

Prediction of Renewable Power Loss caused by Feed-in Management Events

The goal of this project is a model that predicts lost power for the next time interval in dependence of various parameters in the past. This is useful for energy traders, grid operators as well as consumers who participate in Demand-Side Management. In the present notebook test and validation metrics of the various models are shown and compared. A selection of the best performing model will end this project.

Business Context: keeping the energy grid stable

In recent years the expansion of renewable generation capacity has been proceeding due to efforts made to transition to low carbon energy systems. This development creates a variety of challenges including the intermittent availability of renewable generation, such as wind energy, as well as the need for construction of according transmission infrastructure. The resulting mismatch between transmission and generation infrastructure causes congestion in the transmission grid. Germany's electricity market relies on feed-in management to cure short-time congestion when grids cannot absorb all intermittent generation. The term feed-in management refers to the curtailment of power that is fed into the power grid in dependence of the power that is actually used by connected consumers or is being transferred to other grid areas. A prediction of Feed-In Management Orders could aid with Demand Side Management Scheduling, making use of the otherwise lost renewable energy.

Environment Set-Up

In [56]:

```
reset -fs
```

In [57]:

```
# Importing the most important modules and setting the style for following plots
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import cm
import warnings
from datetime import datetime
import pickle
from scipy.integrate import simps
import plotly.offline as pyo
import plotly.graph_objs as go

# For Data Mining and data export
import glob
```

Global Variables and Settings

In [58]:

```
# Setting the random seed for reproducability and several plotting style parameters
%matplotlib inline
warnings.filterwarnings('ignore')
pd.set_option('display.max_columns', None)

# Set notebook mode of plotly to work offline
pyo.init_notebook_mode()
```

Definition of Functions

In [59]:

```
def split_(at_string, separator, at_n, return_after=False):
    """ Helper function to separate file path into name
    """
    words = string.split(separator)
    if return_after:
        return separator.join(words[:at_n])
    else:
        return separator.join(words[:at_n])

def clean_brackets(df_result):
    """
    Explanation: Working with LSTMs, the error metrics are sometimes encapsulated into square bracket
    """
    Return datafram without square brackets.
    """
    for col in df_result.columns:
        if df_result[col].dtype == np.number:
            df_result[col] = [float(x.replace("[", "").replace("]", "")) for x in df_result[col]]
    return df_result
```

In [60]:

```
def get_errors(metric = 'MAPE', folder='Test Errors'):
    """
    Reason: Error Metrics are saved into .csv files, one file per model including multiple error metric
    metric: ['RMSE', 'R2', 'MAE', 'MAPE']
    folder: ['Test Errors', 'Validation Errors']
    Return pd.DataFrame with specified Error Metric for all .csvs in specified folder
    """
    file_start = '_'.join(folder.split('_')) + '_'
    errors = pd.DataFrame()
    for file in glob.glob('*' + file_start + '*.csv'):
        # Preparation of column Name
        name = file
        name = split_at_file_name(name, 2, return_after=True)
        name = name.replace('_', '')
        #Loading raw data
        raw_table = pd.read_csv(file, header=0, usecols=[metric])
        #concatenate data to the right
        raw_table.rename(columns={metric: name}, inplace=True)
        raw_table.index+= 1
        errors = pd.concat([errors, raw_table], axis=1, ignore_index = False)
    errors.index.name = 'Step'
    errors = clean_brackets(errors).T
    errors = errors.sort_index()

    return errors
```

In [61]:

```
def plot_static_metrics(df_results, metric='MAPE', val_or_test='Test'):

    ##### COLOR SETTINGS #####
    # evenly spaced colors for len(colm)
    colors = ['olive', 'goldenrod', 'darkred', 'grey', 'midnightblue', 'crimson', 'forestgreen', 'darkmagenta']
    if len(names) > len(colors):
        df_results.shape[1]
        eveny_spaced_interval = np.linspace(0, 1, len(df_results.columns))
        colors = [cm.jet(x) for x in eveny_spaced_interval]
    ##### DATA PLOTTING #####
    fig, ax = plt.subplots(figsize=(15,11))
    for col, c in zip(df_results.columns, colors):
        plt.plot(df_results[col], label=col, color=c, lw=4)

    ##### PLOT SETTINGS #####
    plt.title(f'{metric} for each predicted timestep into the future ({val_or_test} set)', fontsize=20)
    plt.xlabel('STEPS INTO THE FUTURE', fontsize=14)
    plt.ylabel(f'{metric}', fontsize=14)
    plt.ylim(0, 1)
    plt.legend(loc='upper left', fontsize=14, bbox_to_anchor=(1.01, 1))

    ##### OUTPUT #####
    plt.savefig(f'figures/results_{metric}_{val_or_test}.png', bbox_inches='tight', transparent=True)
    plt.show()
```

In [62]:

```
def plot_interactive_metrics():
    names = list(MAPE_val.columns)
    # colors, if less than defined, create evenly spaced colors
    colors = ['olive', 'goldenrod', 'darkred', 'grey', 'midnightblue', 'crimson', 'forestgreen', 'darkmagenta', 'darkslategray', 'darkslategrey', 'darkturquoise', 'darkviolet', 'deeppink', 'deepskyblue', 'dimgrey', 'dodgerblue', 'firebrick', 'floralwhite', 'forestgreen', 'fuchsia', 'gainsboro', 'ghostwhite', 'gold', 'goldenrod', 'gray', 'green', 'greenyellow', 'honeydew', 'hotpink', 'indianred', 'indigo', 'ivory', 'khaki', 'lavender', 'lavenderblush', 'lawngreen', 'lemonchiffon', 'lightblue', 'lightcoral', 'lightcyan']
    if len(names) > len(colors):
        eveny_spaced_interval = np.linspace(0, 1, len(names))
        colors = [cm.jet(x) for x in eveny_spaced_interval]

    # plotly setup
    fig = go.Figure()

    # Add one more trace
    for indx in range(len(names)):
        fig.add_traces(go.line(y=MAPE_test[names[indx]], name=names[indx],
                               fillcolor='blue',
                               mode='lines',
                               line=dict(color=colors[indx])))

    # construct menus
    updatemenus = ['buttons': [{"method": 'update',
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                                "args": [{"y": [MAPE_test[names[indx]] for indx in range(len(names))]}]},
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