In [37]:
```
# ! pip install seaborn

#! pip install lightgbm
```

```
Collecting lightgbm
  Downloading lightgbm-2.3.1-py2.py3-none-win_amd64.whl (544 kB)
Requirement already satisfied: scipy in c:\users\sonak\.conda\envs\tensorflow_c
pu\lib\site-packages (from lightgbm) (1.3.2)
Requirement already satisfied: numpy in c:\users\sonak\.conda\envs\tensorflow_c
pu\lib\site-packages (from lightgbm) (1.18.1)
Requirement already satisfied: scikit-learn in c:\users\sonak\.conda\envs\tenso
rflow_cpu\lib\site-packages (from lightgbm) (0.22.1)
Requirement already satisfied: joblib>=0.11 in c:\users\sonak\.conda\envs\tenso
rflow_cpu\lib\site-packages (from scikit-learn->lightgbm) (0.14.1)
Installing collected packages: lightgbm
Successfully installed lightgbm-2.3.1

WARNING: pip is being invoked by an old script wrapper. This will fail in a fut
ure version of pip.
Please see https://github.com/pypa/pip/issues/5599 (https://github.com/pypa/pi
p/issues/5599) for advice on fixing the underlying issue.
To avoid this problem you can invoke Python with '-m pip' instead of running pi
p directly.
```

In [74]:
```
import numpy as np
import pandas as pd
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.simplefilter('ignore')
import gc
%matplotlib inline
from plotly import tools, subplots
import plotly.offline as py
py.init_notebook_mode(connected=True)
import plotly.graph_objs as go
import plotly.express as px
pd.set_option('max_columns', 100)
import lightgbm as lgb
from sklearn.metrics import r2_score
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
```

Loading Datasets

In [62]:
```
building_data = pd.read_csv('building_metadata.csv')
weather_train = pd.read_csv('weather_train.csv')
weather_test = pd.read_csv('weather_test.csv')
train = pd.read_csv('train.csv')
test = pd.read_csv('test.csv')
```

Count and info of rows and Columns in dataset

In [63]:
```
print(building_data.head(5))
# print(building_data.tail(5))
print(building_data.info())
```

```
   site_id  building_id primary_use  square_feet  year_built  floor_count
0        0            0   Education         7432      2008.0          NaN
1        0            1   Education         2720      2004.0          NaN
2        0            2   Education         5376      1991.0          NaN
3        0            3   Education        23685      2002.0          NaN
4        0            4   Education       116607      1975.0          NaN
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1449 entries, 0 to 1448
Data columns (total 6 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   site_id      1449 non-null   int64  
 1   building_id  1449 non-null   int64  
 2   primary_use  1449 non-null   object 
 3   square_feet  1449 non-null   int64  
 4   year_built   675 non-null    float64
 5   floor_count  355 non-null    float64
dtypes: float64(2), int64(3), object(1)
memory usage: 68.0+ KB
None
```

label Encoding

In [64]:
```
le = LabelEncoder()
building_data.primary_use = le.fit_transform(building_data.primary_use)
```

In [65]:
```
print(weather_train.head(5))
# print(weather_train.tail(5))
print(weather_train.info())
```

```
   site_id            timestamp  air_temperature  cloud_coverage  \
0        0  2016-01-01 00:00:00             25.0             6.0
1        0  2016-01-01 01:00:00             24.4             NaN
2        0  2016-01-01 02:00:00             22.8             2.0
3        0  2016-01-01 03:00:00             21.1             2.0
4        0  2016-01-01 04:00:00             20.0             2.0

   dew_temperature  precip_depth_1_hr  sea_level_pressure  wind_direction  \
0             20.0                NaN              1019.7             0.0
1             21.1               -1.0              1020.2            70.0
2             21.1                0.0              1020.2             0.0
3             20.6                0.0              1020.1             0.0
4             20.0               -1.0              1020.0           250.0

   wind_speed
0         0.0
1         1.5
2         0.0
3         0.0
4         2.6
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 139773 entries, 0 to 139772
Data columns (total 9 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   site_id             139773 non-null  int64
 1   timestamp           139773 non-null  object
 2   air_temperature     139718 non-null  float64
 3   cloud_coverage      70600 non-null   float64
 4   dew_temperature     139660 non-null  float64
 5   precip_depth_1_hr   89484 non-null   float64
 6   sea_level_pressure  129155 non-null  float64
 7   wind_direction      133505 non-null  float64
 8   wind_speed          139469 non-null  float64
dtypes: float64(7), int64(1), object(1)
memory usage: 9.6+ MB
None
```

In [66]:
```
print(weather_test.head(5))
# print(weather_test.tail(5))
print(weather_test.info())
```

```
   site_id            timestamp  air_temperature  cloud_coverage  \
0        0  2017-01-01 00:00:00             17.8             4.0
1        0  2017-01-01 01:00:00             17.8             2.0
2        0  2017-01-01 02:00:00             16.1             0.0
3        0  2017-01-01 03:00:00             17.2             0.0
4        0  2017-01-01 04:00:00             16.7             2.0

   dew_temperature  precip_depth_1_hr  sea_level_pressure  wind_direction  \
0             11.7                NaN              1021.4           100.0
1             12.8                0.0              1022.0           130.0
2             12.8                0.0              1021.9           140.0
3             13.3                0.0              1022.2           140.0
4             13.3                0.0              1022.3           130.0

   wind_speed
0         3.6
1         3.1
2         3.1
3         3.1
4         2.6
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 277243 entries, 0 to 277242
Data columns (total 9 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   site_id             277243 non-null  int64
 1   timestamp           277243 non-null  object
 2   air_temperature     277139 non-null  float64
 3   cloud_coverage      136795 non-null  float64
 4   dew_temperature     276916 non-null  float64
 5   precip_depth_1_hr   181655 non-null  float64
 6   sea_level_pressure  255978 non-null  float64
 7   wind_direction      264873 non-null  float64
 8   wind_speed          276783 non-null  float64
dtypes: float64(7), int64(1), object(1)
memory usage: 19.0+ MB
None
```

Train and Test description

In [67]:
```
train.describe(include='all')
```

Out[67]:

	building_id	meter	timestamp	meter_reading
count	2.021610e+07	2.021610e+07	20216100	2.021610e+07
unique	NaN	NaN	8784	NaN
top	NaN	NaN	2016-12-27 22:00:00	NaN
freq	NaN	NaN	2370	NaN
mean	7.992780e+02	6.624412e-01	NaN	2.117121e+03
std	4.269133e+02	9.309921e-01	NaN	1.532356e+05
min	0.000000e+00	0.000000e+00	NaN	0.000000e+00
25%	3.930000e+02	0.000000e+00	NaN	1.830000e+01
50%	8.950000e+02	0.000000e+00	NaN	7.877500e+01
75%	1.179000e+03	1.000000e+00	NaN	2.679840e+02
max	1.448000e+03	3.000000e+00	NaN	2.190470e+07

In [68]:
```
train.columns
```

Out[68]:
```
Index(['building_id', 'meter', 'timestamp', 'meter_reading'], dtype='object')
```

In [69]:
```
test.describe(include='all')
```

Out[69]:

	row_id	building_id	meter	timestamp
count	4.169760e+07	4.169760e+07	4.169760e+07	41697600
unique	NaN	NaN	NaN	17520
top	NaN	NaN	NaN	2017-08-24 02:00:00
freq	NaN	NaN	NaN	2380
mean	2.084880e+07	8.075824e+02	6.642857e-01	NaN
std	1.203706e+07	4.297680e+02	9.278067e-01	NaN
min	0.000000e+00	0.000000e+00	0.000000e+00	NaN
25%	1.042440e+07	4.047500e+02	0.000000e+00	NaN
50%	2.084880e+07	9.000000e+02	0.000000e+00	NaN
75%	3.127320e+07	1.194250e+03	1.000000e+00	NaN
max	4.169760e+07	1.448000e+03	3.000000e+00	NaN

In [70]:
```
test.isnull().sum()
```

Out[70]:
```
row_id         0
building_id    0
meter          0
timestamp      0
dtype: int64
```

Merging building and weather data into test and train

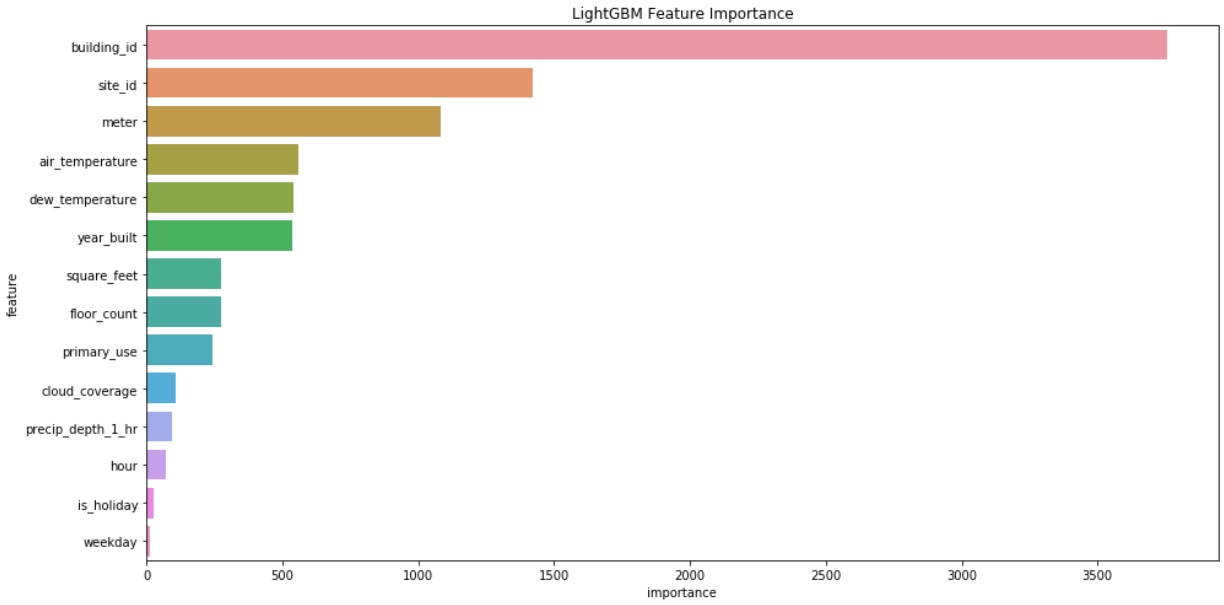
In [71]:
```
def prepare_data(X, building_data, weather_data, test=False):
    """
    Preparing final dataset with all features.
    """

    X = X.merge(building_data, on="building_id", how="left")
    X = X.merge(weather_data, on=["site_id", "timestamp"], how="left")

    X.timestamp = pd.to_datetime(X.timestamp, format="%Y-%m-%d %H:%M:%S")
    X.square_feet = np.log1p(X.square_feet)

    if not test:
        X.sort_values("timestamp", inplace=True)
        X.reset_index(drop=True, inplace=True)

    gc.collect()

    holidays = ["2016-01-01", "2016-01-18", "2016-02-15", "2016-05-30", "2016-07-
                "2016-09-05", "2016-10-10", "2016-11-11", "2016-11-24", "2016-12-
                "2017-01-01", "2017-01-16", "2017-02-20", "2017-05-29", "2017-07-
                "2017-09-04", "2017-10-09", "2017-11-10", "2017-11-23", "2017-12-
                "2018-01-01", "2018-01-15", "2018-02-19", "2018-05-28", "2018-07-
                "2018-09-03", "2018-10-08", "2018-11-12", "2018-11-22", "2018-12-
                "2019-01-01"]

    X["hour"] = X.timestamp.dt.hour
    X["weekday"] = X.timestamp.dt.weekday
    X["is_holiday"] = (X.timestamp.dt.date.astype("str").isin(holidays)).astype(i

    drop_features = ["timestamp", "sea_level_pressure", "wind_direction", "wind_s

    X.drop(drop_features, axis=1, inplace=True)

    if test:
        row_ids = X.row_id
        X.drop("row_id", axis=1, inplace=True)
        return X, row_ids
    else:
        y = np.log1p(X.meter_reading)
        X.drop("meter_reading", axis=1, inplace=True)
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2
        return X_train, X_test, y_train, y_test
```

In [75]:
```
X_train, X_test, y_train, y_test = prepare_data(train, building_data, weather_tra
```

In [9]:
```
train = train.merge(building_data, on='building_id', how='left')
test = test.merge(building_data, on='building_id', how='left')

train = train.merge(weather_train, on=['site_id', 'timestamp'], how='left')
test = test.merge(weather_test, on=['site_id', 'timestamp'], how='left')
```

In [76]:
```
# int(X_train.shape[0]/2)

# X_train[:int(X_train.shape[0] / 2)]
# X_train[int(X_train.shape[0] / 2):]
categorical_features = ["building_id", "site_id", "meter", "primary_use", "hour",

data_trained = lgb.Dataset(X_train, label=y_train, categorical_feature=categorica

params = {}
params['learning_rate'] = 0.003
params['boosting_type'] = 'gbdt'
params['objective'] = 'binary'
params['metric'] = 'binary_logloss'
params['sub_feature'] = 0.5
params['num_leaves'] = 10
params['min_data'] = 50
params['max_depth'] = 10

# clf = lgb.train(params, d_train, 100)
model = lgb.train(params, train_set=data_trained, num_boost_round=1000)
#verbose_eval=200,
```

In [77]:
```
df_fimp = pd.DataFrame()
df_fimp["feature"] = X_train.columns.values
df_fimp["importance"] = model.feature_importance()


plt.figure(figsize=(14, 7))
sns.barplot(x="importance", y="feature", data=df_fimp.sort_values(by="importance"
plt.title("LightGBM Feature Importance")
plt.tight_layout()
```



Preparing for test data

In [83]:
```
# X_test, row_ids = prepare_data(test, building_data, weather_test, test=True)
y_train
```

Out[83]:
```
7015320     5.994767
413213      2.772589
4053667     5.439986
6820221     8.603485
19281929    3.850679
               ...
15039847    0.000000
5157699     5.299756
2215104     7.391742
18261621    2.756840
8325804     5.664106
Name: meter_reading, Length: 15162075, dtype: float64
```

Scoring for the test data

In [78]:
```
pred = np.expm1(model.predict(X_test, num_iteration=model.best_iteration))
```

In [84]:
```
msecat = mean_squared_error(y_test,pred)
print(msecat)
rmsecat = np.sqrt(msecat)
print(rmsecat)
```

```
11.339043701010707
3.36734965529431
```

Count of Data Missing in Train

In [10]:
```
for col in train.columns:
    if train[col].isna().sum()>0:
        print (col,train[col].isna().sum())
```

```
year_built 12127645
floor_count 16709167
air_temperature 96658
cloud_coverage 8825365
dew_temperature 100140
precip_depth_1_hr 3749023
sea_level_pressure 1231669
wind_direction 1449048
wind_speed 143676
```

Count of Data Missing in test

In [13]:
```
for col in test.columns:
    if test[col].isna().sum()>0:
        print (col,test[col].isna().sum())
```

```
year_built 24598080
floor_count 34444320
air_temperature 221901
cloud_coverage 19542180
dew_temperature 260799
precip_depth_1_hr 7801563
sea_level_pressure 2516826
wind_direction 2978663
wind_speed 302089
```

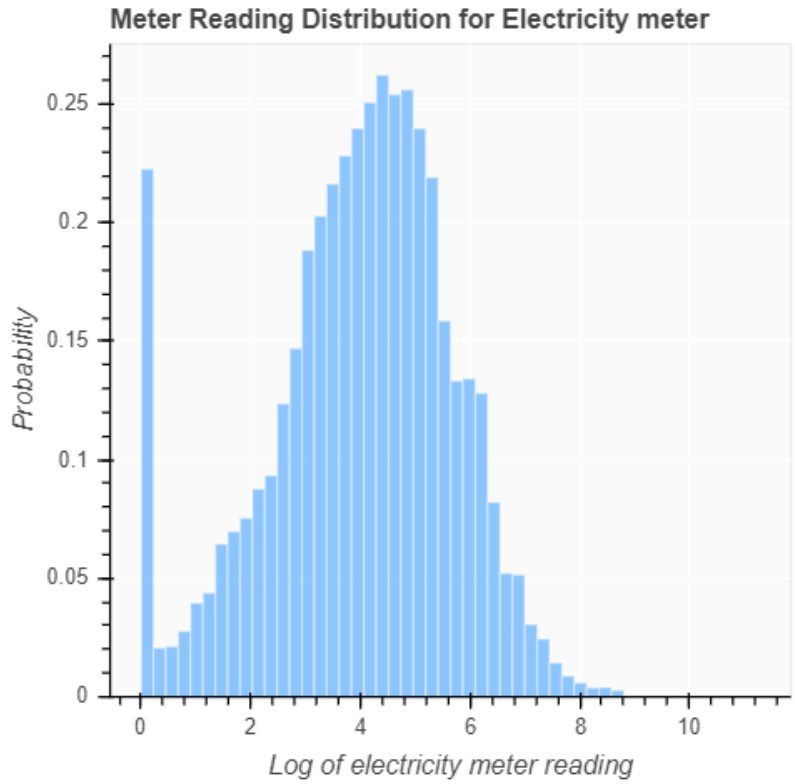
In [13]:
```
train.columns
```

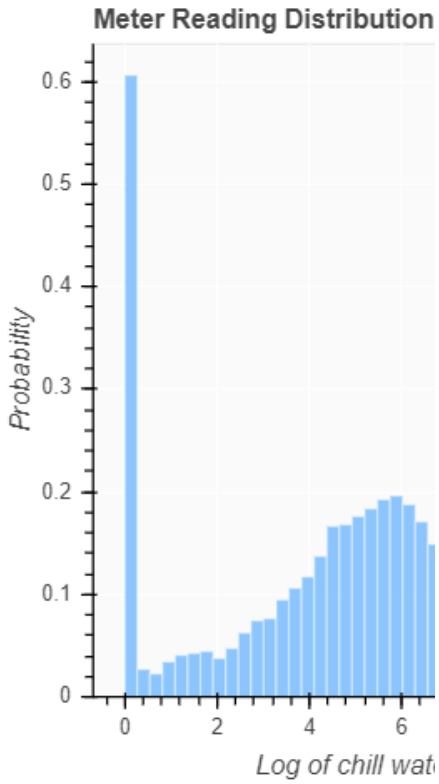
Out[13]:
```
Index(['building_id', 'meter', 'timestamp', 'meter_reading'], dtype='object')
```

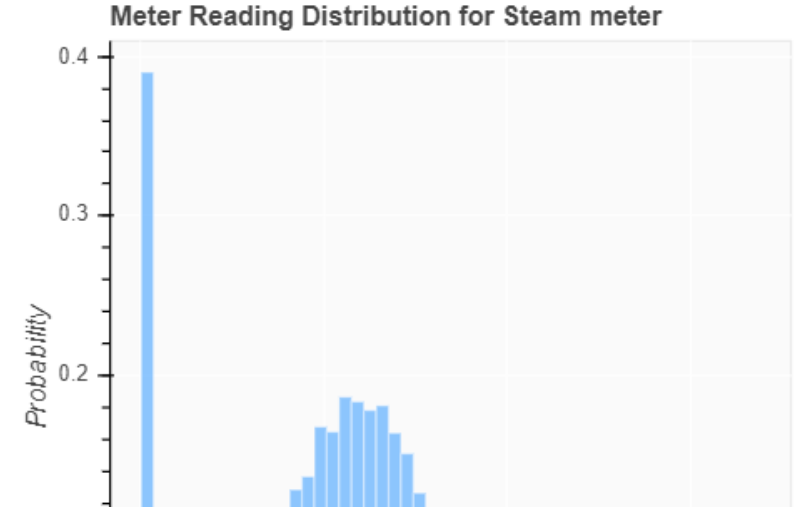
Distribution plot for the target variable

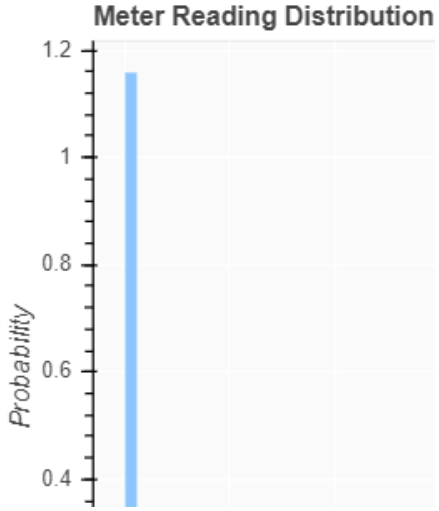
In [33]:
```
from bokeh.layouts import gridplot
from bokeh.plotting import figure, show, output_file
from bokeh.io import output_notebook

output_notebook()

def make_plot(title, hist, edges, xlabel):
    p = figure(title=title, tools='', background_fill_color="#fafafa")
    p.quad(top=hist, bottom=0, left=edges[:-1], right=edges[1:],
           fill_color="#1E90FF", line_color="white", alpha=0.5)
    p.y_range.start = 0
    p.xaxis.axis_label = f'Log of {xlabel} meter reading'
    p.yaxis.axis_label = 'Probability'
    p.grid.grid_line_color="white"
    return p

def scatter_plot(cnt_srs, color):
    trace = go.Scatter(
        x=cnt_srs.index[::-1],
        y=cnt_srs.values[::-1],
        showlegend=False,
        marker=dict(
            color=color,
        ),
    )
    return trace
```

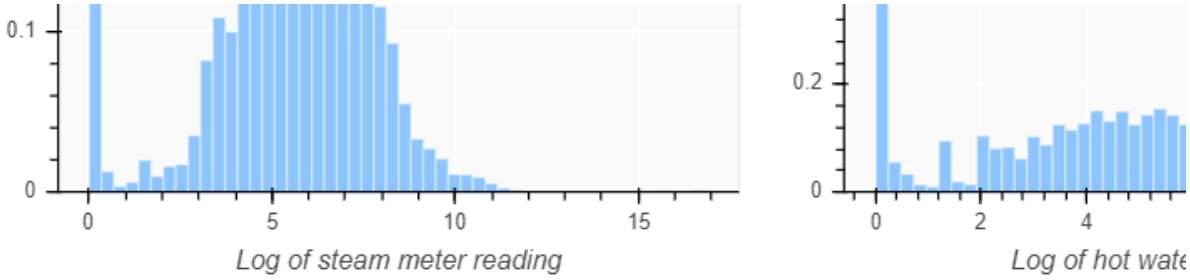
In [57]:
```
dataset = train[train["meter"]==0]
hist, edges = np.histogram(np.log1p(dataset["meter_reading"].values), density=Tru
p1 = make_plot("Meter Reading Distribution for Electricity meter", hist, edges, '

dataset = train[train["meter"]==1]
hist, edges = np.histogram(np.log1p(dataset["meter_reading"].values), density=Tru
p2 = make_plot("Meter Reading Distribution for Chilled Water meter", hist, edges,

dataset = train[train["meter"]==2]
hist, edges = np.histogram(np.log1p(dataset["meter_reading"].values), density=Tru
p3 = make_plot("Meter Reading Distribution for Steam meter", hist, edges, 'steam'

dataset = train[train["meter"]==3]
hist, edges = np.histogram(np.log1p(dataset["meter_reading"].values), density=Tru
p4 = make_plot("Meter Reading Distribution for Hot Water meter", hist, edges, 'ho

show(gridplot([p1,p2,p3,p4], ncols=2, plot_width=400, plot_height=400, toolbar_lo
```







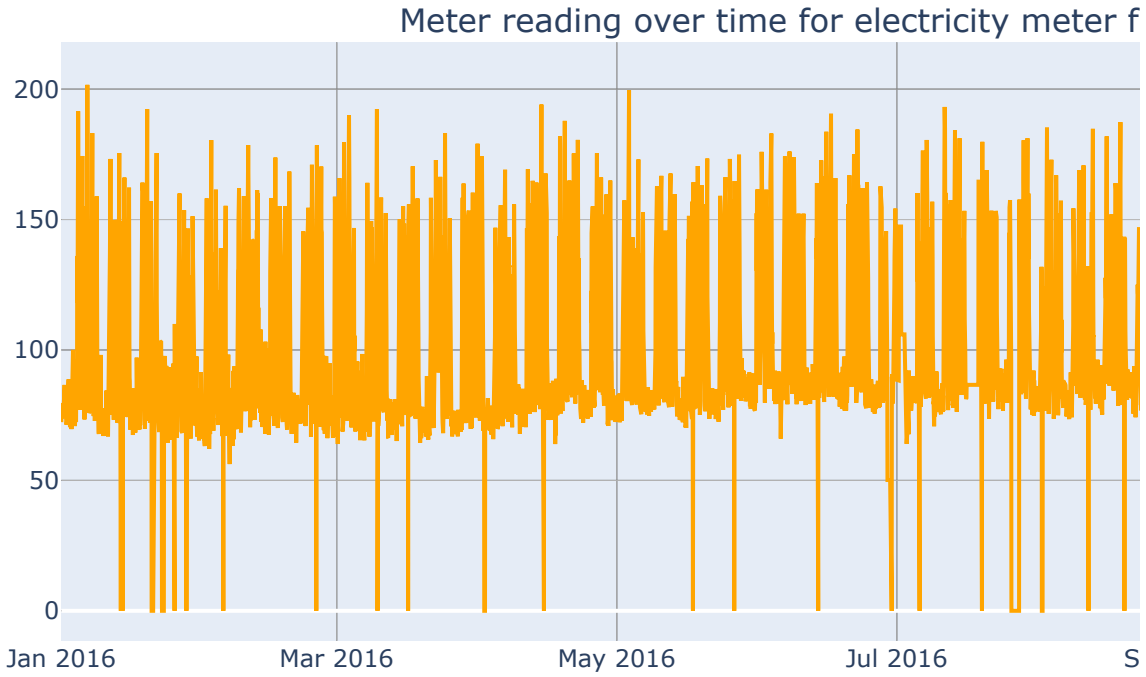


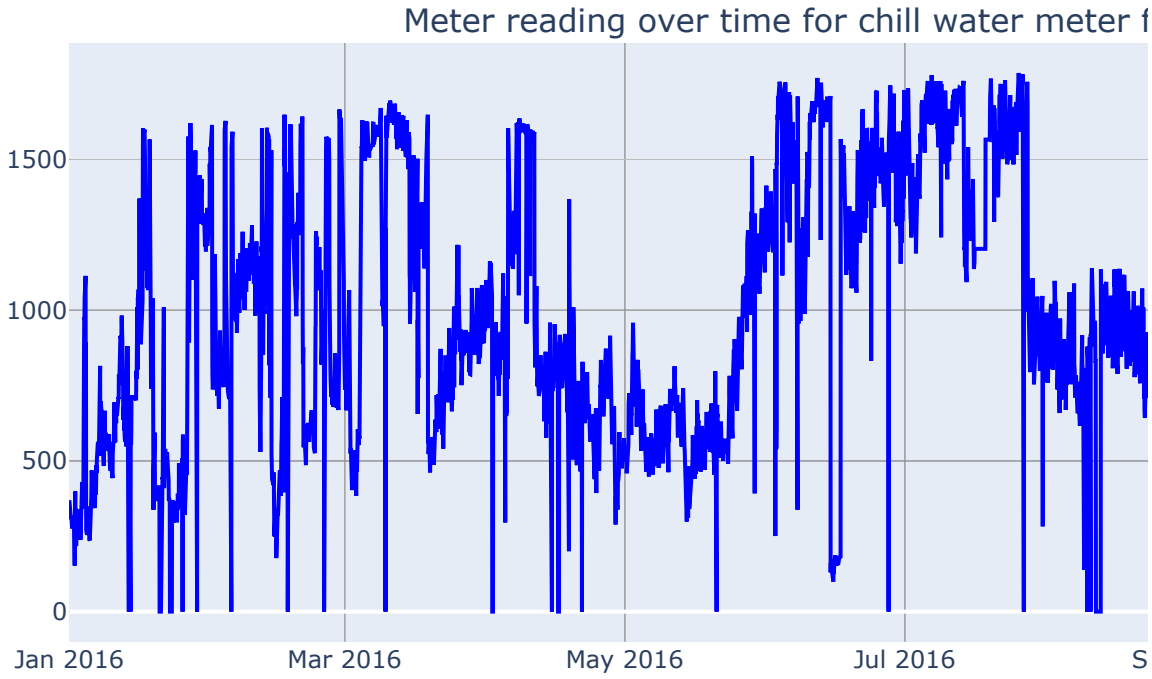


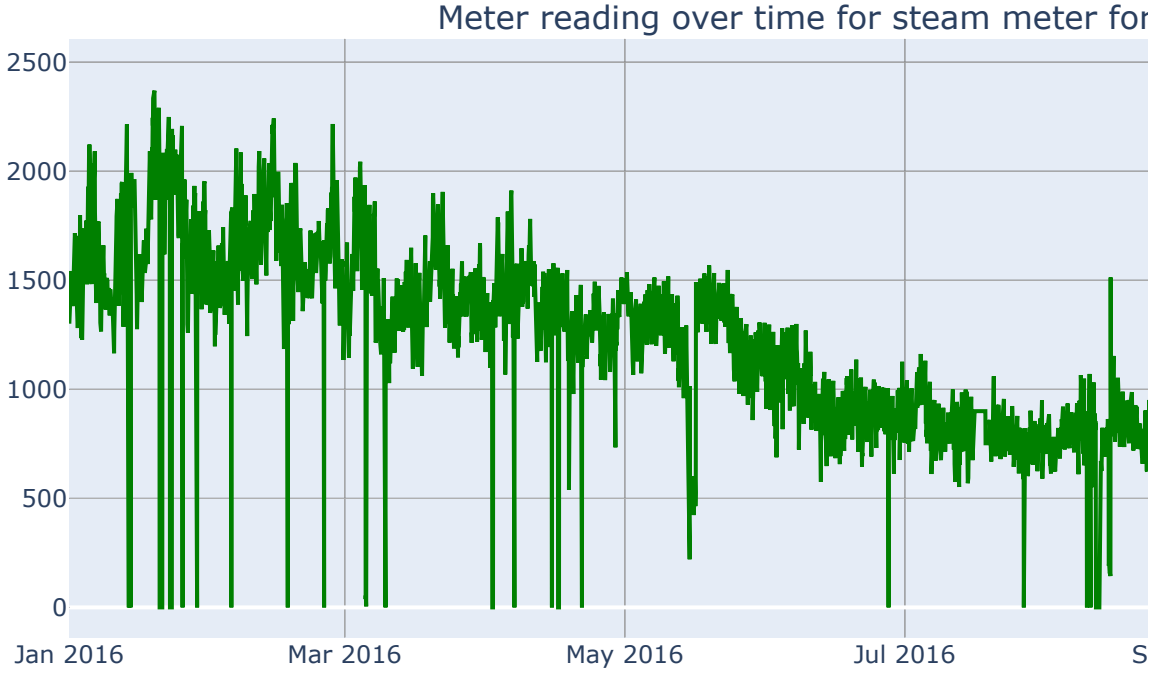
Electricty meter type has the most number of rows

Distribution of target variable meter readings over a time period

In [66]:
```
dataset = train[train["building_id"]==1292].reset_index(drop=True)


tdf = dataset[dataset["meter"]==0]
col = tdf["meter_reading"]
col.index = tdf["timestamp"]
trace1 = scatter_plot(col, 'orange')

tdf = dataset[dataset["meter"]==1]
col = tdf["meter_reading"]
col.index = tdf["timestamp"]
trace2 = scatter_plot(col, 'blue')

tdf = dataset[dataset["meter"]==2]
col = tdf["meter_reading"]
col.index = tdf["timestamp"]
trace3 = scatter_plot(col, 'green')


subtitles = ["Meter reading over time for electricity meter for building 1292",
             "Meter reading over time for chill water meter for building 1292",
             "Meter reading over time for steam meter for building 1292",
            ]
fig = subplots.make_subplots(rows=3, cols=1, vertical_spacing=0.06,
                             subplot_titles=subtitles)
fig.append_trace(trace1, 1, 1)
fig.append_trace(trace2, 2, 1)
fig.append_trace(trace3, 3, 1)
fig['layout'].update(height=1200, width=1000, paper_bgcolor='rgb(223,223,233)')
py.iplot(fig, filename='meter-plots')
```







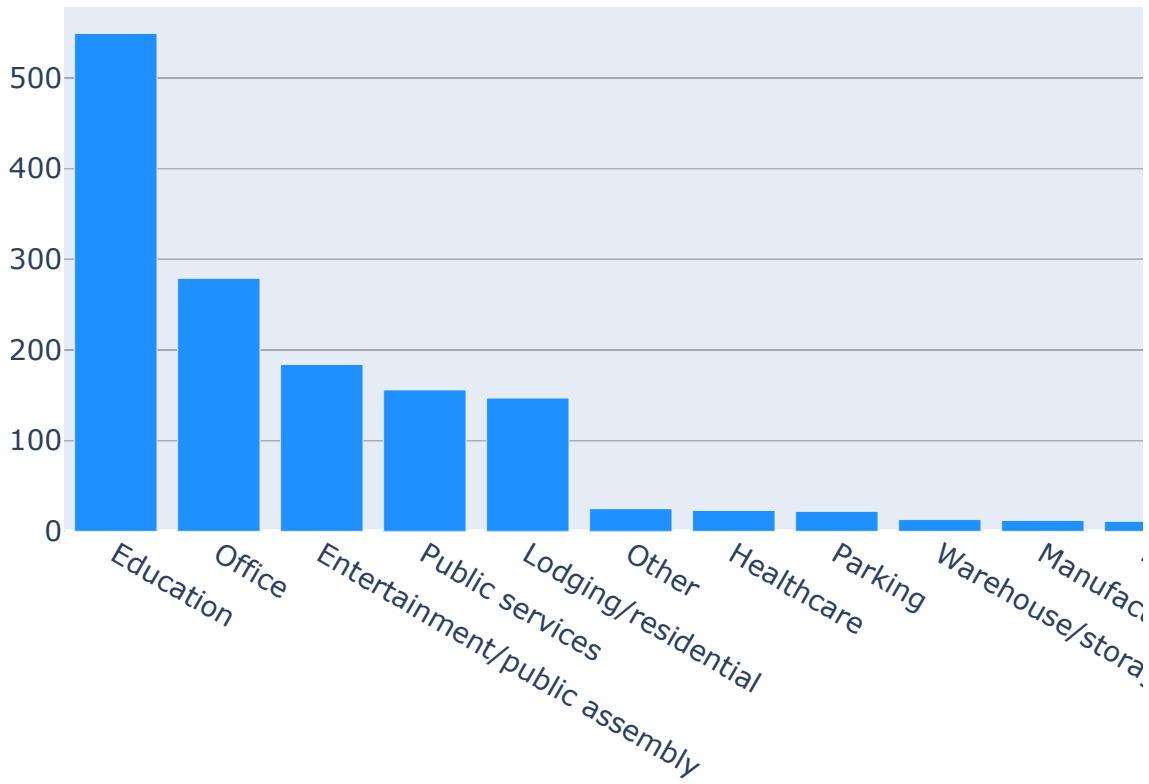
The electricity meter readings are generally in the range of 60 to 400 but becomes 0 at times in between.

We can see an increase in the chill water meter from sep to octof 2016 for this building probably due to summer time

Distribution plots for Building

Energy consumption in building will if it is used for commerical purpose

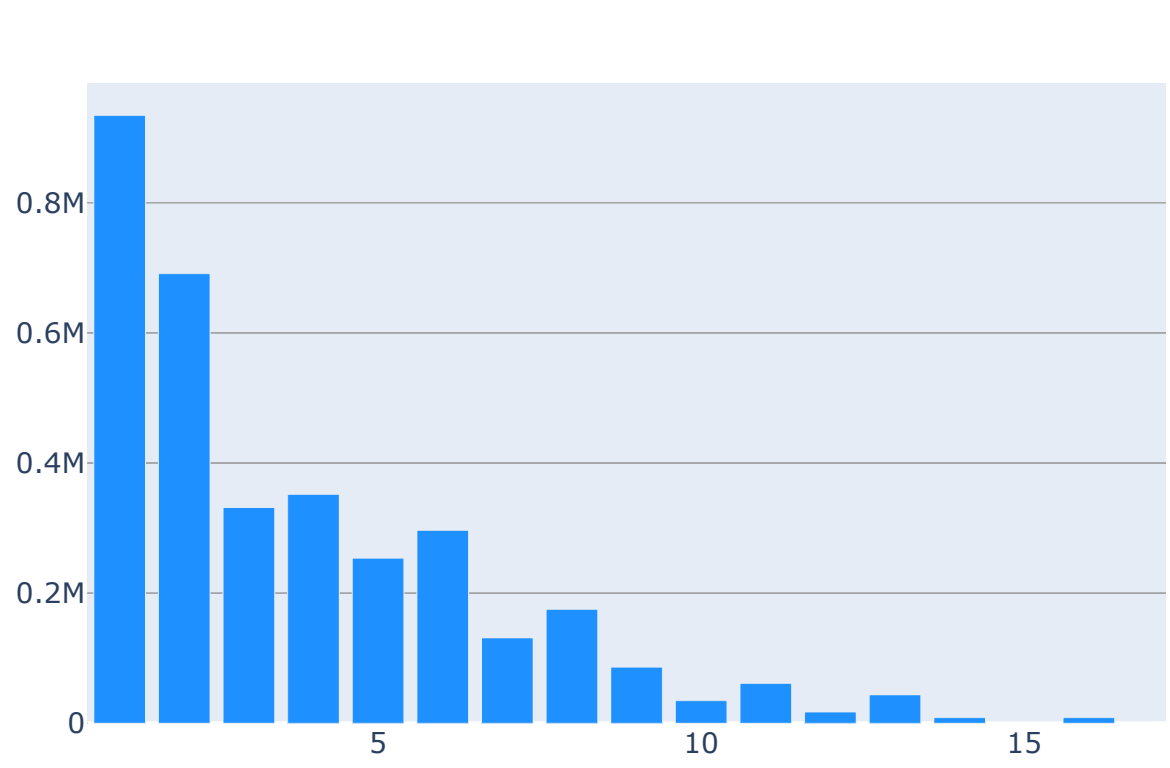
In [58]:
```
data_index = building_data["primary_use"].value_counts()
#data_index = data_index.sort_index()
trace = go.Bar(
    x=data_index.index,
    y=data_index.values,
    marker=dict(
        color="#1E90FF",
    ),
)

layout = go.Layout(
    title=go.layout.Title(
        text="Distribution of primary use of Buildings",
        x=0.5
    ),
    font=dict(size=14),
    width=1000,
    height=500,
)

data = [trace]
fig = go.Figure(data=data, layout=layout)
py.iplot(fig, filename="meter")
```



Education is the one with most number of primary usage followed by office adn entertainment

Floor count in the building

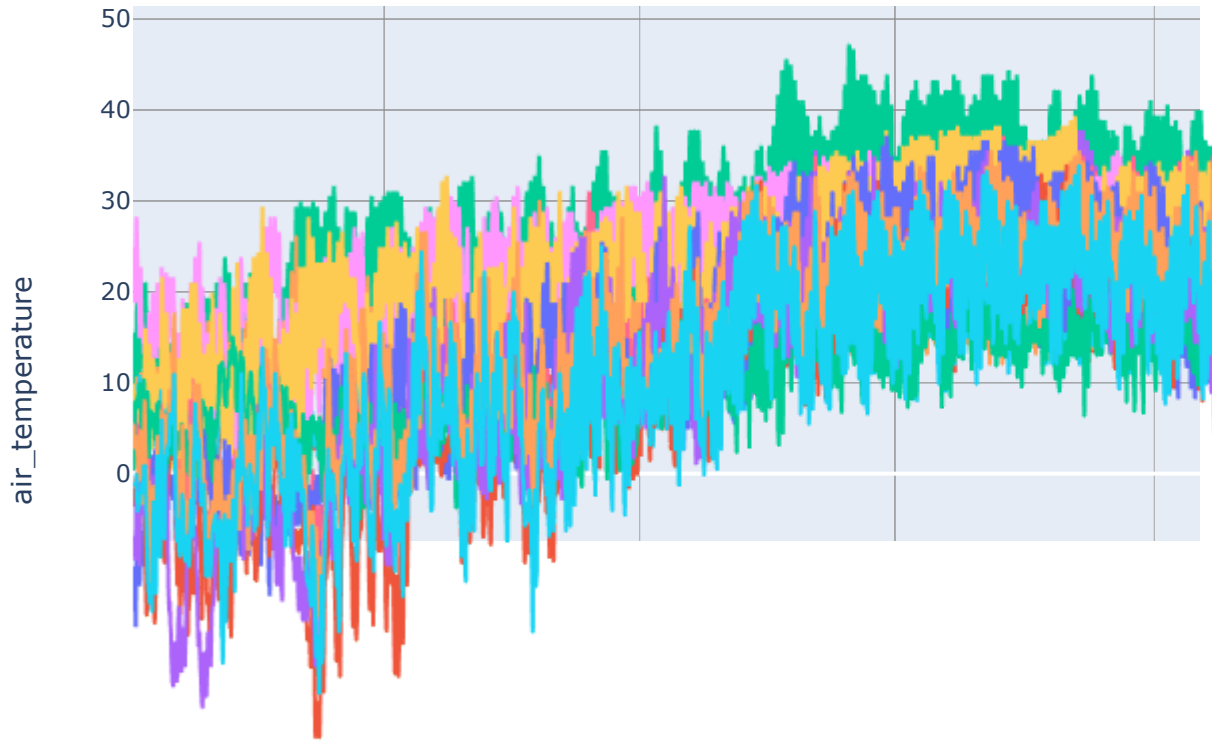
In [61]:
```
dataset = train["floor_count"].value_counts()

trace = go.Bar(
    x=dataset.index,
    y=dataset.values,
    marker=dict(
        color="#1E90FF",
    ),
)

layout = go.Layout(
    title=go.layout.Title(
        text="Distribution of floors in building",
        x=0.5
    ),
    font=dict(size=14),
    width=1000,
    height=500,
)

data = [trace]
fig = go.Figure(data=data, layout=layout)
py.iplot(fig, filename="meter")
```



Distribution plots for Weather

Air temperature distribution

In [63]:
```
fig = px.line(weather_train, x='timestamp', y='air_temperature', color='site_id')
fig.show()
```



Looking at the graph it seems that the temperature increases in all the sites towards the middle of the year and decreases at the end of year.

In [ ]:
```

```