1) Import relevant libraries

In [367]:
```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 [246]:
```python
df1 = data1.copy()
df2 = data2.copy()
df3 = data3.copy()
```

3) Overview DataFrames

In [247]:
```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 each period for every unique LOC ID 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 [248]:
```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 [249]:
```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(' ','_')

df1.columns = col_labels
df2.columns = col_labels
df3.columns = col_labels
```

In [250]:
```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 [251]:
```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 [252]:
```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
```

LOC_ID is not a numeric variable, since it is the ID of customers I'll change its datatype to string.

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

In [253]:
```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[253]:

	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.

4) Checking missing values and validity of non numeric variables

4.1) LOC_ID variable

In [254]:
```python
#Convert datatype of int64 to string for the column LOC_ID.
#df1.LOC_ID = df1.LOC_ID.astype('str')
#df2.LOC_ID = df2.LOC_ID.astype('str')
#df3.LOC_ID = df3.LOC_ID.astype('str')
```

In [255]:
```python
#Check if there is duplicated values or Nan in 'LOC_ID' column.
df1.LOC_ID.value_counts(dropna= False).head()
```

Out[255]:
```
1000001510    1
1000000204    1
1000030909    1
1000037054    1
1000035007    1
Name: LOC_ID, dtype: int64
```

In [256]:
```python
#Check if there is duplicated values or Nan in 'LOC_ID' column.
df2.LOC_ID.value_counts(dropna= False).head()
```

Out[256]:
```
1000001510    1
1000000204    1
1000030909    1
1000037054    1
1000035007    1
Name: LOC_ID, dtype: int64
```

In [257]:
```python
#Check if there is duplicated values or Nan in 'LOC_ID' column.
df3.LOC_ID.value_counts(dropna= False).head()
```

Out[257]:
```
1000001510    1
1000000204    1
1000030909    1
1000037054    1
1000035007    1
Name: LOC_ID, dtype: int64
```

In [258]:
```python
#Check the LOC_ID colum in all three DataFrame are same.
((df1.LOC_ID != df2.LOC_ID) & (df2.LOC_ID != df3.LOC_ID)).sum()
```

Out[258]: 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 [259]:
```python
df1.RATE.head()
```

Out[259]:
```
0    W-RSFD
1    W-RSFD
2    W-RSFD
3     W-RMF
4    W-RSFD
Name: RATE, dtype: object
```

In [260]:
```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: How many pure commercial customers are there in each dataframe?

In [261]:
```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: 5132
# pure commercial customers in df2: 5131
# pure commercial customers in df3: 5123
```

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

In [262]:
```python
#Define a new category of COM&RES for commercial accounts that don't use water for pure commercial pru
pose.
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 [263]:
```python
#Set the value one for dwelling units of COM&RES 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 [264]:
```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 [265]:
```python
df1.RATE.unique()
```

Out[265]:
```
[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.

In [266]:
```python
#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 [267]:
```python
#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 [268]:
```python
#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 [269]:
```python
#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 [270]:
```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 [271]:
```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
```

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

In [272]:
```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:  168
```

In [273]:
```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: 84
```

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

In [274]:
```python
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 [275]:
```python
#Calculate the market share of each Rate(customer type), the number of Rate based on the number of Dwe
llling unit
#and % of related missing values.
dict1= {rate:count(df1,rate) for rate in df1.RATE.unique()}
customer = pd.DataFrame(dict1)
customer.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial','C
ommercial and Residual']
customer = customer.T
customer.columns = ['count', '# missing_value', '% missing_value']
print('df1')
customer
```

```
df1
```

Out[275]:

	count	# missing_value	% missing_value
Singel_family	53845.0	2.0	0.0
Multi_family	88064.0	0.0	0.0
Duplex	13461.0	2.0	0.0
Commercial	5268.0	0.0	0.0
Irrigation	1122.0	0.0	0.0
Industrial	197.0	0.0	0.0
Commercial and Residual	1578.0	0.0	0.0

Check missing values in dwelling unit column with the RATE of Single family and Duplex

In [276]:
```python
#check the two missing values of dwelling unit among single family customers.
df1[(df1.RATE == 'RSFD') & (df1.DWEL_UNIT.isna())].T
```

Out[276]:

	17509	35946
LOC_ID	1000017509	1000035946
RATE	RSFD	RSFD
DWEL_UNIT	NaN	NaN
USE1	NaN	365
USE2	NaN	25
USE3	NaN	26
USE4	NaN	20
USE5	NaN	16
USE6	NaN	20
USE7	NaN	25
USE8	NaN	21
USE9	NaN	20
USE10	NaN	19
USE11	NaN	24
USE12	NaN	23
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 [277]:
```python
#check the customer with LOC_ID of 1000017509 in df2 and df3.
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000017509], df2[df2.LOC_ID == 1000017509],
                                       df3[df3.LOC_ID == 1000017509]],axis=0).T)

temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[277]:

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

There is no data for customer with LOC_ID of 1000017509 in any DataFrames. So its row is not informative and let's drop it from all three df.

In [278]:
```python
df1 = df1[df1.LOC_ID != 1000017509]
df2 = df2[df2.LOC_ID != 1000017509]
df3 = df3[df3.LOC_ID != 1000017509]
```

