Inside a Boiler - Slagging Prediction

[https://opendata.edp.com/pages/challenges/#description (https://opendata.edp.com/pages/challenges/#description)](https://opendata.edp.com/pages/challenges/#description)

In [1]:
```
### Chec#from imblearn.combine import SMOTETomek
import pandas as pd
import numpy as np
from numpy import sort, sqrt, argsort, inf
from sklearn.feature_selection import SelectFromModel

from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import cross_val_score, KFold

from sklearn.metrics import precision_score
from sklearn.metrics import fbeta_score
from sklearn.metrics import accuracy_score
from sklearn.metrics import make_scorer, precision_recall_curve,confusion_matrix
from sklearn.metrics import roc_auc_score
from xgboost import XGBClassifier
```

Cargamos X_scaled_interpolated

In [2]:
```
X_scaled_interpolated_from_csv = pd.read_csv('../data/boiler_Y_train_data_scaled_inte
rpolated.csv')
```

In [3]:
```
X_scaled_interpolated_from_csv.set_index('ID_sampling', inplace=True)
```

In [4]:
```
X_scaled_interpolated_from_csv
```

Out[4]:

	TARGET	DAYS_TILL_SLAG	HOUR	DAY	MONTH	Active Power_median	Active Power_mean	Active Power_max
ID_sampling								
01-01-00	0	0	0	1	1	0.315556	0.319098	0.305600
01-01-01	0	0	1	1	1	0.318278	0.319591	0.306575
01-01-02	0	0	2	1	1	0.317615	0.319754	0.286789
01-01-03	0	0	3	1	1	0.315965	0.318521	0.292057
01-01-04	0	0	4	1	1	0.329135	0.321204	0.372476
...	...	...	...	...	...	...	...	...
12-31-19	0	0	19	31	12	-2.699895	-2.710722	-2.830760
12-31-20	0	0	20	31	12	-2.709318	-2.705418	-2.747917
12-31-21	0	0	21	31	12	-2.708999	-2.726121	-2.841609
12-31-22	0	0	22	31	12	-2.710773	-2.722842	-2.807134
12-31-23	0	0	23	31	12	-1.260923	-1.506261	-0.895884

8759 rows × 149 columns

Aquí aún no metemos atributos de tiempo (por posible estacionalidad)

Mantenemos 'DAYS_TILL_SLAG' para usarlo en la validación

In [5]:
```
X_scaled_interpolated = X_scaled_interpolated_from_csv

numeric_features = [x for x in X_scaled_interpolated.columns if x not in ['TARGET',
'DAYS_TILL_SLAG', 'HOUR', 'DAY', 'MONTH']]
```

In [6]:
```
### Stratified train-test split
from sklearn.model_selection import train_test_split

features_to_train_no_temp = [x for x in X_scaled_interpolated.columns if x not in ['T
ARGET', 'HOUR', 'DAY', 'MONTH']]
X_train, X_test, y_train, y_test=train_test_split(X_scaled_interpolated[features_to_t
rain_no_temp],
                                                  X_scaled_interpolated['TARGET'], te
st_size=0.20, stratify=X_scaled_interpolated['TARGET'])
```

Esto nos hace ver la importancia de probar otro sampleo con el que tengamos más datos, a parte de probar el SMOTE para oversamplear; de hecho necesito los days until slag para la función de coste de EDP, y no puedo oversamplear (no puede generar ficticos days till slag, a priori) Probar también con el parámetro 'scale_pos_weight' de XGBOOST para el desbalanceo

In [7]:
```
X_train_attributes = numeric_features
X_test_attributes = numeric_features

train_slagdays_to_concat = X_train['DAYS_TILL_SLAG']
test_slagdays_to_concat = X_test['DAYS_TILL_SLAG']
```

EDP cost function to evaluate our training

In [42]:
```
features_to_train_on = numeric_features
len(features_to_train_on)
```

Out[42]: 144

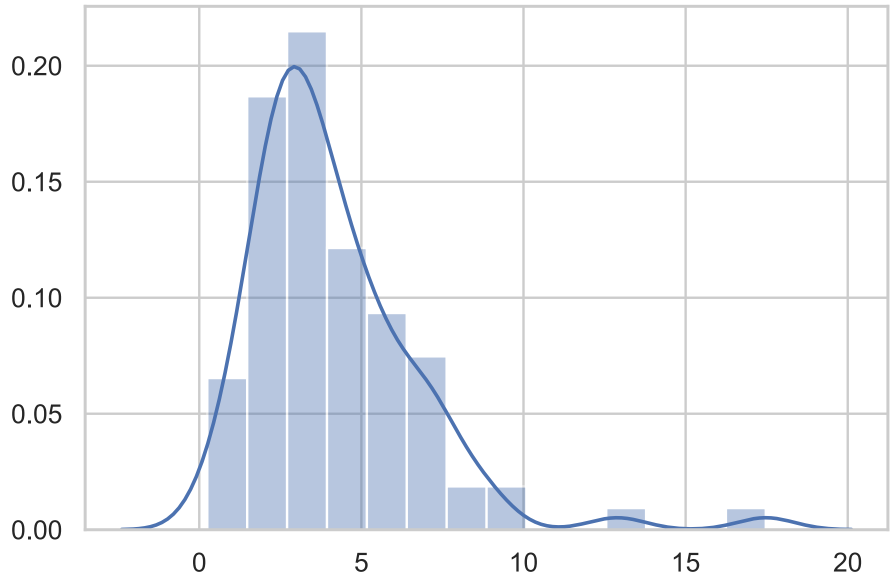
Model feature importances

In [45]:
```
f = 'gain'
feature_importances = xgb_best_params.get_booster().get_score(importance_type= f)

feature_importances
```

Out[45]:
```
{'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_mean': 7.3618539525,
 'Main Steam Turbine Control Valve #B_max': 5.982777598,
 'Secondary Air Row #5 (Side 2)_min': 5.21072328,
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_median': 5.7554569073333335,
 'Coal Feeder #1_mean': 6.90781784,
 'Main Steam Second Desuperheater Control Valve position (Side 2)_median': 7.87830829
5,
 'Active Power_median': 2.3815271036666665,
 'Boiler Outlet Pressure_max': 4.12917972,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_median': 2.3863817066666666,
 'Boiler Furnace Pressure_std': 2.482228436666667,
 'Boiler Furnace Pressure_mean': 4.488096475,
 'Secondary Air Row #3 (Side 2)_median': 3.43906355,
 'Main Steam Turbine Control Valve #D_max': 4.516999563333333,
 'Main Steam Turbine Control Valve #B_skew': 0.247436523,
 'Main Steam Second Desuperheater Control Valve position (Side 2)_mean': 5.0980778933
333335,
 'Secondary Air Row #3 (Side 2)_max': 2.758950393333333,
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_min': 4.506832123333333,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_mean': 1.89883113,
 'Coal Feeder #1_min': 17.4726448,
 'Secondary Air Fan #1 Temperature 2_min': 8.8665896,
 'Air Heater #1 Differential Pressure_mean': 6.851722715,
 'Boiler Outlet Pressure_median': 7.0391650199999996,
 'Coal Feeder #1_max': 4.60749793,
 'Boosted Overfire Air (Side 1)_max': 6.960177007499999,
 'Secondary Air Row #5 (Side 2)_std': 2.3557353,
 'Main Steam Turbine Control Valve #B_median': 4.66950345025,
 'Coal Feeder #5_mean': 3.80552673,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_min': 5.71082306,
 'Coal Feeder #5_min': 3.3425575899999997,
 'Main Steam Second Desuperheater Control Valve position (Side 2)_max': 4.58510064999
9999,
 'Boiler Feedwater Pressure_max': 7.1644783,
 'Secondary Air Fan #1 Temperature 2_std': 2.05794477,
 'Boiler Outlet Pressure_min': 3.108326433333333,
 'Boosted Overfire Air (Side 1)_min': 7.13581228,
 'Air Heater #1 Differential Pressure_min': 3.4101753225,
 'Secondary Air Fan #1 Temperature 2_mean': 8.35124016,
 'Coal Feeder #1_median': 5.65260315,
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_max': 8.93370819,
 'Boiler Feedwater Pressure_median': 5.22210836,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_min': 5.52341056,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_max': 1.29857063,
 'Boiler Outlet Pressure_skew': 1.05137014,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_min': 5.75047016,
 'Total Atemperator Feedwater Flow_max': 4.13528824,
 'Main Steam First Desuperheater Control Valve position (Side 2)_min': 6.98350525,
 'Secondary Air Row #3 (Side 2)_skew': 1.09901619,
 'Boiler Outlet Pressure_mean': 6.10137653,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_max': 3.086510775,
 'Main Steam Second Desuperheater Control Valve position (Side 1)_max': 3.82786834499
99997,
 'Coal Feeder #5_median': 1.82025099,
 'Boiler Furnace Pressure_max': 2.80676627,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_std': 1.57674944,
 'Main Steam First Desuperheater Control Valve position (Side 2)_std': 2.03016257,
 'Reheated Steam Temperature 1 @Outlet_skew': 1.88479471,
 'Boiler Feedwater Pressure_std': 4.07723343,
 'Secondary Air Row #3 (Side 2)_mean': 3.76955128,
 'Active Power_mean': 5.21495819,
 'Secondary Air Row #3 (Side 2)_std': 3.3271920699999997,
 'Boosted Overfire Air (Side 2)_mean': 2.948147415,
 'Air Heater #1 Differential Pressure_std': 2.72964978,
 'Air Heater #1 Differential Pressure_skew': 3.36660767,
 'Secondary Air Row #5 (Side 2)_skew': 2.480572345,
 'Main Steam First Desuperheater Control Valve position (Side 1)_std': 3.490771054999
```

```
9997,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_std': 2.788110255,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_mean': 2.27873516,
 'Boiler Outlet Pressure_std': 3.990482335,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_std': 2.61374402,
 'Air Heater #1 Differential Pressure_max': 3.3230474,
 'Reheated Steam Temperature 1 @Outlet_std': 3.13103724,
 'Main Steam Turbine Control Valve #D_std': 2.5680809,
 'Secondary Air Row #5 (Side 2)_median': 0.841907382,
 'Boosted Overfire Air (Side 1)_mean': 12.8904676,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_skew': 2.46124244,
 'Coal Feeder #5_skew': 2.055166485,
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_skew': 2.4772415184999996,
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_median': 1.41218472,
 'Main Steam Second Desuperheater Control Valve position (Side 2)_min': 2.51277637,
 'Total Atemperator Feedwater Flow_std': 2.88615727,
 'Boosted Overfire Air (Side 1)_median': 4.13162518,
 'Main Steam Turbine Control Valve #D_min': 3.14946079,
 'Main Steam Second Desuperheater Control Valve position (Side 1)_mean': 3.08952808,
 'Boosted Overfire Air (Side 2)_min': 3.88291359,
 'Main Steam Second Desuperheater Control Valve position (Side 1)_std': 1.94115627,
 'Boiler Furnace Pressure_skew': 3.65023994,
 'Main Steam Turbine Control Valve #D_skew': 2.03048158,
 'Coal Feeder #5_max': 4.88155651,
 'Main Steam Turbine Control Valve #B_mean': 0.826366425}
```

In [49]:
```python
import seaborn as sns
sns.set(style="whitegrid")

f_importances = [value for key, value in feature_importances.items()]
ax = sns.distplot(f_importances)
```



In [13]:
```
selected_features_thr_3 = ['Flue Gas Induced Draft Fan #1 Blade Pitch Angle_mean',
 'Main Steam Turbine Control Valve #B_max',
 'Secondary Air Row #5 (Side 2)_min',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_median',
 'Coal Feeder #1_mean',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_median',
 'Boiler Outlet Pressure_max',
 'Boiler Furnace Pressure_mean',
 'Secondary Air Row #3 (Side 2)_median',
 'Main Steam Turbine Control Valve #D_max',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_mean',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_min',
 'Coal Feeder #1_min',
 'Secondary Air Fan #1 Temperature 2_min',
 'Air Heater #1 Differential Pressure_mean',
 'Boiler Outlet Pressure_median',
 'Coal Feeder #1_max',
 'Boosted Overfire Air (Side 1)_max',
 'Main Steam Turbine Control Valve #B_median',
 'Coal Feeder #5_mean',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_min',
 'Coal Feeder #5_min',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_max',
 'Boiler Feedwater Pressure_max',
 'Boiler Outlet Pressure_min',
 'Boosted Overfire Air (Side 1)_min',
 'Air Heater #1 Differential Pressure_min',
 'Secondary Air Fan #1 Temperature 2_mean',
 'Coal Feeder #1_median',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_max',
 'Boiler Feedwater Pressure_median',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_min',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_min',
 'Total Atemperator Feedwater Flow_max',
 'Main Steam First Desuperheater Control Valve position (Side 2)_min',
 'Boiler Outlet Pressure_mean',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_max',
 'Main Steam Second Desuperheater Control Valve position (Side 1)_max',
 'Boiler Feedwater Pressure_std',
 'Secondary Air Row #3 (Side 2)_mean',
 'Active Power_mean',
 'Secondary Air Row #3 (Side 2)_std',
 'Air Heater #1 Differential Pressure_skew',
 'Main Steam First Desuperheater Control Valve position (Side 1)_std',
 'Boiler Outlet Pressure_std',
 'Air Heater #1 Differential Pressure_max',
 'Reheated Steam Temperature 1 @Outlet_std',
 'Boosted Overfire Air (Side 1)_mean',
 'Boosted Overfire Air (Side 1)_median',
 'Main Steam Turbine Control Valve #D_min',
 'Main Steam Second Desuperheater Control Valve position (Side 1)_mean',
 'Boosted Overfire Air (Side 2)_min',
 'Boiler Furnace Pressure_skew',
 'Coal Feeder #5_max']
```

In [14]:
```
selected_features_thr_4 = ['Flue Gas Induced Draft Fan #1 Blade Pitch Angle_mean',
 'Main Steam Turbine Control Valve #B_max',
 'Secondary Air Row #5 (Side 2)_min',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_median',
 'Coal Feeder #1_mean',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_median',
 'Boiler Outlet Pressure_max',
 'Boiler Furnace Pressure_mean',
 'Main Steam Turbine Control Valve #D_max',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_mean',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_min',
 'Coal Feeder #1_min',
 'Secondary Air Fan #1 Temperature 2_min',
 'Air Heater #1 Differential Pressure_mean',
 'Boiler Outlet Pressure_median',
 'Coal Feeder #1_max',
 'Boosted Overfire Air (Side 1)_max',
 'Main Steam Turbine Control Valve #B_median',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #1_min',
 'Main Steam Second Desuperheater Control Valve position (Side 2)_max',
 'Boiler Feedwater Pressure_max',
 'Boosted Overfire Air (Side 1)_min',
 'Secondary Air Fan #1 Temperature 2_mean',
 'Coal Feeder #1_median',
 'Flue Gas Induced Draft Fan #1 Blade Pitch Angle_max',
 'Boiler Feedwater Pressure_median',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #2_min',
 'Dynamic Coal Classifier Rotational Speed Coal Mill #3_min',
 'Total Atemperator Feedwater Flow_max',
 'Main Steam First Desuperheater Control Valve position (Side 2)_min',
 'Boiler Outlet Pressure_mean',
 'Boiler Feedwater Pressure_std',
 'Active Power_mean',
 'Boosted Overfire Air (Side 1)_mean',
 'Boosted Overfire Air (Side 1)_median',
 'Coal Feeder #5_max']
```

Cargamos ambos modelos a comparar

In [44]:
```
import pickle

file_data = r'..\models\xgb_best_params_right_boiler_Y_2.pkl'
file_data = open(file_data, 'rb')
xgb_best_params_edp_funct_model_boiler_Y_2 = pickle.load(file_data)
file_data.close()

file_data = r'..\models\xgb_best_params_right_boiler_Y_3.pkl'
file_data = open(file_data, 'rb')
xgb_best_params_edp_funct_model_boiler_Y_3 = pickle.load(file_data)
file_data.close()

file_data = r'..\models\xgb_best_params_right_boiler_Y_feat_sel_thres_4.pkl'
file_data = open(file_data, 'rb')
xgb_best_params_edp_funct_model_boiler_y_sel_feat_th_4 = pickle.load(file_data)
file_data.close()
```

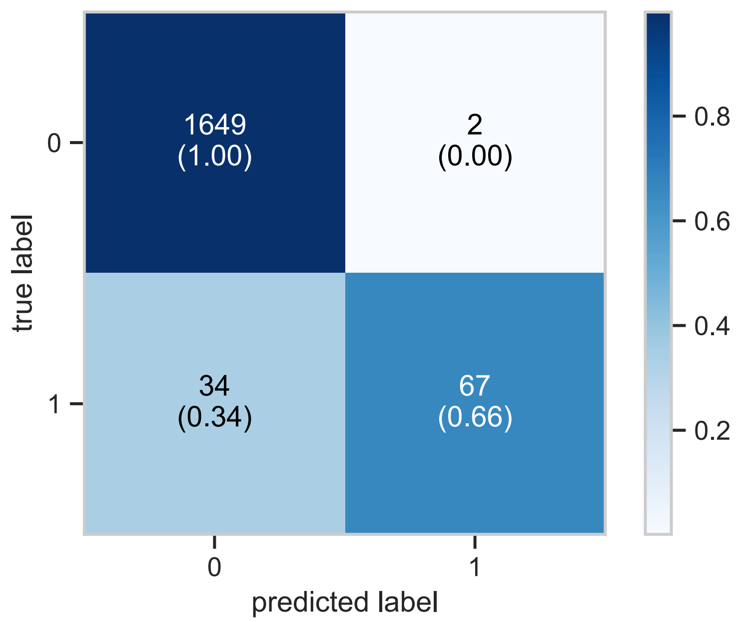
In [46]:
```
xgb_best_params_edp_funct_model_boiler_Y_2.predict(X_test[numeric_features])
```

Out[46]:
```
array([0, 0, 0, ..., 0, 0, 0], dtype=int64)
```

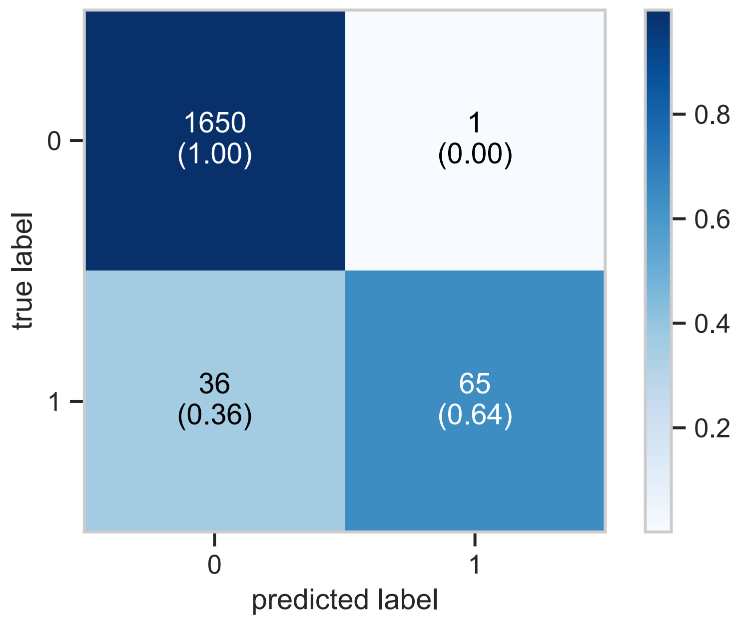
In [47]:
```
best_params_xgb_predictions_all_feat = xgb_best_params_edp_funct_model_boiler_Y_2.predict(X_test[numeric_features])
best_params_xgb_probas_all_feat = xgb_best_params_edp_funct_model_boiler_Y_2.predict_proba(X_test[numeric_features])

best_params_xgb_predictions_feat_th_3 = xgb_best_params_edp_funct_model_boiler_Y_3.predict(X_test[selected_features_thr_3])
best_params_xgb_probas_feat_th_3 = xgb_best_params_edp_funct_model_boiler_Y_3.predict_proba(X_test[selected_features_thr_3])

best_params_xgb_predictions_feat_th_4 = xgb_best_params_edp_funct_model_boiler_y_sel_feat_th_4.predict(X_test[selected_features_thr_4])
best_params_xgb_probas_feat_th_4 = xgb_best_params_edp_funct_model_boiler_y_sel_feat_th_4.predict_proba(X_test[selected_features_thr_4])
```

In [48]:
```
preds_probas_df_all_feat = pd.DataFrame({'y_true_values': y_test, 'y_predicted_values':best_params_xgb_predictions_all_feat, 'y_predicted_probas': best_params_xgb_probas_all_feat[:, 1]})
positive_preds_probas_df_all_feat = preds_probas_df_all_feat[preds_probas_df_all_feat.y_predicted_values==1]

preds_probas_df_th_3 = pd.DataFrame({'y_true_values': y_test, 'y_predicted_values':best_params_xgb_predictions_feat_th_3, 'y_predicted_probas': best_params_xgb_probas_feat_th_3[:, 1]})
positive_preds_probas_df_th_3 = preds_probas_df_th_3[preds_probas_df_th_3.y_predicted_values==1]

preds_probas_df_th_4 = pd.DataFrame({'y_true_values': y_test, 'y_predicted_values':best_params_xgb_predictions_feat_th_4, 'y_predicted_probas': best_params_xgb_probas_feat_th_4[:, 1]})
positive_preds_probas_df_th_4 = preds_probas_df_th_4[preds_probas_df_th_4.y_predicted_values==1]
```

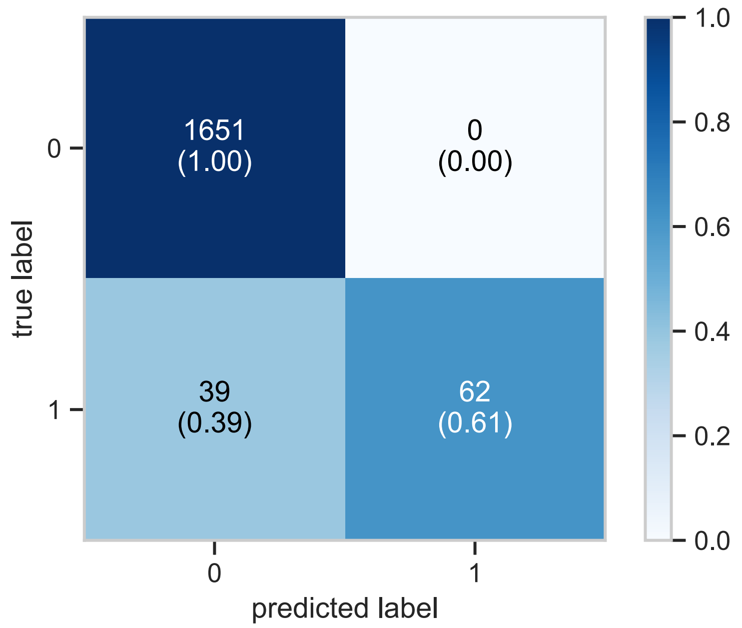
In [49]:
```
from mlxtend.plotting import plot_confusion_matrix
import matplotlib.pyplot as plt
import numpy as np

fig, ax = plot_confusion_matrix(conf_mat=confusion_matrix(preds_probas_df_all_feat.y_true_values, preds_probas_df_all_feat.y_predicted_values),
                                show_absolute=True,
                                show_normed=True,
                                colorbar=True)
```



In [36]:
```
fig, ax = plot_confusion_matrix(conf_mat=confusion_matrix(preds_probas_df_th_3.y_true
_values, preds_probas_df_th_3.y_predicted_values),
                                show_absolute=True,
                                show_normed=True,
                                colorbar=True)
```



In [37]:
```
fig, ax = plot_confusion_matrix(conf_mat=confusion_matrix(preds_probas_df_th_4.y_true
_values, preds_probas_df_th_4.y_predicted_values),
                                show_absolute=True,
                                show_normed=True,
                                colorbar=True)
```



Determinación del área bajo la curva ROC de cada clasificador

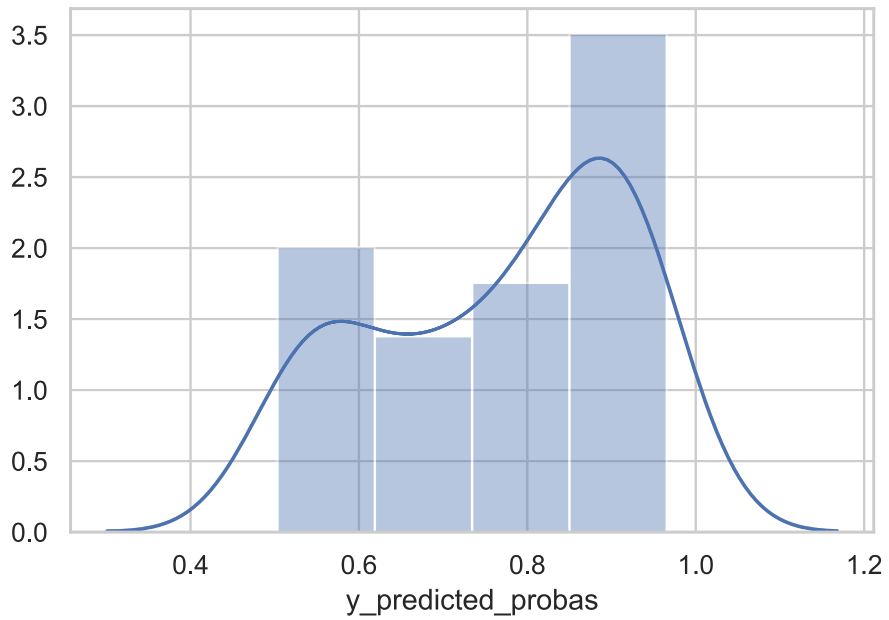
In [51]:
```
from sklearn.metrics import roc_auc_score

print('roc_auc_score con validation set all features: ', roc_auc_score(y_test,
      preds_probas_df_all_feat.y_predicted_probas))

print('roc_auc_score con validation set threshold 3: ', roc_auc_score(y_test,
      preds_probas_df_th_3.y_predicted_probas))

print('roc_auc_score con validation set threshold 4: ', roc_auc_score(y_test,
      preds_probas_df_th_4.y_predicted_probas))
```

```
roc_auc_score con validation set all features:  0.9944468099141835
roc_auc_score con validation set threshold 3:  0.9924588158391854
roc_auc_score con validation set threshold 4:  0.9966896750244377
```

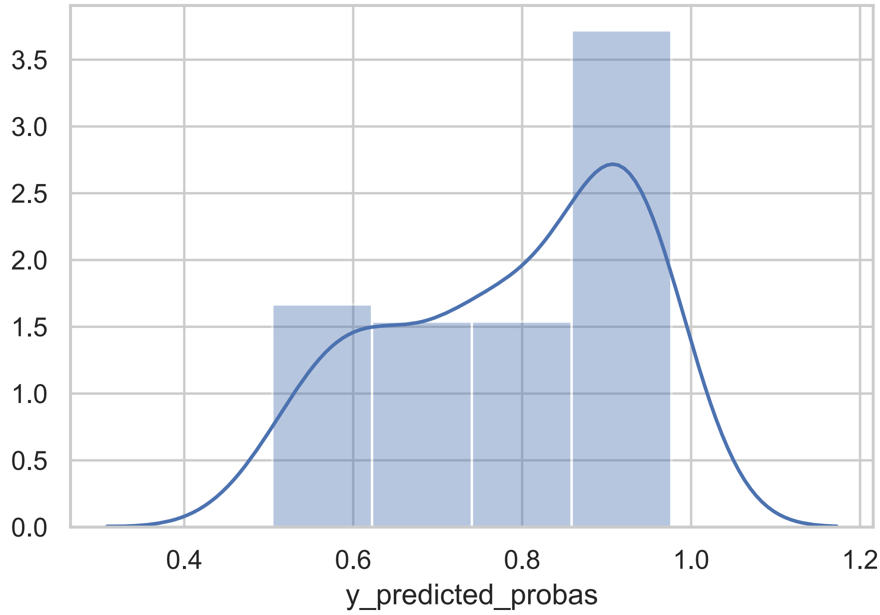
Vemos que con valores de área bajo la curva ROC casi idénticas, tenemos matrices de confusión ligeramente diferentes; éstas se han construido con el threshold de decisión por defecto. En este caso, vamos a plotear las probabilidades de decisión predichas por cada uno, con lo cual podremos ver qué clasificador aporta más seguridad en sus predicciones (esto es, cuál tiene más casos de altas probas)

Plot de la distribución de probabilidades de nuestros clasificadores

In [53]:
```
import seaborn as sns
sns.set(style="whitegrid")

ax = sns.distplot(positive_preds_probas_df_all_feat.y_predicted_probas)
```

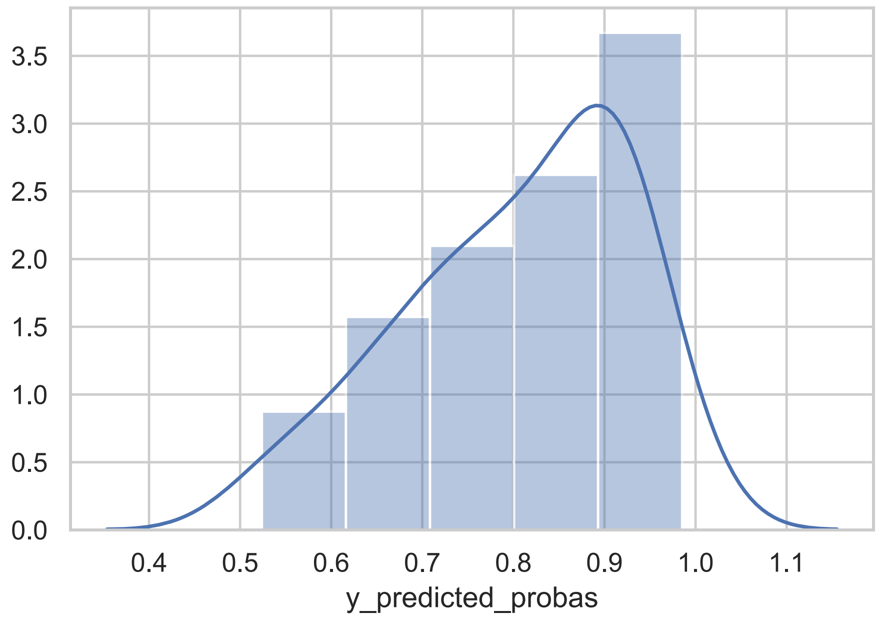


In [54]:
```
sns.set(style="whitegrid")

ax = sns.distplot(positive_preds_probas_df_th_3.y_predicted_probas)
```



Y éste al último de selección de atributos con thres. 0.4

In [55]:
```
sns.set(style="whitegrid")

ax = sns.distplot(positive_preds_probas_df_th_4.y_predicted_probas)
```



SE VE CLARAMENTE UNA MEJOR DISTRIBUCIÓN DE PROBABILIDADES DE PREDICCIÓN EN EL SEGUNDO CASO, DONDE ADEMÁS DE TENER MÁS FRECUENCIAS DE OCURRENCIA EN PROBABILIDADES ENTRE 0.7 Y 0.9, TIENE MÁS CASOS EN LA PROBABILIDAD MÁS FRECUENTE, QUE ES 0.9 EN AMBOS CASOS

In [2]:

```
jupyter nbconvert --to html first_project_edp_cost_function_boiler_Y_right_tag_auc_pr
obas_check.ipynb
```

```
  File "<ipython-input-2-8ebbeaa4488c>", line 1
    jupyter nbconvert --to html first_project_edp_cost_function_boiler_Y_right_tag_au
c_probas_check.ipynb
                    ^
SyntaxError: invalid syntax
```

In [ ]: