Modèles de Machine Learning

Implémentation de différents modèles de machine learning appliqués à la prédiction de données sur les données de consommation électrique.

Import des librairies nécessaires, initialisation et mise en forme du set de données.

On importe les différentes librairies Python nécessaires : Pandas / Numpy / Seaborn / XGBoost.

In [1]:
```
#importation des librairies nécéssaires
import pandas as pd
import numpy as np
import seaborn as sns
import xgboost as xgb
from sklearn.metrics import mean_squared_error, mean_absolute_error,average_
import matplotlib.pyplot as plt

dataset = pd.read_csv('AEP_hourly.csv')
dataset = dataset.set_index('Datetime')
dataset.index = pd.to_datetime(dataset.index)
```

In [2]:
```
#info du dataset
dataset.info()
dataset.shape
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 121273 entries, 2004-12-31 01:00:00 to 2018-01-02 00:00:00
Data columns (total 1 columns):
 #   Column  Non-Null Count   Dtype  
---  ------  --------------   -----  
 0   AEP_MW  121273 non-null  float64
dtypes: float64(1)
memory usage: 1.9 MB
```

Out[2]: (121273, 1)

On met en forme de set de données sur lequel nous travaillons.

In [3]:
```
#comptage du nombre de données manquantes dans le dataset
dataset.isnull().sum()
```

Out[3]:
```
AEP_MW    0
dtype: int64
```

In [4]:
```
#résumé statistique
dataset.describe()
```

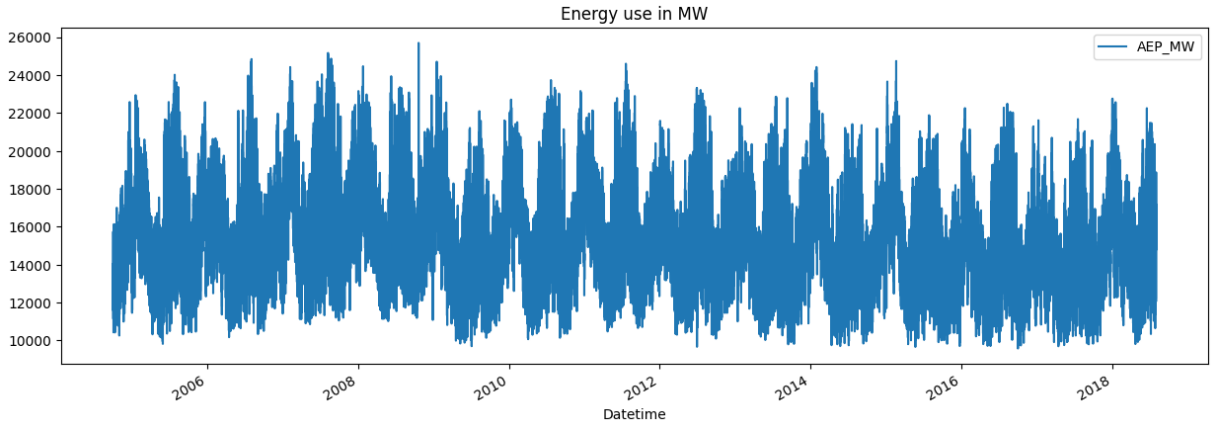
Out[4]:

	AEP_MW
count	121273.000000
mean	15499.513717
std	2591.399065
min	9581.000000
25%	13630.000000
50%	15310.000000
75%	17200.000000
max	25695.000000

In [5]:
```
dataset = dataset.sort_values(by="Datetime")
```

In [6]:
```
# plot des données
dataset.plot(figsize=(15,5),title='Energy use in MW')
```

Out[6]:
```
<AxesSubplot:title={'center':'Energy use in MW'}, xlabel='Datetime'>
```



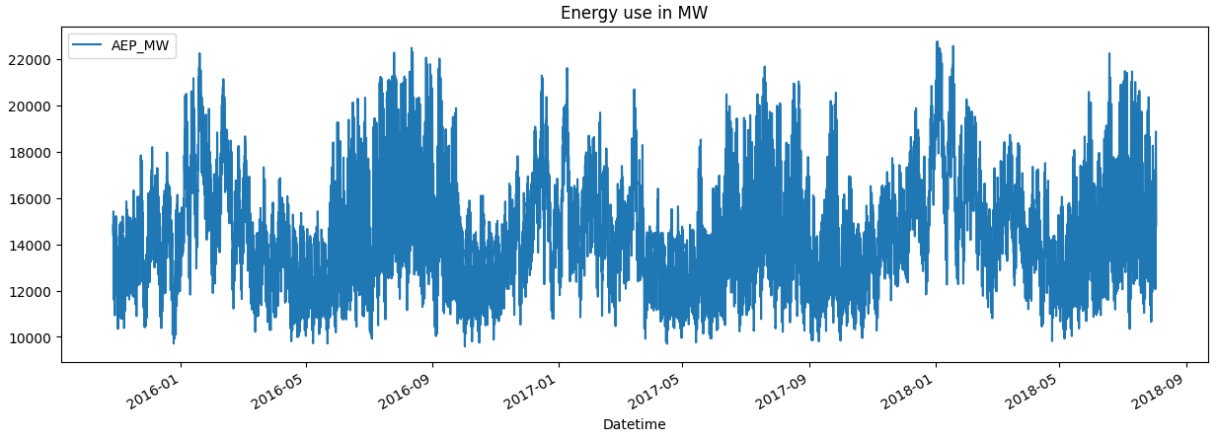
Séparation du set de données.

Le set de données est séparé en 2 parties, l'une appelée "**Train**" contenant 80 % des données du set et l'autre appelée "**Test**".

In [7]:
```
#split train et test
nb_lines = dataset.shape[0]
train = dataset.iloc[:int(nb_lines*0.8)]
test = dataset.iloc[int(nb_lines*0.8)+1:]
```

In [8]:
```
test.plot(figsize=(15,5),title='Energy use in MW')
```

Out[8]:
```
<AxesSubplot:title={'center':'Energy use in MW'}, xlabel='Datetime'>
```



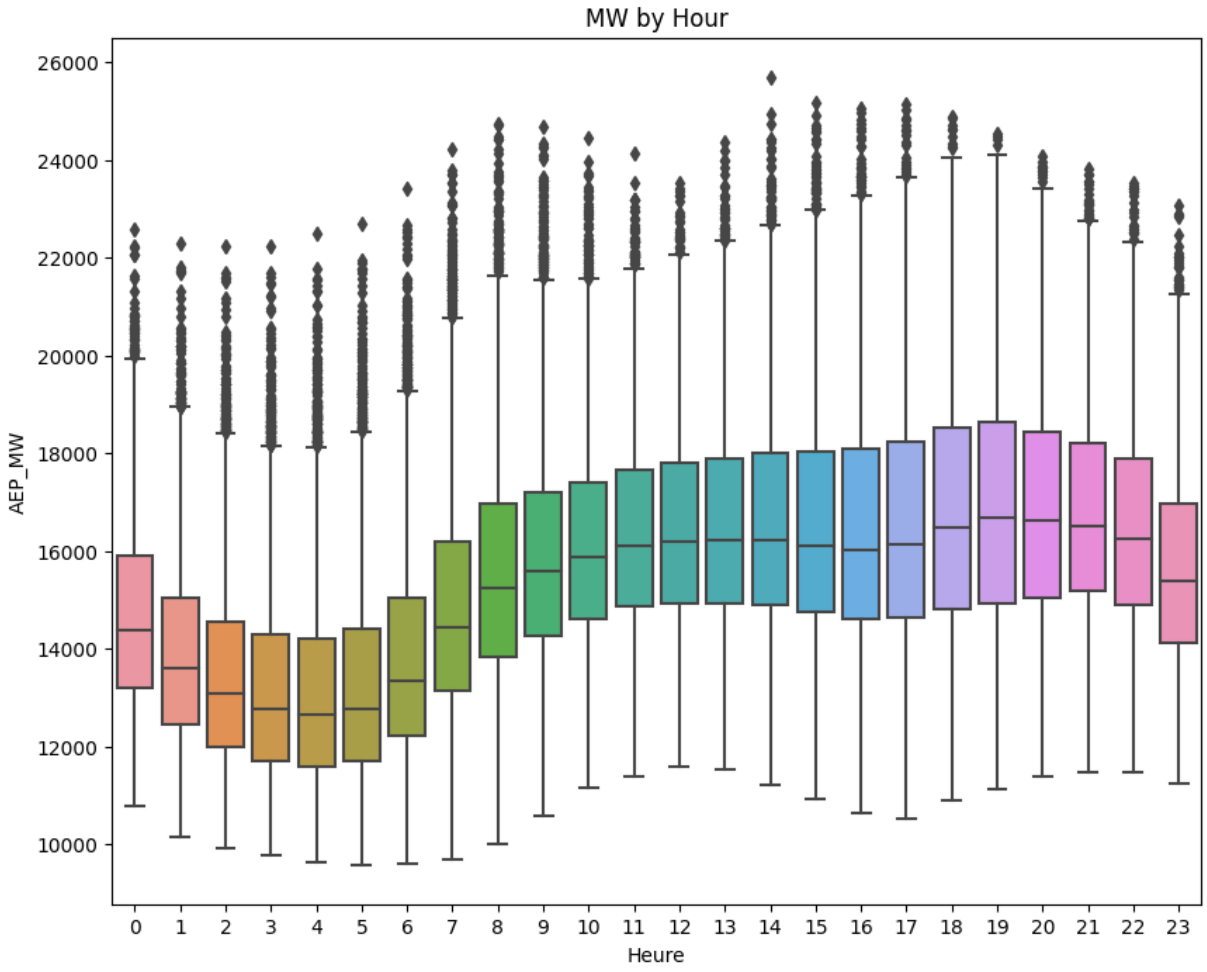
Création d'une fonction qui explicite l'heure, le jour, la semaine, le mois et l'année pour chaque données présente dans notre set de données.

In [9]:
```
def creation_index_temps(ds):
    ds['Heure']=ds.index.hour
    ds['Jour(Semaine)']=ds.index.dayofweek
    ds['Semaine']=ds.index.week
    ds['Mois']=ds.index.month
    ds['Année']=ds.index.year
    ds['Jour(Année)']=ds.index.day
    return ds

ds = creation_index_temps(dataset)
```

```
/tmp/ipykernel_33255/3953485566.py:4: FutureWarning: weekofyear and week have been deprecated, please use DatetimeIndex.isocalendar().week instead, which returns a Series. To exactly reproduce the behavior of week and weekofyear and return an Index, you may call pd.Int64Index(idx.isocalendar().week)
  ds['Semaine']=ds.index.week
```

In [10]:
```
fig, ax = plt.subplots(figsize=(10, 8))
sns.boxplot(data=ds, x='Heure', y='AEP_MW')
ax.set_title('MW par heure')
plt.show()
```



In [11]:
```
creation_index_temps(dataset)
```

```
/tmp/ipykernel_33255/3953485566.py:4: FutureWarning: weekofyear and week have
been deprecated, please use DatetimeIndex.isocalendar().week instead, which r
eturns a Series. To exactly reproduce the behavior of week and weekofyear and
return an Index, you may call pd.Int64Index(idx.isocalendar().week)
  ds['Semaine']=ds.index.week
```

Out[11]:

Datetime	AEP_MW	Heure	Jour(Semaine)	Semaine	Mois	Année	Jour(Année)
2004-10-01 01:00:00	12379.0	1	4	40	10	2004	1
2004-10-01 02:00:00	11935.0	2	4	40	10	2004	1
2004-10-01 03:00:00	11692.0	3	4	40	10	2004	1
2004-10-01 04:00:00	11597.0	4	4	40	10	2004	1
2004-10-01 05:00:00	11681.0	5	4	40	10	2004	1
...	...	...	...	...	...	...	...
2018-08-02 20:00:00	17673.0	20	3	31	8	2018	2
2018-08-02 21:00:00	17303.0	21	3	31	8	2018	2
2018-08-02 22:00:00	17001.0	22	3	31	8	2018	2
2018-08-02 23:00:00	15964.0	23	3	31	8	2018	2
2018-08-03 00:00:00	14809.0	0	4	31	8	2018	3

121273 rows × 7 columns

In [12]:
```
train = creation_index_temps(train)
test = creation_index_temps(test)
```

```
/tmp/ipykernel_33255/3953485566.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Heure']=ds.index.hour
/tmp/ipykernel_33255/3953485566.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Jour(Semaine)']=ds.index.dayofweek
/tmp/ipykernel_33255/3953485566.py:4: FutureWarning: weekofyear and week have
been deprecated, please use DatetimeIndex.isocalendar().week instead, which r
eturns a Series. To exactly reproduce the behavior of week and weekofyear and
return an Index, you may call pd.Int64Index(idx.isocalendar().week)
  ds['Semaine']=ds.index.week
/tmp/ipykernel_33255/3953485566.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Semaine']=ds.index.week
/tmp/ipykernel_33255/3953485566.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Mois']=ds.index.month
/tmp/ipykernel_33255/3953485566.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Année']=ds.index.year
/tmp/ipykernel_33255/3953485566.py:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Jour(Année)']=ds.index.day
/tmp/ipykernel_33255/3953485566.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Heure']=ds.index.hour
/tmp/ipykernel_33255/3953485566.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
```

```
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Jour(Semaine)']=ds.index.dayofweek
/tmp/ipykernel_33255/3953485566.py:4: FutureWarning: weekofyear and week have
been deprecated, please use DatetimeIndex.isocalendar().week instead, which r
eturns a Series. To exactly reproduce the behavior of week and weekofyear and
return an Index, you may call pd.Int64Index(idx.isocalendar().week)
  ds['Semaine']=ds.index.week
/tmp/ipykernel_33255/3953485566.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Semaine']=ds.index.week
/tmp/ipykernel_33255/3953485566.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Mois']=ds.index.month
/tmp/ipykernel_33255/3953485566.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Année']=ds.index.year
/tmp/ipykernel_33255/3953485566.py:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  ds['Jour(Année)']=ds.index.day
```

Entraînement sur le set de données "**Train**".

On liste toutes les entrées sur lesquelles nous allons appliquer l'algorithme d'entraînement, ainsi que la sortie souhaitée (la valeur que nous souhaitons prédire avec le modèle).

In [13]:
```
ENTREES = ['Heure', 'Jour(Semaine)', 'Semaine', 'Mois', 'Année', 'Jour(Année
SORTIE = ['AEP_MW']
```

In [14]:
```
X_train = train[ENTREES]
Y_train = train[SORTIE]

X_test = test[ENTREES]
Y_test = test[SORTIE]
```

On entraîne le modèle de machine learning sur le set de données "**Train**" en utilisant la

méthode de boosting de gradient extrême (XGBoost).

In [15]:
```
reg = xgb.XGBRegressor(
    n_estimators=100000,         # Hauteur maximale de l'arbre de décision cr
    early_stopping_rounds=100,   # Nombre maximal de sorties de la fonction
    learning_rate=0.0001)        # Ratio d'apprentissage
reg.fit(
    X_train, Y_train,
    eval_set=[(X_train, Y_train),(X_test,Y_test)],
    verbose=1000)                # Pas d'affichage des sorties (ici toutes le
```

```
[0]     validation_0-rmse:15905.62657   validation_1-rmse:14915.45600
[1000]  validation_0-rmse:14408.21706   validation_1-rmse:13421.35247
[2000]  validation_0-rmse:13054.74408   validation_1-rmse:12071.99231
[3000]  validation_0-rmse:11831.66248   validation_1-rmse:10857.12886
[4000]  validation_0-rmse:10726.92948   validation_1-rmse:9772.66067
[5000]  validation_0-rmse:9729.11530    validation_1-rmse:8794.73497
[6000]  validation_0-rmse:8827.91104    validation_1-rmse:7910.22430
[7000]  validation_0-rmse:8013.82637    validation_1-rmse:7123.05729
[8000]  validation_0-rmse:7279.62662    validation_1-rmse:6419.58070
[9000]  validation_0-rmse:6617.25072    validation_1-rmse:5787.64806
[10000] validation_0-rmse:6020.01896    validation_1-rmse:5218.39694
[11000] validation_0-rmse:5482.04142    validation_1-rmse:4709.61984
[12000] validation_0-rmse:4997.93892    validation_1-rmse:4256.25822
[13000] validation_0-rmse:4562.79783    validation_1-rmse:3855.06255
[14000] validation_0-rmse:4172.04058    validation_1-rmse:3500.29853
[15000] validation_0-rmse:3821.60218    validation_1-rmse:3188.56866
[16000] validation_0-rmse:3506.54528    validation_1-rmse:2917.70457
[17000] validation_0-rmse:3225.24085    validation_1-rmse:2679.89379
[18000] validation_0-rmse:2974.14022    validation_1-rmse:2473.56002
[19000] validation_0-rmse:2750.78036    validation_1-rmse:2297.90345
[20000] validation_0-rmse:2552.37543    validation_1-rmse:2149.97111
[21000] validation_0-rmse:2376.93519    validation_1-rmse:2026.90722
[22000] validation_0-rmse:2221.84850    validation_1-rmse:1925.53272
[23000] validation_0-rmse:2085.37621    validation_1-rmse:1845.98032
[24000] validation_0-rmse:1965.81963    validation_1-rmse:1782.29759
[25000] validation_0-rmse:1861.21089    validation_1-rmse:1732.55650
[26000] validation_0-rmse:1770.51955    validation_1-rmse:1695.31412
[27000] validation_0-rmse:1691.80913    validation_1-rmse:1666.33206
[28000] validation_0-rmse:1622.01498    validation_1-rmse:1645.36442
[29000] validation_0-rmse:1561.46075    validation_1-rmse:1630.91140
[30000] validation_0-rmse:1508.96172    validation_1-rmse:1622.28758
[31000] validation_0-rmse:1463.10362    validation_1-rmse:1617.91136
[32000] validation_0-rmse:1423.06658    validation_1-rmse:1616.55077
[32096] validation_0-rmse:1419.51395    validation_1-rmse:1616.56765
```

Out[15]:

```
▼                                XGBRegressor
XGBRegressor(base_score=None, booster=None, callbacks=None,
             colsample_bylevel=None, colsample_bynode=None,
             colsample_bytree=None, early_stopping_rounds=100,
             enable_categorical=False, eval_metric=None, feature_ty
pes=None,
             gamma=None, gpu_id=None, grow_policy=None, importance_
type=None,
             interaction_constraints=None, learning_rate=0.0001, ma
x_bin=None,
```

L'algorithme s'exécute de manière à faire diminuer l'erreur "root-mean-squared-error" ou "rmse" sur le set de données d'entraînement, ce qui la fait parrallèlement diminuer pour le set de test (les données que nous souhaitons prédire). L'algorithme entraîne le modèle jusqu'à ce que l'erreur calculée sur le set de test soit minimale, en effet celle-ci augmente quand le modèle apprend par coeur les données sur lesquelles il s'est entraîné (cela s'appelle l'overfitting et ce n'est pas souhaitable pour les prédictions sur des nouveaux sets de données).

On trie dans l'ordre décroissant les paramètres pris en entrée selon leur utilisation et leur importance dans l'entraînement du modèle.

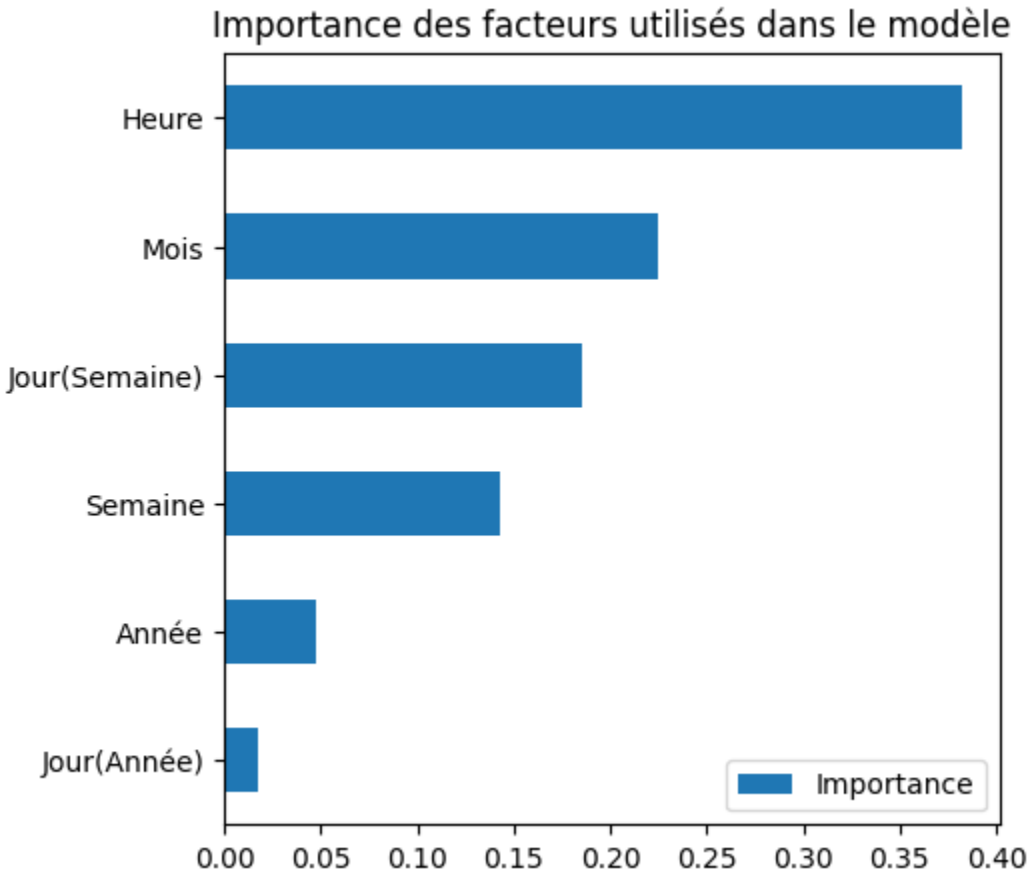
In [16]:

```
imp = pd.DataFrame(
    data=reg.feature_importances_,
    index=reg.feature_names_in_,
    columns=['Importance'])

imp.sort_values('Importance').plot(
    figsize=(5,5),
    kind='barh',
    title='Importance des facteurs utilisés dans le modèle')
```

Out[16]:

```
<AxesSubplot:title={'center':'Importance des facteurs utilisés dans le modè
le'}>
```



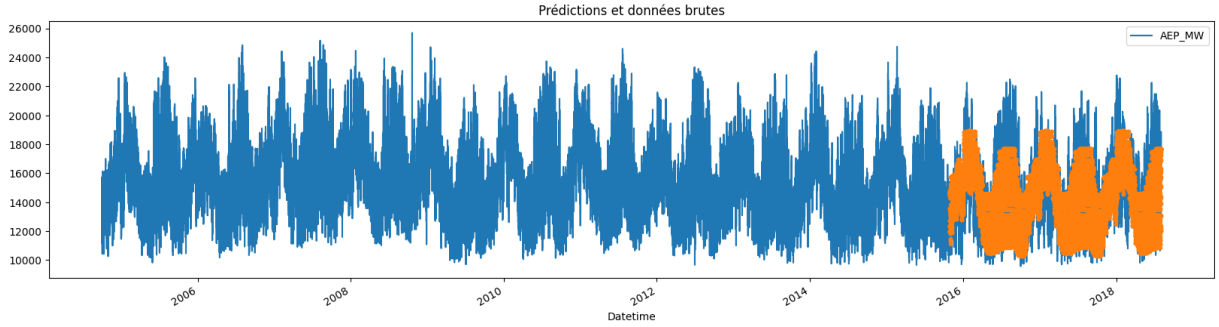
On trace les données présentes dans le set de données "**Test**" ainsi que les prédictions estimées par le modèle.

In [17]:
```
test['prediction'] = reg.predict(X_test)
dataset = dataset.merge(test[['prediction']], how='left', left_index=True, r
ax = dataset[['AEP_MW']].plot(figsize=(20,5))
dataset['prediction'].plot(ax=ax,style='.')
ax.set_title('Prédictions et données brutes')
```

```
/tmp/ipykernel_33255/2908521693.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  test['prediction'] = reg.predict(X_test)
```

Out[17]:
```
Text(0.5, 1.0, 'Prédictions et données brutes')
```

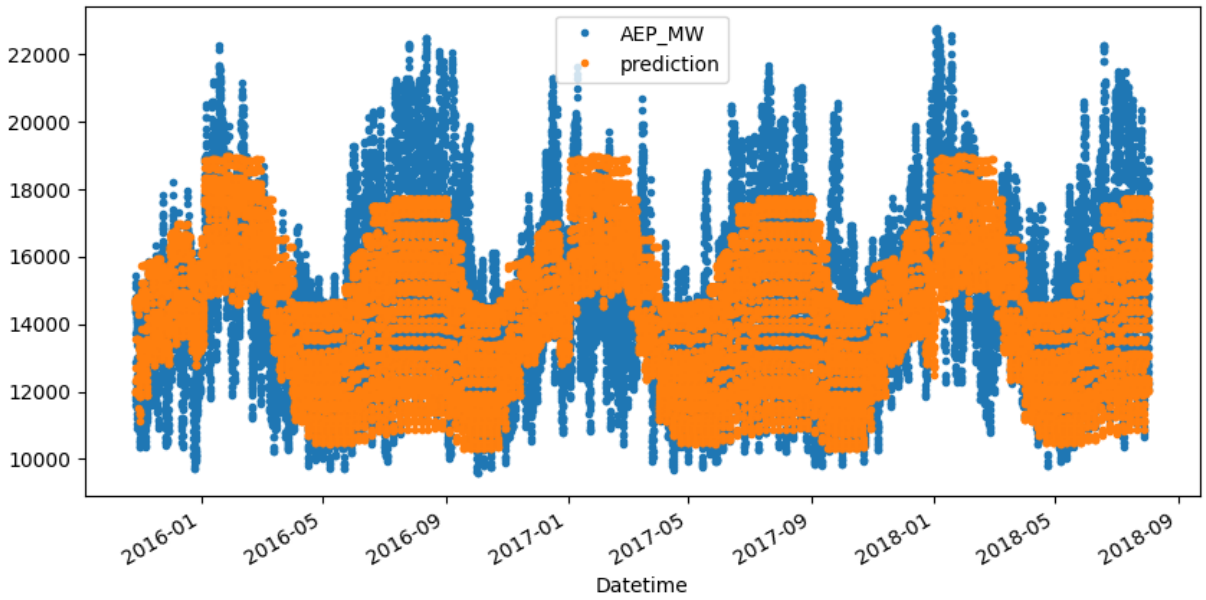


Intégralité des données prédites.

In [18]:
```
test_predic = dataset.iloc[int(nb_lines*0.8)+1:]
```

In [19]:
```
test_predic.plot(y=['AEP_MW','prediction'], style='.',figsize=(10,5))
```

Out[19]: <AxesSubplot:xlabel='Datetime'>

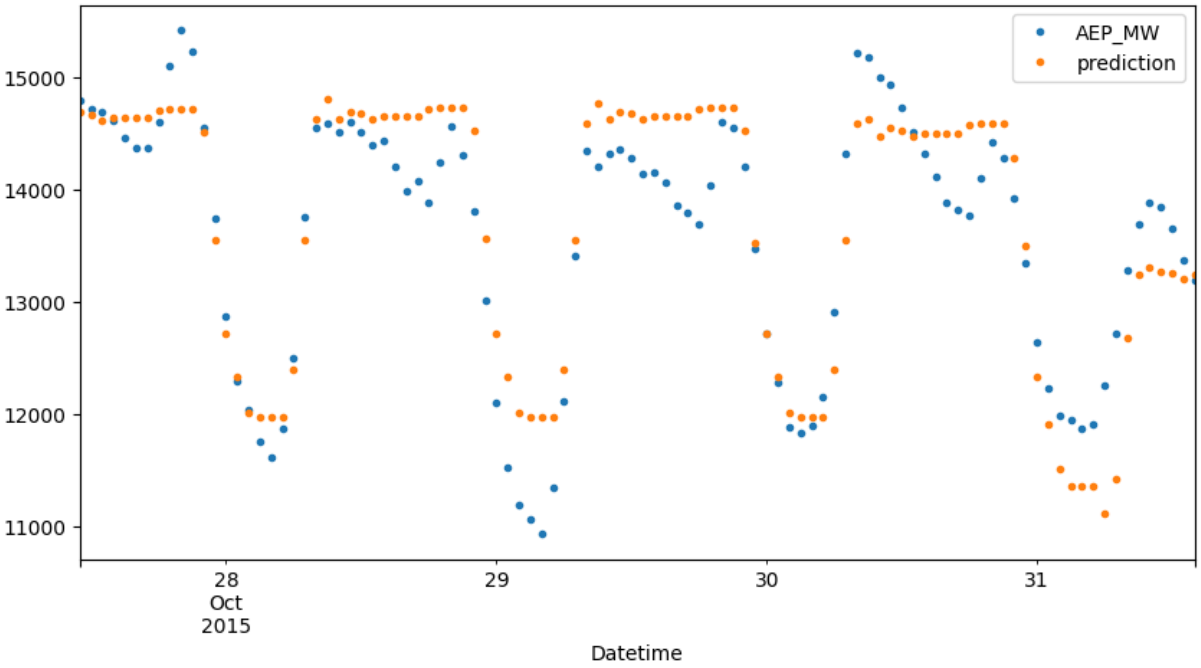


Centaine de données prédites.

In [20]:
```
test_predic = dataset.iloc[int(nb_lines*0.8)+1:int(nb_lines*0.8)+101]
```

In [21]:
```
test_predic.plot(y=['AEP_MW','prediction'], style='.',figsize=(10,5))
```

Out[21]: <AxesSubplot:xlabel='Datetime'>



Calcul de l'erreur (root_mean_squared_error) entre les prédictions et les données réelles brutes du set "**Test**".

In [25]:
```
score = mean_squared_error(test['AEP_MW'], test['prediction'], squared=False
print('RMSE =', score)
```

```
RMSE = 1616.5457531791394
```