In [279]:
```
#check the customer with LOC_ID of 1000035946 in df2 and df3.
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000035946], df2[df2.LOC_ID == 1000035946],
                                       df3[df3.LOC_ID == 1000035946]],axis=0).T)

temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[279]:

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

In [280]:
```
#Usage data for the customer with the LOC_ID of 1000035946 were recorded but without any READ Date records in year1.
#let's check the residential accounts before and after the customer with LOC_ID of 1000035946.
df1[(df1.LOC_ID == 1000035945) | (df1.LOC_ID ==1000035946) | (df1.LOC_ID == 1000035947)].T
```

Out[280]:

	35945	35946	35947
LOC_ID	1000035945	1000035946	1000035947
RATE	RSFD	RSFD	RSFD
DWEL_UNIT	1	NaN	1
USE1	10	365	14
USE2	8	25	13
USE3	7	26	10
USE4	22	20	11
USE5	7	16	11
USE6	10	20	11
USE7	11	25	13
USE8	11	21	12
USE9	10	20	13
USE10	10	19	13
USE11	10	24	16
USE12	11	23	13
READ_DT1	2018-07-25 00:00:00	NaT	2018-07-30 00:00:00
READ_DT2	2018-06-25 00:00:00	NaT	2018-06-27 00:00:00
READ_DT3	2018-05-24 00:00:00	NaT	2018-05-30 00:00:00
READ_DT4	2018-04-25 00:00:00	NaT	2018-04-30 00:00:00
READ_DT5	2018-03-27 00:00:00	NaT	2018-03-30 00:00:00
READ_DT6	2018-02-26 00:00:00	NaT	2018-03-01 00:00:00
READ_DT7	2018-01-25 00:00:00	NaT	2018-01-30 00:00:00
READ_DT8	2017-12-22 00:00:00	NaT	2017-12-28 00:00:00
READ_DT9	2017-11-21 00:00:00	NaT	2017-11-28 00:00:00
READ_DT10	2017-10-23 00:00:00	NaT	2017-10-26 00:00:00
READ_DT11	2017-09-22 00:00:00	NaT	2017-09-27 00:00:00
READ_DT12	2017-08-23 00:00:00	NaT	2017-08-28 00:00:00
READ_DAYS1	30	NaN	33
READ_DAYS2	32	NaN	28
READ_DAYS3	29	NaN	30
READ_DAYS4	29	NaN	31
READ_DAYS5	29	NaN	29
READ_DAYS6	32	NaN	30
READ_DAYS7	34	NaN	33
READ_DAYS8	31	NaN	30
READ_DAYS9	29	NaN	33
READ_DAYS10	31	NaN	29
READ_DAYS11	30	NaN	30
READ_DAYS12	29	NaN	31

In [281]:
```
#Use forward fillna approach, since it looks more look like its next accout in terms of usage volume.
df1.loc[df1.LOC_ID == 1000035946, 'DWEL_UNIT']= 1

#The value of USE1 seems to be wrong *(data entry error)* because it is too different from its previous usage.
df1.loc[df1.LOC_ID == 1000035946, 'USE1'] = math.ceil(np.mean(df1.loc[df1.LOC_ID == 1000035946,'USE2':'USE12'].values))
df1[df1.LOC_ID == 1000035946].T
```

Out[281]:

	35946
LOC_ID	1000035946
RATE	RSFD
DWEL_UNIT	1
USE1	22
USE2	25
USE3	26
USE4	20
USE5	16
USE6	20
USE7	25
USE8	21
USE9	20
USE10	19
USE11	24
USE12	23
READ_DT1	NaT
READ_DT2	NaT
READ_DT3	NaT
READ_DT4	NaT
READ_DT5	NaT
READ_DT6	NaT
READ_DT7	NaT
READ_DT8	NaT
READ_DT9	NaT
READ_DT10	NaT
READ_DT11	NaT
READ_DT12	NaT
READ_DAYS1	NaN
READ_DAYS2	NaN
READ_DAYS3	NaN
READ_DAYS4	NaN
READ_DAYS5	NaN
READ_DAYS6	NaN
READ_DAYS7	NaN
READ_DAYS8	NaN
READ_DAYS9	NaN
READ_DAYS10	NaN
READ_DAYS11	NaN
READ_DAYS12	NaN

In [282]:
```
#check the two missing values of dwelling unit among Duplex customers in df1.
df1[(df1.RATE == 'RDUPLX') & (df1.DWEL_UNIT.isna())].T
```

Out[282]:

	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 [283]:
```
#check the customer with LOC_ID of 1000012743 in df2 and df3.
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000012743], df2[df2.LOC_ID == 1000012743],
                                       df3[df3.LOC_ID == 1000012743]],axis=0).T)

temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[283]:

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

In [284]:
```
#check the customer with LOC_ID of 1000012743 in df2 and df3.
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000065066], df2[df2.LOC_ID == 1000065066],
                                       df3[df3.LOC_ID == 1000065066]],axis=0).T)

temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[284]:

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

There are no values for customer with LOC_ID of 1000012743 and 1000065066 over three years . So those rows are not informative and let's drop from all DataFrames.

In [285]:
```
df1 = df1[(df1.LOC_ID  != 1000012743) & (df1.LOC_ID  != 1000065066)]
df2 = df2[(df2.LOC_ID  != 1000012743) & (df2.LOC_ID  != 1000065066)]
df3 = df3[(df3.LOC_ID  != 1000012743) & (df3.LOC_ID  != 1000065066)]
df1.shape
```

Out[285]: (78891, 39)

df2

In [287]:
```
#Calculate the market share of each Rate(customer type), the number of Rate based on the number of Dwelling unit
#and % of related missing values.
dict2= {rate:count(df2,rate) for rate in df2.RATE.unique()}
customer = pd.DataFrame(dict2)
customer.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial','Commercial and Residual']
customer = customer.T
customer.columns = ['count', '# missing_value', '% missing_value']
print('df2')
customer
```

df2

Out[287]:

	count	# missing_value	% missing_value
Singel_family	53839.0	2.0	0.0
Multi_family	88047.0	1.0	0.0
Duplex	13460.0	0.0	0.0
Commercial	5269.0	0.0	0.0
Irrigation	1124.0	0.0	0.0
Industrial	194.0	0.0	0.0
Commercial and Residual	1580.0	0.0	0.0

In [288]:
```
#check the two missing values of dwelling unit among single family in df2.
df2[(df2.RATE == 'RSFD') & (df2.DWEL_UNIT.isna())].T
```

Out[288]:

	35946	63905
LOC_ID	1000035946	1000063905
RATE	RSFD	RSFD
DWEL_UNIT	NaN	NaN
USE1	NaN	NaN
USE2	NaN	NaN
USE3	0	NaN
USE4	1	NaN
USE5	2	NaN
USE6	0	NaN
USE7	0	NaN
USE8	0	NaN
USE9	0	NaN
USE10	1	NaN
USE11	3	NaN
USE12	4	NaN
READ_DT1	NaT	NaT
READ_DT2	2019-07-10 00:00:00	NaT
READ_DT3	2019-06-11 00:00:00	NaT
READ_DT4	2019-05-10 00:00:00	NaT
READ_DT5	2019-04-11 00:00:00	NaT
READ_DT6	2019-03-13 00:00:00	NaT
READ_DT7	2019-02-11 00:00:00	NaT
READ_DT8	2019-01-10 00:00:00	NaT
READ_DT9	2018-12-10 00:00:00	NaT
READ_DT10	2018-11-06 00:00:00	NaT
READ_DT11	2018-10-09 00:00:00	NaT
READ_DT12	2018-09-10 00:00:00	NaT
READ_DAYS1	1	NaN
READ_DAYS2	29	NaN
READ_DAYS3	32	NaN
READ_DAYS4	29	NaN
READ_DAYS5	29	NaN
READ_DAYS6	30	NaN
READ_DAYS7	32	NaN
READ_DAYS8	31	NaN
READ_DAYS9	34	NaN
READ_DAYS10	28	NaN
READ_DAYS11	29	NaN
READ_DAYS12	33	NaN

In [289]:
```
#check the customer with LOC_ID of 1000035946 in df1
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000035946], df2[df2.LOC_ID == 1000035946],
                                       df3[df3.LOC_ID == 1000035946]],axis=0).T)

temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[289]:

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

In [290]:
```
#Assign the value of dwelling unit in year1 to dwelling unit in year2 and year3
df2.loc[df2.LOC_ID == 1000035946,'DWEL_UNIT'] = df1.loc[df1.LOC_ID == 1000035946,'DWEL_UNIT'].values
df3.loc[df3.LOC_ID == 1000035946,'DWEL_UNIT'] = df1.loc[df1.LOC_ID == 1000035946,'DWEL_UNIT'].values

#Assign the mean value of usages in period 3 to 12 to usge in period 1 and 2 in year2
df2.loc[df2.LOC_ID == 1000035946,'USE1'] = np.mean(df2.loc[df2.LOC_ID == 1000035946,'USE3':'USE12'].values)
df2.loc[df2.LOC_ID == 1000035946,'USE2'] = np.mean(df2.loc[df2.LOC_ID == 1000035946,'USE3':'USE12'].values)

#Assign the mean value of usages in period 3 to 12 to usge in period 1 and 2 in year3
df3.loc[df3.LOC_ID == 1000035946,'USE1'] = np.mean(df3.loc[df3.LOC_ID == 1000035946,'USE3':'USE12'].values)
df3.loc[df3.LOC_ID == 1000035946,'USE2'] = np.mean(df3.loc[df3.LOC_ID == 1000035946,'USE3':'USE12'].values)
```

In [293]:
```
#check the customer with LOC_ID of 1000035946 in df1
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000035946], df2[df2.LOC_ID == 1000035946],
                                       df3[df3.LOC_ID == 1000035946]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[293]:

	label	df1	df2	df3
0	LOC_ID	1000035946	1000035946	1000035946
1	RATE	RSFD	RSFD	RSFD
2	DWEL_UNIT	1	1	1
3	USE1	22	1.1	2.8
4	USE2	25	1.1	2.8
5	USE3	26	0	0
6	USE4	20	1	0
7	USE5	16	2	0
8	USE6	20	0	2
9	USE7	25	0	1
10	USE8	21	0	6
11	USE9	20	0	10
12	USE10	19	1	4
13	USE11	24	3	4
14	USE12	23	4	1
15	READ_DT1	NaT	NaT	NaT
16	READ_DT2	NaT	2019-07-10 00:00:00	2020-07-12 00:00:00
17	READ_DT3	NaT	2019-06-11 00:00:00	2020-06-10 00:00:00
18	READ_DT4	NaT	2019-05-10 00:00:00	2020-05-11 00:00:00
19	READ_DT5	NaT	2019-04-11 00:00:00	2020-04-12 00:00:00
20	READ_DT6	NaT	2019-03-13 00:00:00	2020-03-12 00:00:00
21	READ_DT7	NaT	2019-02-11 00:00:00	2020-02-10 00:00:00
22	READ_DT8	NaT	2019-01-10 00:00:00	2020-01-10 00:00:00
23	READ_DT9	NaT	2018-12-10 00:00:00	2019-12-10 00:00:00
24	READ_DT10	NaT	2018-11-06 00:00:00	2019-11-06 00:00:00
25	READ_DT11	NaT	2018-10-09 00:00:00	2019-10-08 00:00:00
26	READ_DT12	NaT	2018-09-10 00:00:00	2019-09-11 00:00:00
27	READ_DAYS1	NaN	1	1
28	READ_DAYS2	NaN	29	32
29	READ_DAYS3	NaN	32	30
30	READ_DAYS4	NaN	29	29
31	READ_DAYS5	NaN	29	31
32	READ_DAYS6	NaN	30	31
33	READ_DAYS7	NaN	32	31
34	READ_DAYS8	NaN	31	31
35	READ_DAYS9	NaN	34	34
36	READ_DAYS10	NaN	28	29
37	READ_DAYS11	NaN	29	27
38	READ_DAYS12	NaN	33	33

In [294]:
```
#check the customer with LOC_ID of 1000035946 in df1
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000063905], df2[df2.LOC_ID == 1000063905],
                                       df3[df3.LOC_ID == 1000063905]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[294]:

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

There is no data related to customer with LOC_ID of 1000063905 in year2 and year3. Let's drop it from all dataframes.

In [295]:
```
df1 = df1[df1.LOC_ID != 1000063905]
df2 = df2[df2.LOC_ID != 1000063905]
df3 = df3[df3.LOC_ID != 1000063905]
```

In [296]:
```
#check the two missing values of dwelling unit among single family in df2.
df2[(df2.RATE == 'RMF') & (df2.DWEL_UNIT.isna())].T
```

Out[296]:

	52668
LOC_ID	1000052668
RATE	RMF
DWEL_UNIT	NaN
USE1	NaN
USE2	NaN
USE3	NaN
USE4	NaN
USE5	NaN
USE6	NaN
USE7	NaN
USE8	NaN
USE9	NaN
USE10	NaN
USE11	NaN
USE12	NaN
READ_DT1	NaT
READ_DT2	NaT
READ_DT3	NaT
READ_DT4	NaT
READ_DT5	NaT
READ_DT6	NaT
READ_DT7	NaT
READ_DT8	NaT
READ_DT9	NaT
READ_DT10	NaT
READ_DT11	NaT
READ_DT12	NaT
READ_DAYS1	NaN
READ_DAYS2	NaN
READ_DAYS3	NaN
READ_DAYS4	NaN
READ_DAYS5	NaN
READ_DAYS6	NaN
READ_DAYS7	NaN
READ_DAYS8	NaN
READ_DAYS9	NaN
READ_DAYS10	NaN
READ_DAYS11	NaN
READ_DAYS12	NaN

In [297]:
```python
#check the customer with LOC_ID of 1000052668 in df2,df3
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000052668], df2[df2.LOC_ID == 1000052668],
                                       df3[df3.LOC_ID == 1000052668]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df2.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[297]:

	label	df1	df2	df3
0	LOC_ID	1000052668	1000052668	1000052668
1	RATE	RMF	RMF	RMF
2	DWEL_UNIT	3	NaN	NaN
3	USE1	19	NaN	NaN
4	USE2	19	NaN	NaN
5	USE3	20	NaN	NaN
6	USE4	19	NaN	NaN
7	USE5	17	NaN	NaN
8	USE6	18	NaN	NaN
9	USE7	17	NaN	NaN
10	USE8	17	NaN	NaN
11	USE9	18	NaN	NaN
12	USE10	17	NaN	NaN
13	USE11	18	NaN	NaN
14	USE12	18	NaN	NaN
15	READ_DT1	2018-08-02 00:00:00	NaT	NaT
16	READ_DT2	2018-07-03 00:00:00	NaT	NaT
17	READ_DT3	2018-06-04 00:00:00	NaT	NaT
18	READ_DT4	2018-05-03 00:00:00	NaT	NaT
19	READ_DT5	2018-04-04 00:00:00	NaT	NaT
20	READ_DT6	2018-03-06 00:00:00	NaT	NaT
21	READ_DT7	2018-02-02 00:00:00	NaT	NaT
22	READ_DT8	2018-01-03 00:00:00	NaT	NaT
23	READ_DT9	2017-12-04 00:00:00	NaT	NaT
24	READ_DT10	2017-10-31 00:00:00	NaT	NaT
25	READ_DT11	2017-10-02 00:00:00	NaT	NaT
26	READ_DT12	2017-08-31 00:00:00	NaT	NaT
27	READ_DAYS1	30	NaN	NaN
28	READ_DAYS2	29	NaN	NaN
29	READ_DAYS3	32	NaN	NaN
30	READ_DAYS4	29	NaN	NaN
31	READ_DAYS5	29	NaN	NaN
32	READ_DAYS6	32	NaN	NaN
33	READ_DAYS7	30	NaN	NaN
34	READ_DAYS8	30	NaN	NaN
35	READ_DAYS9	34	NaN	NaN
36	READ_DAYS10	29	NaN	NaN
37	READ_DAYS11	32	NaN	NaN
38	READ_DAYS12	29	NaN	NaN

There is no data related to customer with LOC_ID of 1000052668 in year2 and year3. Let's drop from all dataframes.

In [298]:
```python
df1 = df1[df1.LOC_ID != 1000052668]
df2 = df2[df2.LOC_ID != 1000052668]
df3 = df3[df3.LOC_ID != 1000052668]
```

df3

In [299]:
```python
#Calculate the market share of each Rate(customer type), the number of Rate based on the number of Dwe
lling unit
#and % of related missing values.
dict3= {rate:count(df3,rate) for rate in df3.RATE.unique()}
customer = pd.DataFrame(dict3)
customer.columns = ['Singel_family', 'Multi_family','Duplex','Commercial','Irrigation','Industrial','C
ommercial and Residual']
customer = customer.T
customer.columns = ['count', '# missing_value', '% missing_value']
print('df3')
customer
```

```
df3
```

Out[299]:

	count	# missing_value	% missing_value
Singel_family	53744.0	3.0	0.0
Multi_family	88126.0	0.0	0.0
Duplex	13597.0	0.0	0.0
Commercial	5267.0	0.0	0.0
Irrigation	1125.0	0.0	0.0
Industrial	195.0	0.0	0.0
Commercial and Residual	1308.0	0.0	0.0

In [300]:
```python
#check the two missing values of dwelling unit among single family in df2.
df3[(df3.RATE == 'RSFD') & (df3.DWEL_UNIT.isna())].T
```

Out[300]:

	24304	54741	62574
LOC_ID	1000024304	1000054741	1000062574
RATE	RSFD	RSFD	RSFD
DWEL_UNIT	NaN	NaN	NaN
USE1	NaN	NaN	NaN
USE2	NaN	NaN	NaN
USE3	NaN	NaN	NaN
USE4	NaN	NaN	NaN
USE5	NaN	NaN	NaN
USE6	NaN	NaN	NaN
USE7	NaN	NaN	NaN
USE8	NaN	NaN	NaN
USE9	NaN	NaN	NaN
USE10	NaN	NaN	NaN
USE11	NaN	NaN	NaN
USE12	NaN	NaN	NaN
READ_DT1	NaT	NaT	NaT
READ_DT2	NaT	NaT	NaT
READ_DT3	NaT	NaT	NaT
READ_DT4	NaT	NaT	NaT
READ_DT5	NaT	NaT	NaT
READ_DT6	NaT	NaT	NaT
READ_DT7	NaT	NaT	NaT
READ_DT8	NaT	NaT	NaT
READ_DT9	NaT	NaT	NaT
READ_DT10	NaT	NaT	NaT
READ_DT11	NaT	NaT	NaT
READ_DT12	NaT	NaT	NaT
READ_DAYS1	NaN	NaN	NaN
READ_DAYS2	NaN	NaN	NaN
READ_DAYS3	NaN	NaN	NaN
READ_DAYS4	NaN	NaN	NaN
READ_DAYS5	NaN	NaN	NaN
READ_DAYS6	NaN	NaN	NaN
READ_DAYS7	NaN	NaN	NaN
READ_DAYS8	NaN	NaN	NaN
READ_DAYS9	NaN	NaN	NaN
READ_DAYS10	NaN	NaN	NaN
READ_DAYS11	NaN	NaN	NaN
READ_DAYS12	NaN	NaN	NaN

In [301]:
```python
#check the customer with LOC_ID of 1000024304 in df1,df2
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000024304], df2[df2.LOC_ID == 1000024304],
                                       df3[df3.LOC_ID == 1000024304]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df3.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[301]:

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

In [302]:
```python
#check the customer with LOC_ID of 1000054741 in df1,df2
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000054741], df2[df2.LOC_ID == 1000054741],
                                       df3[df3.LOC_ID == 1000054741]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df3.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[302]:

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

In [303]:
```python
#check the customer with LOC_ID of 1000062574 in df1,df2
temp_df = pd.DataFrame(np.concatenate([df1[df1.LOC_ID == 1000062574], df2[df2.LOC_ID == 1000062574],
                                       df3[df3.LOC_ID == 1000062574]],axis=0).T)
temp_df.columns = ['df1', 'df2','df3']
temp_df['label'] = df3.columns
temp_df = temp_df[['label','df1', 'df2','df3']]
temp_df
```

Out[303]:

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

There is no data related to customers with LOC_ID of 1000024304, 1000054741 and 1000062574 in year3. Let's drop from all dataframes.

In [304]:
```python
df1 = df1[(df1.LOC_ID != 1000024304) & (df1.LOC_ID != 1000054741) & (df1.LOC_ID != 1000062574)]
df2 = df2[(df2.LOC_ID != 1000024304) & (df2.LOC_ID != 1000054741) & (df2.LOC_ID != 1000062574)]
df3 = df3[(df3.LOC_ID != 1000024304) & (df3.LOC_ID != 1000054741) & (df3.LOC_ID != 1000062574)]
```

df1

In [305]:
```python
#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[305]:

	market_share	count	# missing_value	% missing_value
Singel_family	68.24	53842.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.19	13461.0	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 [306]:
```python
#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[306]:

	market_share	count	# missing_value	% missing_value
Singel_family	68.23	53842.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.20	13461.0	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 [307]:
```python
#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[307]:

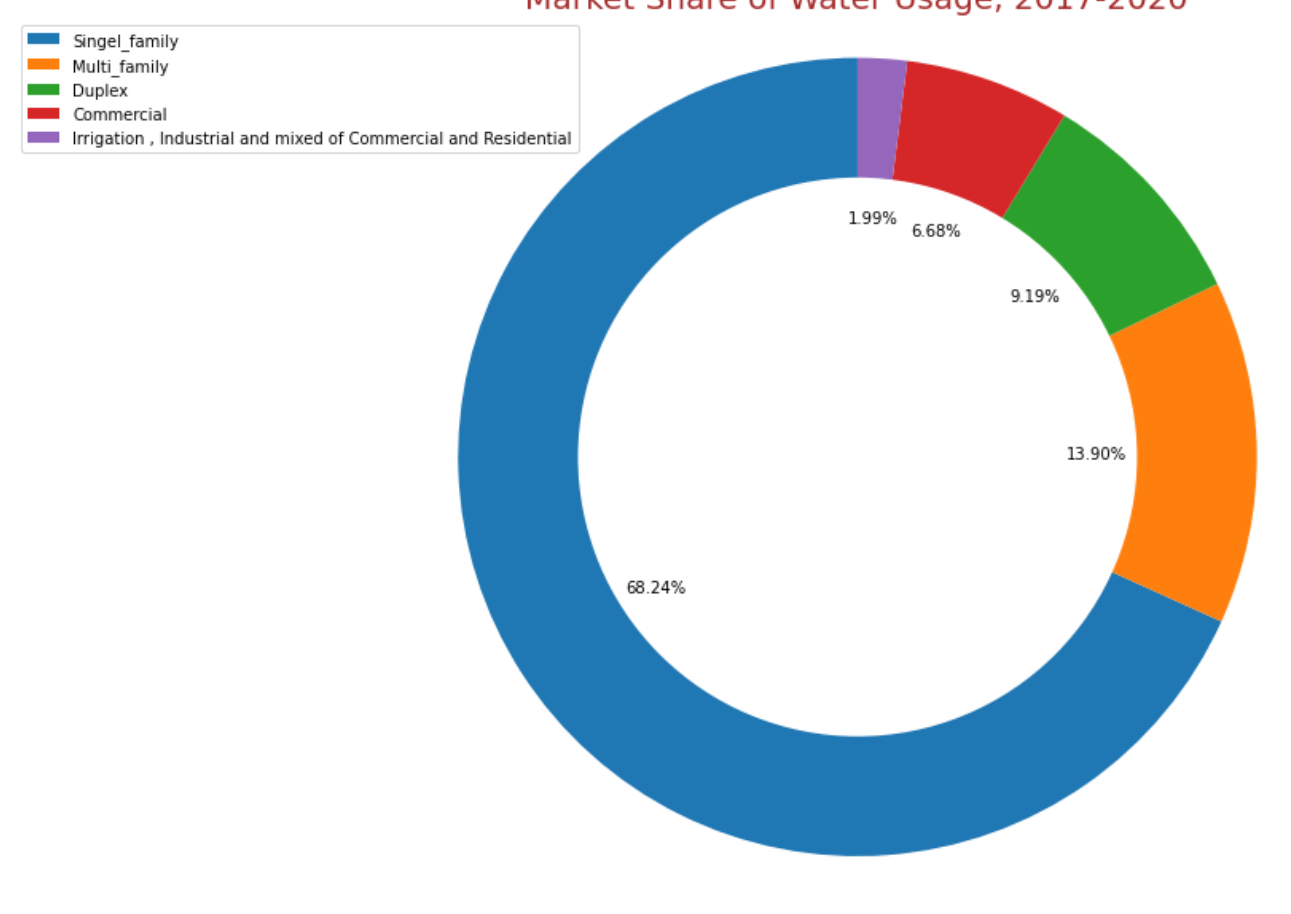
	market_share	count	# missing_value	% missing_value
Singel_family	68.11	53842.0	0.0	0.0
Multi_family	13.90	88061.0	0.0	0.0
Duplex	9.31	13461.0	0.0	0.0
Commercial	6.68	5268.0	0.0	0.0
Irrigation	1.43	1122.0	0.0	0.0
Industrial	0.33	197.0	0.0	0.0
Commercial and Residential	0.25	1578.0	0.0	0.0

In [308]:
```python
# 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.

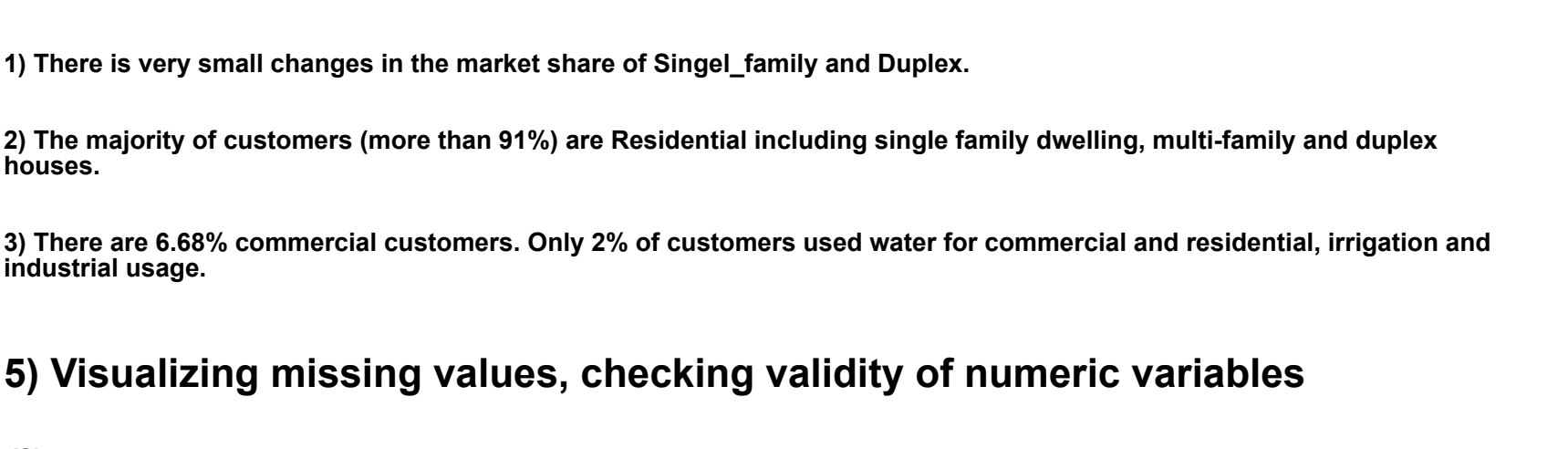
2) The majority of customers (more than 91%) are Residential including single family dwelling, multi-family and duplex houses.

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

5) Visualizing missing values, checking validity of numeric variables

df1

In [309]:
```python
#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()
```



5.1) Find previous read date of each read date and caculate the usage per RATE and month, 2017-2018

df1

In [310]:
```python
#Create a new dataframe that each row has a unique id of LOC_ID and RATE, a group of columns of usage,
 read date and
#read days which include all values of related columns in main df1. Remaining column of df1 are left i
ntact.

long_df1 =pd.wide_to_long(df1, stubnames= ['USE','READ_DT', 'READ_DAYS'],
                i= ['LOC_ID','RATE'],
                j='period').reset_index()
#long_df1['READ_DT'] = long_df1['READ_DT'].dt.strftime('%d-%m-%Y')

long_df1.head()
```

Out[310]:

	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 [313]:
```python
#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(35)
```

Out[313]:

	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
5	1000000000	RSFD	6	1.0	10.0	2018-02-09	31.0	2018-01-09
6	1000000000	RSFD	7	1.0	11.0	2018-01-09	32.0	2017-12-08
7	1000000000	RSFD	8	1.0	9.0	2017-12-08	31.0	2017-11-07
8	1000000000	RSFD	9	1.0	11.0	2017-11-07	29.0	2017-10-09
9	1000000000	RSFD	10	1.0	13.0	2017-10-09	31.0	2017-09-08
10	1000000000	RSFD	11	1.0	15.0	2017-09-08	30.0	2017-08-09
11	1000000000	RSFD	12	1.0	15.0	2017-08-09	29.0	2017-07-11
12	1000000001	RSFD	1	1.0	9.0	2018-07-19	30.0	2018-06-19
13	1000000001	RSFD	2	1.0	8.0	2018-06-19	32.0	2018-05-18
14	1000000001	RSFD	3	1.0	7.0	2018-05-18	29.0	2018-04-19
15	1000000001	RSFD	4	1.0	5.0	2018-04-19	29.0	2018-03-21
16	1000000001	RSFD	5	1.0	4.0	2018-03-21	29.0	2018-02-20
17	1000000001	RSFD	6	1.0	7.0	2018-02-20	32.0	2018-01-19
18	1000000001	RSFD	7	1.0	5.0	2018-01-19	32.0	2017-12-18
19	1000000001	RSFD	8	1.0	6.0	2017-12-18	33.0	2017-11-15
20	1000000001	RSFD	9	1.0	6.0	2017-11-15	29.0	2017-10-17
21	1000000001	RSFD	10	1.0	8.0	2017-10-17	29.0	2017-09-18
22	1000000001	RSFD	11	1.0	8.0	2017-09-18	32.0	2017-08-17
23	1000000001	RSFD	12	1.0	9.0	2017-08-17	29.0	2017-07-19
24	1000000002	RSFD	1	1.0	10.0	2018-07-16	32.0	2018-06-14
25	1000000002	RSFD	2	1.0	7.0	2018-06-14	30.0	2018-05-15
26	1000000002	RSFD	3	1.0	7.0	2018-05-15	29.0	2018-04-16
27	1000000002	RSFD	4	1.0	8.0	2018-04-16	31.0	2018-03-16
28	1000000002	RSFD	5	1.0	7.0	2018-03-16	30.0	2018-02-14
29	1000000002	RSFD	6	1.0	8.0	2018-02-14	29.0	2018-01-16
30	1000000002	RSFD	7	1.0	12.0	2018-01-16	34.0	2017-12-13
31	1000000002	RSFD	8	1.0	10.0	2017-12-13	33.0	2017-11-10
32	1000000002	RSFD	9	1.0	20.0	2017-11-10	25.0	2017-10-16
33	1000000002	RSFD	10	1.0	NaN	NaT	NaN	NaT
34	1000000002	RSFD	11	1.0	NaN	NaT	NaN	NaT

In [317]:
```python
#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()]
long_df1.head()
```

Out[317]:

	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 [382]:
```python
missing_read_date1.shape
```

Out[382]:
```
(30161, 8)
```

In [318]:
```python
long_df1.shape
```

Out[318]:
```
(916474, 8)
```

In [350]:
```python
#Chunk the long_df1
chunk1 = long_df1.iloc[0:45000,:]
chunk2 = long_df1.iloc[45000:,:]
```

In [351]:
```python
#Create a list of dataframes, each dataframe with index of month(s) between previous read data and rea
d date,
#and extracting the month and year of index(s)
def yr_month(small):
    result = []
    for tup in small.itertuples():
        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 [352]:
```python
result1 = yr_month(chunk1)
```

In [354]:
```python
result2 = yr_month(chunk2)
```

In [355]:
```python
result1.head()
```

Out[355]:

	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 [358]:
```python
result2.head()
```

Out[358]:

	0	1	2	3	4	5	6	7	month	year
2017-12	1000003876	RSFD	7	1.0	8.0	2018-01-10	33.0	2017-12-08	12	2017
2018-01	1000003876	RSFD	7	1.0	8.0	2018-01-10	33.0	2017-12-08	1	2018
2017-11	1000003876	RSFD	8	1.0	13.0	2017-12-08	31.0	2017-11-07	11	2017
2017-12	1000003876	RSFD	8	1.0	13.0	2017-12-08	31.0	2017-11-07	12	2017
2017-10	1000003876	RSFD	9	1.0	22.0	2017-11-07	29.0	2017-10-09	10	2017

In [357]:
```python
print('result1 shape:', result1.shape)
print('result2.shape:', result2.shape)
```

```
result1 shape: (90000, 10)
result2.shape: (1742948, 10)
```

In [359]:
```python
#Concatenate the results of chunks, and rename the columns
result = pd.concat([result1,result2], axis= 0).reset_index()
result.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)
result.head()
```

Out[359]:

	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 [360]:
```python
print('result shape:', result.shape)
```

```
result shape: (1832948, 11)
```

In [369]:
```python
result1.reset_index(inplace=True)
```

In [372]:
```python
result1.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)
```

In [376]:
```python
#Create the month start for each row
result1['month_start'] = pd.to_datetime((result1.year * 10000 + result1.month * 100 + 1).apply(str) ,
format='%Y%m%d')

#Find number of days in the month
result1['days_in_month'] = result1[['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
result1['month_start_to_read_date'] = result1[['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
result1['previous_read_date_to_month_start'] = result1[['previous_read_date','month_start','days_in_mo
nth']].apply(
        lambda x: x[2] - pd.Timedelta(x[0]-x[1],'D').days, axis=1)

#Count number of days in each period
result1['days_in_period'] = result1[['previous_read_date_to_month_start','month_start',\
                                     'month_start_to_read_date','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)
```

In [380]:
```python
#Create the month start for each row
result['month_start'] = pd.to_datetime((result.year * 10000 + result1.month * 100 + 1).apply(str) , fo
rmat='%Y%m%d')

#Find number of days in the month
result['days_in_month'] = result[['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
result['month_start_to_read_date'] = result[['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
result['previous_read_date_to_month_start'] = result[['previous_read_date','month_start','days_in_mont
h']].apply(
        lambda x: x[2] - pd.Timedelta(x[0]-x[1],'D').days, axis=1)

#Count number of days in each period
result['days_in_period'] = result[['previous_read_date_to_month_start','month_start_to_read_date','day
s_in_month']].apply(
    lambda x: x[2] if (x[2] <= x[1] and x[0] > x[2])
                   else(x[0] if x[0] <= x[2] else x[1]),axis=1)
```

In [387]:
```python
result['usage_in_period'] = round((result.days_in_period / result.READ_DAYS) * result.USE, 1)
```

In [391]:
```python
result = result[['LOC_ID', 'RATE', 'period', 'DWEL_UNIT', 'USE', 'READ_DT',
       'READ_DAYS', 'previous_read_date', 'month', 'year', 'month_start',
       'days_in_month', 'month_start_to_read_date',
       'previous_read_date_to_month_start', 'days_in_period',
       'usage_in_period']]
```

In [392]:
```python
result.head()
```

Out[392]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year	month_start	days_in_month
0	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	6	2018	2018-06-01	30
1	1000000000	RSFD	1	1.0	22.0	2018-07-11	30.0	2018-06-11	7	2018	2018-07-01	31
2	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	5	2018	2018-05-01	31
3	1000000000	RSFD	2	1.0	22.0	2018-06-11	32.0	2018-05-10	6	2018	2018-06-01	30
4	1000000000	RSFD	3	1.0	15.0	2018-05-10	29.0	2018-04-11	4	2018	2018-04-01	30

In [393]:
```python
result.to_csv('df1_clean.csv', index=False)
```

In [414]:
```python
data2017_18 = pd.DataFrame(result.groupby(['RATE','month_start'])[['DWEL_UNIT','days_in_period','usage
_in_period']].sum())
data2017_18.head(20)
```

Out[414]:

RATE	month_start	DWEL_UNIT	days_in_period	usage_in_period
COM	2017-02-01	1.0	17.0	0.6
	2017-05-01	1.0	28.0	2.6
	2017-06-01	4.0	45.0	6.3
	2017-07-01	170.0	1978.0	4054.1
	2017-08-01	443.0	7692.0	14457.8
	2017-09-01	442.0	6636.0	12536.6
	2017-10-01	489.0	7595.0	13738.2
	2017-11-01	453.0	6819.0	11669.4
	2017-12-01	450.0	6989.0	10833.4
	2018-01-01	479.0	7430.0	11561.1
	2018-02-01	429.0	5987.0	8030.3
	2018-03-01	507.0	7909.0	11784.8
	2018-04-01	486.0	7309.0	11671.2
	2018-05-01	534.0	8382.0	15244.7
	2018-06-01	500.0	7455.0	12339.5
	2018-07-01	324.0	5905.0	9934.4
	2018-08-01	72.0	258.0	302.2
COM&RES	2017-07-01	67.0	64.0	109.0
	2017-08-01	142.0	305.0	404.5
	2017-09-01	142.0	270.0	362.1

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

In [415]:
```python
#Create a new df that assign all READ_DT, all READ_Days and all USE values from df2 in 3 columns.
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()
long_df2.head()
```

Out[415]:

	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 [416]:
```python
#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[416]:

	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 [417]:
```python
#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()]
long_df2.head()
```

Out[417]:

	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 [386]:
```python
missing_read_date2.shape
```

Out[386]:
```
(3470, 8)
```

In [418]:
```python
long_df2.shape
```

Out[418]:
```
(943186, 9)
```

In [422]:
```python
#Chunk the long_df2
chunk3 = long_df2.iloc[0:310000,:]
chunk4 = long_df2.iloc[310000:620000,:]
chunk5 = long_df2.iloc[620000:,:]
```

In [423]:
```python
result4 = yr_month(chunk3)
```

In [425]:
```python
result4.head()
```

Out[425]:

	0	1	2	3	4	5	6	7	month	year
2019-06	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	6	2019
2019-07	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	7	2019
2019-05	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	5	2019
2019-06	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	6	2019
2019-04	1000000000	RSFD	3	1.0	6.0	2019-05-10	29.0	2019-04-11	4	2019

In [426]:
```python
result5 = yr_month(chunk4)
```

In [427]:
```python
result6 = yr_month(chunk5)
```

In [429]:
```python
data2 = pd.concat([result4,result5, result6], axis=0).reset_index()
```

In [432]:
```python
data2.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)
```

In [433]:
```python
data2.head()
```

Out[433]:

	index	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year	month_start	days_in
0	2019-06	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	6	2019	2019-06-01	
1	2019-07	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	7	2019	2019-07-01	
2	2019-05	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	5	2019	2019-05-01	
3	2019-06	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	6	2019	2019-06-01	
4	2019-04	1000000000	RSFD	3	1.0	6.0	2019-05-10	29.0	2019-04-11	4	2019	2019-04-01	

In [434]:
```python
#Create the month start for each row
data2['month_start'] = pd.to_datetime((data2.year * 10000 + data2.month * 100 + 1).apply(str) , format
='%Y%m%d')

#Find number of days in the month
data2['days_in_month'] = data2[['year','month']].apply(lambda x: calendar.monthrange(x[0],x[1])[1], ax
is= 1)

#Count number of days between start of month and read date
data2['month_start_to_read_date'] = data2[['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
data2['previous_read_date_to_month_start'] = data2[['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
data2['days_in_period'] = data2[['previous_read_date_to_month_start','month_start_to_read_date','days_
in_month']].apply(
    lambda x: x[2] if (x[2] <= x[1] and x[0] > x[2])
                   else(x[0] if x[0] <= x[2] else x[1]),axis=1)
data2['usage_in_period'] = round((data2.days_in_period / data2.READ_DAYS) * data2.USE, 1)
```

In [435]:
```python
data2 = data2[['LOC_ID', 'RATE', 'period', 'DWEL_UNIT', 'USE', 'READ_DT',
       'READ_DAYS', 'previous_read_date', 'month', 'year', 'month_start',
       'days_in_month', 'month_start_to_read_date',
       'previous_read_date_to_month_start', 'days_in_period',
       'usage_in_period']]
```

In [436]:
```python
data2.head()
```

Out[436]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year	month_start	days_in_month
0	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	6	2019	2019-06-01	30
1	1000000000	RSFD	1	1.0	20.0	2019-07-10	30.0	2019-06-10	7	2019	2019-07-01	31
2	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	5	2019	2019-05-01	31
3	1000000000	RSFD	2	1.0	13.0	2019-06-10	31.0	2019-05-10	6	2019	2019-06-01	30
4	1000000000	RSFD	3	1.0	6.0	2019-05-10	29.0	2019-04-11	4	2019	2019-04-01	30

In [437]:
```python
data2.to_csv('df2_clean.csv', index=False)
```

In [485]:
```python
data2018_19 = pd.DataFrame(data2.groupby(['RATE','month_start'])[['DWEL_UNIT','days_in_period','usage_
in_period']].sum())
data2018_19.head(10)
```

Out[485]:

RATE	month_start	DWEL_UNIT	days_in_period	usage_in_period
COM	2016-04-01	1.0	20	4.7
	2017-06-01	2.0	30	7.3
	2018-02-01	3.0	23	14.7
	2018-03-01	7.0	107	38.8
	2018-04-01	6.0	107	193.8
	2018-05-01	22.0	350	7150.1
	2018-06-01	80.0	1087	13622.7
	2018-07-01	3853.0	41107	185239.8
	2018-08-01	10076.0	174052	503290.8
	2018-09-01	9437.0	141571	439041.8

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

In [440]:
```python
#Create a new df that assign all READ_DT, all READ_Days and all USE values from df3 in 3 columns.
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()
long_df3.head()
```

Out[440]:

	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 [441]:
```python
#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[441]:

	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 [442]:
```python
#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()]
long_df3.head()
```

Out[442]:

	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 [443]:
```python
missing_read_date3.shape
```

Out[443]:
```
(3209, 9)
```

In [445]:
```python
long_df3.shape
```

Out[445]:
```
(943423, 9)
```

In [446]:
```python
#Chunk the long_df3
chunk6 = long_df3.iloc[0:310000,:]
chunk7 = long_df3.iloc[310000:620000,:]
chunk8 = long_df3.iloc[620000:,:]
```

In [447]:
```python
result7 = yr_month(chunk6)
```

In [448]:
```python
result8 = yr_month(chunk7)
```

In [449]:
```python
result9 = yr_month(chunk8)
```

In [450]:
```python
data3 = pd.concat([result7,result8, result9], axis=0).reset_index()
```

In [451]:
```python
data3.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)
```

In [452]:
```python
#Create the month start for each row
data3['month_start'] = pd.to_datetime((data3.year * 10000 + data3.month * 100 + 1).apply(str) , format
='%Y%m%d')

#Find number of days in the month
data3['days_in_month'] = data3[['year','month']].apply(lambda x: calendar.monthrange(x[0],x[1])[1], ax
is= 1)

#Count number of days between start of month and read date
data3['month_start_to_read_date'] = data3[['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
data3['previous_read_date_to_month_start'] = data3[['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
data3['days_in_period'] = data3[['previous_read_date_to_month_start','month_start_to_read_date','days_
in_month']].apply(
    lambda x: x[2] if (x[2] <= x[1] and x[0] > x[2])
                   else(x[0] if x[0] <= x[2] else x[1]),axis=1)
data3['usage_in_period'] = round((data3.days_in_period / data3.READ_DAYS) * data3.USE, 1)
```

In [453]:
```python
data3 = data3[['LOC_ID', 'RATE', 'period', 'DWEL_UNIT', 'USE', 'READ_DT',
       'READ_DAYS', 'previous_read_date', 'month', 'year', 'month_start',
       'days_in_month', 'month_start_to_read_date',
       'previous_read_date_to_month_start', 'days_in_period',
       'usage_in_period']]
```

In [454]:
```python
data3.head()
```

Out[454]:

	LOC_ID	RATE	period	DWEL_UNIT	USE	READ_DT	READ_DAYS	previous_read_date	month	year	month_start	days_in_month
0	1000000000	RSFD	1	1.0	16.0	2020-07-10	31.0	2020-06-09	6	2020	2020-06-01	30
1	1000000000	RSFD	1	1.0	16.0	2020-07-10	31.0	2020-06-09	7	2020	2020-07-01	31
2	1000000000	RSFD	2	1.0	13.0	2020-06-09	29.0	2020-05-11	5	2020	2020-05-01	31
3	1000000000	RSFD	2	1.0	13.0	2020-06-09	29.0	2020-05-11	6	2020	2020-06-01	30
4	1000000000	RSFD	3	1.0	20.0	2020-05-11	31.0	2020-04-10	4	2020	2020-04-01	30

In [455]:
```python
data3.to_csv('df3_clean.csv', index=False)
```

In [484]:
```python
data2019_20 = pd.DataFrame(result.groupby(['RATE','month_start'])[['DWEL_UNIT','days_in_period','usage
_in_period']].sum())
data2019_20.head()
```

Out[484]:

RATE	month_start	DWEL_UNIT	days_in_period	usage_in_period
COM	2017-02-01	1.0	17.0	0.6
	2017-05-01	1.0	28.0	2.6
	2017-06-01	4.0	45.0	6.3
	2017-07-01	170.0	1978.0	4054.1
	2017-08-01	443.0	7692.0	14457.8

5.4) Integrating the data, 2017-2020

In [480]:
```python
data2017_20 = pd.concat([data2017_18.reset_index(), data2018_19.reset_index(), data2019_20.reset_index
()],axis=0)
data2017_20 = data2017_20.groupby(['RATE','month_start'])[['DWEL_UNIT','days_in_period','usage_in_peri
od']].sum()
data2017_20 = data2017_20.reset_index()
data2017_20.head()
```

Out[480]:

	RATE	month_start	DWEL_UNIT	days_in_period	usage_in_period
0	COM	2016-04-01	1.0	20.0	4.7
1	COM	2017-02-01	2.0	34.0	1.2
2	COM	2017-05-01	2.0	56.0	5.2
3	COM	2017-06-01	10.0	120.0	19.9
4	COM	2017-07-01	340.0	3956.0	8108.2

In [483]:
```python
data2017_20.to_csv('data_clean.csv', index=False)
```