
           6   READ_DAYS         916474 non-null  float64
           7   Previous_READ_DT  916474 non-null  datetime64[ns]
          dtypes: category(1), datetime64[ns](2), float64(3), int64(2)
          memory usage: 56.8 MB
```

5.2) Find previous read date of each read date and caculate the usage of each account per month, 2018-2019

```
In [111]: #Create a new df that assign all READ_DT, all READ_Days and all USE values from df2 in 3 columns.
          #with the index columns of LOC_ID and RATE.
          df2.reset_index(inplace= True)
          long_df2 =pd.wide_to_long(df2, stubnames= ['USE','READ_DT', 'READ_DAYS'],
                            i= ['LOC_ID','RATE'],
                           j='period').reset_index()
          print(long_df2.shape)
          long_df2.head()

          (946620, 8)
```

Out[111]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS
0	1000000000	RSFD	1	0	1.0	20.0	2019-07-10	30.0
1	1000000000	RSFD	2	0	1.0	13.0	2019-06-10	31.0
2	1000000000	RSFD	3	0	1.0	6.0	2019-05-10	29.0
3	1000000000	RSFD	4	0	1.0	5.0	2019-04-11	30.0
4	1000000000	RSFD	5	0	1.0	5.0	2019-03-12	29.0

```
In [112]: #Find the previous read date for each read date based on its associated read days.
          long_df2['Previous_READ_DT'] = long_df2['READ_DT'] - pd.to_timedelta(long_df2['READ_DAYS'], unit='D')
          long_df2.Previous_READ_DT = pd.to_datetime(long_df2.Previous_READ_DT)
          long_df2.head()
```

Out[112]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	0	1.0	20.0	2019-07-10	30.0	2019-06-10
1	1000000000	RSFD	2	0	1.0	13.0	2019-06-10	31.0	2019-05-10
2	1000000000	RSFD	3	0	1.0	6.0	2019-05-10	29.0	2019-04-11
3	1000000000	RSFD	4	0	1.0	5.0	2019-04-11	30.0	2019-03-12
4	1000000000	RSFD	5	0	1.0	5.0	2019-03-12	29.0	2019-02-11

```
In [113]: #Dropping the accouts that its Read date and previous read date are Nat.
          missing_read_date2 = long_df2[long_df2['READ_DT'].isna()]
          long_df2 = long_df2[~long_df2['READ_DT'].isna()]
          print(long_df2.shape)
          long_df2.head()

          (943175, 9)
```

Out[113]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	0	1.0	20.0	2019-07-10	30.0	2019-06-10
1	1000000000	RSFD	2	0	1.0	13.0	2019-06-10	31.0	2019-05-10
2	1000000000	RSFD	3	0	1.0	6.0	2019-05-10	29.0	2019-04-11
3	1000000000	RSFD	4	0	1.0	5.0	2019-04-11	30.0	2019-03-12
4	1000000000	RSFD	5	0	1.0	5.0	2019-03-12	29.0	2019-02-11

```
In [114]: long_df2.info()

          <class 'pandas.core.frame.DataFrame'>
          Int64Index: 943175 entries, 0 to 946619
          Data columns (total 9 columns):
           #   Column            Non-Null Count   Dtype
          ---  ------            --------------   -----
           0   LOC_ID            943175 non-null  int64
           1   RATE              943175 non-null  category
           2   period            943175 non-null  int64
           3   index             943175 non-null  int64
           4   DWEL_UNIT         943175 non-null  float64
           5   USE               943175 non-null  float64
           6   READ_DT           943175 non-null  datetime64[ns]
           7   READ_DAYS         943175 non-null  float64
           8   Previous_READ_DT  943175 non-null  datetime64[ns]
          dtypes: category(1), datetime64[ns](2), float64(3), int64(3)
          memory usage: 65.7 MB
```

7.2) Find previous read date of each read date and caculate the usage of each account per month, 2019-2020

```
In [115]: #Create a new df that assign all READ_DT, all READ_Days and all USE values from df3 in 3 columns.
          #with the index columns of LOC_ID and RATE.
          df3.reset_index(inplace= True)
          long_df3 =pd.wide_to_long(df3, stubnames= ['USE','READ_DT', 'READ_DAYS'],
                            i= ['LOC_ID','RATE'],
                           j='period').reset_index()
          print(long_df3.shape)
          long_df3.head()

          (946620, 8)
```

Out[115]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS
0	1000000000	RSFD	1	0	1.0	16.0	2020-07-10	31.0
1	1000000000	RSFD	2	0	1.0	13.0	2020-06-09	29.0
2	1000000000	RSFD	3	0	1.0	20.0	2020-05-11	31.0
3	1000000000	RSFD	4	0	1.0	10.0	2020-04-10	30.0
4	1000000000	RSFD	5	0	1.0	5.0	2020-03-11	29.0

```
In [116]: #Find the previous read date for each read date based on its associated read days.
          long_df3['Previous_READ_DT'] = long_df3['READ_DT'] - pd.to_timedelta(long_df3['READ_DAYS'], unit='D')
          long_df3.Previous_READ_DT = pd.to_datetime(long_df3.Previous_READ_DT)
          long_df3.head()
```

Out[116]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	0	1.0	16.0	2020-07-10	31.0	2020-06-09
1	1000000000	RSFD	2	0	1.0	13.0	2020-06-09	29.0	2020-05-11
2	1000000000	RSFD	3	0	1.0	20.0	2020-05-11	31.0	2020-04-10
3	1000000000	RSFD	4	0	1.0	10.0	2020-04-10	30.0	2020-03-11
4	1000000000	RSFD	5	0	1.0	5.0	2020-03-11	29.0	2020-02-11

```
In [117]: #Dropping the accouts that its Read date and previous read date are Nat.
          missing_read_date3 = long_df3[long_df3['READ_DT'].isna()]
          long_df3 = long_df3[~long_df3['READ_DT'].isna()]
          print(long_df3.shape)
          long_df3.head()

          (943412, 9)
```

Out[117]:

	LOC_ID	RATE	period	index	DWEL_UNIT	USE	READ_DT	READ_DAYS	Previous_READ_DT
0	1000000000	RSFD	1	0	1.0	16.0	2020-07-10	31.0	2020-06-09
1	1000000000	RSFD	2	0	1.0	13.0	2020-06-09	29.0	2020-05-11
2	1000000000	RSFD	3	0	1.0	20.0	2020-05-11	31.0	2020-04-10
3	1000000000	RSFD	4	0	1.0	10.0	2020-04-10	30.0	2020-03-11
4	1000000000	RSFD	5	0	1.0	5.0	2020-03-11	29.0	2020-02-11

```
In [118]: long_df3.info()

          <class 'pandas.core.frame.DataFrame'>
          Int64Index: 943412 entries, 0 to 946619
          Data columns (total 9 columns):
           #   Column            Non-Null Count   Dtype
          ---  ------            --------------   -----
           0   LOC_ID            943412 non-null  int64
           1   RATE              943412 non-null  category
           2   period            943412 non-null  int64
           3   index             943412 non-null  int64
           4   DWEL_UNIT         943412 non-null  float64
           5   USE               943410 non-null  float64
           6   READ_DT           943412 non-null  datetime64[ns]
           7   READ_DAYS         943412 non-null  float64
           8   Previous_READ_DT  943412 non-null  datetime64[ns]
          dtypes: category(1), datetime64[ns](2), float64(3), int64(3)
          memory usage: 65.7 MB
```

8) Caculate the usage of each account per month

Functions

In [119]:
```python
#Create a list of dataframes, each dataframe with index of month(s) between previous read data and read date,
#and extracting the month and year of index(s)
def yr_month(small):
    result = []
    for tup in small.itertuples():
        #find the month between previous read date and read date
        index = pd.PeriodIndex([tup.Previous_READ_DT, tup.READ_DT],freq='M')
        temp = pd.DataFrame([(tup.LOC_ID, tup.RATE, tup.period, tup.DWEL_UNIT, tup.USE, tup.READ_DT,
                              tup.READ_DAYS, tup.Previous_READ_DT)], index= index)
        temp['month'] = temp.index.month
        temp['year'] = temp.index.year
        result.append(temp)
    result = pd.concat(result, axis= 0)
    return result
```

In [120]:
```python
def days_in_period(data):
    #Create the month start for each row
    data['month_start'] = pd.to_datetime((data.year * 10000 + data.month * 100 + 1).apply(str) , format='%Y%m%d')

    #Find number of days in the month
    data['days_in_month'] = data[['year','month']].apply(lambda x: calendar.monthrange(x[0],x[1])[1], axis= 1)

    #Count number of days between start of month and read date
    data['read_date_to_month_start'] = data[['month_start','READ_DT']].apply(
                                         lambda x:pd.Timedelta(x[1]-x[0],'D').days, axis= 1)

    #Count number of days between previous read date and end of the month
    data['previous_read_date_to_month_end'] = data[['previous_read_date','month_start','days_in_month']].apply(
        lambda x: x[2] - pd.Timedelta(x[0]-x[1],'D').days, axis=1)

    #Count number of days in each period
    data['days_to_count_in_period'] = data[['previous_read_date_to_month_end','month_start',\
                                     'read_date_to_month_start','days_in_month']].apply(
                                    lambda x: x[3] if (x[0] > x[3] & x[2] >= x[3])
                                               else(x[0] if x[0] <= x[3] else x[2]),axis=1)


    return data[['RATE','LOC_ID','DWEL_UNIT','month_start','days_in_month','previous_read_date',
                 'READ_DAYS','READ_DT', 'month','year','days_to_count_in_period','USE']]
```

df1

In [121]:
```python
#Chunk the long_df1
chunk1 = long_df1.iloc[0:300000,:]
chunk2 = long_df1.iloc[300000:,:]
```

In [122]:
```python
result1 = yr_month(chunk1)
```

In [123]:
```python
result1.head()
```

Out[123]:

	0	1	2	3	4	5	6	7	month	year
2018-06	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	6	2018
2018-07	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	7	2018
2018-05	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	5	2018
2018-06	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	6	2018
2018-04	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0	2018-04-11	4	2018

In [124]:
```python
result2 = yr_month(chunk2)
```

In [125]:
```python
#Concatenate the results of chunks, and rename the columns
long_df1 = pd.concat([result1,result2], axis= 0).reset_index()

#Label columns appropriately
long_df1.rename(columns = {0:'LOC_ID', 1:'RATE', 2:'period',3:'DWEL_UNIT',4:'USE',
                           5:'READ_DT',6:'READ_DAYS', 7:'previous_read_date'}, inplace=True)

print(long_df1.shape)
long_df1.head()
```

```
(1832948, 11)
```

Out[125]:

	index	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year
0	2018-06	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	6	2018
1	2018-07	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	7	2018
2	2018-05	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	5	2018
3	2018-06	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	6	2018
4	2018-04	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0	2018-04-11	4	2018

In [126]:
```python
long_df1.reset_index(inplace=True)
small_df1 = days_in_period(long_df1)
small_df1.head()
```

Out[126]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2018-06-01	30	2018-06-11	30.0	2018-07-11	6	2018	
1	RSFD	1000000000	1.0	2018-07-01	31	2018-06-11	30.0	2018-07-11	7	2018	
2	RSFD	1000000000	1.0	2018-05-01	31	2018-05-10	32.0	2018-06-11	5	2018	
3	RSFD	1000000000	1.0	2018-06-01	30	2018-05-10	32.0	2018-06-11	6	2018	
4	RSFD	1000000000	1.0	2018-04-01	30	2018-04-11	29.0	2018-05-10	4	2018	

In [127]:
```python
small_df1['usage_to_count_in_period'] = round((small_df1.days_to_count_in_period / small_df1.READ_DAYS
) * small_df1.USE, 1)
small_df1.head()
```

```
<ipython-input-127-15baa3d7d8d5>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexin
g.html#returning-a-view-versus-a-copy
  small_df1['usage_to_count_in_period'] = round((small_df1.days_to_count_in_period / small_df1.READ_D
AYS) * small_df1.USE, 1)
```

Out[127]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2018-06-01	30	2018-06-11	30.0	2018-07-11	6	2018	
1	RSFD	1000000000	1.0	2018-07-01	31	2018-06-11	30.0	2018-07-11	7	2018	
2	RSFD	1000000000	1.0	2018-05-01	31	2018-05-10	32.0	2018-06-11	5	2018	
3	RSFD	1000000000	1.0	2018-06-01	30	2018-05-10	32.0	2018-06-11	6	2018	
4	RSFD	1000000000	1.0	2018-04-01	30	2018-04-11	29.0	2018-05-10	4	2018	

In [128]:
```python
small_df1.isnull().sum()
```

Out[128]:
```
RATE                        0
LOC_ID                      0
DWEL_UNIT                   0
month_start                 0
days_in_month               0
previous_read_date          0
READ_DAYS                   0
READ_DT                     0
month                       0
year                        0
days_to_count_in_period     0
USE                         0
usage_to_count_in_period    0
dtype: int64
```

In [129]:
```python
small_df1.describe()
```

Out[129]:

	LOC_ID	DWEL_UNIT	days_in_month	READ_DAYS	month	year	days_to_count_in_period	USE	u
count	1.832948e+06	1.832948e+06	1.832948e+06	1.832948e+06	1.832948e+06	1.832948e+06	1.832948e+06	1.832948e+06	
mean	1.000039e+09	2.091431e+00	3.044337e+01	3.045399e+01	6.466700e+00	2.017569e+03	1.524685e+01	2.191004e+01	
std	2.277445e+04	7.366812e+00	8.410156e-01	2.897039e+00	3.413716e+00	4.951835e-01	8.482162e+00	1.772236e+02	
min	1.000000e+09	1.000000e+00	2.800000e+01	8.000000e+00	1.000000e+00	2.015000e+03	0.000000e+00	0.000000e+00	
25%	1.000020e+09	1.000000e+00	3.000000e+01	2.900000e+01	4.000000e+00	2.017000e+03	8.000000e+00	6.000000e+00	
50%	1.000039e+09	1.000000e+00	3.100000e+01	3.000000e+01	6.000000e+00	2.018000e+03	1.500000e+01	1.000000e+01	
75%	1.000059e+09	1.000000e+00	3.100000e+01	3.200000e+01	9.000000e+00	2.018000e+03	2.200000e+01	1.700000e+01	
max	1.000079e+09	5.700000e+02	3.100000e+01	7.630000e+02	1.200000e+01	2.018000e+03	3.100000e+01	4.817200e+04	

Min of days_to_count_in_period is zero.

In [130]:
```python
small_df1 = small_df1.groupby(['RATE', 'month_start'])\
                              [['DWEL_UNIT','days_to_count_in_period', 'usage_to_count_in_period']].sum
().reset_index()
small_df1.rename(columns= {'days_to_count_in_period': 'days_in_period', 'usage_to_count_in_period': 'u
sge_in_period'})
small_df1.head()
```

Out[130]:

	RATE	month_start	DWEL_UNIT	days_to_count_in_period	usage_to_count_in_period
0	COM	2016-04-01	1.0	19	1.4
1	COM	2016-05-01	1.0	12	0.5
2	COM	2016-11-01	3.0	56	5.7
3	COM	2016-12-01	4.0	62	6.7
4	COM	2017-01-01	5.0	69	8.4

df2

In [131]:
```python
#Chunk the long_df2
chunk3 = long_df2.iloc[0:450000,:]
chunk4 = long_df2.iloc[450000:,:]
```

In [132]:
```python
result3 = yr_month(chunk3)
```

In [133]:
```python
result4 = yr_month(chunk4)
```

In [134]:
```python
long_df2 = pd.concat([result3,result4], axis=0).reset_index()
long_df2.rename(columns = {0:'LOC_ID', 1:'RATE', 2:'period',3:'DWEL_UNIT',4:'USE',
                           5:'READ_DT',6:'READ_DAYS', 7:'previous_read_date'}, inplace=True)
print(long_df2.shape)
long_df2.head()
```

```
(1886350, 11)
```

Out[134]:

	index	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year
0	2019-06	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	6	2019
1	2019-07	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	7	2019
2	2019-05	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	5	2019
3	2019-06	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	6	2019
4	2019-04	1000000000	RSFD	3	1.0	6.0	2019-05-10	29.0	2019-04-11	4	2019

In [135]:
```python
long_df2 = long_df2.reset_index()
small_df2 = days_in_period(long_df2)
small_df2.head()
```

Out[135]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2019-06-01	30	2019-06-10	30.0	2019-07-10	6	2019	
1	RSFD	1000000000	1.0	2019-07-01	31	2019-06-10	30.0	2019-07-10	7	2019	
2	RSFD	1000000000	1.0	2019-05-01	31	2019-05-10	31.0	2019-06-10	5	2019	
3	RSFD	1000000000	1.0	2019-06-01	30	2019-05-10	31.0	2019-06-10	6	2019	
4	RSFD	1000000000	1.0	2019-04-01	30	2019-04-11	29.0	2019-05-10	4	2019	

In [139]:
```python
small_df2['usage_to_count_in_period'] = round((small_df2.days_to_count_in_period / small_df2.READ_DAYS
) * small_df2.USE, 1)
small_df2.head()
```

```
<ipython-input-139-91894a2fea5d>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexin
g.html#returning-a-view-versus-a-copy
  small_df2['usage_to_count_in_period'] = round((small_df2.days_to_count_in_period / small_df2.READ_D
AYS) * small_df2.USE, 1)
```

Out[139]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2019-06-01	30	2019-06-10	30.0	2019-07-10	6	2019	
1	RSFD	1000000000	1.0	2019-07-01	31	2019-06-10	30.0	2019-07-10	7	2019	
2	RSFD	1000000000	1.0	2019-05-01	31	2019-05-10	31.0	2019-06-10	5	2019	
3	RSFD	1000000000	1.0	2019-06-01	30	2019-05-10	31.0	2019-06-10	6	2019	
4	RSFD	1000000000	1.0	2019-04-01	30	2019-04-11	29.0	2019-05-10	4	2019	

In [140]:
```python
small_df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1886350 entries, 0 to 1886349
Data columns (total 13 columns):
 #   Column                    Dtype
---  ------                    -----
 0   RATE                      object
 1   LOC_ID                    int64
 2   DWEL_UNIT                 float64
 3   month_start               datetime64[ns]
 4   days_in_month             int64
 5   previous_read_date        datetime64[ns]
 6   READ_DAYS                 float64
 7   READ_DT                   datetime64[ns]
 8   month                     int64
 9   year                      int64
 10  days_to_count_in_period   int64
 11  USE                       float64
 12  usage_to_count_in_period  float64
dtypes: datetime64[ns](3), float64(4), int64(5), object(1)
memory usage: 187.1+ MB
```

In [141]:
```python
small_df2.describe()
```

Out[141]:

	LOC_ID	DWEL_UNIT	days_in_month	READ_DAYS	month	year	days_to_count_in_period	USE	u
count	1.886350e+06	1.886350e+06	1.886350e+06	1.886350e+06	1.886350e+06	1.886350e+06	1.886350e+06	1.886350e+06	
mean	1.000039e+09	2.089456e+00	3.044847e+01	3.046122e+01	6.497316e+00	2.018563e+03	1.527481e+01	2.070706e+01	
std	2.277606e+04	7.360706e+00	8.403948e-01	2.162086e+00	3.415857e+00	4.960451e-01	8.458280e+00	1.636639e+02	
min	1.000000e+09	1.000000e+00	2.800000e+01	8.000000e+00	1.000000e+00	2.016000e+03	0.000000e+00	0.000000e+00	
25%	1.000020e+09	1.000000e+00	3.000000e+01	2.900000e+01	4.000000e+00	2.018000e+03	8.000000e+00	6.000000e+00	
50%	1.000039e+09	1.000000e+00	3.100000e+01	3.000000e+01	7.000000e+00	2.019000e+03	1.500000e+01	1.000000e+01	
75%	1.000059e+09	1.000000e+00	3.100000e+01	3.200000e+01	9.000000e+00	2.019000e+03	2.200000e+01	1.600000e+01	
max	1.000079e+09	5.700000e+02	3.100000e+01	4.830000e+02	1.200000e+01	2.019000e+03	3.100000e+01	2.609700e+04	

In [142]:
```python
small_df2 = small_df2.groupby(['RATE', 'month_start'])\
                              [['DWEL_UNIT','days_to_count_in_period', 'usage_to_count_in_period']].sum
().reset_index()
small_df2.rename(columns= {'days_to_count_in_period': 'days_in_period', 'usage_to_count_in_period': 'u
sge_in_period'})
small_df2.head()
```

Out[142]:

	RATE	month_start	DWEL_UNIT	days_to_count_in_period	usage_to_count_in_period
0	COM	2016-04-01	1.0	20	4.7
1	COM	2017-06-01	2.0	30	7.3
2	COM	2018-02-01	3.0	23	14.7
3	COM	2018-03-01	7.0	107	38.8
4	COM	2018-04-01	6.0	107	193.8

df3

In [143]:
```python
#Chunk the long_df3
chunk5 = long_df3.iloc[0:450000,:]
chunk6 = long_df3.iloc[450000:,:]
```

In [144]:
```python
result5 = yr_month(chunk5)
```

In [145]:
```python
result6 = yr_month(chunk6)
```

In [146]:
```python
long_df3 = pd.concat([result5, result6], axis=0).reset_index()
long_df3.rename(columns = {0:'LOC_ID', 1:'RATE', 2:'period',3:'DWEL_UNIT',4:'USE',
                           5:'READ_DT',6:'READ_DAYS', 7:'previous_read_date'}, inplace=True)
long_df3.head()
```

Out[146]:

	index	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year
0	2020-06	1000000000	RSFD	1	1.0	16.0	2020-07-10	31.0	2020-06-09	6	2020
1	2020-07	1000000000	RSFD	1	1.0	16.0	2020-07-10	31.0	2020-06-09	7	2020
2	2020-05	1000000000	RSFD	2	1.0	13.0	2020-06-09	29.0	2020-05-11	5	2020
3	2020-06	1000000000	RSFD	2	1.0	13.0	2020-06-09	29.0	2020-05-11	6	2020
4	2020-04	1000000000	RSFD	3	1.0	20.0	2020-05-11	31.0	2020-04-10	4	2020

In [147]:
```python
long_df3 = long_df3.reset_index()
small_df3 = days_in_period(long_df3)
small_df3.head()
```

Out[147]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2020-06-01	30	2020-06-09	31.0	2020-07-10	6	2020	
1	RSFD	1000000000	1.0	2020-07-01	31	2020-06-09	31.0	2020-07-10	7	2020	
2	RSFD	1000000000	1.0	2020-05-01	31	2020-05-11	29.0	2020-06-09	5	2020	
3	RSFD	1000000000	1.0	2020-06-01	30	2020-05-11	29.0	2020-06-09	6	2020	
4	RSFD	1000000000	1.0	2020-04-01	30	2020-04-10	31.0	2020-05-11	4	2020	

In [150]:
```python
small_df3['usage_to_count_in_period'] = round((small_df3.days_to_count_in_period / small_df3.READ_DAYS
) * small_df3.USE, 1)
small_df3.head()
```

```
<ipython-input-150-481aaab3d3cb>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexin
g.html#returning-a-view-versus-a-copy
  small_df3['usage_to_count_in_period'] = round((small_df3.days_to_count_in_period / small_df3.READ_D
AYS) * small_df3.USE, 1)
```

Out[150]:

	RATE	LOC_ID	DWEL_UNIT	month_start	days_in_month	previous_read_date	READ_DAYS	READ_DT	month	year	days_to_cou
0	RSFD	1000000000	1.0	2020-06-01	30	2020-06-09	31.0	2020-07-10	6	2020	
1	RSFD	1000000000	1.0	2020-07-01	31	2020-06-09	31.0	2020-07-10	7	2020	
2	RSFD	1000000000	1.0	2020-05-01	31	2020-05-11	29.0	2020-06-09	5	2020	
3	RSFD	1000000000	1.0	2020-06-01	30	2020-05-11	29.0	2020-06-09	6	2020	
4	RSFD	1000000000	1.0	2020-04-01	30	2020-04-10	31.0	2020-05-11	4	2020	

In [151]:
```python
long_df3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1886824 entries, 0 to 1886823
Data columns (total 17 columns):
 #   Column                           Dtype
---  ------                           -----
 0   level_0                          int64
 1   index                            period[M]
 2   LOC_ID                           int64
 3   RATE                             object
 4   period                           int64
 5   DWEL_UNIT                        float64
 6   USE                              float64
 7   READ_DT                          datetime64[ns]
 8   READ_DAYS                        float64
 9   previous_read_date               datetime64[ns]
 10  month                            int64
 11  year                             int64
 12  month_start                      datetime64[ns]
 13  days_in_month                    int64
 14  read_date_to_month_start         int64
 15  previous_read_date_to_month_end  int64
 16  days_to_count_in_period          int64
dtypes: datetime64[ns](3), float64(3), int64(9), object(1), period[M](1)
memory usage: 244.7+ MB
```

In [152]:
```python
long_df3.describe()
```

Out[152]:

	level_0	LOC_ID	period	DWEL_UNIT	USE	READ_DAYS	month	year	days_in_month
count	1.886824e+06	1.886824e+06	1.886824e+06	1.886824e+06	1.886820e+06	1.886824e+06	1.886824e+06	1.886824e+06	1.886824e+06
mean	9.434115e+05	1.000039e+09	6.493438e+00	2.086654e+00	2.072445e+01	3.050588e+01	6.503100e+00	2.019562e+03	3.051732e+01
std	5.446793e+05	2.277349e+04	3.452018e+00	7.295967e+00	1.632797e+02	2.088067e+00	3.428426e+00	4.960862e-01	6.347279e-01
min	0.000000e+00	1.000000e+09	1.000000e+00	1.000000e+00	0.000000e+00	8.000000e+00	1.000000e+00	2.018000e+03	2.800000e+01
25%	4.717058e+05	1.000020e+09	3.000000e+00	1.000000e+00	6.000000e+00	2.900000e+01	4.000000e+00	2.019000e+03	3.000000e+01
50%	9.434115e+05	1.000039e+09	6.000000e+00	1.000000e+00	1.000000e+01	3.000000e+01	6.000000e+00	2.020000e+03	3.100000e+01
75%	1.415117e+06	1.000059e+09	9.000000e+00	1.000000e+00	1.700000e+01	3.200000e+01	9.000000e+00	2.020000e+03	3.100000e+01
max	1.886823e+06	1.000079e+09	1.200000e+01	5.700000e+02	2.644800e+04	2.680000e+02	1.200000e+01	2.020000e+03	3.100000e+01

In [153]:
```python
small_df3 = small_df3.groupby(['RATE', 'month_start'])\
                              [['DWEL_UNIT','days_to_count_in_period', 'usage_to_count_in_period']].sum
().reset_index()
small_df3.rename(columns= {'days_to_count_in_period': 'days_in_period', 'usage_to_count_in_period': 'u
sge_in_period'})
print(small_df3.shape)
small_df3.head()
```

```
(131, 5)
```

Out[153]:

	RATE	month_start	DWEL_UNIT	days_to_count_in_period	usage_to_count_in_period
0	COM	2019-01-01	1.0	21	46.7
1	COM	2019-02-01	4.0	44	61.0
2	COM	2019-03-01	6.0	118	567.0
3	COM	2019-04-01	13.0	184	852.1
4	COM	2019-05-01	24.0	357	2161.7

9) Integrating the cleaned data

In [163]:
```python
small_df3
```

Out[163]:

	RATE	month_start	DWEL_UNIT	days_to_count_in_period	usage_to_count_in_period
0	COM	2019-01-01	1.0	21	46.7
1	COM	2019-02-01	4.0	44	61.0
2	COM	2019-03-01	6.0	118	567.0
3	COM	2019-04-01	13.0	184	852.1
4	COM	2019-05-01	24.0	357	2161.7
...	...	...	...	...	...
126	RSFD	2020-04-01	109581.0	1645378	497014.6
127	RSFD	2020-05-01	104436.0	1618833	583202.5
128	RSFD	2020-06-01	110173.0	1654069	636767.1
129	RSFD	2020-07-01	67105.0	1135416	448037.8
130	RSFD	2020-08-01	12636.0	41566	16817.3

131 rows × 5 columns

In [176]:
```python
data2017_2020 = pd.concat([small_df1.set_index(['RATE','month_start']), small_df2.set_index(['RATE','m
onth_start']),
                           small_df3.set_index(['RATE','month_start'])], axis=0)
data2017_2020.reset_index(inplace=True)
print(data2017_2020.shape)
print(data2017_2020.head())
data2017_2020.to_excel('data2017_2020.xlsx', index= False)
```

```
(412, 5)
  RATE month_start  DWEL_UNIT  days_to_count_in_period  \
0  COM  2016-04-01        1.0                       19
1  COM  2016-05-01        1.0                       12
2  COM  2016-11-01        3.0                       56
3  COM  2016-12-01        4.0                       62
4  COM  2017-01-01        5.0                       69

   usage_to_count_in_period
0                       1.4
1                       0.5
2                       5.7
3                       6.7
4                       8.4
```