Project 5 : Great Energy Predictor

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In [1]:
```
#load libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import category_encoders
from sklearn.model_selection import train_test_split
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn import linear_model
from sklearn.ensemble import GradientBoostingRegressor
from sklearn.ensemble import RandomForestRegressor
from math import sqrt
from sklearn.metrics import mean_squared_error

import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)
```

In [2]:
```
# get building metadata
building_metadata = pd.read_csv("building_metadata.csv")
print(building_metadata.shape)
building_metadata.head(10)
```

```
(1449, 6)
```

Out[2]:

	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
5	0	5	Education	8000	2000.0	NaN
6	0	6	Lodging/residential	27926	1981.0	NaN
7	0	7	Education	121074	1989.0	NaN
8	0	8	Education	60809	2003.0	NaN
9	0	9	Office	27000	2010.0	NaN

In [3]:

```python
# get train data
train_data = pd.read_csv("train.csv")
print(train_data.shape)
train_data["timestamp"] = pd.to_datetime(train_data["timestamp"])
train_data.head(10)
```

```
(20216100, 4)
```

Out[3]:

	building_id	meter	timestamp	meter_reading
0	0	0	2016-01-01	0.0
1	1	0	2016-01-01	0.0
2	2	0	2016-01-01	0.0
3	3	0	2016-01-01	0.0
4	4	0	2016-01-01	0.0
5	5	0	2016-01-01	0.0
6	6	0	2016-01-01	0.0
7	7	0	2016-01-01	0.0
8	8	0	2016-01-01	0.0
9	9	0	2016-01-01	0.0

In [4]:

```python
# get weather train data
weather_train_data = pd.read_csv("weather_train.csv")
print(weather_train_data.shape)
weather_train_data["timestamp"] = pd.to_datetime(weather_train_data["timestamp"])
weather_train_data.head(10)
```

```
(139773, 9)
```

Out[4]:

	site_id	timestamp	air_temperature	cloud_coverage	dew_temperature	precip_depth_1_hr	sea
0	0	2016-01-01 00:00:00	25.0	6.0	20.0	NaN	
1	0	2016-01-01 01:00:00	24.4	NaN	21.1	-1.0	
2	0	2016-01-01 02:00:00	22.8	2.0	21.1	0.0	
3	0	2016-01-01 03:00:00	21.1	2.0	20.6	0.0	
4	0	2016-01-01 04:00:00	20.0	2.0	20.0	-1.0	
5	0	2016-01-01 05:00:00	19.4	NaN	19.4	0.0	
6	0	2016-01-01 06:00:00	21.1	6.0	21.1	-1.0	
7	0	2016-01-01 07:00:00	21.1	NaN	21.1	0.0	
8	0	2016-01-01 08:00:00	20.6	NaN	20.0	0.0	
9	0	2016-01-01 09:00:00	21.1	NaN	20.6	0.0	

In [5]:
```python
# merge building_metadata and train data
building_train_merged = pd.merge(building_metadata, train_data, how = 'i
nner', on = ['building_id'], sort = True)
print(building_train_merged.shape)
building_train_merged.head(10)
```

(20216100, 9)

Out[5]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	meter	timestamp	mete
0	0	0	Education	7432	2008.0	NaN	0	2016-01-01 00:00:00	
1	0	0	Education	7432	2008.0	NaN	0	2016-01-01 01:00:00	
2	0	0	Education	7432	2008.0	NaN	0	2016-01-01 02:00:00	
3	0	0	Education	7432	2008.0	NaN	0	2016-01-01 03:00:00	
4	0	0	Education	7432	2008.0	NaN	0	2016-01-01 04:00:00	
5	0	0	Education	7432	2008.0	NaN	0	2016-01-01 05:00:00	
6	0	0	Education	7432	2008.0	NaN	0	2016-01-01 06:00:00	
7	0	0	Education	7432	2008.0	NaN	0	2016-01-01 07:00:00	
8	0	0	Education	7432	2008.0	NaN	0	2016-01-01 08:00:00	
9	0	0	Education	7432	2008.0	NaN	0	2016-01-01 09:00:00	

In [6]:
```
# merge weather_train with merged building_metadata and train data
data_merged = pd.merge(building_train_merged, weather_train_data, how =
'left', on = ['site_id', 'timestamp'], sort = True)
print(data_merged.shape)
data_merged.head(10)
```

(20216100, 16)

Out[6]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	meter	timestamp
0	0	0	Education	7432	2008.0	NaN	0	2016-01-01
1	0	1	Education	2720	2004.0	NaN	0	2016-01-01
2	0	2	Education	5376	1991.0	NaN	0	2016-01-01
3	0	3	Education	23685	2002.0	NaN	0	2016-01-01
4	0	4	Education	116607	1975.0	NaN	0	2016-01-01
5	0	5	Education	8000	2000.0	NaN	0	2016-01-01
6	0	6	Lodging/residential	27926	1981.0	NaN	0	2016-01-01
7	0	7	Education	121074	1989.0	NaN	0	2016-01-01
8	0	8	Education	60809	2003.0	NaN	0	2016-01-01
9	0	9	Office	27000	2010.0	NaN	0	2016-01-01

In [7]:
```
# extract hour, day, weekday, month from timestamp attribute in data_mer
ged
data_merged['hour'] = data_merged['timestamp'].dt.hour
data_merged['day'] = data_merged['timestamp'].dt.day
data_merged['weekday'] = data_merged['timestamp'].dt.weekday
data_merged['month'] = data_merged['timestamp'].dt.month
del data_merged['timestamp']
data_merged.head(10)
```

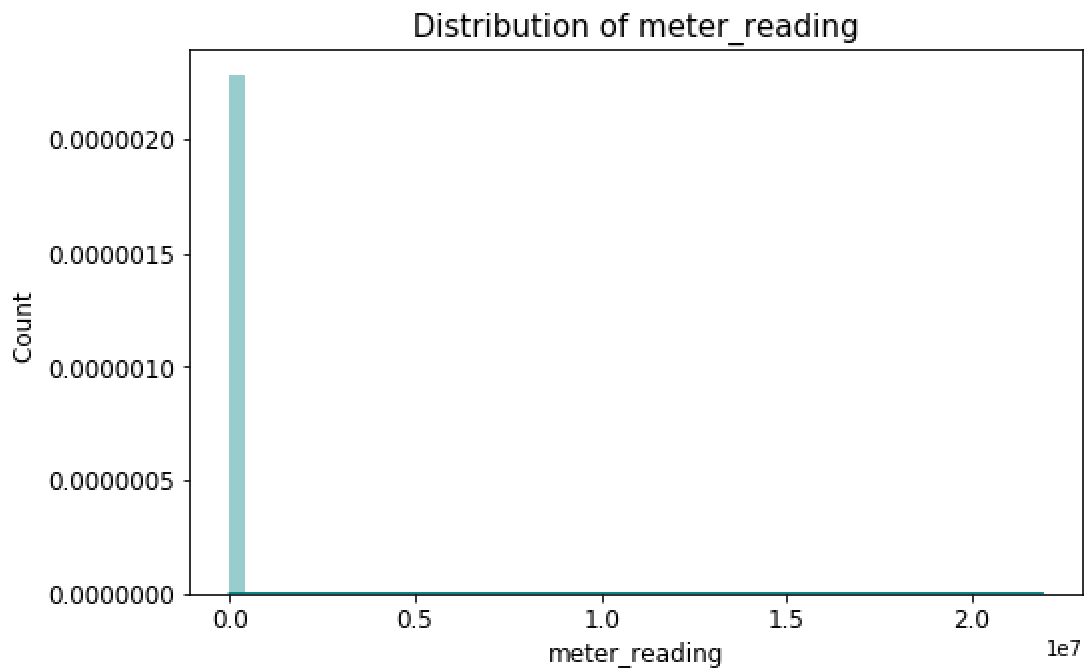
Out[7]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	meter	meter_readi
0	0	0	Education	7432	2008.0	NaN	0	C
1	0	1	Education	2720	2004.0	NaN	0	C
2	0	2	Education	5376	1991.0	NaN	0	C
3	0	3	Education	23685	2002.0	NaN	0	C
4	0	4	Education	116607	1975.0	NaN	0	C
5	0	5	Education	8000	2000.0	NaN	0	C
6	0	6	Lodging/residential	27926	1981.0	NaN	0	C
7	0	7	Education	121074	1989.0	NaN	0	C
8	0	8	Education	60809	2003.0	NaN	0	C
9	0	9	Office	27000	2010.0	NaN	0	C

In [8]:
```
# replace numerical values of meter with categorical values
data_merged['meter'].replace({0:"Electricity",1:"ChilledWater",2:"Steam"
,3:"HotWater"},inplace=True)
```

In [9]:
```
# plot for distribution of meter reading
plt.rcParams['figure.figsize'] = (8, 5)
ax = sns.distplot(data_merged['meter_reading'], color = 'teal')
plt.xlabel('meter_reading', fontsize = 12)
plt.ylabel('Count ', fontsize = 12)
plt.xticks(fontsize = 12)
plt.yticks(fontsize = 12)
plt.title(' Distribution of meter_reading ', fontsize = 15)
plt.show()
```

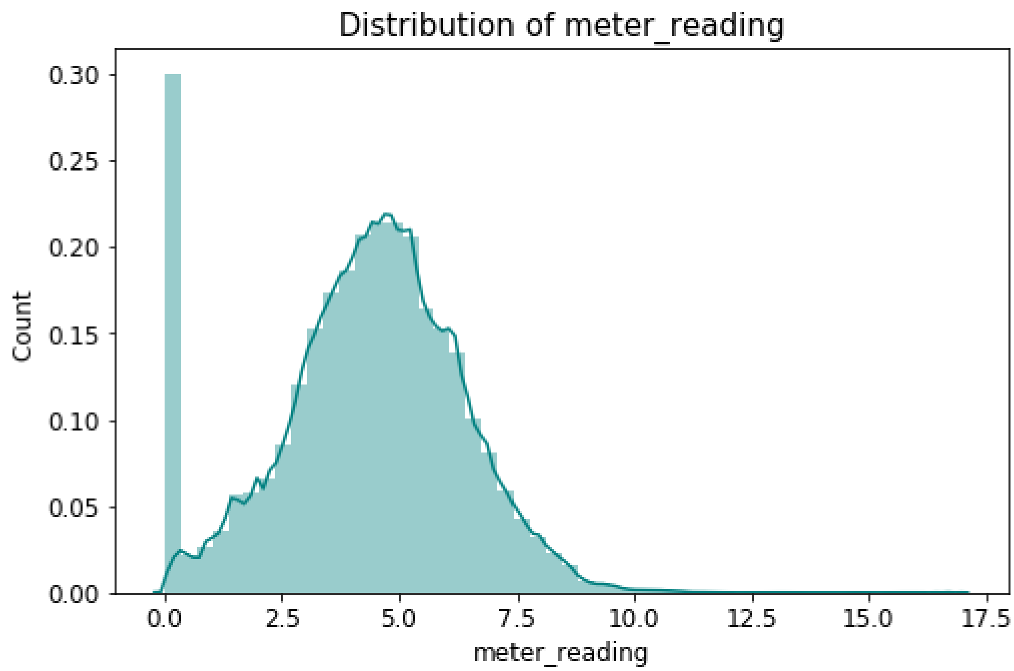
```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/site-pa
ckages/seaborn/distributions.py:218: MatplotlibDeprecationWarning:
The 'normed' kwarg was deprecated in Matplotlib 2.1 and will be removed
in 3.1. Use 'density' instead.
  color=hist_color, **hist_kws)
```



In [10]:
```
# descriptive statistics of meter_reading
data_merged['meter_reading'].describe()
```

Out[10]:
```
count    2.021610e+07
mean     2.117121e+03
std      1.532356e+05
min      0.000000e+00
25%      1.830000e+01
50%      7.877500e+01
75%      2.679840e+02
max      2.190470e+07
Name: meter_reading, dtype: float64
```

In [11]:
```python
# log transformation of meter_reading and distribution of meter reading
 after transformation
data_merged['meter_reading'] = np.log1p(data_merged['meter_reading'])
plt.rcParams['figure.figsize'] = (8,5)
ax = sns.distplot(data_merged['meter_reading'], color = 'teal')
plt.xlabel('meter_reading', fontsize = 12)
plt.ylabel('Count ', fontsize = 12)
plt.xticks(fontsize = 12)
plt.yticks(fontsize = 12)
plt.title(' Distribution of meter_reading ', fontsize = 15)
plt.show()
```

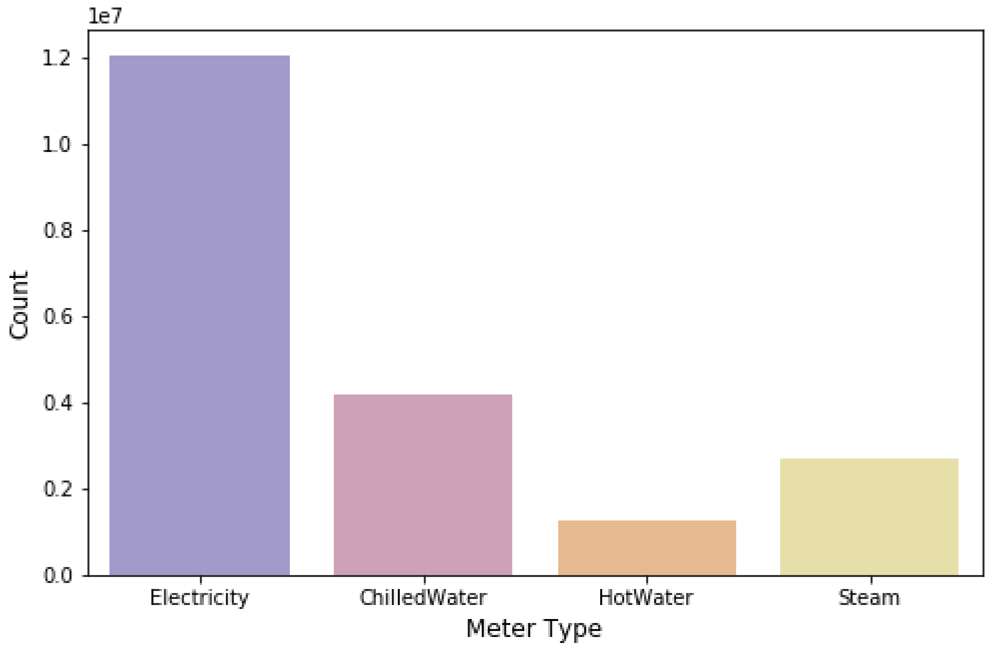


In [12]:
```python
# check the maximum and minimum values of meter_reading in training set
print("Max: ",data_merged['meter_reading'].max())
print("Min: ",data_merged['meter_reading'].min())
```

```
Max:  16.902211829285342
Min:  0.0
```

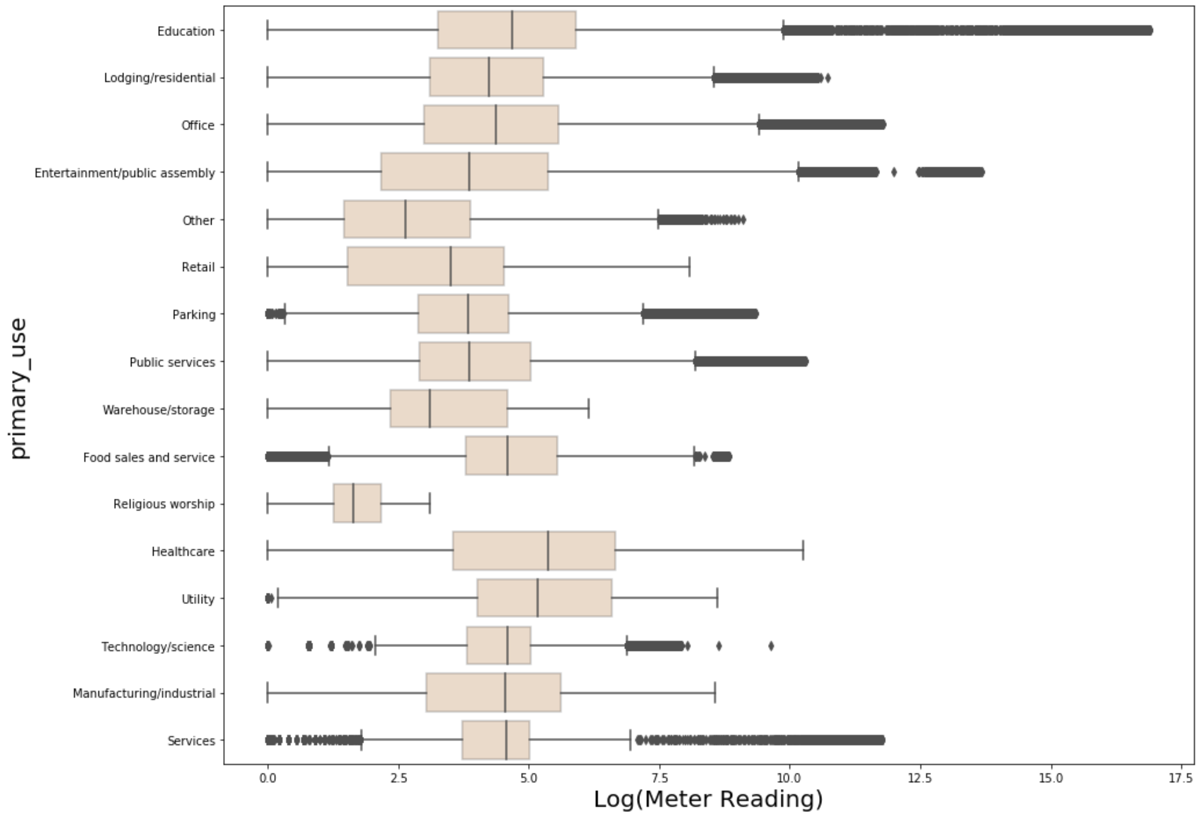
In [13]:

```
# Distribution of data with respect to meter type
plt.rcParams['figure.figsize'] = (8, 5)
ax = sns.countplot(data = data_merged, x ='meter', palette = 'CMRmap', a
lpha = 0.5)
ax.set_ylabel('Count', fontsize = 12)
ax.set_xlabel('Meter Type', fontsize = 12)
plt.show()
```



In [14]:

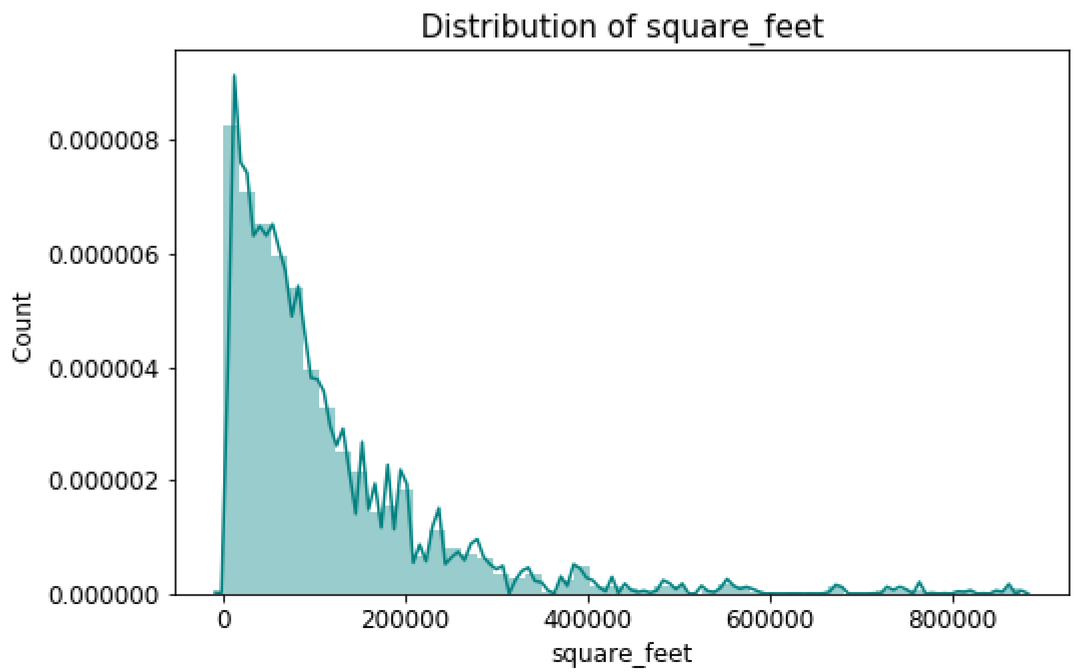
```
# Distribution of data with respect to primary_use
plt.rcParams['figure.figsize'] = (15, 12)
ax = sns.boxplot(data = data_merged, y ='primary_use', x = 'meter_readin
g', color = 'peru', boxprops=dict(alpha=.3))
ax.set_xlabel('Log(Meter Reading)', fontsize = 20)
ax.set_ylabel('primary_use', fontsize = 20)
plt.show()
```



In [15]:

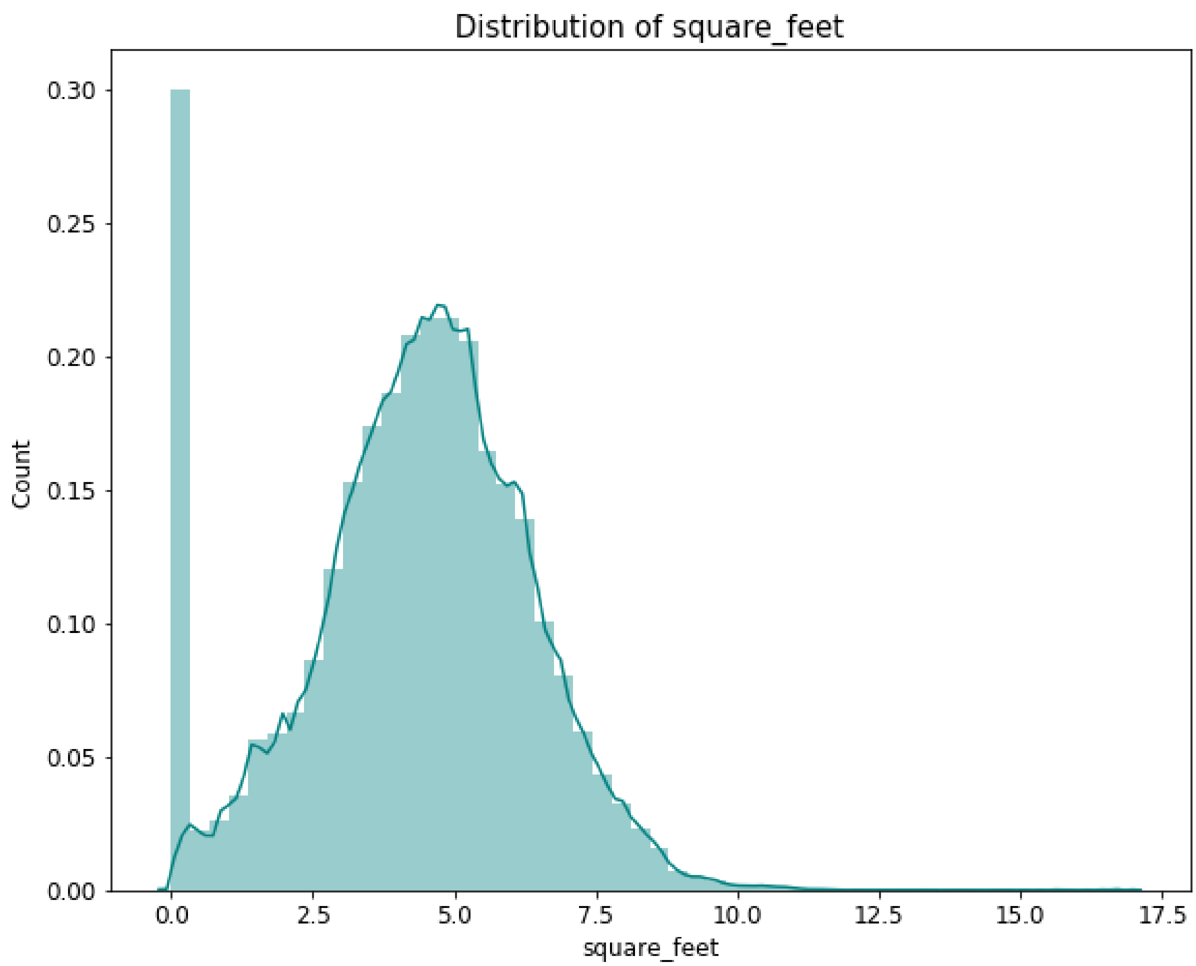
```
# plot for distribution of square feet
plt.rcParams['figure.figsize'] = (8, 5)
ax = sns.distplot(data_merged['square_feet'], color = 'teal')
plt.xlabel('square_feet', fontsize = 12)
plt.ylabel('Count ', fontsize = 12)
plt.xticks(fontsize = 12)
plt.yticks(fontsize = 12)
plt.title(' Distribution of square_feet ', fontsize = 15)
plt.show()
```

```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/site-pa
ckages/seaborn/distributions.py:218: MatplotlibDeprecationWarning:
The 'normed' kwarg was deprecated in Matplotlib 2.1 and will be removed
in 3.1. Use 'density' instead.
  color=hist_color, **hist_kws)
```



In [16]:

```
# log transformation of square_feet and distribution of square_feet afte
r transformation
data_merged['square_feet'] = np.log1p(data_merged['square_feet'])
plt.rcParams['figure.figsize'] = (10, 8)
ax = sns.distplot(data_merged['meter_reading'], color = 'teal')
plt.xlabel('square_feet', fontsize = 12)
plt.ylabel('Count ', fontsize = 12)
plt.xticks(fontsize = 12)
plt.yticks(fontsize = 12)
plt.title(' Distribution of square_feet ', fontsize = 15)
plt.show()
```



In [17]:
```
# encode the categorical values of primary_use to numeric values
data_merged['primary_use']=data_merged.primary_use.map({'Education':1,'Lodging/residential':2,'Entertainment/public assembly':3,
                                                        'Public services':4,'Office':5,'Technology/science':6,'Utility':7,
                                                        'Parking':8,'Other':9,'Healthcare':10,'Manufacturing/industrial':11})
data_merged.head()
```

Out[17]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	meter	meter_reading
0	0	0	1.0	8.913685	2008.0	NaN	Electricity	0.0
1	0	1	1.0	7.908755	2004.0	NaN	Electricity	0.0
2	0	2	1.0	8.589886	1991.0	NaN	Electricity	0.0
3	0	3	1.0	10.072639	2002.0	NaN	Electricity	0.0
4	0	4	1.0	11.666573	1975.0	NaN	Electricity	0.0

In [18]:
```
# get dummies for the catergorical attribute 'meter'
meter_dummies = pd.get_dummies(data_merged['meter'])
```

In [19]:
```
# drop the actual attribute 'meter'
data_merged = data_merged.drop(columns=['meter'], axis = 1)
data_merged.head(10)
```

Out[19]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	meter_reading	air_tempe
0	0	0	1.0	8.913685	2008.0	NaN	0.0	
1	0	1	1.0	7.908755	2004.0	NaN	0.0	
2	0	2	1.0	8.589886	1991.0	NaN	0.0	
3	0	3	1.0	10.072639	2002.0	NaN	0.0	
4	0	4	1.0	11.666573	1975.0	NaN	0.0	
5	0	5	1.0	8.987322	2000.0	NaN	0.0	
6	0	6	2.0	10.237349	1981.0	NaN	0.0	
7	0	7	1.0	11.704165	1989.0	NaN	0.0	
8	0	8	1.0	11.015510	2003.0	NaN	0.0	
9	0	9	5.0	10.203629	2010.0	NaN	0.0	

In [20]:

```python
# concatinate the data set with dummies of 'meter'
data_merged = pd.concat([meter_dummies, data_merged], axis = 1)
data_merged.head(10)
```

Out[20]:

	ChilledWater	Electricity	HotWater	Steam	site_id	building_id	primary_use	square_feet	year
0	0	1	0	0	0	0	1.0	8.913685	2
1	0	1	0	0	0	1	1.0	7.908755	2
2	0	1	0	0	0	2	1.0	8.589886	1
3	0	1	0	0	0	3	1.0	10.072639	2
4	0	1	0	0	0	4	1.0	11.666573	1
5	0	1	0	0	0	5	1.0	8.987322	2
6	0	1	0	0	0	6	2.0	10.237349	1
7	0	1	0	0	0	7	1.0	11.704165	1
8	0	1	0	0	0	8	1.0	11.015510	2
9	0	1	0	0	0	9	5.0	10.203629	2

10 rows × 22 columns

In [21]:

```python
# standardize year values
data_merged['year_built'] = np.uint8(data_merged['year_built']-1900, inp
lace = True)
```

In [22]:

```python
# encode categorical features
categorical_features = ['ChilledWater', 'Electricity', 'HotWater', 'Stea
m',"site_id", "building_id",
                        "primary_use", "hour", "weekday", "wind_directio
n"]
ce = category_encoders.CountEncoder(cols=categorical_features)
ce.fit(data_merged)
data_merged = ce.transform(data_merged)
data_merged.head()
```

Out[22]:

	ChilledWater	Electricity	HotWater	Steam	site_id	building_id	primary_use	square_feet
0	16033660	12060910	18952063	17507387	1076662	8784	8165504	8.913685
1	16033660	12060910	18952063	17507387	1076662	8784	8165504	7.908755
2	16033660	12060910	18952063	17507387	1076662	8784	8165504	8.589886
3	16033660	12060910	18952063	17507387	1076662	8784	8165504	10.072639
4	16033660	12060910	18952063	17507387	1076662	8784	8165504	11.666573

5 rows × 22 columns

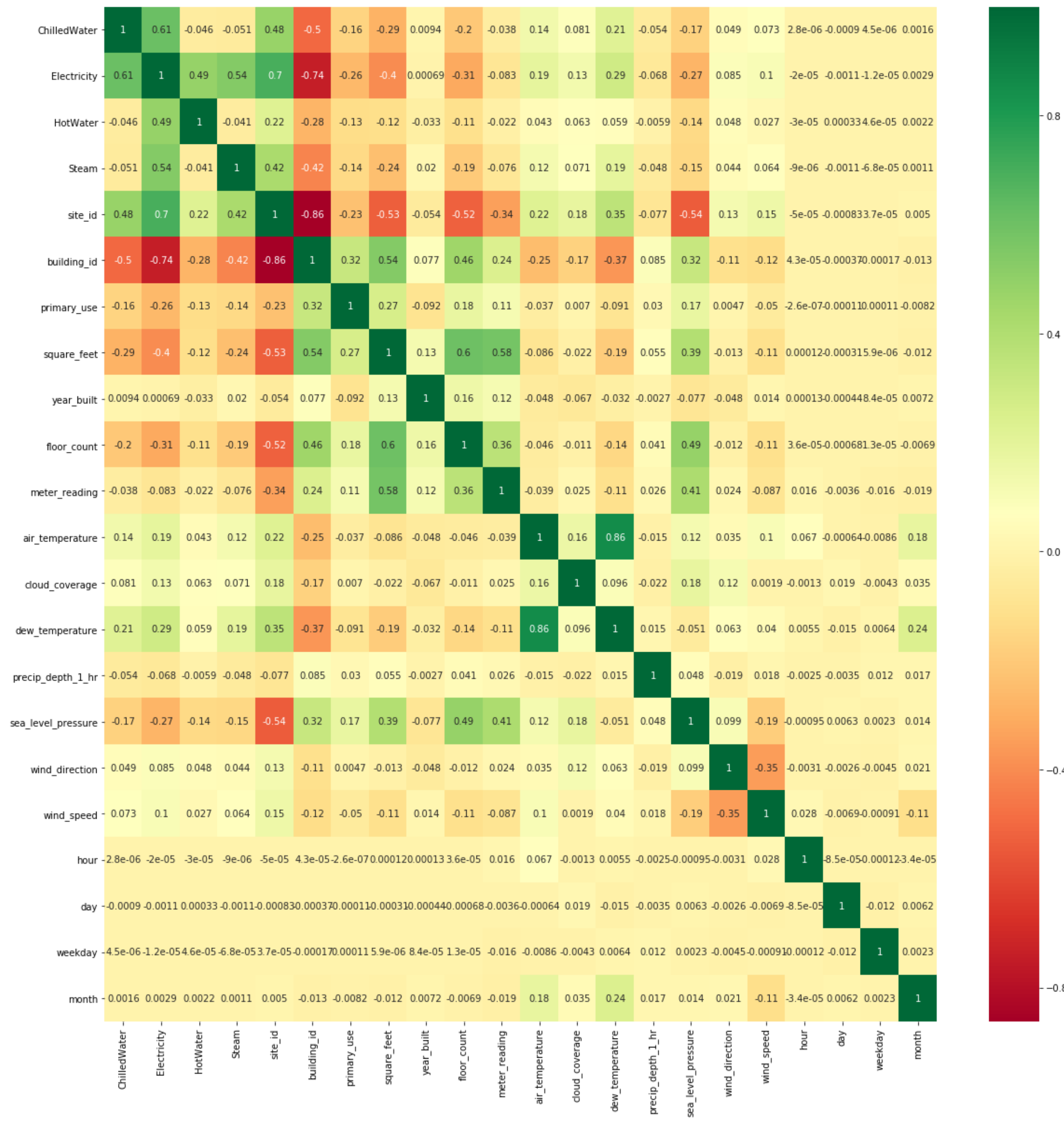
In [23]:
```
# find the number of missing values in each column
data_merged.isnull().sum(axis = 0)
```

Out[23]:
```
ChilledWater                0
Electricity                 0
HotWater                    0
Steam                       0
site_id                     0
building_id                 0
primary_use                 0
square_feet                 0
year_built                  0
floor_count          16709167
meter_reading               0
air_temperature         96658
cloud_coverage        8825365
dew_temperature        100140
precip_depth_1_hr     3749023
sea_level_pressure    1231669
wind_direction              0
wind_speed             143676
hour                        0
day                         0
weekday                     0
month                       0
dtype: int64
```

In [24]:
```
# replace the missing values with 0
data_merged = data_merged.fillna(0)
```

In [25]:
```
# get the valid rows from the data_merged which are non zero
data_merged = data_merged[(data_merged.square_feet>0) & (data_merged.yea
r_built>0) & (data_merged.floor_count >0)
            & (data_merged.primary_use >0)]
```

In [26]:
```python
# get the correlation matrix of the attributes in the data_merged datase
t
import seaborn as sns
corrmat = data_merged.corr()
top_corr_features = corrmat.index
plt.figure(figsize=(20,20))

#plot heat map
g=sns.heatmap(data_merged[top_corr_features].corr(),annot=True,cmap="RdY
lGn")
```



In [27]:
```python
# Partition the data into training and validation set to evaluate variou
s models using validation set
X_train,X_val,Y_train,Y_val = train_test_split(data_merged.iloc[:,[0,1,2
,3,4,5,6,7,8,9,11,12,13,14,15,16,17,18,19,20,21]],
                                              data_merged.iloc[:,[10]],
test_size=0.25,random_state =0)
```

In [28]:
```
# Standardize(scale) the data
scalerX = StandardScaler()
columnsX = X_train.columns
scalerX.fit(X_train)
X_train_scaled = scalerX.transform(X_train)
X_val_scaled = scalerX.transform(X_val)
X_train_scaled_df = pd.DataFrame(X_train_scaled, columns=columnsX)
X_val_scaled_df = pd.DataFrame(X_val_scaled, columns=columnsX)
```

In [29]:
```
#LINEAR REGRESSION model
LR_model = linear_model.LinearRegression().fit(X = X_train_scaled_df, y
= Y_train)

LR_predicted = LR_model.predict(X_val_scaled_df)

print('Linear Regression Model')

LR_R_square = LR_model.score(X = X_val_scaled_df,y = Y_val)
print()
print('R square')
print(LR_R_square)

LR_RootMeanSquareError = np.sqrt(mean_squared_error(Y_val, LR_predicted
))
print()
print('Root Mean Square Error')
print(LR_RootMeanSquareError)
```

```
Linear Regression Model

R square
0.43923074997777584

Root Mean Square Error
1.561774097294691
```

In [30]:

```
#Ridge REGRESSION model
Ridge_model = linear_model.Ridge(alpha=.5).fit(X = X_train_scaled_df, y
= Y_train)

Ridge_predicted = Ridge_model.predict(X_val_scaled_df)

print('Ridge Regression Model')

Ridge_R_square = Ridge_model.score(X = X_val_scaled_df,y = Y_val)
print()
print('R square')
print(Ridge_R_square)

Ridge_RootMeanSquareError = np.sqrt(mean_squared_error(Y_val, Ridge_pred
icted))
print()
print('Root Mean Square Error')
print(Ridge_RootMeanSquareError)
```

```
Ridge Regression Model

R square
0.4392309491413351

Root Mean Square Error
1.5617738199537743
```

In [31]:

```
#Bayesian Ridge REGRESSION model
Y_train = Y_train.values.ravel()
Bayesian_Ridge_model = linear_model.BayesianRidge().fit(X = X_train_scal
ed_df, y = Y_train)

Bayesian_Ridge_predicted = Bayesian_Ridge_model.predict(X_val_scaled_df)

print('Bayesian Ridge Regression Model')

Bayesian_Ridge_R_square = Bayesian_Ridge_model.score(X = X_val_scaled_df
,y = Y_val)
print()
print('R square')
print(Bayesian_Ridge_R_square)

Bayesian_Ridge_RootMeanSquareError = np.sqrt(mean_squared_error(Y_val, B
ayesian_Ridge_predicted))
print()
print('Root Mean Square Error')
print(Bayesian_Ridge_RootMeanSquareError)
```

```
Bayesian Ridge Regression Model

R square
0.43923087396057203

Root Mean Square Error
1.5617739246451292
```

In [32]:

```
# Gradient Boosting REGRESSION model
GB_model = GradientBoostingRegressor(n_estimators=10, learning_rate=0.1,
          max_depth=1, random_state=0).fit(X = X_train_scaled_df, y = Y_
train)

GB_predicted = GB_model.predict(X_val_scaled_df)

print('Gradient Boosting Regressor')

GB_R_square = GB_model.score(X = X_val_scaled_df,y = Y_val)
print()
print('R square')
print(GB_R_square)

GB_RootMeanSquareError = np.sqrt(mean_squared_error(Y_val, GB_predicted
))
print()
print('Root Mean Square Error')
print(GB_RootMeanSquareError)

print()
print('Feature importances')
print(GB_model.feature_importances_ )
```

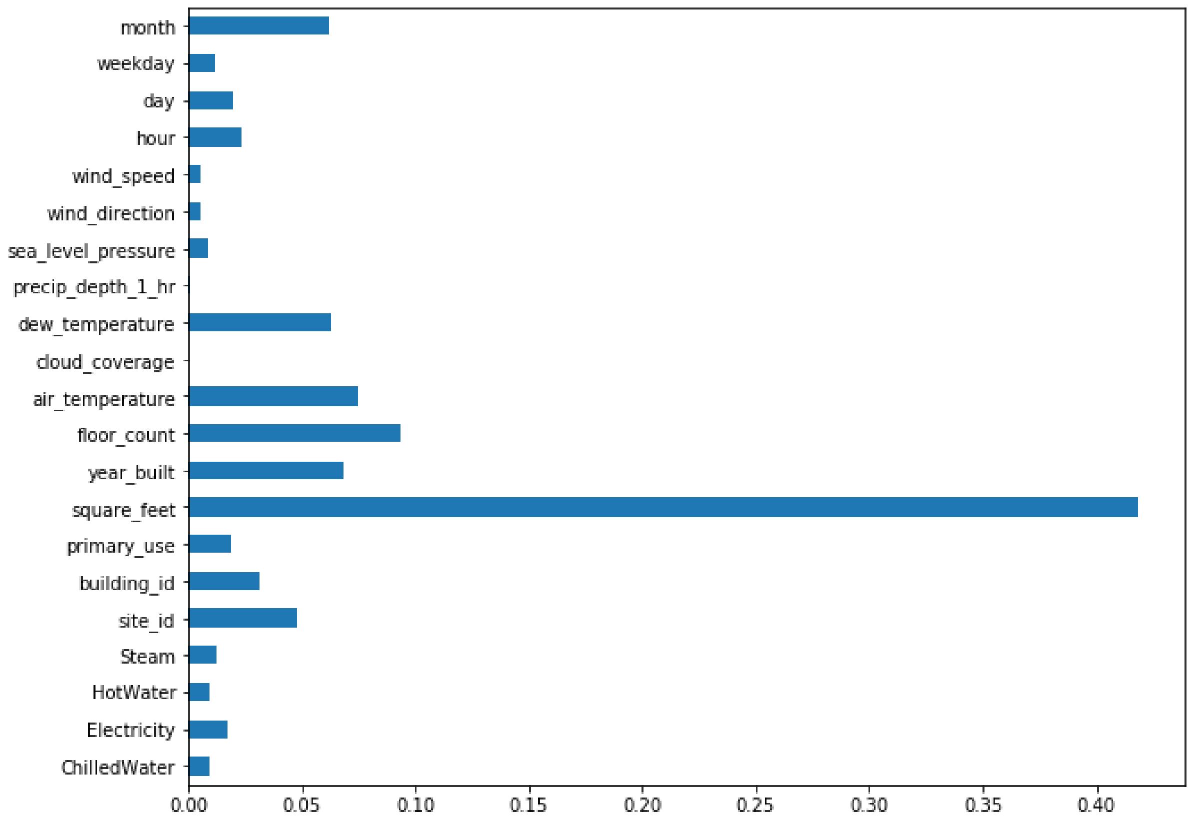
```
Gradient Boosting Regressor

R square
0.3026301927146213

Root Mean Square Error
1.7416371924352358

Feature importances
[0.         0.         0.         0.         0.         0.
 0.         0.69540225 0.         0.30459775 0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.        ]
```

In [33]:
```
# Random Forest REGRESSION model
RF_model = RandomForestRegressor(n_estimators=10, random_state=42).fit(X
= X_train_scaled_df, y = Y_train)

RF_predicted = RF_model.predict(X_val_scaled_df)

print('Random Forest Regressor')

RF_R_square = RF_model.score(X = X_val_scaled_df,y = Y_val)
print()
print('R square')
print(RF_R_square)

RF_RootMeanSquareError = np.sqrt(mean_squared_error(Y_val, RF_predicted
))
print()
print('Root Mean Square Error')
print(RF_RootMeanSquareError)

print()
print('Feature importances')
print(RF_model.feature_importances_ )
```

```
Random Forest Regressor

R square
0.9655695882252688

Root Mean Square Error
0.3869877595712031

Feature importances
[9.55050710e-03 1.74860238e-02 9.59637762e-03 1.24279025e-02
 4.74667305e-02 3.11190941e-02 1.85284481e-02 4.18146707e-01
 6.84833133e-02 9.38473759e-02 7.43693295e-02 9.78923142e-05
 6.29277176e-02 3.60597681e-04 8.52371138e-03 5.09873214e-03
 5.26616847e-03 2.38243250e-02 1.91478862e-02 1.16321861e-02
 6.20989739e-02]
```

In [34]:
```
# plot feature importances
imp_features = pd.Series(RF_model.feature_importances_, index = X_train.
columns)
imp_features.plot(kind = "barh")
```

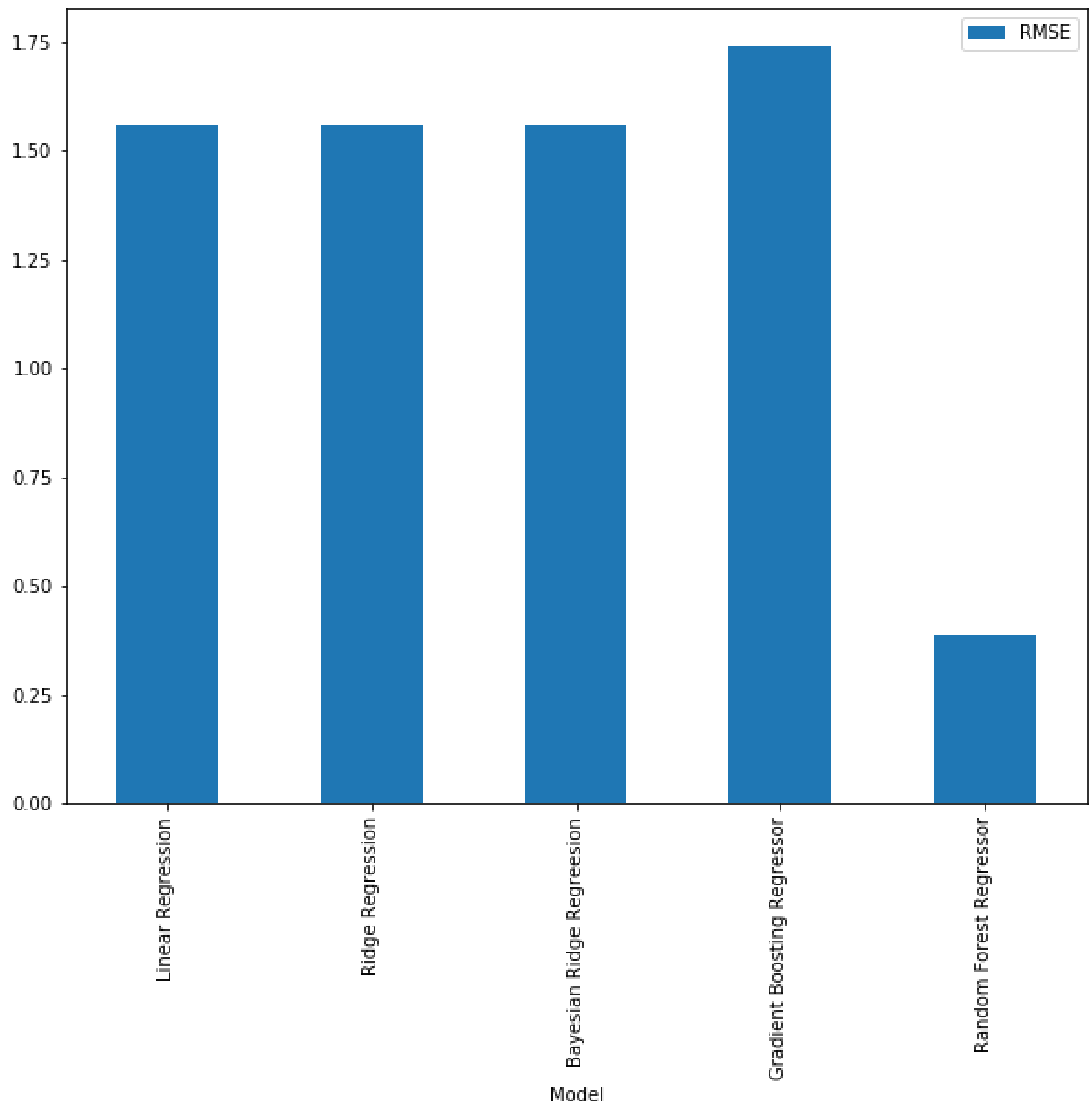
Out[34]: <matplotlib.axes._subplots.AxesSubplot at 0x128e4f320>



In [35]:
```
# create a dataframe with models and corresponding RMSE
R2_RMSE = [['Linear Regression', LR_RootMeanSquareError, LR_R_square],
              ['Ridge Regression', Ridge_RootMeanSquareError, Ridge_R_sq
uare],
              ['Bayesian Ridge Regreesion', Bayesian_Ridge_RootMeanSquar
eError, Bayesian_Ridge_R_square],
              ['Gradient Boosting Regressor', GB_RootMeanSquareError, GB
_R_square],
              ['Random Forest Regressor', RF_RootMeanSquareError, RF_R_s
quare]]
ModelEvaluation = pd.DataFrame(R2_RMSE, columns = ['Model', 'RMSE', 'R_S
quare'])
```

In [36]:
```
# plot RMSE for the evaluation of models
plt.rcParams['figure.figsize'] = (10, 8)
ModelEvaluation.plot(kind='bar',x='Model',y='RMSE')
```

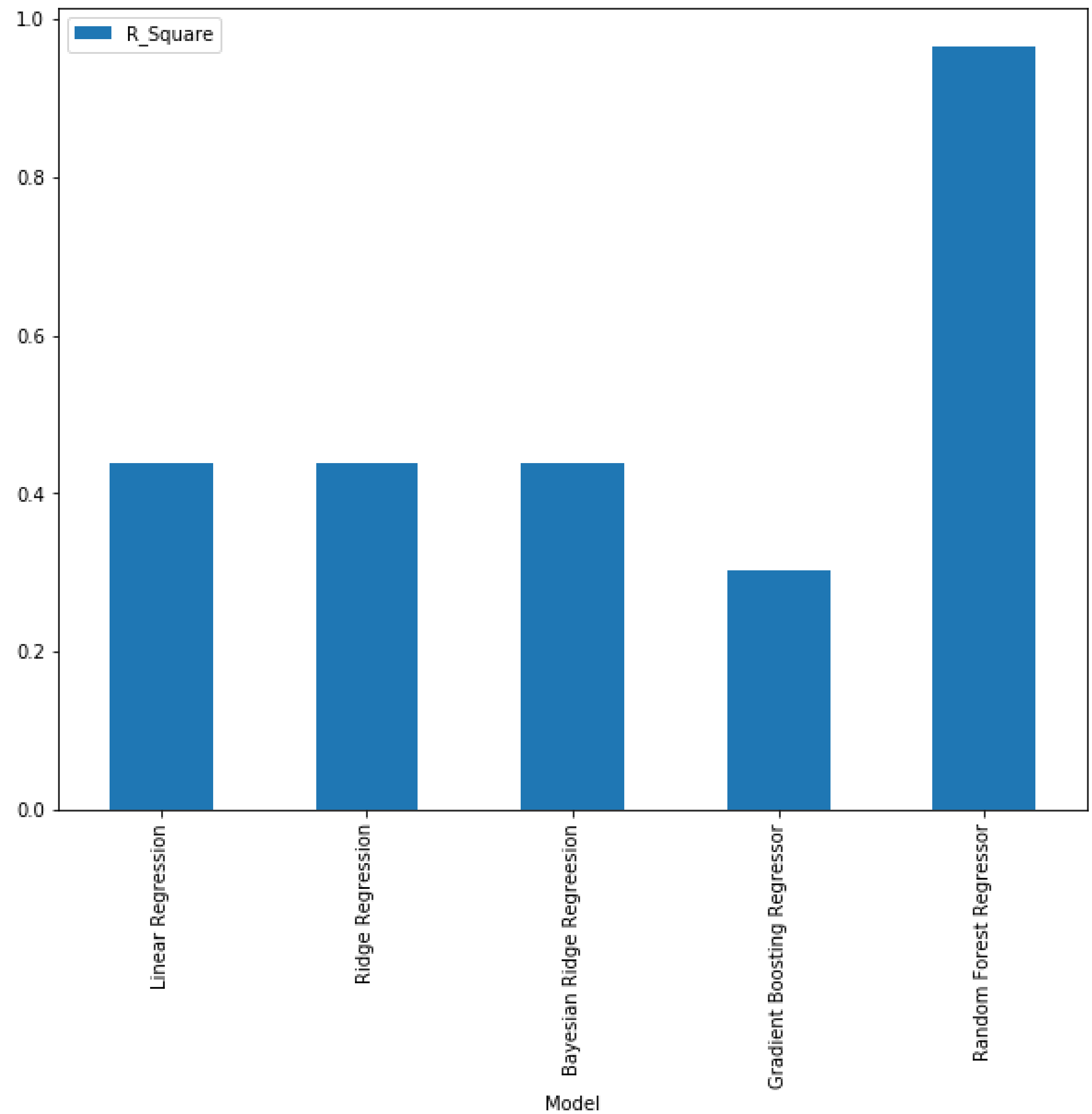
Out[36]: <matplotlib.axes._subplots.AxesSubplot at 0x1290a92b0>



In [37]:

```python
# plot R_Square for the evaluation of models
plt.rcParams['figure.figsize'] = (10, 8)
ModelEvaluation.plot(kind='bar',x='Model',y='R_Square')
```

Out[37]: <matplotlib.axes._subplots.AxesSubplot at 0x128aa7048>



In [38]:
```python
# get test data
test_data = pd.read_csv("test.csv")
print(test_data.shape)
test_data["timestamp"] = pd.to_datetime(test_data["timestamp"])
test_data.head(10)
```

```
(41697600, 4)
```

Out[38]:

	row_id	building_id	meter	timestamp
0	0	0	0	2017-01-01
1	1	1	0	2017-01-01
2	2	2	0	2017-01-01
3	3	3	0	2017-01-01
4	4	4	0	2017-01-01
5	5	5	0	2017-01-01
6	6	6	0	2017-01-01
7	7	7	0	2017-01-01
8	8	7	1	2017-01-01
9	9	8	0	2017-01-01

In [39]:
```
# get weather test data
weather_test_data = pd.read_csv("weather_test.csv")
print(weather_test_data.shape)
weather_test_data["timestamp"] = pd.to_datetime(weather_test_data["times
tamp"])
weather_test_data.head(10)
```

```
(277243, 9)
```

Out[39]:

	site_id	timestamp	air_temperature	cloud_coverage	dew_temperature	precip_depth_1_hr	sea
0	0	2017-01-01 00:00:00	17.8	4.0	11.7	NaN	
1	0	2017-01-01 01:00:00	17.8	2.0	12.8	0.0	
2	0	2017-01-01 02:00:00	16.1	0.0	12.8	0.0	
3	0	2017-01-01 03:00:00	17.2	0.0	13.3	0.0	
4	0	2017-01-01 04:00:00	16.7	2.0	13.3	0.0	
5	0	2017-01-01 05:00:00	15.6	2.0	12.8	0.0	
6	0	2017-01-01 06:00:00	15.0	0.0	12.8	0.0	
7	0	2017-01-01 07:00:00	15.0	2.0	13.3	0.0	
8	0	2017-01-01 08:00:00	13.3	0.0	12.2	0.0	
9	0	2017-01-01 09:00:00	12.2	4.0	11.7	0.0	

In [40]:
```python
# merge building_metadata and test data
building_test_merged = pd.merge(building_metadata, test_data, how = 'inner', on = ['building_id'], sort = True)
print(building_test_merged.shape)
building_test_merged.head(10)
```

```
(41697600, 9)
```

Out[40]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	row_id	meter	timestam
0	0	0	Education	7432	2008.0	NaN	0	0	2017-01 0 00:00:0
1	0	0	Education	7432	2008.0	NaN	129	0	2017-01 0 01:00:0
2	0	0	Education	7432	2008.0	NaN	258	0	2017-01 0 02:00:0
3	0	0	Education	7432	2008.0	NaN	387	0	2017-01 0 03:00:0
4	0	0	Education	7432	2008.0	NaN	516	0	2017-01 0 04:00:0
5	0	0	Education	7432	2008.0	NaN	645	0	2017-01 0 05:00:0
6	0	0	Education	7432	2008.0	NaN	774	0	2017-01 0 06:00:0
7	0	0	Education	7432	2008.0	NaN	903	0	2017-01 0 07:00:0
8	0	0	Education	7432	2008.0	NaN	1032	0	2017-01 0 08:00:0
9	0	0	Education	7432	2008.0	NaN	1161	0	2017-01 0 09:00:0

In [41]:
```python
# merge weather_train with merged building_metadata and test data
data_merged_test = pd.merge(building_test_merged, weather_test_data, how
= 'left', on = ['site_id', 'timestamp'], sort = True)
print(data_merged_test.shape)
data_merged_test.head(10)
```

```
(41697600, 16)
```

Out[41]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	row_id	meter	time
0	0	0	Education	7432	2008.0	NaN	0	0	2(
1	0	1	Education	2720	2004.0	NaN	1	0	2(
2	0	2	Education	5376	1991.0	NaN	2	0	2(
3	0	3	Education	23685	2002.0	NaN	3	0	2(
4	0	4	Education	116607	1975.0	NaN	4	0	2(
5	0	5	Education	8000	2000.0	NaN	5	0	2(
6	0	6	Lodging/residential	27926	1981.0	NaN	6	0	2(
7	0	7	Education	121074	1989.0	NaN	7	0	2(
8	0	7	Education	121074	1989.0	NaN	8	1	2(
9	0	8	Education	60809	2003.0	NaN	9	0	2(

In [42]:
```python
# extract hour, day, weekday, month from timestamp attribute in data_mer
ged
data_merged_test['hour'] = data_merged_test['timestamp'].dt.hour
data_merged_test['day'] = data_merged_test['timestamp'].dt.day
data_merged_test['weekday'] = data_merged_test['timestamp'].dt.weekday
data_merged_test['month'] = data_merged_test['timestamp'].dt.month
del data_merged_test['timestamp']
data_merged_test.head(10)
```

Out[42]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	row_id	meter	air_
0	0	0	Education	7432	2008.0	NaN	0	0	
1	0	1	Education	2720	2004.0	NaN	1	0	
2	0	2	Education	5376	1991.0	NaN	2	0	
3	0	3	Education	23685	2002.0	NaN	3	0	
4	0	4	Education	116607	1975.0	NaN	4	0	
5	0	5	Education	8000	2000.0	NaN	5	0	
6	0	6	Lodging/residential	27926	1981.0	NaN	6	0	
7	0	7	Education	121074	1989.0	NaN	7	0	
8	0	7	Education	121074	1989.0	NaN	8	1	
9	0	8	Education	60809	2003.0	NaN	9	0	

In [43]:
```python
# replace numerical values of meter with categorical values
data_merged_test['meter'].replace({0:"Electricity",1:"ChilledWater",2:"S
team",3:"HotWater"},inplace=True)
```

In [44]:
```python
# apply log transformation on square_feet
data_merged_test['square_feet'] = np.log1p(data_merged_test['square_fee
t'])
```

In [45]:
```
# encode the categorical values of primary_use in data_merged_test to nu
meric values
data_merged_test['primary_use']=data_merged_test.primary_use.map({'Educa
tion':1,'Lodging/residential':2,'Entertainment/public assembly':3,
                                              'Public services':4,'Office':
5,'Technology/science':6,'Utility':7,
                                              'Parking':8,'Other':9,'Health
care':10,'Manufacturing/industrial':11})
data_merged_test.head()
```

Out[45]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	row_id	meter	air_te
0	0	0	1.0	8.913685	2008.0	NaN	0	Electricity	
1	0	1	1.0	7.908755	2004.0	NaN	1	Electricity	
2	0	2	1.0	8.589886	1991.0	NaN	2	Electricity	
3	0	3	1.0	10.072639	2002.0	NaN	3	Electricity	
4	0	4	1.0	11.666573	1975.0	NaN	4	Electricity	

In [46]:
```
# get the dummies of the attribute 'meter'
meter_dummies = pd.get_dummies(data_merged_test['meter'])
```

In [47]:
```
# drop the actual attribute 'meter'
data_merged_test = data_merged_test.drop(columns=['meter'], axis = 1)
data_merged_test.head(10)
```

Out[47]:

	site_id	building_id	primary_use	square_feet	year_built	floor_count	row_id	air_temperature
0	0	0	1.0	8.913685	2008.0	NaN	0	17.8
1	0	1	1.0	7.908755	2004.0	NaN	1	17.8
2	0	2	1.0	8.589886	1991.0	NaN	2	17.8
3	0	3	1.0	10.072639	2002.0	NaN	3	17.8
4	0	4	1.0	11.666573	1975.0	NaN	4	17.8
5	0	5	1.0	8.987322	2000.0	NaN	5	17.8
6	0	6	2.0	10.237349	1981.0	NaN	6	17.8
7	0	7	1.0	11.704165	1989.0	NaN	7	17.8
8	0	7	1.0	11.704165	1989.0	NaN	8	17.8
9	0	8	1.0	11.015510	2003.0	NaN	9	17.8

In [48]:
```
# concatinate the data set with dummies of 'meter'
data_merged_test = pd.concat([meter_dummies, data_merged_test], axis = 1
)
data_merged_test.head(10)
```

Out[48]:

	ChilledWater	Electricity	HotWater	Steam	site_id	building_id	primary_use	square_feet	year
0	0	1	0	0	0	0	1.0	8.913685	2
1	0	1	0	0	0	1	1.0	7.908755	2
2	0	1	0	0	0	2	1.0	8.589886	1
3	0	1	0	0	0	3	1.0	10.072639	2
4	0	1	0	0	0	4	1.0	11.666573	1
5	0	1	0	0	0	5	1.0	8.987322	2
6	0	1	0	0	0	6	2.0	10.237349	1
7	0	1	0	0	0	7	1.0	11.704165	1
8	1	0	0	0	0	7	1.0	11.704165	1
9	0	1	0	0	0	8	1.0	11.015510	2

10 rows × 22 columns

In [49]:
```
data_merged_test['year_built'] = np.uint8(data_merged_test['year_built']
-1900, inplace = True)
```

In [50]:
```
categorical_features = ['ChilledWater', 'Electricity', 'HotWater', 'Stea
m',"site_id", "building_id",
                        "primary_use", "hour", "weekday", "wind_directio
n"]
ce = category_encoders.CountEncoder(cols=categorical_features)
ce.fit(data_merged_test)
data_merged_test = ce.transform(data_merged_test)
data_merged_test.head()
```

Out[50]:

	ChilledWater	Electricity	HotWater	Steam	site_id	building_id	primary_use	square_feet
0	32972640	24755760	39157200	36021120	2260080	17520	16801680	8.913685
1	32972640	24755760	39157200	36021120	2260080	17520	16801680	7.908755
2	32972640	24755760	39157200	36021120	2260080	17520	16801680	8.589886
3	32972640	24755760	39157200	36021120	2260080	17520	16801680	10.072639
4	32972640	24755760	39157200	36021120	2260080	17520	16801680	11.666573

5 rows × 22 columns

In [51]:
```python
# find the number of missing values in each column
data_merged_test.isnull().sum(axis = 0)
```

Out[51]:
```
ChilledWater                 0
Electricity                  0
HotWater                     0
Steam                        0
site_id                      0
building_id                  0
primary_use                  0
square_feet                  0
year_built                   0
floor_count           34444320
row_id                       0
air_temperature         221901
cloud_coverage        19542180
dew_temperature         260799
precip_depth_1_hr      7801563
sea_level_pressure     2516826
wind_direction               0
wind_speed              302089
hour                         0
day                          0
weekday                      0
month                        0
dtype: int64
```

In [52]:
```python
# replace the missing values with averages
avgs = data_merged_test.loc[:,data_merged_test.isnull().sum(axis = 0) >
0].mean()
avgs = avgs.astype(int)
data_merged_test = data_merged_test.fillna(avgs)
```

In [53]:
```python
# get the shape of the data_merged_test set
data_merged_test.shape
```

Out[53]:
```
(41697600, 22)
```

In [54]:
```
# get sample_submission to see the format of output
sample_submission = pd.read_csv("sample_submission.csv")
print(sample_submission.shape)
sample_submission.head(10)
```

(41697600, 2)

Out[54]:

	row_id	meter_reading
0	0	0
1	1	0
2	2	0
3	3	0
4	4	0
5	5	0
6	6	0
7	7	0
8	8	0
9	9	0

In [55]:
```
# get rowids from data_merged_test and then drop them
rowids = pd.DataFrame(data_merged_test['row_id'])
data_merged_test=data_merged_test.drop(["row_id"],axis=1)
```

In [56]:
```
# standardize(scale) the test set
columnsX = data_merged_test.columns
X_test_scaled = scalerX.transform(data_merged_test)
X_test_scaled_df = pd.DataFrame(X_test_scaled, columns=columnsX)
```

In [57]:
```
# Use the best model with least Root Mean Square Error (RandomForestRegr
essor) to predict the target on the test set
RF_test_predicted = RF_model.predict(X_test_scaled_df)
#test_pred = scalerY.inverse_transform(LR_test_predicted)
test_pred = RF_test_predicted
```

In [58]:
```
# Build the output in the required format with rowids and predicted valu
es on the test set
output = pd.DataFrame({'row_id':rowids["row_id"], 'meter_reading': test_
pred})
```

In [59]:
```
# check the output
output
```

Out[59]:

	row_id	meter_reading
0	0	1.533930
1	1	0.557138
2	2	1.755082
3	3	2.412684
4	4	3.958811
5	5	1.473085
6	6	2.728818
7	7	3.958811
8	8	3.958811
9	9	2.135211
10	10	2.343753
11	11	2.343753
12	12	6.158011
13	13	3.495652
14	14	4.168485
15	15	3.336897
16	16	3.336897
17	17	2.695239
18	18	2.695239
19	19	2.695239
20	20	2.695239
21	21	4.158408
22	22	2.250648
23	23	3.958811
24	24	2.203024
25	25	3.958811
26	26	1.533930
27	27	0.557138
28	28	3.958811
29	29	3.426255
...	...	...
41697570	41498533	4.575191
41697571	41498534	2.473921
41697572	41498535	0.694374

	row_id	meter_reading
41697573	41498536	4.161283
41697574	41498537	4.161283
41697575	41498538	4.187002
41697576	41498569	4.187002
41697577	41498539	4.575191
41697578	41498540	2.273064
41697579	41498541	2.273064
41697580	41498542	2.389645
41697581	41498543	2.389645
41697582	41498544	1.159257
41697583	41498545	2.421060
41697584	41498546	2.421060
41697585	41498547	4.304390
41697586	41498548	4.304390
41697587	41498549	3.923303
41697588	41498550	3.923303
41697589	41498551	4.092965
41697590	41498552	4.392161
41697591	41498553	2.330136
41697592	41498554	2.696598
41697593	41498555	2.696598
41697594	41498556	0.694374
41697595	41498557	2.559255
41697596	41498558	0.134225
41697597	41498559	2.749679
41697598	41498560	2.499639
41697599	41498570	3.485455

41697600 rows × 2 columns

In [60]:

```
# check the maximum and minimum values for predicted meter reading
print("Max: ",output['meter_reading'].max())
print("Min: ",output['meter_reading'].min())
```

```
Max:  9.414237718580951
Min:  0.0
```

In [61]:
```
# copy the output to Project5_submission_results.csv
output.to_csv('Project5_submission_results.csv', index=False)
```

In [62]:
```
# check Project5_submission_results.csv
Project5_submission_results = pd.read_csv("Project5_submission_results.c
sv")
print(Project5_submission_results.shape)
Project5_submission_results.head(10)
```

```
(41697600, 2)
```

Out[62]:

	row_id	meter_reading
0	0	1.533930
1	1	0.557138
2	2	1.755082
3	3	2.412684
4	4	3.958811
5	5	1.473085
6	6	2.728818
7	7	3.958811
8	8	3.958811
9	9	2.135211

In [ ]: