wth8n36z9

August 12, 2023

1 Client History EDA

[2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
import warnings
warnings.filterwarnings('ignore')
```

[38]:
```
client_df = pd.read_csv('client_data.
 ↪csv',parse_dates=['date_activ','date_end','date_modif_prod','date_renewal'],dayfirst=True)
```

[39]:
```
client_df.head()
```

[39]:

	id	channel_sales	\
0	24011ae4ebbe3035111d65fa7c15bc57	foosdfpfkusacimwkcsosbicdxkicaua	
1	d29c2c54acc38ff3c0614d0a653813dd	MISSING	
2	764c75f661154dac3a6c254cd082ea7d	foosdfpfkusacimwkcsosbicdxkicaua	
3	bba03439a292a1e166f80264c16191cb	lmkebamcaaclubfxadlmueccxoimlema	
4	149d57cf92fc41cf94415803a877cb4b	MISSING	

	cons_12m	cons_gas_12m	cons_last_month	date_activ	date_end	\
0	0	54946	0	2013-06-15	2016-06-15	
1	4660	0	0	2009-08-21	2016-08-30	
2	544	0	0	2010-04-16	2016-04-16	
3	1584	0	0	2010-03-30	2016-03-30	
4	4425	0	526	2010-01-13	2016-03-07	

	date_modif_prod	date_renewal	forecast_cons_12m	…	has_gas	imp_cons	\
0	2015-11-01	2015-06-23	0.00	…	t	0.00	
1	2009-08-21	2015-08-31	189.95	…	f	0.00	
2	2010-04-16	2015-04-17	47.96	…	f	0.00	
3	2010-03-30	2015-03-31	240.04	…	f	0.00	
4	2010-01-13	2015-03-09	445.75	…	f	52.32	

	margin_gross_pow_ele	margin_net_pow_ele	nb_prod_act	net_margin	\

```
0                25.44               25.44            2      678.99
1                16.38               16.38            1       18.89
2                28.60               28.60            1        6.60
3                30.22               30.22            1       25.46
4                44.91               44.91            1       47.98

  num_years_antig                          origin_up  pow_max  churn
0               3  lxidpiddsbxsbosboudacockeimpuepw    43.648      1
1               6  kamkkxfxxuwbdslkwifmmcsiusiuosws    13.800      0
2               6  kamkkxfxxuwbdslkwifmmcsiusiuosws    13.856      0
3               6  kamkkxfxxuwbdslkwifmmcsiusiuosws    13.200      0
4               6  kamkkxfxxuwbdslkwifmmcsiusiuosws    19.800      0

[5 rows x 26 columns]
```

[40]:
```
client_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14606 entries, 0 to 14605
Data columns (total 26 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   id                              14606 non-null  object
 1   channel_sales                   14606 non-null  object
 2   cons_12m                        14606 non-null  int64
 3   cons_gas_12m                    14606 non-null  int64
 4   cons_last_month                 14606 non-null  int64
 5   date_activ                      14606 non-null  datetime64[ns]
 6   date_end                        14606 non-null  datetime64[ns]
 7   date_modif_prod                 14606 non-null  datetime64[ns]
 8   date_renewal                    14606 non-null  datetime64[ns]
 9   forecast_cons_12m               14606 non-null  float64
 10  forecast_cons_year              14606 non-null  int64
 11  forecast_discount_energy        14606 non-null  float64
 12  forecast_meter_rent_12m         14606 non-null  float64
 13  forecast_price_energy_off_peak  14606 non-null  float64
 14  forecast_price_energy_peak      14606 non-null  float64
 15  forecast_price_pow_off_peak     14606 non-null  float64
 16  has_gas                         14606 non-null  object
 17  imp_cons                        14606 non-null  float64
 18  margin_gross_pow_ele            14606 non-null  float64
 19  margin_net_pow_ele              14606 non-null  float64
 20  nb_prod_act                     14606 non-null  int64
 21  net_margin                      14606 non-null  float64
 22  num_years_antig                 14606 non-null  int64
 23  origin_up                       14606 non-null  object
 24  pow_max                         14606 non-null  float64
```

```
 25  churn                           14606 non-null  int64
dtypes: datetime64[ns](4), float64(11), int64(7), object(4)
memory usage: 2.9+ MB
```

[41]:
```
client_df.describe()
```

[41]:

	cons_12m	cons_gas_12m	cons_last_month	forecast_cons_12m
count	1.460600e+04	1.460600e+04	14606.000000	14606.000000
mean	1.592203e+05	2.809238e+04	16090.269752	1868.614880
std	5.734653e+05	1.629731e+05	64364.196422	2387.571531
min	0.000000e+00	0.000000e+00	0.000000	0.000000
25%	5.674750e+03	0.000000e+00	0.000000	494.995000
50%	1.411550e+04	0.000000e+00	792.500000	1112.875000
75%	4.076375e+04	0.000000e+00	3383.000000	2401.790000
max	6.207104e+06	4.154590e+06	771203.000000	82902.830000

	forecast_cons_year	forecast_discount_energy	forecast_meter_rent_12m
count	14606.000000	14606.000000	14606.000000
mean	1399.762906	0.966726	63.086871
std	3247.786255	5.108289	66.165783
min	0.000000	0.000000	0.000000
25%	0.000000	0.000000	16.180000
50%	314.000000	0.000000	18.795000
75%	1745.750000	0.000000	131.030000
max	175375.000000	30.000000	599.310000

	forecast_price_energy_off_peak	forecast_price_energy_peak
count	14606.000000	14606.000000
mean	0.137283	0.050491
std	0.024623	0.049037
min	0.000000	0.000000
25%	0.116340	0.000000
50%	0.143166	0.084138
75%	0.146348	0.098837
max	0.273963	0.195975

	forecast_price_pow_off_peak	imp_cons	margin_gross_pow_ele
count	14606.000000	14606.000000	14606.000000
mean	43.130056	152.786896	24.565121
std	4.485988	341.369366	20.231172
min	0.000000	0.000000	0.000000
25%	40.606701	0.000000	14.280000
50%	44.311378	37.395000	21.640000
75%	44.311378	193.980000	29.880000
max	59.266378	15042.790000	374.640000

	margin_net_pow_ele	nb_prod_act	net_margin	num_years_antig

```
count        14606.000000  14606.000000  14606.000000     14606.000000
mean            24.562517      1.292346    189.264522         4.997809
std             20.230280      0.709774    311.798130         1.611749
min              0.000000      1.000000      0.000000         1.000000
25%             14.280000      1.000000     50.712500         4.000000
50%             21.640000      1.000000    112.530000         5.000000
75%             29.880000      1.000000    243.097500         6.000000
max            374.640000     32.000000  24570.650000        13.000000

            pow_max         churn
count  14606.000000  14606.000000
mean      18.135136      0.097152
std       13.534743      0.296175
min        3.300000      0.000000
25%       12.500000      0.000000
50%       13.856000      0.000000
75%       19.172500      0.000000
max      320.000000      1.000000
```

[42]:
```
client_df.columns
```

[42]:
```
Index(['id', 'channel_sales', 'cons_12m', 'cons_gas_12m', 'cons_last_month',
       'date_activ', 'date_end', 'date_modif_prod', 'date_renewal',
       'forecast_cons_12m', 'forecast_cons_year', 'forecast_discount_energy',
       'forecast_meter_rent_12m', 'forecast_price_energy_off_peak',
       'forecast_price_energy_peak', 'forecast_price_pow_off_peak', 'has_gas',
       'imp_cons', 'margin_gross_pow_ele', 'margin_net_pow_ele', 'nb_prod_act',
       'net_margin', 'num_years_antig', 'origin_up', 'pow_max', 'churn'],
      dtype='object')
```

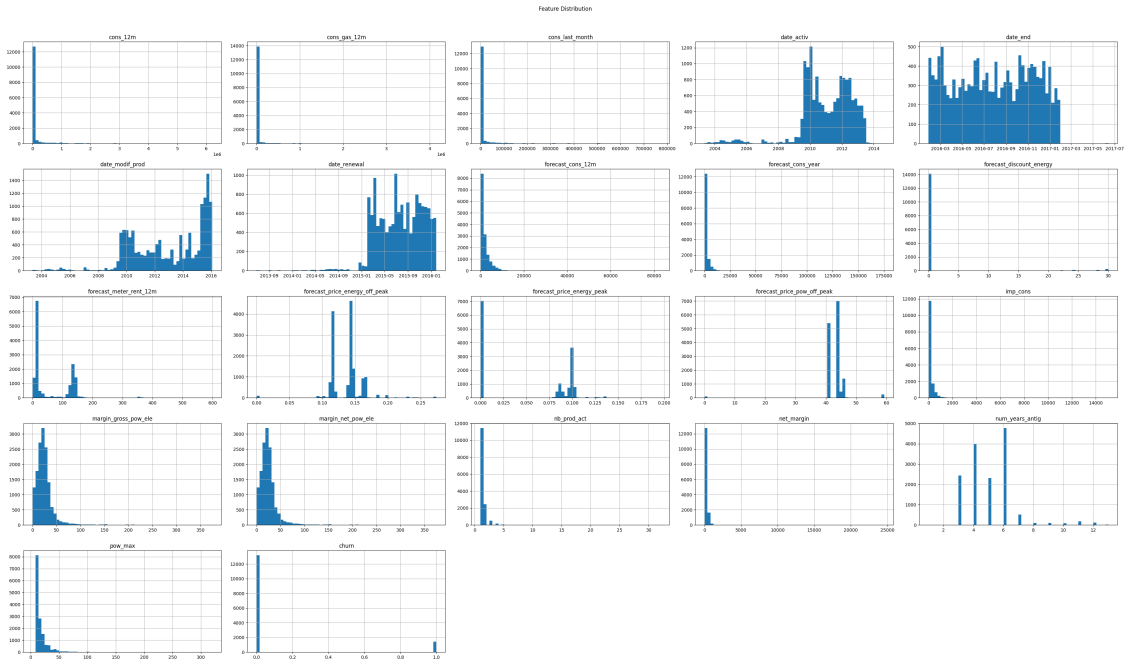
[43]:
```
client_df.isna().sum()
```

[43]:
```
id                              0
channel_sales                   0
cons_12m                        0
cons_gas_12m                    0
cons_last_month                 0
date_activ                      0
date_end                        0
date_modif_prod                 0
date_renewal                    0
forecast_cons_12m               0
forecast_cons_year              0
forecast_discount_energy        0
forecast_meter_rent_12m         0
forecast_price_energy_off_peak  0
forecast_price_energy_peak      0
```

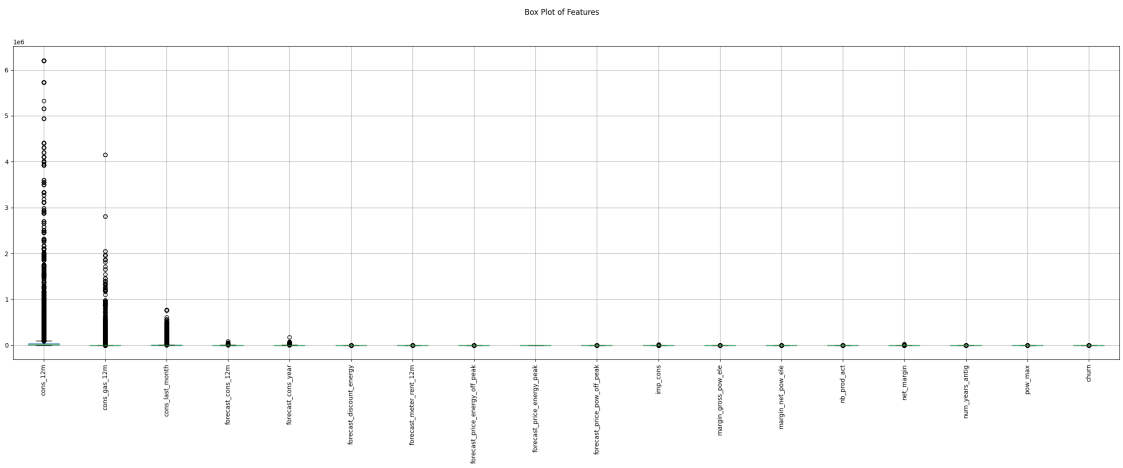
```
forecast_price_pow_off_peak        0
has_gas                            0
imp_cons                           0
margin_gross_pow_ele               0
margin_net_pow_ele                 0
nb_prod_act                        0
net_margin                         0
num_years_antig                    0
origin_up                          0
pow_max                            0
churn                              0
dtype: int64
```

2 Data Visualizations

[44]:
```
client_df.hist(figsize=(35,20),bins=60)
plt.suptitle('Feature Distribution',x=0.5, y=1.02, ha='center')
plt.tight_layout()
```



[45]:
```
client_df.boxplot(figsize=(25,10))
plt.suptitle('Box Plot of Features',x=0.5,y=1.02,ha='center')
plt.xticks(rotation=90)
plt.tight_layout()
```



3 Remove Unwanted Features/Columns

[46]:
```
client_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14606 entries, 0 to 14605
Data columns (total 26 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   id                              14606 non-null  object
 1   channel_sales                   14606 non-null  object
 2   cons_12m                        14606 non-null  int64
 3   cons_gas_12m                    14606 non-null  int64
 4   cons_last_month                 14606 non-null  int64
 5   date_activ                      14606 non-null  datetime64[ns]
 6   date_end                        14606 non-null  datetime64[ns]
 7   date_modif_prod                 14606 non-null  datetime64[ns]
 8   date_renewal                    14606 non-null  datetime64[ns]
 9   forecast_cons_12m               14606 non-null  float64
 10  forecast_cons_year              14606 non-null  int64
 11  forecast_discount_energy        14606 non-null  float64
 12  forecast_meter_rent_12m         14606 non-null  float64
 13  forecast_price_energy_off_peak  14606 non-null  float64
 14  forecast_price_energy_peak      14606 non-null  float64
 15  forecast_price_pow_off_peak     14606 non-null  float64
 16  has_gas                         14606 non-null  object
 17  imp_cons                        14606 non-null  float64
 18  margin_gross_pow_ele            14606 non-null  float64
 19  margin_net_pow_ele              14606 non-null  float64
 20  nb_prod_act                     14606 non-null  int64
```

```
 21  net_margin                      14606 non-null  float64
 22  num_years_antig                 14606 non-null  int64
 23  origin_up                       14606 non-null  object
 24  pow_max                         14606 non-null  float64
 25  churn                           14606 non-null  int64
dtypes: datetime64[ns](4), float64(11), int64(7), object(4)
memory usage: 2.9+ MB
```

[47]:
```
client_df.columns
```

[47]:
```
Index(['id', 'channel_sales', 'cons_12m', 'cons_gas_12m', 'cons_last_month',
       'date_activ', 'date_end', 'date_modif_prod', 'date_renewal',
       'forecast_cons_12m', 'forecast_cons_year', 'forecast_discount_energy',
       'forecast_meter_rent_12m', 'forecast_price_energy_off_peak',
       'forecast_price_energy_peak', 'forecast_price_pow_off_peak', 'has_gas',
       'imp_cons', 'margin_gross_pow_ele', 'margin_net_pow_ele', 'nb_prod_act',
       'net_margin', 'num_years_antig', 'origin_up', 'pow_max', 'churn'],
      dtype='object')
```

[48]:
```
client_df.
↪drop(['id','channel_sales','cons_12m','cons_gas_12m','date_modif_prod','date_renewal','fore
                ␣
↪'forecast_meter_rent_12m','forecast_price_energy_off_peak','forecast_price_energy_peak','fo
                inplace=True,axis=1)
```

[49]:
```
client_df.head(3)
```

[49]:

	cons_last_month	date_activ	date_end	has_gas	margin_gross_pow_ele	margin_net_pow_ele	nb_prod_act	net_margin	num_years_antig	pow_max	churn
0	0	2013-06-15	2016-06-15	t	25.44	25.44	2	678.99	3	43.648	1
1	0	2009-08-21	2016-08-30	f	16.38	16.38	1	18.89	6	13.800	0
2	0	2010-04-16	2016-04-16	f	28.60	28.60	1	6.60	6	13.856	0

[50]:
```
client_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14606 entries, 0 to 14605
Data columns (total 11 columns):
 #   Column                Non-Null Count  Dtype
```

```
---  ------                 --------------  -----
 0   cons_last_month        14606 non-null  int64
 1   date_activ             14606 non-null  datetime64[ns]
 2   date_end               14606 non-null  datetime64[ns]
 3   has_gas                14606 non-null  object
 4   margin_gross_pow_ele   14606 non-null  float64
 5   margin_net_pow_ele     14606 non-null  float64
 6   nb_prod_act            14606 non-null  int64
 7   net_margin             14606 non-null  float64
 8   num_years_antig        14606 non-null  int64
 9   pow_max                14606 non-null  float64
 10  churn                  14606 non-null  int64
dtypes: datetime64[ns](2), float64(4), int64(4), object(1)
memory usage: 1.2+ MB
```

[51]:
```
client_df.describe()
```

[51]:

	cons_last_month	margin_gross_pow_ele	margin_net_pow_ele	\
count	14606.000000	14606.000000	14606.000000	
mean	16090.269752	24.565121	24.562517	
std	64364.196422	20.231172	20.230280	
min	0.000000	0.000000	0.000000	
25%	0.000000	14.280000	14.280000	
50%	792.500000	21.640000	21.640000	
75%	3383.000000	29.880000	29.880000	
max	771203.000000	374.640000	374.640000	

	nb_prod_act	net_margin	num_years_antig	pow_max	churn
count	14606.000000	14606.000000	14606.000000	14606.000000	14606.000000
mean	1.292346	189.264522	4.997809	18.135136	0.097152
std	0.709774	311.798130	1.611749	13.534743	0.296175
min	1.000000	0.000000	1.000000	3.300000	0.000000
25%	1.000000	50.712500	4.000000	12.500000	0.000000
50%	1.000000	112.530000	5.000000	13.856000	0.000000
75%	1.000000	243.097500	6.000000	19.172500	0.000000
max	32.000000	24570.650000	13.000000	320.000000	1.000000

[52]:
```
import datetime
from datetime import datetime, timedelta
```

[53]:
```
client_df['duration'] = (client_df.date_end - client_df.date_activ).dt.days
```

[54]:
```
client_df.head(3)
```

[54]:

	cons_last_month	date_activ	date_end	has_gas	margin_gross_pow_ele	\
0	0	2013-06-15	2016-06-15	t	25.44	
1	0	2009-08-21	2016-08-30	f	16.38	

```
2                0 2010-04-16 2016-04-16       f                  28.60

   margin_net_pow_ele  nb_prod_act  net_margin  num_years_antig  pow_max  \
0               25.44            2      678.99                3   43.648
1               16.38            1       18.89                6   13.800
2               28.60            1        6.60                6   13.856

   churn  duration
0      1      1096
1      0      2566
2      0      2192
```

[55]:
```
client_df.drop(['date_activ','date_end'],inplace=True,axis=1)
```

[56]:
```
client_df.head(3)
```

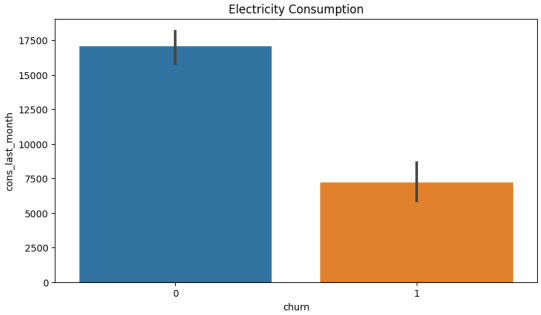
[56]:
```
   cons_last_month has_gas  margin_gross_pow_ele  margin_net_pow_ele  \
0                0       t                 25.44               25.44
1                0       f                 16.38               16.38
2                0       f                 28.60               28.60

   nb_prod_act  net_margin  num_years_antig  pow_max  churn  duration
0            2      678.99                3   43.648      1      1096
1            1       18.89                6   13.800      0      2566
2            1        6.60                6   13.856      0      2192
```

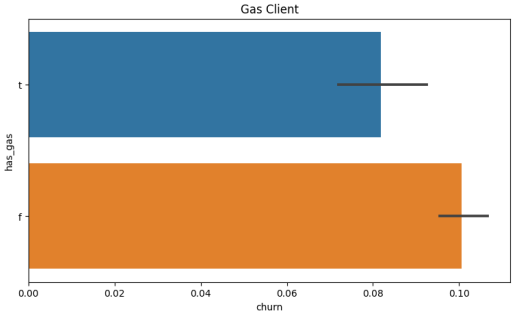
4 Data Visualization 2

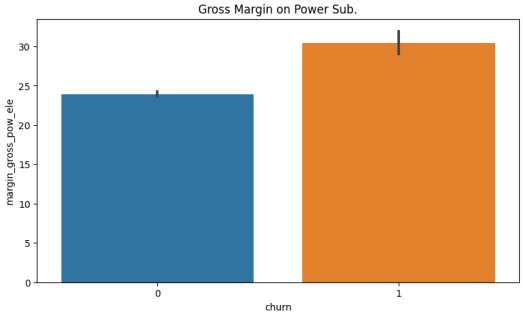
[57]:
```
plt.figure(figsize=(20,35))

plt.subplot(6,2,1)
plt.title('Electricity Consumption')
sns.barplot(x='churn',y='cons_last_month',data=client_df)

plt.subplot(6,2,2)
plt.title('Gas Client')
sns.barplot(x='churn',y='has_gas',data=client_df)

plt.subplot(6,2,3)
plt.title('Gross Margin on Power Sub.')
sns.barplot(x='churn',y='margin_gross_pow_ele',data=client_df)

plt.subplot(6,2,4)
plt.title('Net Margin on Power Sub.')
sns.barplot(x='churn',y='margin_net_pow_ele',data=client_df)
```

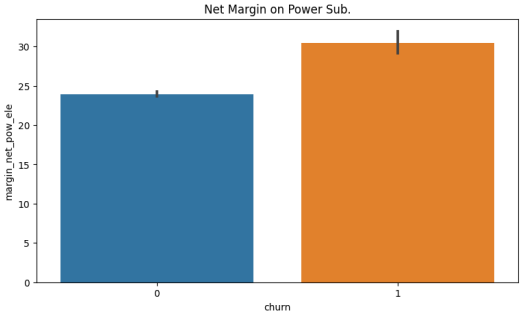
```
plt.subplot(6,2,5)
plt.title('No. of Active Prod. & Services')
sns.barplot(x='churn',y='nb_prod_act',data=client_df)

plt.subplot(6,2,6)
plt.title('Total Net Margin')
sns.barplot(x='churn',y='net_margin',data=client_df)

plt.subplot(6,2,7)
plt.title('Antiquity of the Client')
sns.barplot(x='churn',y='num_years_antig',data=client_df)

plt.subplot(6,2,8)
plt.title('Subscribed Power')
sns.barplot(x='churn',y='pow_max',data=client_df)

plt.subplot(6,2,9)
plt.title('Duration')
sns.barplot(x='churn',y='duration',data=client_df)

plt.subplot(6,2,10)
plt.title('Churn')
sns.countplot(x='churn',data=client_df)
```

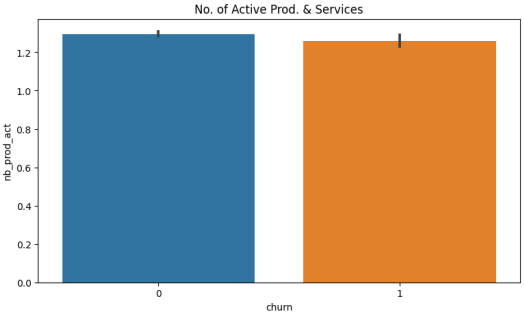
[57]: <Axes: title={'center': 'Churn'}, xlabel='churn', ylabel='count'>

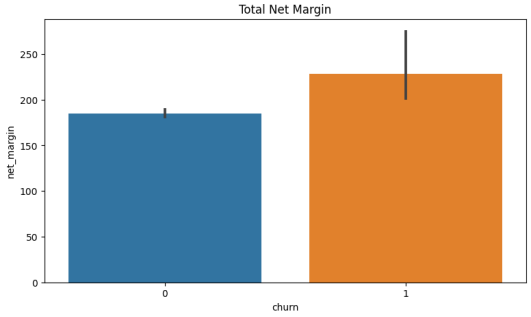

Electricity Consumption
cons_last_month
churn

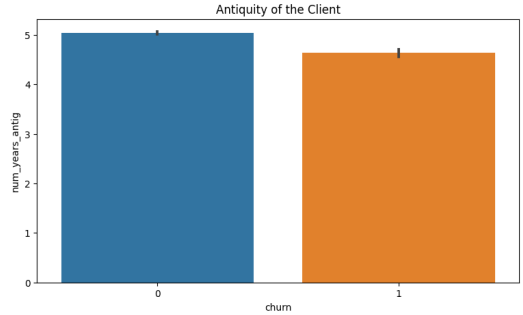

Gas Client
has_gas
t
f
churn

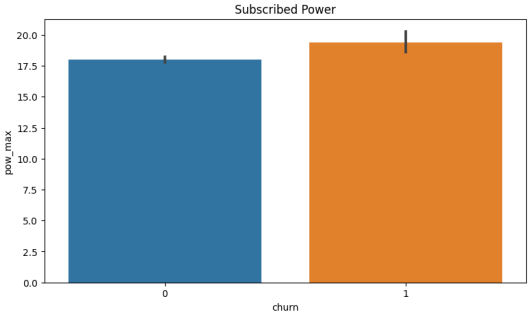

Gross Margin on Power Sub.
margin_gross_pow_ele
churn

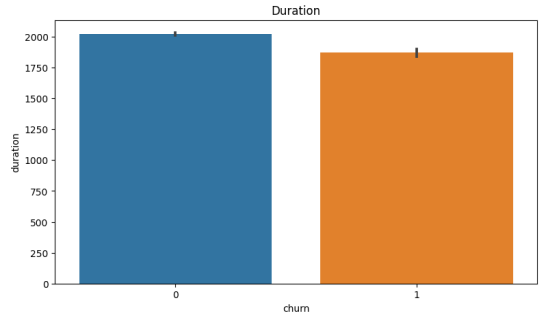

Net Margin on Power Sub.
margin_net_pow_ele
churn

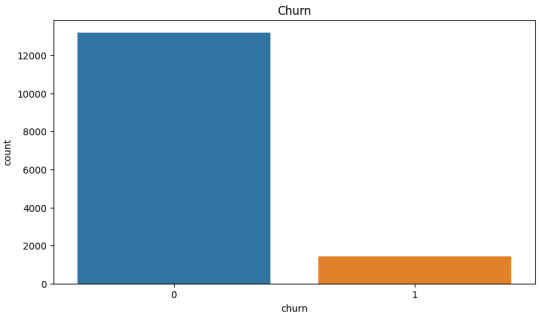

No. of Active Prod. & Services
nb_prod_act
churn


Total Net Margin
net_margin
churn


Antiquity of the Client
num_years_antig
churn

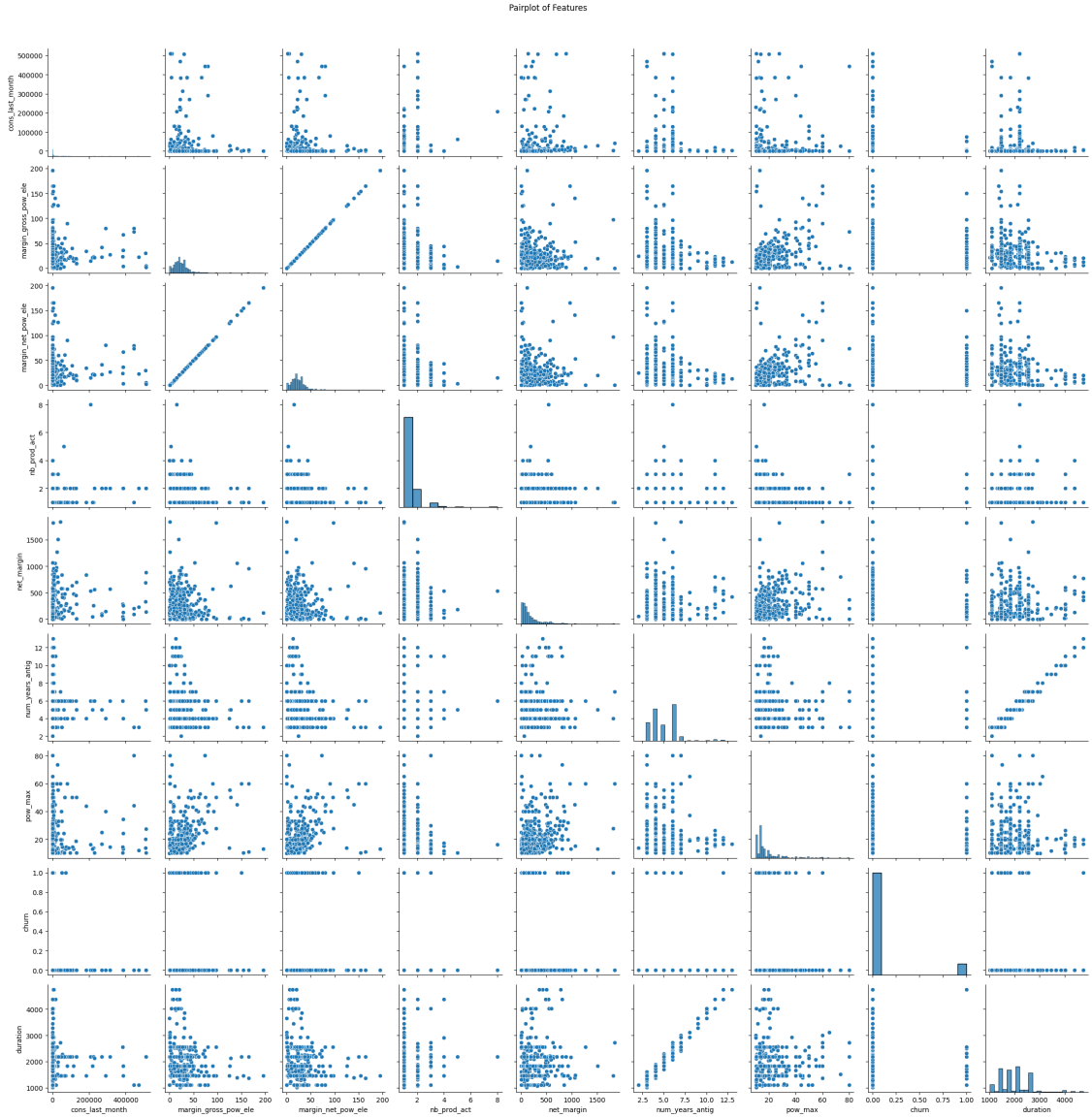

Subscribed Power
pow_max
churn


Duration
duration
churn


Churn
count
churn

[58]:
```
plt.figure(figsize=(35,20))
sns.pairplot(client_df.sample(700))
plt.suptitle('Pairplot of Features', x=0.5, y=1.02, ha='center')
plt.tight_layout()
```

```
<Figure size 3500x2000 with 0 Axes>
```



[59]:
```
client_df.corr()
```

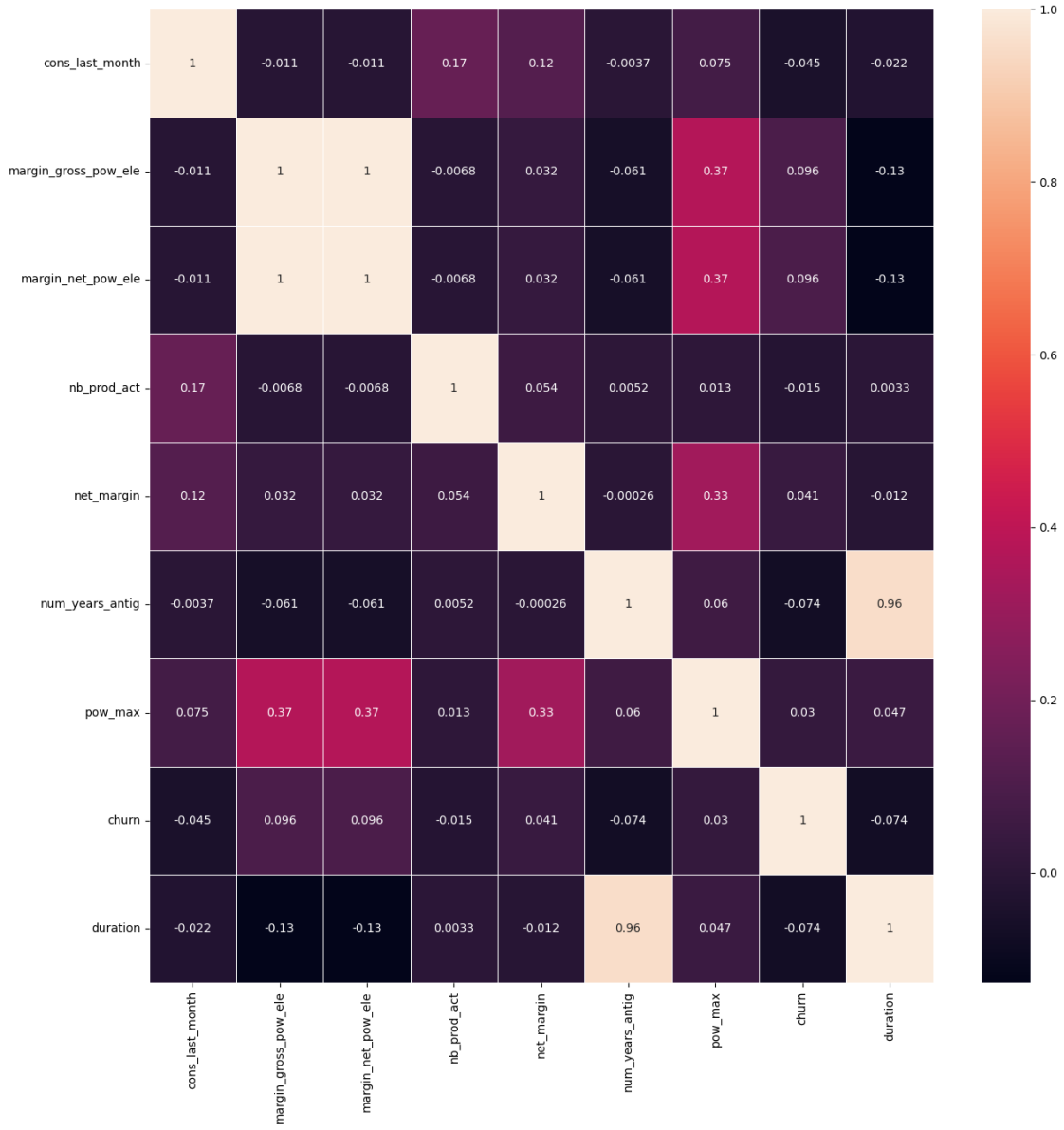
[59]:

	cons_last_month	margin_gross_pow_ele	\
cons_last_month	1.000000	-0.011498	
margin_gross_pow_ele	-0.011498	1.000000	

```
margin_net_pow_ele          -0.011477              0.999914
nb_prod_act                  0.169099             -0.006784
net_margin                   0.121835              0.031814
num_years_antig             -0.003677             -0.061091
pow_max                      0.074529              0.373298
churn                       -0.045284              0.095725
duration                    -0.022239             -0.127738

                     margin_net_pow_ele  nb_prod_act  net_margin  \
cons_last_month                -0.011477     0.169099    0.121835
margin_gross_pow_ele            0.999914    -0.006784    0.031814
margin_net_pow_ele              1.000000    -0.006763    0.031639
nb_prod_act                    -0.006763     1.000000    0.053781
net_margin                      0.031639     0.053781    1.000000
num_years_antig                -0.061197     0.005228   -0.000263
pow_max                         0.373351     0.012712    0.325417
churn                           0.095772    -0.014930    0.041135
duration                       -0.127820     0.003266   -0.012310

                     num_years_antig   pow_max     churn  duration
cons_last_month            -0.003677  0.074529 -0.045284 -0.022239
margin_gross_pow_ele       -0.061091  0.373298  0.095725 -0.127738
margin_net_pow_ele         -0.061197  0.373351  0.095772 -0.127820
nb_prod_act                 0.005228  0.012712 -0.014930  0.003266
net_margin                 -0.000263  0.325417  0.041135 -0.012310
num_years_antig             1.000000  0.059715 -0.074140  0.956437
pow_max                     0.059715  1.000000  0.030362  0.047179
churn                      -0.074140  0.030362  1.000000 -0.073919
duration                    0.956437  0.047179 -0.073919  1.000000
```

[60]:
```
plt.figure(figsize=(15,15))
sns.heatmap(client_df.corr(),annot=True,linewidths=0.5,linecolor='white')
```

[60]: <Axes: >



5 Hypothesis Testing

Levene's Test

[61]:
```
import scipy
```

[62]:
```
scipy.stats.levene(client_df.pow_max,client_df.churn,center='mean')
```

[62]:
```
LeveneResult(statistic=6077.213476037721, pvalue=0.0)
```

T-Test

[63]:
```
scipy.stats.ttest_ind(client_df.pow_max,client_df.churn,equal_var=True)
```

[63]:
```
Ttest_indResult(statistic=161.02735495598836, pvalue=0.0)
```

Chi Square

[64]:
```
cont_table = pd.crosstab(client_df.nb_prod_act,client_df.churn)
cont_table
```

[64]:

churn	0	1
nb_prod_act		
1	10290	1141
2	2237	208
3	471	52
4	135	15
5	28	3
6	8	0
8	4	0
9	11	0
10	2	0
32	1	0

[65]:
```
scipy.stats.chi2_contingency(cont_table,correction=True)
```

[65]:
```
Chi2ContingencyResult(statistic=7.835580246407849, pvalue=0.5507970804381235,
dof=9, expected_freq=array([[1.03204571e+04, 1.11054286e+03],
       [2.20746371e+03, 2.37536286e+02],
       [4.72189580e+02, 5.08104204e+01],
       [1.35427222e+02, 1.45727783e+01],
       [2.79882925e+01, 3.01170752e+00],
       [7.22278516e+00, 7.77214843e-01],
       [3.61139258e+00, 3.88607422e-01],
       [9.93132959e+00, 1.06867041e+00],
       [1.80569629e+00, 1.94303711e-01],
       [9.02848145e-01, 9.71518554e-02]]))
```

6 Data Preprocessing

[66]:
```
client_df.isna().sum()
```

[66]:
```
cons_last_month         0
has_gas                 0
margin_gross_pow_ele    0
margin_net_pow_ele      0
nb_prod_act             0
net_margin              0
```

```
num_years_antig          0
pow_max                  0
churn                    0
duration                 0
dtype: int64
```

[67]:
```
client_df.duplicated(keep='first').sum()
```

[67]:
```
3
```

[68]:
```
client_df.drop_duplicates(ignore_index=True,inplace=True)
```

[69]:
```
client_df.duplicated(keep='first').sum()
```

[69]:
```
0
```

One-Hot Encoding

[70]:
```
client_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14603 entries, 0 to 14602
Data columns (total 10 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   cons_last_month       14603 non-null  int64
 1   has_gas               14603 non-null  object
 2   margin_gross_pow_ele  14603 non-null  float64
 3   margin_net_pow_ele    14603 non-null  float64
 4   nb_prod_act           14603 non-null  int64
 5   net_margin            14603 non-null  float64
 6   num_years_antig       14603 non-null  int64
 7   pow_max               14603 non-null  float64
 8   churn                 14603 non-null  int64
 9   duration              14603 non-null  int64
dtypes: float64(4), int64(5), object(1)
memory usage: 1.1+ MB
```

[71]:
```
client_df['has_gas'] = pd.get_dummies(data=client_df['has_gas'],drop_first=True)
```

[72]:
```
client_df.head()
```

[72]:

	cons_last_month	has_gas	margin_gross_pow_ele	margin_net_pow_ele	\
0	0	1	25.44	25.44	
1	0	0	16.38	16.38	
2	0	0	28.60	28.60	
3	0	0	30.22	30.22	

```
4              526        0                 44.91                44.91

   nb_prod_act  net_margin  num_years_antig  pow_max  churn  duration
0            2      678.99                3   43.648      1      1096
1            1       18.89                6   13.800      0      2566
2            1        6.60                6   13.856      0      2192
3            1       25.46                6   13.200      0      2192
4            1       47.98                6   19.800      0      2245
```

ANOVA

[73]:
```
f_statistic, p_value = scipy.stats.f_oneway(client_df.has_gas,client_df.churn)
print("F_Statistic: {0}, P-Value: {1}".format(f_statistic,p_value))
```

```
F_Statistic: 439.8097533205506, P-Value: 6.181459330306195e-97
```

7 Price History EDA

[3]:
```
df = pd.read_csv('price_data.csv',parse_dates=['price_date'],dayfirst=True)
```

[4]:
```
df.head()
```

[4]:
```
                                 id price_date  price_off_peak_var  \
0  038af19179925da21a25619c5a24b745 2015-01-01            0.151367
1  038af19179925da21a25619c5a24b745 2015-02-01            0.151367
2  038af19179925da21a25619c5a24b745 2015-03-01            0.151367
3  038af19179925da21a25619c5a24b745 2015-04-01            0.149626
4  038af19179925da21a25619c5a24b745 2015-05-01            0.149626

   price_peak_var  price_mid_peak_var  price_off_peak_fix  price_peak_fix  \
0             0.0                 0.0           44.266931             0.0
1             0.0                 0.0           44.266931             0.0
2             0.0                 0.0           44.266931             0.0
3             0.0                 0.0           44.266931             0.0
4             0.0                 0.0           44.266931             0.0

   price_mid_peak_fix
0                 0.0
1                 0.0
2                 0.0
3                 0.0
4                 0.0
```

[5]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 193002 entries, 0 to 193001
```

```
Data columns (total 8 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   id                  193002 non-null  object
 1   price_date          193002 non-null  datetime64[ns]
 2   price_off_peak_var  193002 non-null  float64
 3   price_peak_var      193002 non-null  float64
 4   price_mid_peak_var  193002 non-null  float64
 5   price_off_peak_fix  193002 non-null  float64
 6   price_peak_fix      193002 non-null  float64
 7   price_mid_peak_fix  193002 non-null  float64
dtypes: datetime64[ns](1), float64(6), object(1)
memory usage: 11.8+ MB
```

[6]:
```
df.describe()
```

[6]:
```
       price_off_peak_var  price_peak_var  price_mid_peak_var  \
count       193002.000000   193002.000000       193002.000000
mean             0.141027        0.054630            0.030496
std              0.025032        0.049924            0.036298
min              0.000000        0.000000            0.000000
25%              0.125976        0.000000            0.000000
50%              0.146033        0.085483            0.000000
75%              0.151635        0.101673            0.072558
max              0.280700        0.229788            0.114102

       price_off_peak_fix  price_peak_fix  price_mid_peak_fix
count       193002.000000   193002.000000       193002.000000
mean            43.334477       10.622875            6.409984
std              5.410297       12.841895            7.773592
min              0.000000        0.000000            0.000000
25%             40.728885        0.000000            0.000000
50%             44.266930        0.000000            0.000000
75%             44.444710       24.339581           16.226389
max             59.444710       36.490692           17.458221
```

8 Exploratory Data Analysis

[7]:
```
df.columns
```

[7]:
```
Index(['id', 'price_date', 'price_off_peak_var', 'price_peak_var',
       'price_mid_peak_var', 'price_off_peak_fix', 'price_peak_fix',
       'price_mid_peak_fix'],
      dtype='object')
```

[8]:
```
df['id'].value_counts()
```

[8]:
```
038af19179925da21a25619c5a24b745    12
97589d95ec46ab31ef238d18a616403f    12
97adbcd721fae4874f7ee287ea84200d    12
d74b4544363be674855cf931b6b8af25    12
27276020e48d73f589788d4e37c51879    12
                                    ..
83cf18b07114e495ae8b7fb235e45ee2     8
3e459d61dc831e29f8a9a9a59f95efd2     8
c5dcd5c506e565aaabffa29bc1ec0a37     7
bf89f2d8c1b133a134fd93603cb4c947     7
15b36e47cf04bf151e3f4438d12672e5     7
Name: id, Length: 16096, dtype: int64
```

[9]:
```
df['price_date'].value_counts()
```

[9]:
```
2015-08-01    16094
2015-12-01    16094
2015-07-01    16090
2015-11-01    16087
2015-06-01    16085
2015-10-01    16085
2015-02-01    16082
2015-09-01    16082
2015-05-01    16080
2015-04-01    16079
2015-03-01    16074
2015-01-01    16070
Name: price_date, dtype: int64
```

[10]:
```
df.groupby('price_date').mean()
```

[10]:

price_date	price_off_peak_var	price_peak_var	price_mid_peak_var	\
2015-01-01	0.142568	0.054950	0.030333	
2015-02-01	0.142767	0.055053	0.030367	
2015-03-01	0.143104	0.055118	0.030396	
2015-04-01	0.143259	0.056035	0.030492	
2015-05-01	0.143534	0.055359	0.030393	
2015-06-01	0.143731	0.055255	0.029902	
2015-07-01	0.143683	0.055369	0.030636	
2015-08-01	0.137933	0.053605	0.030717	
2015-09-01	0.137933	0.053532	0.030606	
2015-10-01	0.137899	0.053713	0.030641	
2015-11-01	0.137909	0.053620	0.030737	
2015-12-01	0.138011	0.053957	0.030732	

	price_off_peak_fix	price_peak_fix	price_mid_peak_fix

```
price_date
2015-01-01          43.226643       10.692921           6.455861
2015-02-01          43.238161       10.673719           6.449016
2015-03-01          43.254033       10.644489           6.430121
2015-04-01          43.288439       10.647277           6.423156
2015-05-01          43.315388       10.602453           6.390806
2015-06-01          43.347320       10.415769           6.281304
2015-07-01          43.345012       10.642236           6.421464
2015-08-01          43.365366       10.661678           6.431518
2015-09-01          43.351874       10.602979           6.391788
2015-10-01          43.354226       10.605431           6.396084
2015-11-01          43.422764       10.641489           6.421622
2015-12-01          43.504177       10.644109           6.427104
```

[11]:
```
df.groupby('price_date').median()
```

[11]:
```
            price_off_peak_var  price_peak_var  price_mid_peak_var  \
price_date
2015-01-01            0.148825        0.085058                 0.0
2015-02-01            0.148825        0.085058                 0.0
2015-03-01            0.148825        0.085390                 0.0
2015-04-01            0.148825        0.085483                 0.0
2015-05-01            0.148825        0.085483                 0.0
2015-06-01            0.148825        0.085483                 0.0
2015-07-01            0.148825        0.085570                 0.0
2015-08-01            0.144524        0.085483                 0.0
2015-09-01            0.144698        0.085483                 0.0
2015-10-01            0.144524        0.085483                 0.0
2015-11-01            0.144524        0.085568                 0.0
2015-12-01            0.144524        0.086054                 0.0

            price_off_peak_fix  price_peak_fix  price_mid_peak_fix
price_date
2015-01-01           44.266931             0.0                 0.0
2015-02-01           44.266931             0.0                 0.0
2015-03-01           44.266931             0.0                 0.0
2015-04-01           44.266930             0.0                 0.0
2015-05-01           44.266930             0.0                 0.0
2015-06-01           44.266930             0.0                 0.0
2015-07-01           44.266930             0.0                 0.0
2015-08-01           44.266930             0.0                 0.0
2015-09-01           44.266930             0.0                 0.0
2015-10-01           44.266930             0.0                 0.0
2015-11-01           44.266930             0.0                 0.0
2015-12-01           44.444710             0.0                 0.0
```

[12]:
```
df.groupby('id').mean()
```

[12]:

id	price_off_peak_var	price_peak_var	price_mid_peak_var	price_off_peak_fix	price_peak_fix	price_mid_peak_fix
0002203ffbb812588b632b9e628cc38d	0.124338	0.103794	0.073160	40.701732	24.421038	16.280694
0004351ebdd665e6ee664792efc4fd13	0.146426	0.000000	0.000000	44.385450	0.000000	0.000000
0010bcc39e42b3c2131ed2ce55246e3c	0.181558	0.000000	0.000000	45.319710	0.000000	0.000000
0010ee3855fdea87602a5b7aba8e42de	0.118757	0.098292	0.069032	40.647427	24.388455	16.258971
00114d74e963e47177db89bc70108537	0.147926	0.000000	0.000000	44.266930	0.000000	0.000000
…	…	…	…	…	…	…
ffef185810e44254c3a4c6395e6b4d8a	0.138863	0.115125	0.080780	40.896427	24.637456	16.507972
fffac626da707b1b5ab11e8431a4d0a2	0.147137	0.000000	0.000000	44.311375	0.000000	0.000000
fffc0cacd305dd51f316424bbb08d1bd	0.153879	0.129497	0.094842	41.160171	24.895768	16.763569
fffe4f5646aa39c7f97f95ae2679ce64	0.123858	0.103499	0.073735	40.606699	24.364017	16.242678
ffff7fa066f1fb305ae285bb03bf325a	0.125360	0.104895	0.075635	40.647427	24.388455	16.258971

[16096 rows x 6 columns]

[13]:
```
df.groupby('id').median()
```

[13]:

id	price_off_peak_var	price_peak_var	price_mid_peak_var	price_off_peak_fix	price_peak_fix	price_mid_peak_fix
0002203ffbb812588b632b9e628cc38d	0.126098	0.103975	0.073719	40.728885	24.437330	16.291555
0004351ebdd665e6ee664792efc4fd13	0.148047	0.000000	0.000000	44.444710	0.000000	0.000000
0010bcc39e42b3c2131ed2ce55246e3c	0.201280	0.000000	0.000000	45.944710	0.000000	0.000000
0010ee3855fdea87602a5b7aba8e42de	0.122157	0.100029	0.069027	40.647429	24.388455	16.258972
00114d74e963e47177db89bc70108537	0.149434	0.000000	0.000000	44.266930	0.000000	0.000000
…	…	…	…	…	…	…
ffef185810e44254c3a4c6395e6b4d8a	0.141684	0.116282	0.080223	40.896427	24.637456	16.507972
fffac626da707b1b5ab11e8431a4d0a2	0.148825	0.000000	0.000000	44.266931	0.000000	0.000000
fffc0cacd305dd51f316424bbb08d1bd	0.153159	0.130578	0.091448	41.228885	24.937330	16.791555
fffe4f5646aa39c7f97f95ae2679ce64	0.127566	0.105428	0.073487	40.565973	24.339581	16.226389
ffff7fa066f1fb305ae285bb03bf325a	0.128760	0.106632	0.075631	40.647429	24.388455	16.258972

[16096 rows x 6 columns]

[14]:
```
company_price_df = pd.DataFrame(df.groupby('id').mean())
```

[15]:
```
company_price_df.head()
```

[15]:

id	price_off_peak_var	price_peak_var	price_mid_peak_var	price_off_peak_fix	price_peak_fix	price_mid_peak_fix
0002203ffbb812588b632b9e628cc38d	0.124338	0.103794	0.073160	40.701732	24.421038	16.280694
0004351ebdd665e6ee664792efc4fd13	0.146426	0.000000	0.000000	44.385450	0.000000	0.000000
0010bcc39e42b3c2131ed2ce55246e3c	0.181558	0.000000	0.000000	45.319710	0.000000	0.000000
0010ee3855fdea87602a5b7aba8e42de	0.118757	0.098292	0.069032	40.647427	24.388455	16.258971
00114d74e963e47177db89bc70108537	0.147926	0.000000	0.000000	44.266930	0.000000	0.000000

[17]:
```
output_df = pd.read_csv('output.csv',index_col='id')
```

[18]:
```
output_df.head()
```

[18]:

id	churn
24011ae4ebbe3035111d65fa7c15bc57	1
d29c2c54acc38ff3c0614d0a653813dd	0
764c75f661154dac3a6c254cd082ea7d	0
bba03439a292a1e166f80264c16191cb	0
149d57cf92fc41cf94415803a877cb4b	0

[19]:
```
final_price_df = pd.
↪merge(left=company_price_df,right=output_df,how='inner',left_index=True,right_index=True)
```

[20]:
```
final_price_df.head()
```

[20]:

id	price_off_peak_var	price_peak_var
0002203ffbb812588b632b9e628cc38d	0.124338	0.103794
0004351ebdd665e6ee664792efc4fd13	0.146426	0.000000
0010bcc39e42b3c2131ed2ce55246e3c	0.181558	0.000000
00114d74e963e47177db89bc70108537	0.147926	0.000000

```
0013f326a839a2f6ad87a1859952d227            0.126076        0.105542

                                  price_mid_peak_var  price_off_peak_fix  \
id
0002203ffbb812588b632b9e628cc38d            0.073160           40.701732
0004351ebdd665e6ee664792efc4fd13            0.000000           44.385450
0010bcc39e42b3c2131ed2ce55246e3c            0.000000           45.319710
00114d74e963e47177db89bc70108537            0.000000           44.266930
0013f326a839a2f6ad87a1859952d227            0.074921           40.728885

                                  price_peak_fix  price_mid_peak_fix  churn
id
0002203ffbb812588b632b9e628cc38d       24.421038           16.280694      0
0004351ebdd665e6ee664792efc4fd13        0.000000            0.000000      0
0010bcc39e42b3c2131ed2ce55246e3c        0.000000            0.000000      0
00114d74e963e47177db89bc70108537        0.000000            0.000000      0
0013f326a839a2f6ad87a1859952d227       24.437330           16.291555      0
```

[21]:
```
final_price_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 14606 entries, 0002203ffbb812588b632b9e628cc38d to
ffff7fa066f1fb305ae285bb03bf325a
Data columns (total 7 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   price_off_peak_var  14606 non-null  float64
 1   price_peak_var      14606 non-null  float64
 2   price_mid_peak_var  14606 non-null  float64
 3   price_off_peak_fix  14606 non-null  float64
 4   price_peak_fix      14606 non-null  float64
 5   price_mid_peak_fix  14606 non-null  float64
 6   churn               14606 non-null  int64
dtypes: float64(6), int64(1)
memory usage: 1.4+ MB
```

[22]:
```
final_price_df['churn'].value_counts()
```

[22]:
```
0    13187
1     1419
Name: churn, dtype: int64
```

[23]:
```
print('Percentage of customer churn: {:.2f}%'.format(1419/13187*100))
```

```
Percentage of customer churn: 10.76%
```

[24]:
```
final_price_df.reset_index(inplace=True)
```

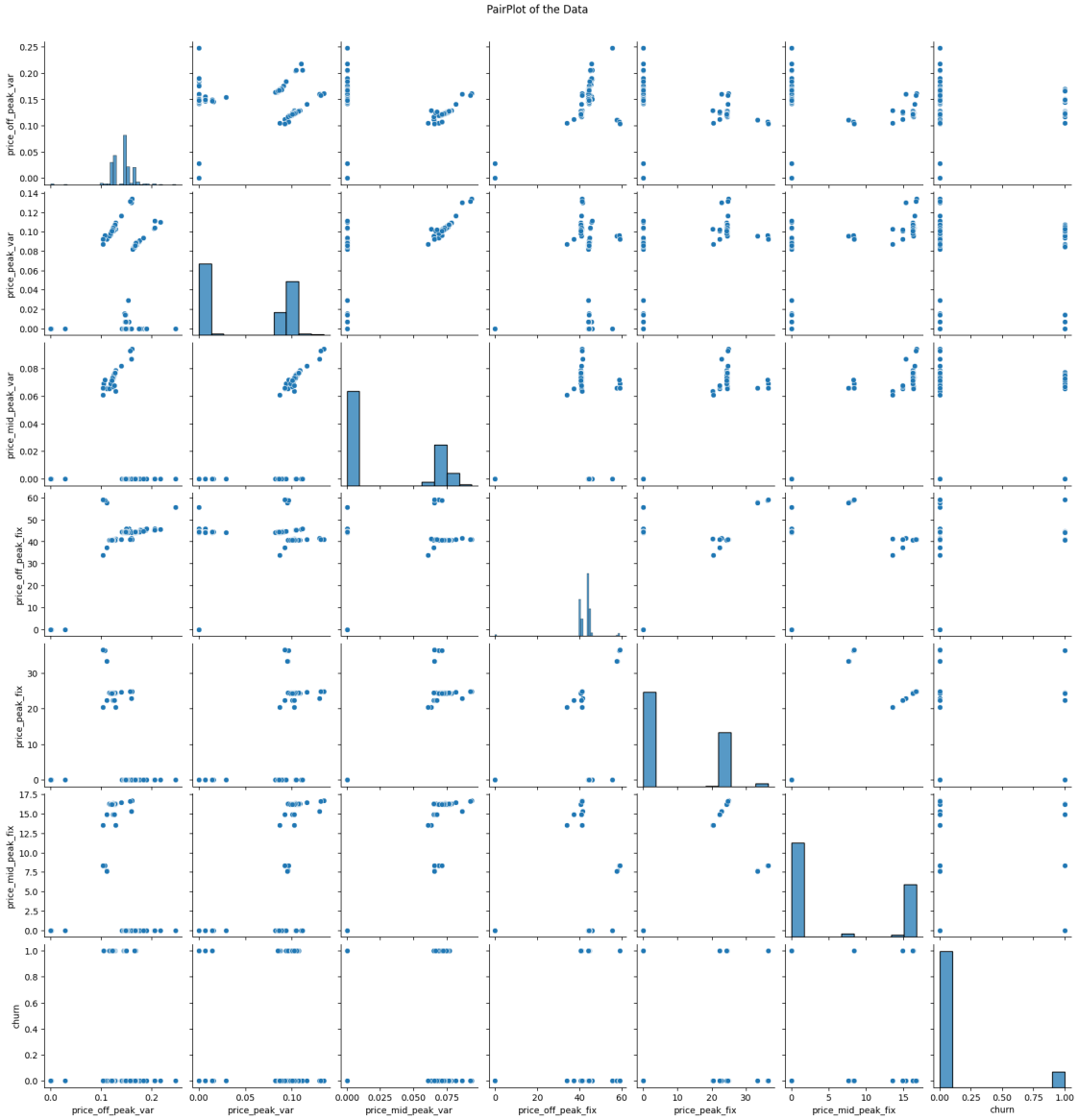
[25]:
```
final_price_df.head(2)
```

[25]:
```
                                 id  price_off_peak_var  price_peak_var  \
0  0002203ffbb812588b632b9e628cc38d            0.124338        0.103794
1  0004351ebdd665e6ee664792efc4fd13            0.146426        0.000000

   price_mid_peak_var  price_off_peak_fix  price_peak_fix  price_mid_peak_fix  \
0             0.07316           40.701732       24.421038           16.280694
1             0.00000           44.385450        0.000000            0.000000

   churn
0      0
1      0
```

9 Data Visualization

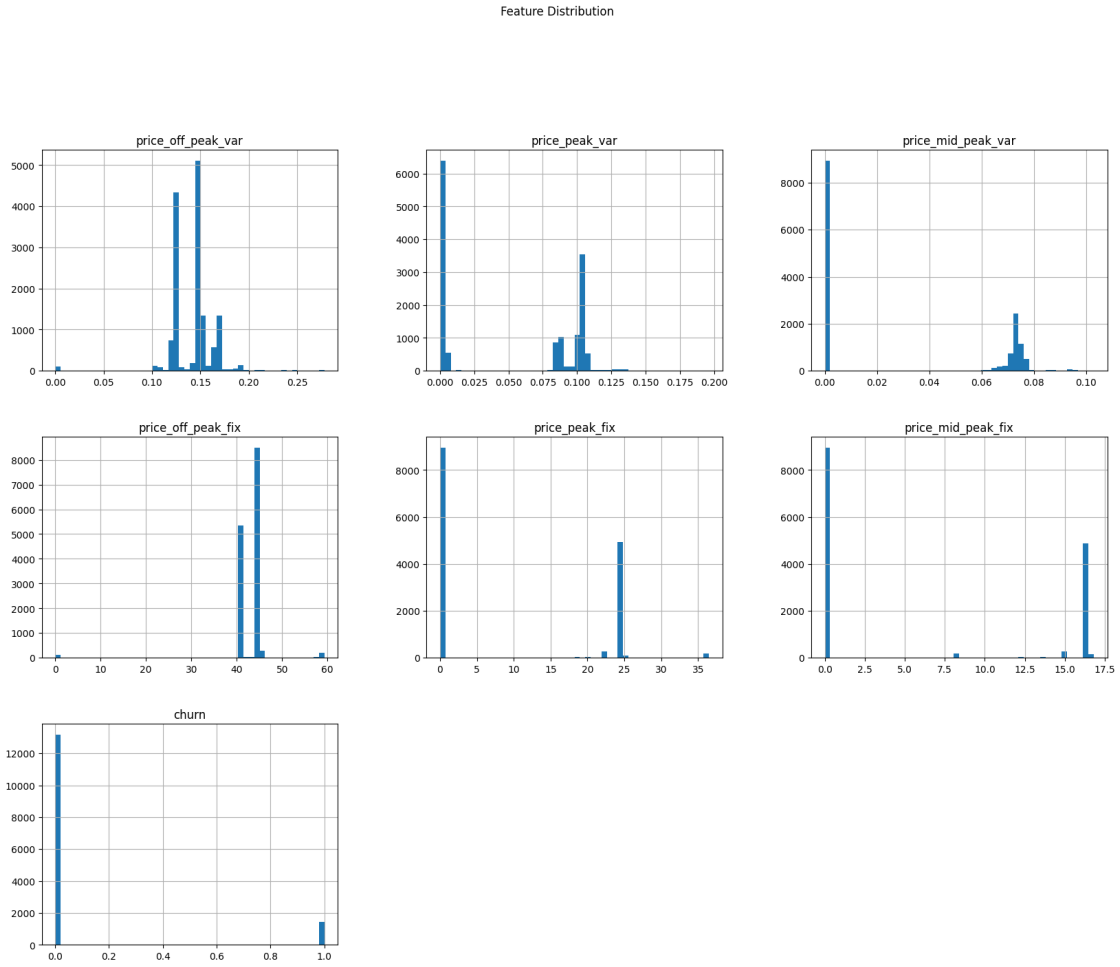
[26]:
```
plt.figure(figsize=(30,15))
sns.pairplot(final_price_df.sample(500))
plt.suptitle('PairPlot of the Data',x=0.5,y=1.02,fontsize='large',ha='center')
```

[26]:
```
Text(0.5, 1.02, 'PairPlot of the Data')

<Figure size 3000x1500 with 0 Axes>
```



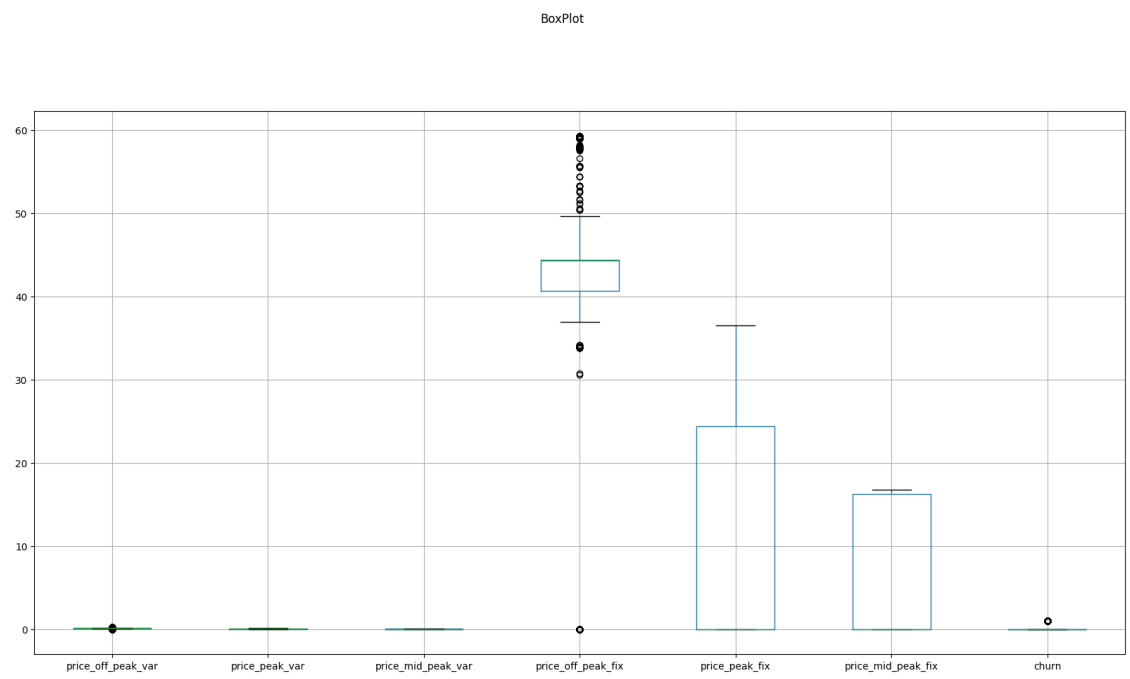
[27]:
```
final_price_df.hist(bins=50,figsize=(20,15))
plt.suptitle('Feature Distribution',x=0.5,y=1.02,ha='center',fontsize='large')
```

[27]: Text(0.5, 1.02, 'Feature Distribution')



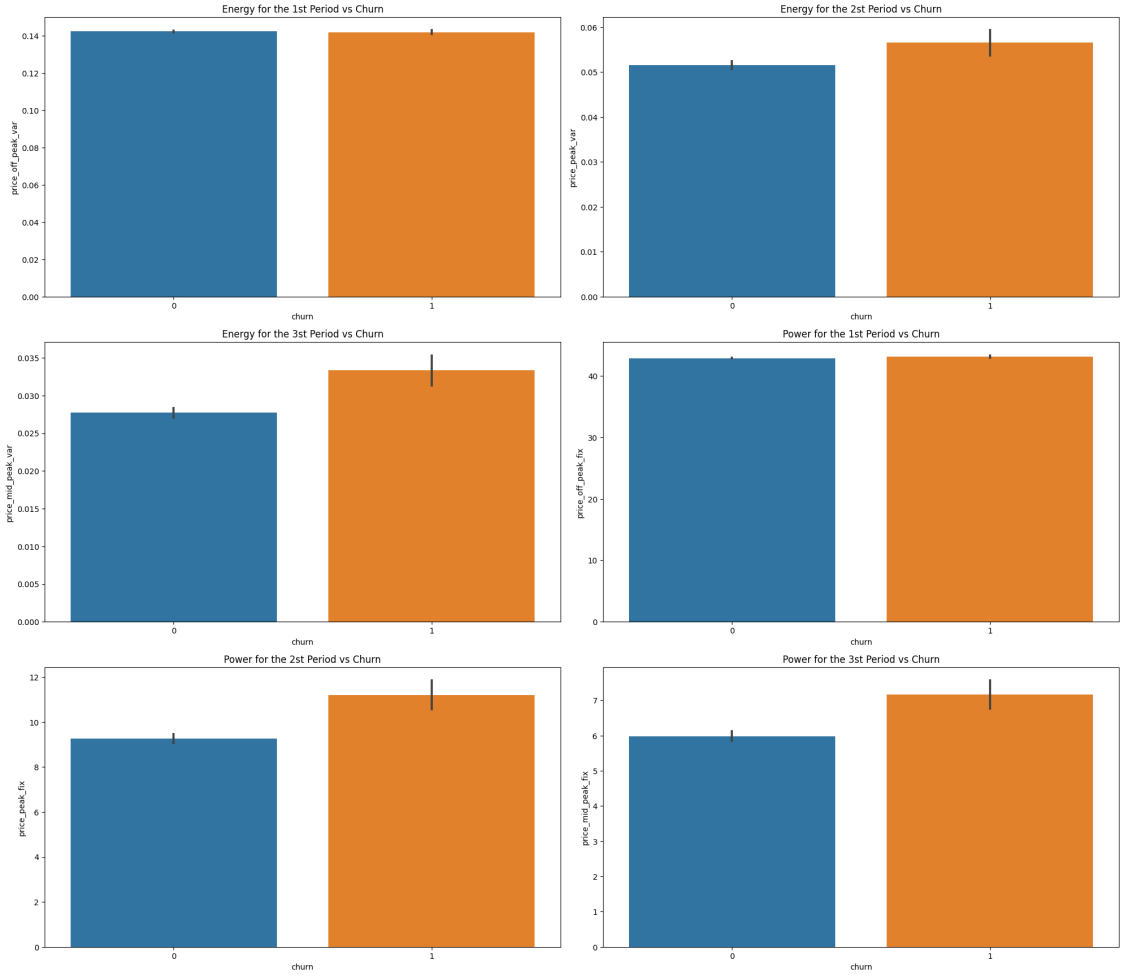
[28]:
```
final_price_df.boxplot(figsize=(20,10))
plt.suptitle('BoxPlot',x=0.5,y=1.02,ha='center',fontsize='large')
```

[28]: Text(0.5, 1.02, 'BoxPlot')



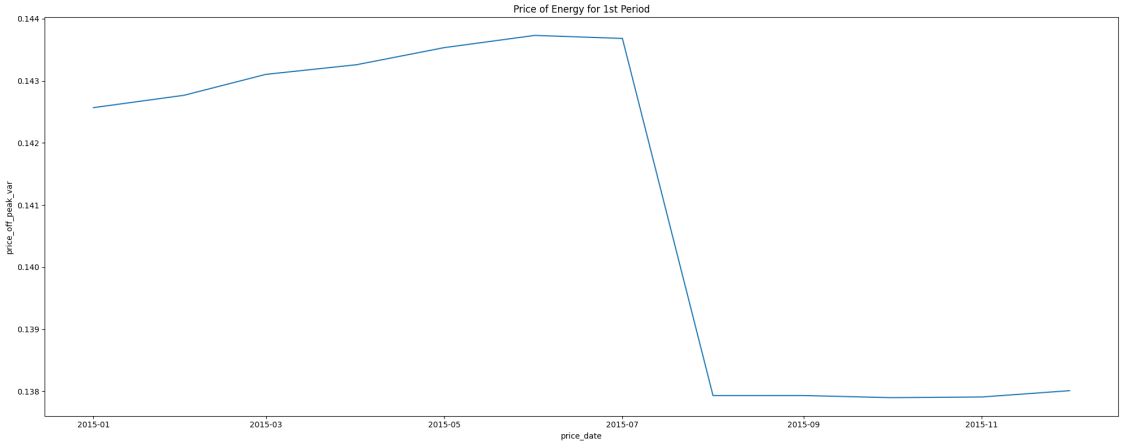
[29]:
```
plt.figure(figsize=(20,40))

plt.subplot(7,2,1)
sns.barplot(data=final_price_df,x='churn',y='price_off_peak_var')
plt.title('Energy for the 1st Period vs Churn')

plt.subplot(7,2,2)
sns.barplot(data=final_price_df,x='churn',y='price_peak_var')
plt.title('Energy for the 2st Period vs Churn')

plt.subplot(7,2,3)
sns.barplot(data=final_price_df,x='churn',y='price_mid_peak_var')
plt.title('Energy for the 3st Period vs Churn')

plt.subplot(7,2,4)
sns.barplot(data=final_price_df,x='churn',y='price_off_peak_fix')
plt.title('Power for the 1st Period vs Churn')

plt.subplot(7,2,5)
sns.barplot(data=final_price_df,x='churn',y='price_peak_fix')
plt.title('Power for the 2st Period vs Churn')

plt.subplot(7,2,6)
sns.barplot(data=final_price_df,x='churn',y='price_mid_peak_fix')
plt.title('Power for the 3st Period vs Churn')
```

```
plt.tight_layout()
```

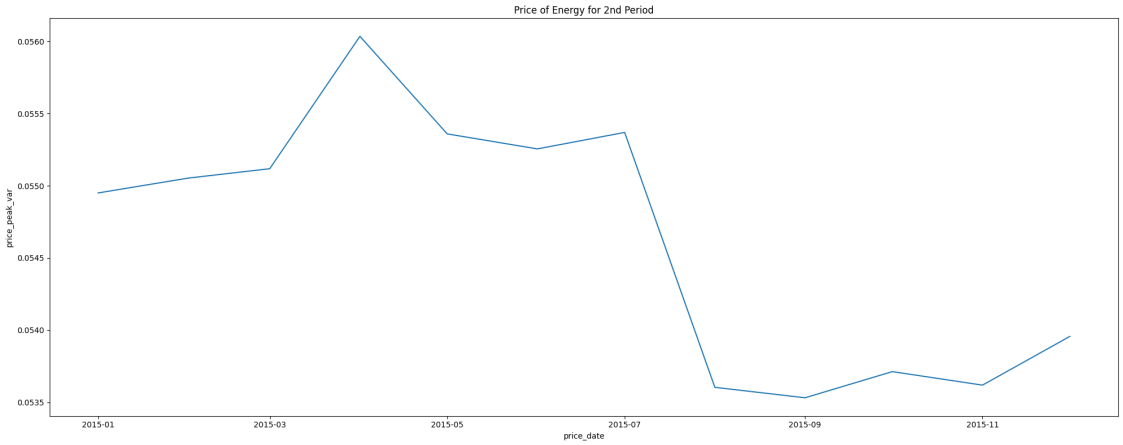


10 Time Series Analysis

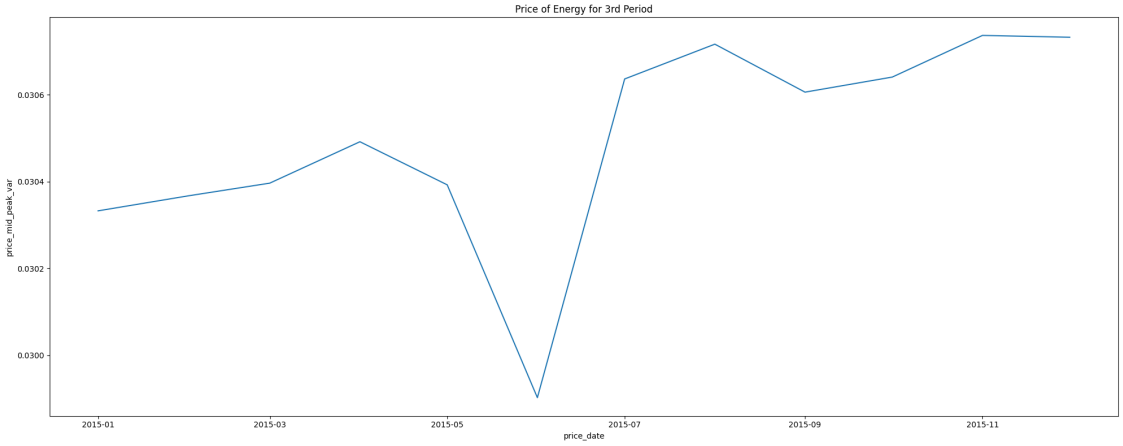
[30]:
```
plt.figure(figsize=(20,8))
sns.
  ↪lineplot(data=df,x='price_date',y='price_off_peak_var',estimator='mean',ci=None)
plt.title('Price of Energy for 1st Period')
plt.tight_layout()
```



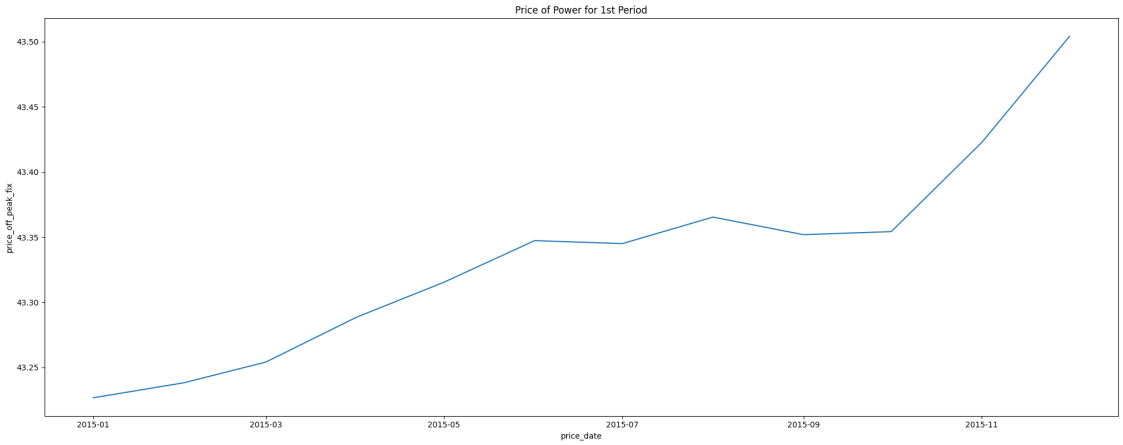
[31]:
```
plt.figure(figsize=(20,8))
sns.lineplot(data=df,x=df.price_date,y=df.
  ↪price_peak_var,estimator='mean',ci=None)
plt.title('Price of Energy for 2nd Period')
plt.tight_layout()
```



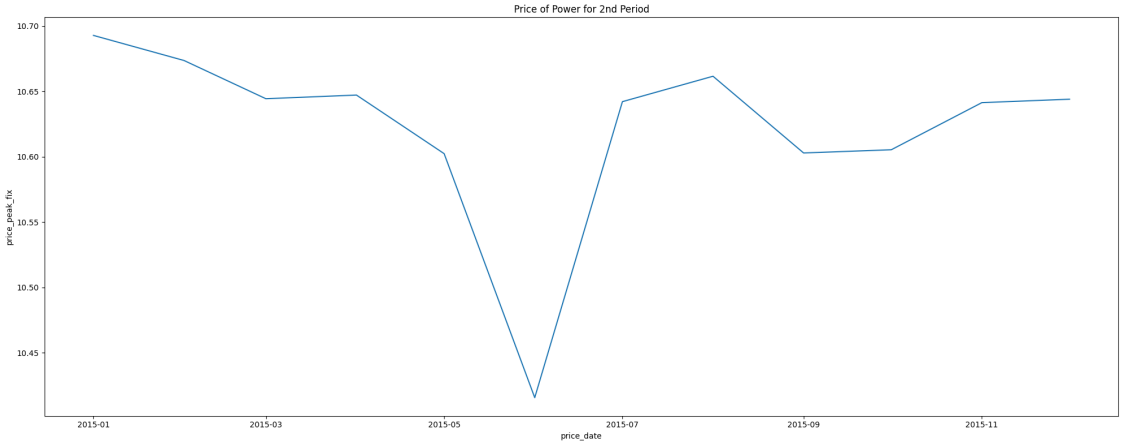
[32]:
```
plt.figure(figsize=(20,8))
sns.
  ↪lineplot(data=df,x='price_date',y='price_mid_peak_var',estimator='mean',ci=None)
plt.title('Price of Energy for 3rd Period')
plt.tight_layout()
```



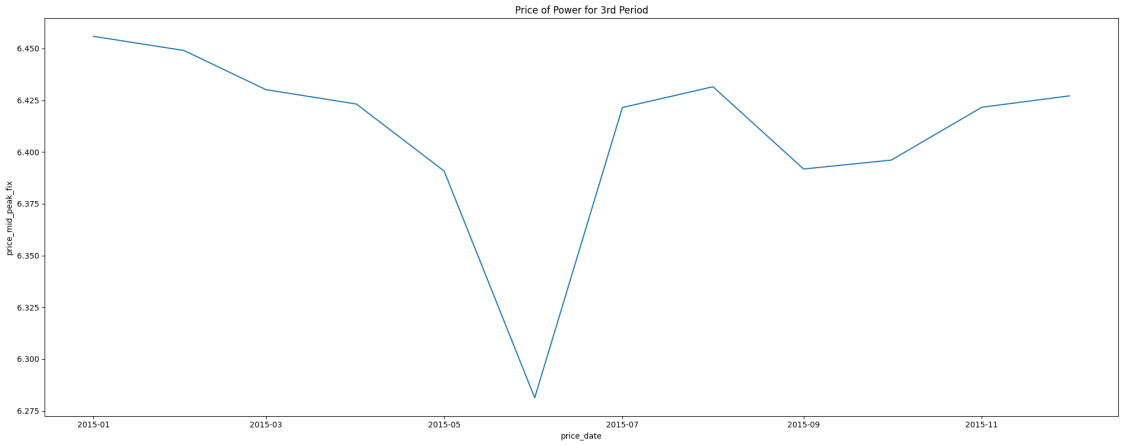
[33]:
```
plt.figure(figsize=(20,8))
sns.
  ↪lineplot(data=df,x='price_date',y='price_off_peak_fix',estimator='mean',ci=None)
plt.title('Price of Power for 1st Period')
plt.tight_layout()
```



[34]:
```
plt.figure(figsize=(20,8))
sns.lineplot(data=df,x='price_date',y='price_peak_fix',estimator='mean',ci=None)
plt.title('Price of Power for 2nd Period')
plt.tight_layout()
```



[35]:
```
plt.figure(figsize=(20,8))
sns.
 ↪lineplot(data=df,x='price_date',y='price_mid_peak_fix',estimator='mean',ci=None)
plt.title('Price of Power for 3rd Period')
plt.tight_layout()
```



11 Correlations

[36]:
```
df.corr()
```

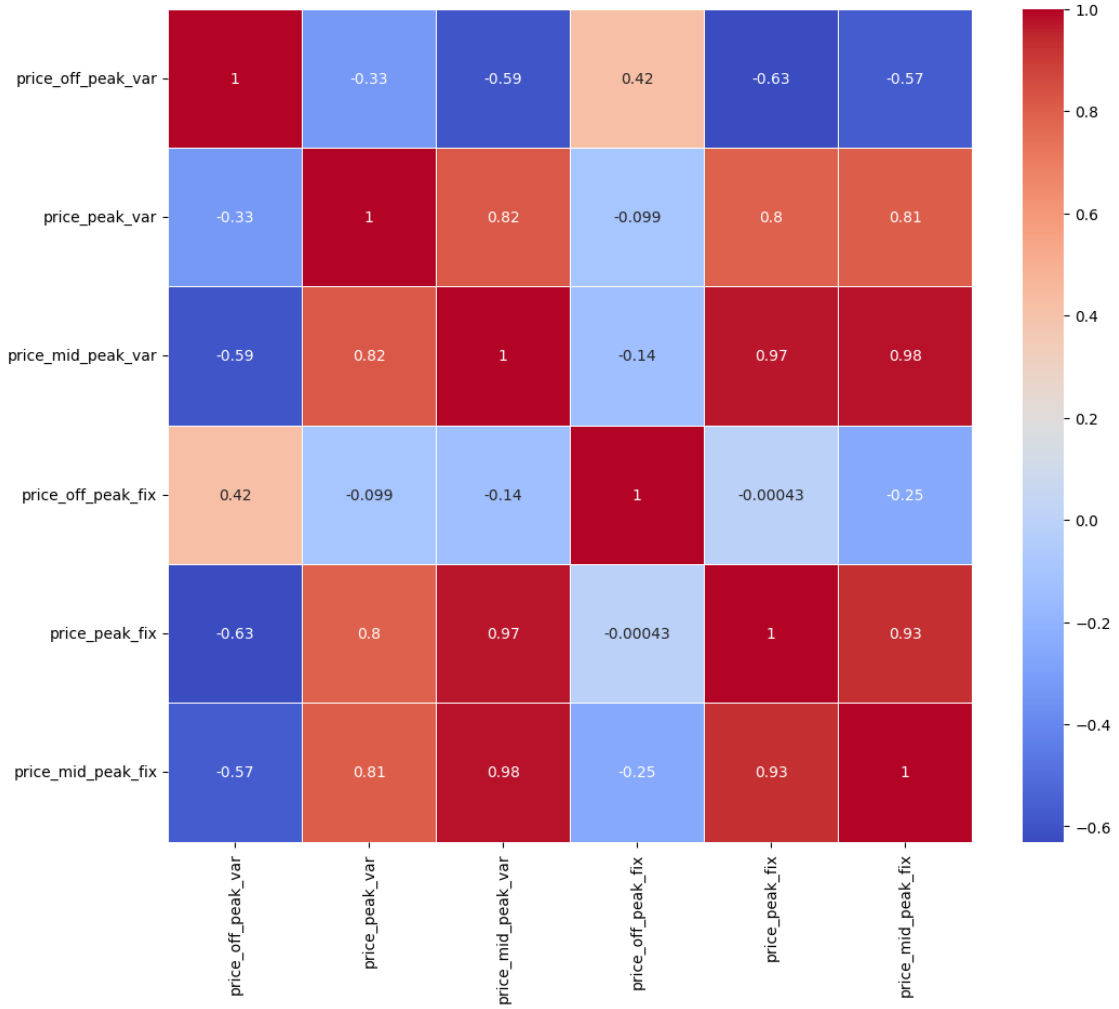
[36]:

	price_off_peak_var	price_peak_var	price_mid_peak_var	\
price_off_peak_var	1.000000	-0.328580	-0.594872	
price_peak_var	-0.328580	1.000000	0.821353	
price_mid_peak_var	-0.594872	0.821353	1.000000	
price_off_peak_fix	0.417097	-0.098627	-0.137848	

```
price_peak_fix              -0.630018        0.796097           0.973960
price_mid_peak_fix          -0.572229        0.807759           0.979717

                    price_off_peak_fix  price_peak_fix  price_mid_peak_fix
price_off_peak_var            0.417097       -0.630018           -0.572229
price_peak_var               -0.098627        0.796097            0.807759
price_mid_peak_var           -0.137848        0.973960            0.979717
price_off_peak_fix            1.000000       -0.000428           -0.252661
price_peak_fix               -0.000428        1.000000            0.927308
price_mid_peak_fix           -0.252661        0.927308            1.000000
```

[37]:
```
plt.figure(figsize=(12,10))
sns.heatmap(df.corr(),cmap='coolwarm',annot=True,linewidths=0.
 ↪5,linecolor='white')
```

[37]: <Axes: >



Conclusion: Period 2nd and 3rd is highly correlated

[ ]: