In [ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive",
force_remount=True).
```

In [ ]:
```
!pip install lightning
!pip install pytorch_forecasting
```

```
Requirement already satisfied: lightning in /usr/local/lib/python3.10/dist-packages (2.1.2)
Requirement already satisfied: PyYAML<8.0,>=5.4 in /usr/local/lib/python3.10/dist-packages (from lightning)
(6.0.1)
Requirement already satisfied: fsspec[http]<2025.0,>2021.06.0 in /usr/local/lib/python3.10/dist-packages (f
rom lightning) (2023.6.0)
Requirement already satisfied: lightning-utilities<2.0,>=0.8.0 in /usr/local/lib/python3.10/dist-packages
(from lightning) (0.10.0)
Requirement already satisfied: numpy<3.0,>=1.17.2 in /usr/local/lib/python3.10/dist-packages (from lightnin
g) (1.23.5)
Requirement already satisfied: packaging<25.0,>=20.0 in /usr/local/lib/python3.10/dist-packages (from light
ning) (23.2)
Requirement already satisfied: torch<4.0,>=1.12.0 in /usr/local/lib/python3.10/dist-packages (from lightnin
g) (2.1.0+cu121)
Requirement already satisfied: torchmetrics<3.0,>=0.7.0 in /usr/local/lib/python3.10/dist-packages (from li
ghtning) (1.2.1)
Requirement already satisfied: tqdm<6.0,>=4.57.0 in /usr/local/lib/python3.10/dist-packages (from lightnin
g) (4.66.1)
Requirement already satisfied: typing-extensions<6.0,>=4.0.0 in /usr/local/lib/python3.10/dist-packages (fr
om lightning) (4.9.0)
Requirement already satisfied: pytorch-lightning in /usr/local/lib/python3.10/dist-packages (from lightnin
g) (2.1.2)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from fsspec[http]<2025.
0,>2021.06.0->lightning) (2.31.0)
Requirement already satisfied: aiohttp!=4.0.0a0,!=4.0.0a1 in /usr/local/lib/python3.10/dist-packages (from
fsspec[http]<2025.0,>2021.06.0->lightning) (3.9.1)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from lightning-utilit
ies<2.0,>=0.8.0->lightning) (67.7.2)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch<4.0,>=1.12.0
->lightning) (3.13.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch<4.0,>=1.12.0->l
ightning) (1.12)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch<4.0,>=1.12.0
->lightning) (3.2.1)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch<4.0,>=1.12.0->
lightning) (3.1.2)
Requirement already satisfied: triton==2.1.0 in /usr/local/lib/python3.10/dist-packages (from torch<4.0,>=
1.12.0->lightning) (2.1.0)
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.
0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (23.1.0)
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.10/dist-packages (from aiohtt
p!=4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (6.0.4)
Requirement already satisfied: yarl<2.0,>=1.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.
0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (1.9.4)
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=
4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (1.4.0)
Requirement already satisfied: aiosignal>=1.1.2 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=
4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (1.3.1)
Requirement already satisfied: async-timeout<5.0,>=4.0 in /usr/local/lib/python3.10/dist-packages (from aio
http!=4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning) (4.0.3)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->tor
ch<4.0,>=1.12.0->lightning) (2.1.3)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from re
quests->fsspec[http]<2025.0,>2021.06.0->lightning) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->fssp
ec[http]<2025.0,>2021.06.0->lightning) (3.6)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests
->fsspec[http]<2025.0,>2021.06.0->lightning) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests
->fsspec[http]<2025.0,>2021.06.0->lightning) (2023.11.17)
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy->torch<
4.0,>=1.12.0->lightning) (1.3.0)
Requirement already satisfied: pytorch_forecasting in /usr/local/lib/python3.10/dist-packages (1.0.0)
Requirement already satisfied: fastapi>=0.80 in /usr/local/lib/python3.10/dist-packages (from pytorch_forec
asting) (0.105.0)
Requirement already satisfied: lightning<3.0.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from pyt
orch_forecasting) (2.1.2)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.10/dist-packages (from pytorch_forecast
ing) (3.7.1)
Requirement already satisfied: optuna<4.0.0,>=3.1.0 in /usr/local/lib/python3.10/dist-packages (from pytorc
h_forecasting) (3.5.0)
Requirement already satisfied: pandas<=3.0.0,>=1.3.0 in /usr/local/lib/python3.10/dist-packages (from pytor
ch_forecasting) (1.5.3)
Requirement already satisfied: pytorch-optimizer<3.0.0,>=2.5.1 in /usr/local/lib/python3.10/dist-packages
(from pytorch_forecasting) (2.12.0)
Requirement already satisfied: scikit-learn<2.0,>=1.2 in /usr/local/lib/python3.10/dist-packages (from pyto
```

```
rch_forecasting) (1.2.2)
Requirement already satisfied: scipy<2.0,>=1.8 in /usr/local/lib/python3.10/dist-packages (from pytorch_for
ecasting) (1.11.4)
Requirement already satisfied: statsmodels in /usr/local/lib/python3.10/dist-packages (from pytorch_forecas
ting) (0.14.0)
Requirement already satisfied: torch<3.0.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from pytorch
_forecasting) (2.1.0+cu121)
Requirement already satisfied: anyio<4.0.0,>=3.7.1 in /usr/local/lib/python3.10/dist-packages (from fastapi
>=0.80->pytorch_forecasting) (3.7.1)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4 in /usr/local/l
ib/python3.10/dist-packages (from fastapi>=0.80->pytorch_forecasting) (1.10.13)
Requirement already satisfied: starlette<0.28.0,>=0.27.0 in /usr/local/lib/python3.10/dist-packages (from f
astapi>=0.80->pytorch_forecasting) (0.27.0)
Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/python3.10/dist-packages (from fa
stapi>=0.80->pytorch_forecasting) (4.9.0)
Requirement already satisfied: PyYAML<8.0,>=5.4 in /usr/local/lib/python3.10/dist-packages (from lightning<
3.0.0,>=2.0.0->pytorch_forecasting) (6.0.1)
Requirement already satisfied: fsspec[http]<2025.0,>2021.06.0 in /usr/local/lib/python3.10/dist-packages (f
rom lightning<3.0.0,>=2.0.0->pytorch_forecasting) (2023.6.0)
Requirement already satisfied: lightning-utilities<2.0,>=0.8.0 in /usr/local/lib/python3.10/dist-packages
(from lightning<3.0.0,>=2.0.0->pytorch_forecasting) (0.10.0)
Requirement already satisfied: numpy<3.0,>=1.17.2 in /usr/local/lib/python3.10/dist-packages (from lightnin
g<3.0.0,>=2.0.0->pytorch_forecasting) (1.23.5)
Requirement already satisfied: packaging<25.0,>=20.0 in /usr/local/lib/python3.10/dist-packages (from light
ning<3.0.0,>=2.0.0->pytorch_forecasting) (23.2)
Requirement already satisfied: torchmetrics<3.0,>=0.7.0 in /usr/local/lib/python3.10/dist-packages (from li
ghtning<3.0.0,>=2.0.0->pytorch_forecasting) (1.2.1)
Requirement already satisfied: tqdm<6.0,>=4.57.0 in /usr/local/lib/python3.10/dist-packages (from lightning
<3.0.0,>=2.0.0->pytorch_forecasting) (4.66.1)
Requirement already satisfied: pytorch-lightning in /usr/local/lib/python3.10/dist-packages (from lightning
<3.0.0,>=2.0.0->pytorch_forecasting) (2.1.2)
Requirement already satisfied: alembic>=1.5.0 in /usr/local/lib/python3.10/dist-packages (from optuna<4.0.
0,>=3.1.0->pytorch_forecasting) (1.13.0)
Requirement already satisfied: colorlog in /usr/local/lib/python3.10/dist-packages (from optuna<4.0.0,>=3.
1.0->pytorch_forecasting) (6.8.0)
Requirement already satisfied: sqlalchemy>=1.3.0 in /usr/local/lib/python3.10/dist-packages (from optuna<4.
0.0,>=3.1.0->pytorch_forecasting) (2.0.23)
Requirement already satisfied: python-dateutil>=2.8.1 in /usr/local/lib/python3.10/dist-packages (from pand
as<=3.0.0,>=1.3.0->pytorch_forecasting) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas<=3.0.0,
>=1.3.0->pytorch_forecasting) (2023.3.post1)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn<
2.0,>=1.2->pytorch_forecasting) (1.3.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit
-learn<2.0,>=1.2->pytorch_forecasting) (3.2.0)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch<3.0.0,>=2.0.
0->pytorch_forecasting) (3.13.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch<3.0.0,>=2.0.0->
pytorch_forecasting) (1.12)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch<3.0.0,>=2.0.
0->pytorch_forecasting) (3.2.1)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch<3.0.0,>=2.0.0-
>pytorch_forecasting) (3.1.2)
Requirement already satisfied: triton==2.1.0 in /usr/local/lib/python3.10/dist-packages (from torch<3.0.0,>
=2.0.0->pytorch_forecasting) (2.1.0)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib
->pytorch_forecasting) (1.2.0)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib->py
torch_forecasting) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotli
b->pytorch_forecasting) (4.46.0)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotli
b->pytorch_forecasting) (1.4.5)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib->p
ytorch_forecasting) (9.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib
->pytorch_forecasting) (3.1.1)
Requirement already satisfied: patsy>=0.5.2 in /usr/local/lib/python3.10/dist-packages (from statsmodels->p
ytorch_forecasting) (0.5.4)
Requirement already satisfied: Mako in /usr/local/lib/python3.10/dist-packages (from alembic>=1.5.0->optuna
<4.0.0,>=3.1.0->pytorch_forecasting) (1.3.0)
Requirement already satisfied: idna>=2.8 in /usr/local/lib/python3.10/dist-packages (from anyio<4.0.0,>=3.
7.1->fastapi>=0.80->pytorch_forecasting) (3.6)
Requirement already satisfied: sniffio>=1.1 in /usr/local/lib/python3.10/dist-packages (from anyio<4.0.0,>=
3.7.1->fastapi>=0.80->pytorch_forecasting) (1.3.0)
```

```
Requirement already satisfied: exceptiongroup in /usr/local/lib/python3.10/dist-packages (from anyio<4.0.0,
>=3.7.1->fastapi>=0.80->pytorch_forecasting) (1.2.0)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from fsspec[http]<2025.
0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (2.31.0)
Requirement already satisfied: aiohttp!=4.0.0a0,!=4.0.0a1 in /usr/local/lib/python3.10/dist-packages (from
fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (3.9.1)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from lightning-utilit
ies<2.0,>=0.8.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (67.7.2)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (from patsy>=0.5.2->statsmode
ls->pytorch_forecasting) (1.16.0)
Requirement already satisfied: greenlet!=0.4.17 in /usr/local/lib/python3.10/dist-packages (from sqlalchemy
>=1.3.0->optuna<4.0.0,>=3.1.0->pytorch_forecasting) (3.0.2)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->tor
ch<3.0.0,>=2.0.0->pytorch_forecasting) (2.1.3)
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy->torch<
3.0.0,>=2.0.0->pytorch_forecasting) (1.3.0)
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.
0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (23.1.0)
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.10/dist-packages (from aiohtt
p!=4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (6.0.4)
Requirement already satisfied: yarl<2.0,>=1.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.
0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (1.9.4)
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=
4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (1.4.0)
Requirement already satisfied: aiosignal>=1.1.2 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=
4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (1.3.1)
Requirement already satisfied: async-timeout<5.0,>=4.0 in /usr/local/lib/python3.10/dist-packages (from aio
http!=4.0.0a0,!=4.0.0a1->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (4.
0.3)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from re
quests->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (3.3.2)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests
->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests
->fsspec[http]<2025.0,>2021.06.0->lightning<3.0.0,>=2.0.0->pytorch_forecasting) (2023.11.17)
```

In [ ]:
```
import lightning.pytorch as pl
from lightning.pytorch.callbacks import EarlyStopping, LearningRateMonitor
from lightning.pytorch.loggers import TensorBoardLogger
import numpy as np
import pandas as pd
import torch

import optuna
from optuna.integration import PyTorchLightningPruningCallback


from pytorch_forecasting import Baseline, TemporalFusionTransformer, TimeSeriesDataSet
from pytorch_forecasting.data import GroupNormalizer, TorchNormalizer, MultiNormalizer,EncoderNormalizer
from pytorch_forecasting.metrics import MAE, SMAPE, PoissonLoss, QuantileLoss, MAPE, MultivariateNormalDist

import pandas as pd
import numpy as np


#from pytorch_forecasting.models.temporal_fusion_transformer.tuning import optimize_hyperparameters
```

Creating Multi Step Dataset

In [ ]:
```
df    = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMH_Clean_UCI_Power_Consumpti
cpi   = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YM_Clean_France_CPI_Electric
temp  = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMH_Clean_TempISD.csv")
cci   = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YM_Clean_CCI.csv")
gt1   = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMW_Clean_GoogleTrends1.csv")
gt2   = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMW_Clean_GoogleTrends2.csv")
gt3   = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMW_Clean_GoogleTrends3.csv")
```

```
<ipython-input-33-968a71a3a344>:1: DtypeWarning: Columns (2,3,4,5,6,7) have mixed types. Specify dtype opti
on on import or set low_memory=False.
  df    = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMH_Clean_UCI_Power_Consump
tion_Dataset.csv")
<ipython-input-33-968a71a3a344>:3: DtypeWarning: Columns (20) have mixed types. Specify dtype option on imp
ort or set low_memory=False.
  temp  = pd.read_csv("/content/drive/MyDrive/BDA696Project/Datasets/processsed/YMH_Clean_TempISD.csv")
```

In [ ]:
```
ISD = pd.read_csv('/content/drive/MyDrive/BDA696Project/TFT_Model_Datasets/ISD_cleaned.csv')
ISD['Date'] = pd.to_datetime(ISD['New_Date'])
ISD=ISD[['Date','Wind_Speed_Norm','Prec_Depth_Norm','Air_Temp_Norm']]
# ISD = ISD.drop_duplicates(subset='New_Date', keep='first')
# ISD.sort_values(by='New_Date', ascending = False)
# Wind_Speed_Agg = ISD.resample('D', on='New_Date').Wind_Speed_Norm.mean()
# Prec_Depth_Agg = ISD.resample('D', on='New_Date').Prec_Depth_Norm.mean()
# Air_Temp_Agg = ISD.resample('D', on='New_Date').Air_Temp_Norm.mean()
```

```
<ipython-input-34-a0624b3daacb>:1: DtypeWarning: Columns (27) have mixed types. Specify dtype option on imp
ort or set low_memory=False.
  ISD = pd.read_csv('/content/drive/MyDrive/BDA696Project/TFT_Model_Datasets/ISD_cleaned.csv')
```

In [ ]:
```
# df    = pd.read_csv("Downloads/processsed/YMH_Clean_UCI_Power_Consumption_Dataset.csv")
# cpi   = pd.read_csv("Downloads/processsed/YM_Clean_France_CPI_Electricity.csv")
# temp  = pd.read_csv("Downloads/processsed/YMH_Clean_TempISD.csv")
# cci   = pd.read_csv("Downloads/processsed/YM_Clean_CCI.csv")
# gt1   = pd.read_csv("Downloads/processsed/YMW_Clean_GoogleTrends1.csv")
# gt2   = pd.read_csv("Downloads/processsed/YMW_Clean_GoogleTrends2.csv")
# gt3   = pd.read_csv("Downloads/processsed/YMW_Clean_GoogleTrends3.csv")
```

In [ ]:
```
df['Date'] = pd.to_datetime(df['Date'])
df=df.query('(Date.dt.hour==0 or Date.dt.hour==6 or Date.dt.hour==12 or Date.dt.hour==18) and Date.dt.minut
df=df.replace('?',0.0)
df.head()
```

Out[ ]:

	Date	Time	Global_active_power	Global_reactive_power	Voltage	Global_intensity	Sub_metering_1	Sub_
0	2007-01-01 00:00:00	00:00:00	2.580	0.136	241.970	10.600	0.000	
360	2007-01-01 06:00:00	06:00:00	2.460	0.064	241.130	10.200	0.000	
720	2007-01-01 12:00:00	12:00:00	2.478	0.000	235.300	10.400	0.000	
1080	2007-01-01 18:00:00	18:00:00	1.416	0.000	239.130	5.800	0.000	
1440	2007-01-02 00:00:00	00:00:00	0.442	0.122	241.060	1.800	0.000	

Creating and using function to foward fill weekly and monthly values

In [ ]:
```
def fillblanks(df_temp):
  temp = pd.DataFrame(pd.date_range(start=df_temp['Date'].min(), end= df_temp['Date'].max()),columns=['Date
  temp['Date'] = pd.to_datetime(temp['Date'])
  temp = temp.merge(df_temp, on='Date', how='left')
  temp = temp.replace(0, np.nan).ffill()
  return temp
```

In [ ]:
```
#temp['Date'] = pd.to_datetime(cci['Date'])
#df=pd.merge_asof(df,temp, on='Date')

#df.dtypes

cpi['Date'] = pd.to_datetime(cpi['Date'])
df=df.merge(fillblanks(cpi), on='Date', how='left')
df['CPI'] = df['CPI'].replace(0, np.nan).ffill()
```

```
cci['Date'] = pd.to_datetime(cci['Date'])
df=df.merge(fillblanks(cci), on='Date', how='left')
df['CCI'] = df['CCI'].replace(0, np.nan).ffill()

ISD['Date'] = pd.to_datetime(ISD['Date'])
df=df.merge(fillblanks(ISD), on='Date', how='left')
df['Wind_Speed_Norm'] = df['Wind_Speed_Norm'].replace(0, np.nan).ffill()
df['Prec_Depth_Norm'] = df['Prec_Depth_Norm'].replace(0, np.nan).ffill()
df['Air_Temp_Norm'] = df['Air_Temp_Norm'].replace(0, np.nan).ffill()


gt1['Date'] = pd.to_datetime(gt1['Date'])
df=df.merge(fillblanks(gt1), on='Date', how='left')
df['GT1_Hits'] = df['GT1_Hits'].replace(0, np.nan).ffill()


gt2['Date'] = pd.to_datetime(gt2['Date'])
df=df.merge(fillblanks(gt2), on='Date', how='left')
df['GT2_Hits'] = df['GT2_Hits'].replace(0, np.nan).ffill()


gt3['Date'] = pd.to_datetime(gt3['Date'])
df=df.merge(fillblanks(gt3), on='Date', how='left')
df['GT3_Hits'] = df['GT3_Hits'].replace(0, np.nan).ffill()
```

In [ ]:
```
df=df.fillna(value=0)
```

In [ ]:
```
earliest_time= df['Date'].min()
```

In [ ]:
```
df["day_of_week"] = df['Date'].dt.dayofweek.astype(str) # categories have be strings
df["week_of_year"] = df['Date'].dt.isocalendar().week.astype(str)  # categories have be strings
df["month"] = df['Date'].dt.month.astype(str)
df['hour'] = df['Date'].dt.hour.astype(str)
df['day'] = df['Date'].dt.day.astype(str)
df['year'] = df['Date'].dt.year-2006
df['year']=df['year'].astype('int')
#df['minute'] = df['Date'].dt.minute.astype(str).astype("int")
df['time_idx']=df.index
df['hours_from_start'] = (df['Date'] - earliest_time).dt.seconds / 60 / 60 + (df['Date'] - earliest_time).d
df['hours_from_start'] = df['hours_from_start'].astype('int')
df['days_from_start'] = (df['Date'] - earliest_time).dt.days
df['group']=0
df['Global_active_power']=df['Global_active_power'].astype("float64")
df['Voltage']=df['Voltage'].astype("float64")
df['Global_intensity']=df['Global_intensity'].astype("float64")
df['Sub_metering_1']=df['Sub_metering_1'].astype("float64")
df['Sub_metering_2']=df['Sub_metering_2'].astype("float64")
df['Wind_Speed_Norm'] = df['Wind_Speed_Norm'].astype("float64")
df['Prec_Depth_Norm'] = df['Prec_Depth_Norm'].astype("float64")
df['Air_Temp_Norm'] = df['Air_Temp_Norm'].astype("float64")


time_df = df[[
    'Global_active_power'
    ,'Sub_metering_1'
    ,'Sub_metering_2'
    ,'Sub_metering_3'
,'CPI'
,'CCI'
,'GT1_Hits'
,'GT2_Hits'
,'GT3_Hits'
,'Wind_Speed_Norm'
,'Prec_Depth_Norm'
,'Air_Temp_Norm'
,'day_of_week'
,'week_of_year'
,'year'
,'month'
,'hour'
,'day'
,'time_idx'
,'days_from_start'
```

```
,'group'
,'Date'
]]
df.dtypes
```

Out[ ]:
```
Date                    datetime64[ns]
Time                            object
Global_active_power            float64
Global_reactive_power           object
Voltage                        float64
Global_intensity               float64
Sub_metering_1                 float64
Sub_metering_2                 float64
Sub_metering_3                 float64
CPI                            float64
CCI                            float64
Wind_Speed_Norm                float64
Prec_Depth_Norm                float64
Air_Temp_Norm                  float64
GT1_Hits                       float64
GT2_Hits                       float64
GT3_Hits                       float64
day_of_week                     object
week_of_year                    object
month                           object
hour                            object
day                             object
year                             int64
time_idx                         int64
hours_from_start                 int64
days_from_start                  int64
group                            int64
dtype: object
```

In [ ]:
```
time_df.isna().values.sum()
```

Out[ ]:
```
0
```

In [ ]:
```
time_df.head()
```

Out[ ]:

	Global_active_power	Sub_metering_1	Sub_metering_2	Sub_metering_3	CPI	CCI	GT1_Hits	GT2_Hits	GT3_Hits
0	2.580	0.0	0.0	0.0	72.71	100.0	45.0	41.0	0.0
1	2.460	0.0	0.0	0.0	72.71	100.0	45.0	41.0	0.0
2	2.478	0.0	0.0	0.0	72.71	100.0	45.0	41.0	0.0
3	1.416	0.0	0.0	17.0	72.71	100.0	45.0	41.0	0.0
4	0.442	0.0	0.0	0.0	72.71	100.0	45.0	41.0	0.0

5 rows × 22 columns

Setting up Time Series DataLoaders

In [ ]:
```
#Hyperparameters
#batch size=64
#number heads=4, hidden sizes=160, lr=0.001, gr_clip=0.1

max_prediction_length = 4*7*4*6 #sixmonths
max_encoder_length = 4*365 #one year
training_cutoff = time_df["time_idx"].max() - max_prediction_length
```

```
training = TimeSeriesDataSet(
    time_df[lambda x: x.time_idx <= training_cutoff],
    time_idx="time_idx",
    target="Global_active_power",
    group_ids=['group'],
    min_encoder_length=4*7, #one week
    max_encoder_length=max_encoder_length,
    min_prediction_length=4, #one day
    max_prediction_length=max_prediction_length,
    #static_categoricals=["consumer_id"],
    time_varying_known_categoricals=["day","day_of_week", "month", 'hour' ], #year to be added
    time_varying_known_reals=["time_idx",'year'],
    time_varying_unknown_reals=['Sub_metering_1', 'Sub_metering_2', 'Sub_metering_3','CPI','CCI','GT1_Hits
    target_normalizer=GroupNormalizer(
          groups=["group"], transformation="softplus"
      ),  # we normalize by group
    add_relative_time_idx=True,
    add_target_scales=True,
    add_encoder_length=True,
    #add_nan=True,
    allow_missing_timesteps=True
)


validation = TimeSeriesDataSet.from_dataset(training, time_df, predict=True, stop_randomization=True)

# create dataloaders for  our model
batch_size = 64
# if you have a strong GPU, feel free to increase the number of workers
train_dataloader = training.to_dataloader(train=True, batch_size=batch_size, num_workers=10)
val_dataloader = validation.to_dataloader(train=False, batch_size=batch_size * 10, num_workers=10)
```

```
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:557: UserWarning: This DataLoader wi
ll create 10 worker processes in total. Our suggested max number of worker in current system is 8, which is
smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might
get DataLoader running slow or even freeze, lower the worker number to avoid potential slowness/freeze if n
ecessary.
  warnings.warn(_create_warning_msg(
```

[I 2023-12-10 07:14:28,911] Trial 3 finished with value: 0.31155362725257874 and parameters: {'gradient_clip_val': 0.8223697202530604, 'hidden_size': 22, 'dropout': 0.2972505585187706, 'hidden_continuous_size': 9, 'attention_head_size': 1, 'learning_rate': 0.014035308702029799}. Best is trial 2 with value: 0.29049456119537354.

Saving the Model

In [ ]:
```
#!unzip /content/drive/MyDrive/BDA696Project/Model/model.zip
#torch.save(best_tft.state_dict(), path)
```

In [ ]:
```
best_model_path='/content/drive/MyDrive/BDA696Project/Model/model_saved/lightning_logs/lightning_logs/vers
best_tft = TemporalFusionTransformer.load_from_checkpoint(best_model_path)
```

```
/usr/local/lib/python3.10/dist-packages/lightning/pytorch/utilities/parsing.py:198: Attribute 'loss' is an
instance of `nn.Module` and is already saved during checkpointing. It is recommended to ignore them using `
self.save_hyperparameters(ignore=['loss'])`.
/usr/local/lib/python3.10/dist-packages/lightning/pytorch/utilities/parsing.py:198: Attribute 'logging_metr
ics' is an instance of `nn.Module` and is already saved during checkpointing. It is recommended to ignore t
hem using `self.save_hyperparameters(ignore=['logging_metrics'])`.
```

In [ ]:
```
#Take a look at what the raw_predictions variable contains

raw_predictions = best_tft.predict(val_dataloader, mode="raw", return_x=True)
print(raw_predictions._fields)
#('output', 'x', 'index', 'decoder_lengths', 'y')

print('\n')
#print(raw_predictions.output._fields)
# ('prediction',
# 'encoder_attention',
# 'decoder_attention',
# 'static_variables',
# 'encoder_variables',
```

```
# 'decoder_variables',
# 'decoder_lengths',
# 'encoder_lengths')

print('\n')
#print(raw_predictions.output.prediction.shape)
#torch.Size([5, 24, 7])

# We get predictions of 5 time-series for 24 days.
# For each day we get 7 predictions - these are the 7 quantiles:
#[0.02, 0.1, 0.25, 0.5, 0.75, 0.9, 0.98]
# We are mostly interested in the 4th quantile which represents, let's say, the 'median loss'
# fyi, although docs use the term quantiles, the most accurate term are percentiles

# We get predictions of 5 time-series for 24 days.
# For each day we get 7 predictions - these are the 7 quantiles:
#[0.02, 0.1, 0.25, 0.5, 0.75, 0.9, 0.98]
# We are mostly interested in the 4th quantile which represents, let's say, the 'median loss'
# fyi, although docs use the term quantiles, the most accurate term are percentiles
```

```
INFO: GPU available: True (cuda), used: True
INFO:lightning.pytorch.utilities.rank_zero:GPU available: True (cuda), used: True
INFO: TPU available: False, using: 0 TPU cores
INFO:lightning.pytorch.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO: IPU available: False, using: 0 IPUs
INFO:lightning.pytorch.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO: HPU available: False, using: 0 HPUs
INFO:lightning.pytorch.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO: LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:lightning.pytorch.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:557: UserWarning: This DataLoader wi
ll create 10 worker processes in total. Our suggested max number of worker in current system is 8, which is
smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might
get DataLoader running slow or even freeze, lower the worker number to avoid potential slowness/freeze if n
ecessary.
  warnings.warn(_create_warning_msg(
('output', 'x', 'index', 'decoder_lengths', 'y')
```

Loss Comparision: TFT VS Baseline

Using 'prediction' mode for calculating loss function

In [ ]:
```
actuals = torch.cat([y[0] for x, y in iter(val_dataloader)])
predictions = best_tft.predict(val_dataloader, mode="prediction").to('cpu')
baseline_predictions = Baseline().predict(val_dataloader).to('cpu')
```

```
INFO: GPU available: True (cuda), used: True
INFO:lightning.pytorch.utilities.rank_zero:GPU available: True (cuda), used: True
INFO: TPU available: False, using: 0 TPU cores
INFO:lightning.pytorch.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO: IPU available: False, using: 0 IPUs
INFO:lightning.pytorch.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO: HPU available: False, using: 0 HPUs
INFO:lightning.pytorch.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO: LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:lightning.pytorch.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO: GPU available: True (cuda), used: True
INFO:lightning.pytorch.utilities.rank_zero:GPU available: True (cuda), used: True
INFO: TPU available: False, using: 0 TPU cores
INFO:lightning.pytorch.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO: IPU available: False, using: 0 IPUs
INFO:lightning.pytorch.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO: HPU available: False, using: 0 HPUs
INFO:lightning.pytorch.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO: LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:lightning.pytorch.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
```

MAE

In [ ]:
```
mae_loss = MAE()
print(f"TFT: {mae_loss.loss(actuals, predictions).mean(axis = 1).median().item()}")
print(f"Baseline: {mae_loss.loss(actuals, baseline_predictions).mean(axis = 1).median().item()}")
```

```
TFT: 0.549065113067627
Baseline: 0.5105714201927185
```

SMAPE

In [ ]:
```
sm = SMAPE()
print(f"TFT: {sm.loss(actuals, predictions).mean(axis = 1).median().item()}")
print(f"Baseline: {sm.loss(actuals, baseline_predictions).mean(axis = 1).median().item()}")
```

```
TFT: 0.6751478910446167
Baseline: 0.729117214679718
```

MAPE

In [ ]:
```
mape = MAPE()
print(f"TFT: {mape.loss(actuals, predictions).mean(axis = 1).median().item()}")
print(f"Baseline: {mape.loss(actuals, baseline_predictions).mean(axis = 1).median().item()}")
```

```
TFT: 0.9968411326408386
Baseline: 1.7605912685394287
```

Poisson Loss

In [ ]:
```
pl = PoissonLoss()
print(f"TFT: {pl.loss(actuals, predictions).mean(axis = 1).median().item()}")
print(f"Baseline: {pl.loss(actuals, baseline_predictions).mean(axis = 1).median().item()}")
```

```
TFT: 3.1876018047332764
Baseline: 3.5891759395599365
```

Quantile Loss

In [ ]:
```
ql = QuantileLoss()
print(f"TFT: {ql.loss(actuals.view(1, -1),predictions.view(1, -1)).mean().item()}")
print(f"Baseline: {ql.loss(actuals.view(1, -1),baseline_predictions.view(1, -1)).mean().item()}")
```

```
TFT: 0.9532883763313293
Baseline: 1.0016515254974365
```

Observed vs Predicted

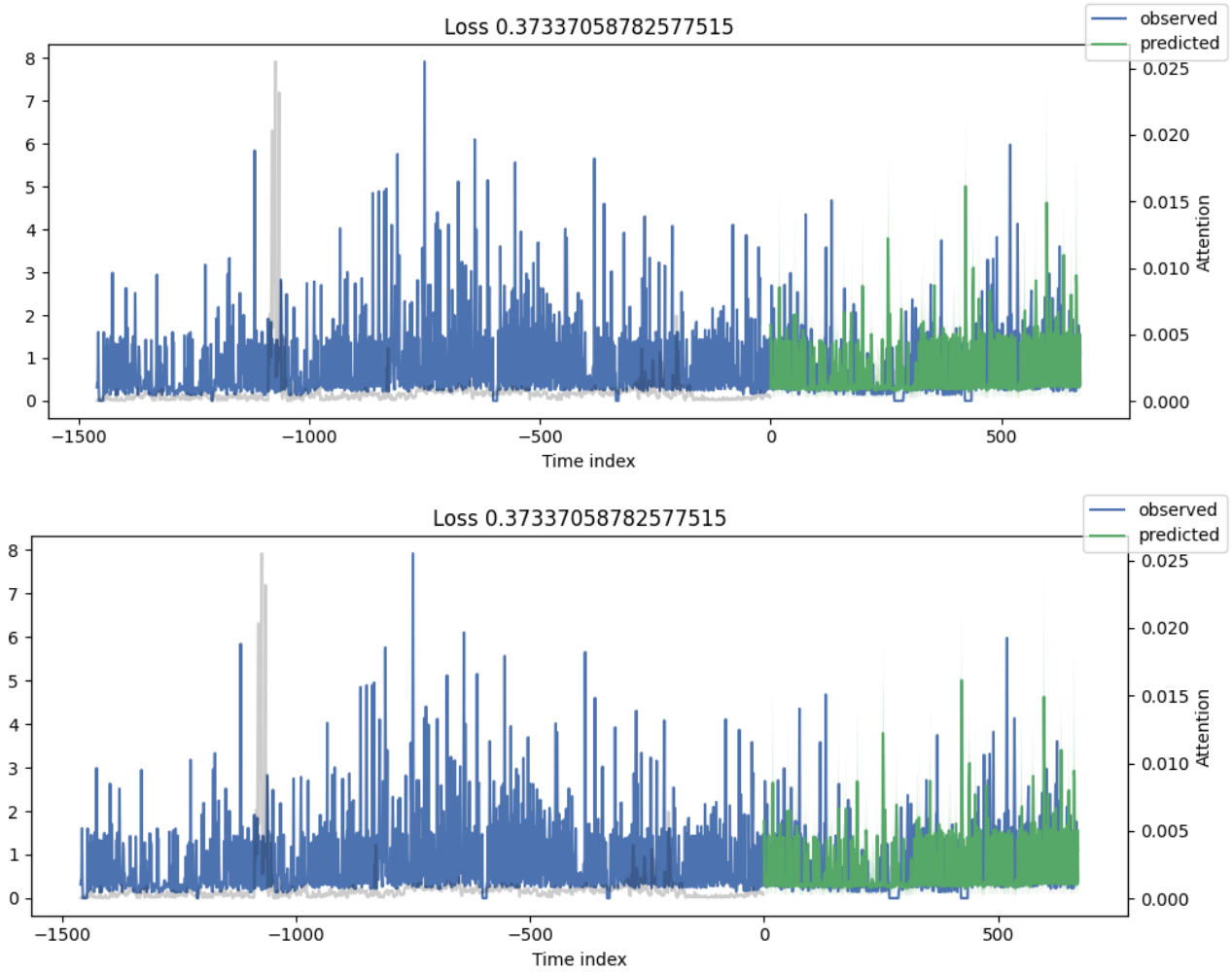
Using 'raw' mode

In [ ]:
```
import matplotlib.pyplot as plt
import seaborn as sns

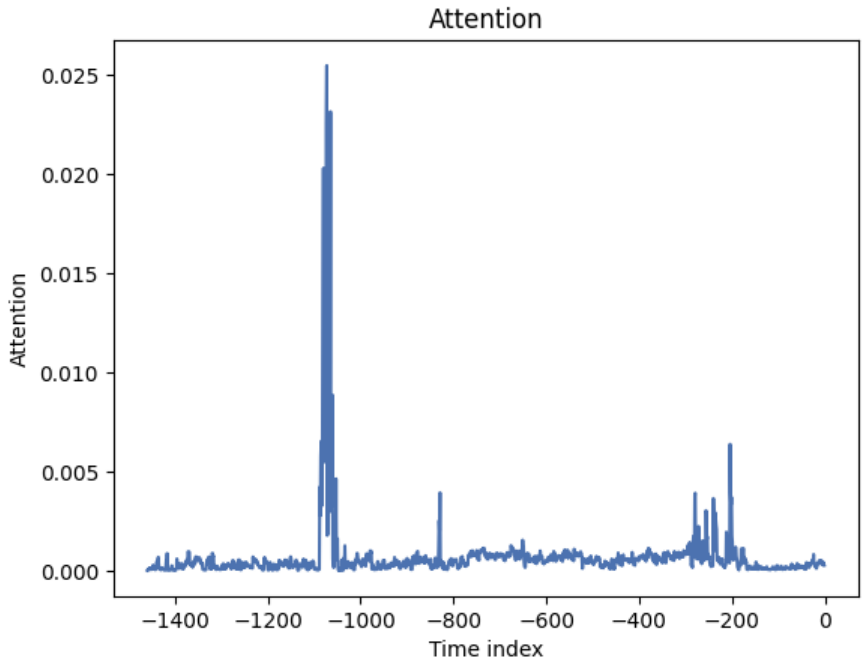
plt.style.use('seaborn-deep')
fig, ax = plt.subplots(figsize=(10, 4))
best_tft.plot_prediction(raw_predictions.x, raw_predictions.output, idx=0, add_loss_to_title=True,ax=ax)
```

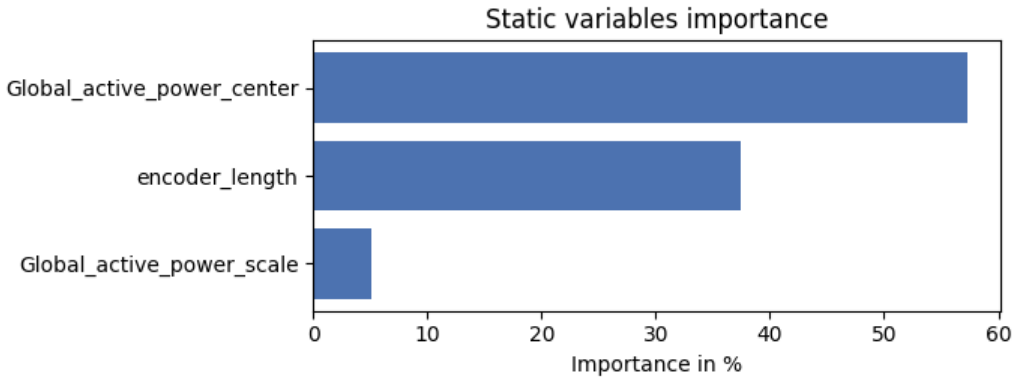
```
<ipython-input-54-86e257ce8775>:4: MatplotlibDeprecationWarning: The seaborn styles shipped by Matplotlib a
re deprecated since 3.6, as they no longer correspond to the styles shipped by seaborn. However, they will
remain available as 'seaborn-v0_8-<style>'. Alternatively, directly use the seaborn API instead.
  plt.style.use('seaborn-deep')
```

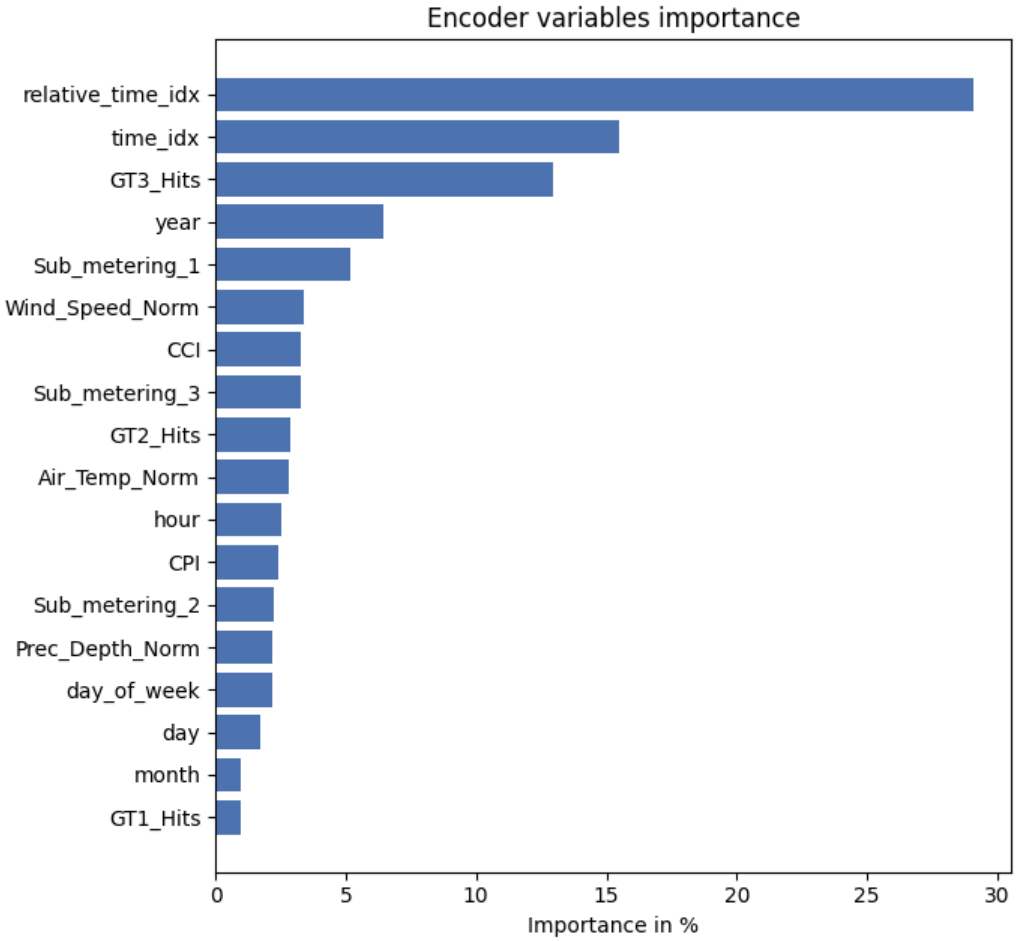
Out[ ]:

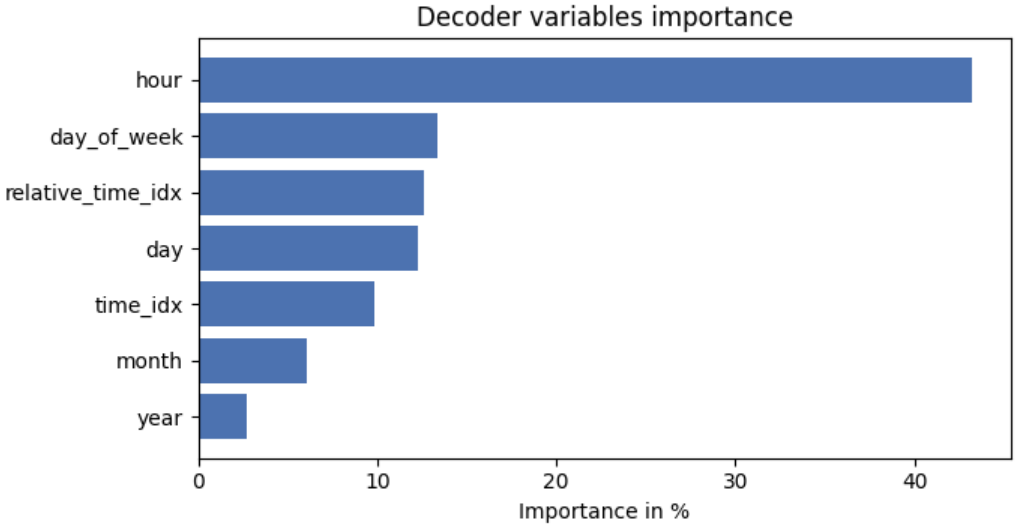


In [ ]:
```
interpretation = best_tft.interpret_output(raw_predictions.output, reduction="sum")
#interpretation
plt.show(best_tft.plot_interpretation(interpretation))
```




Static variables importance
Global_active_power_center
encoder_length
Global_active_power_scale
0
10
20
30
40
50
60
Importance in %


Encoder variables importance
relative_time_idx
time_idx
GT3_Hits
year
Sub_metering_1
Wind_Speed_Norm
CCI
Sub_metering_3
GT2_Hits
Air_Temp_Norm
hour
CPI
Sub_metering_2
Prec_Depth_Norm
day_of_week
day
month
GT1_Hits
0
5
10
15
20
25
30
Importance in %

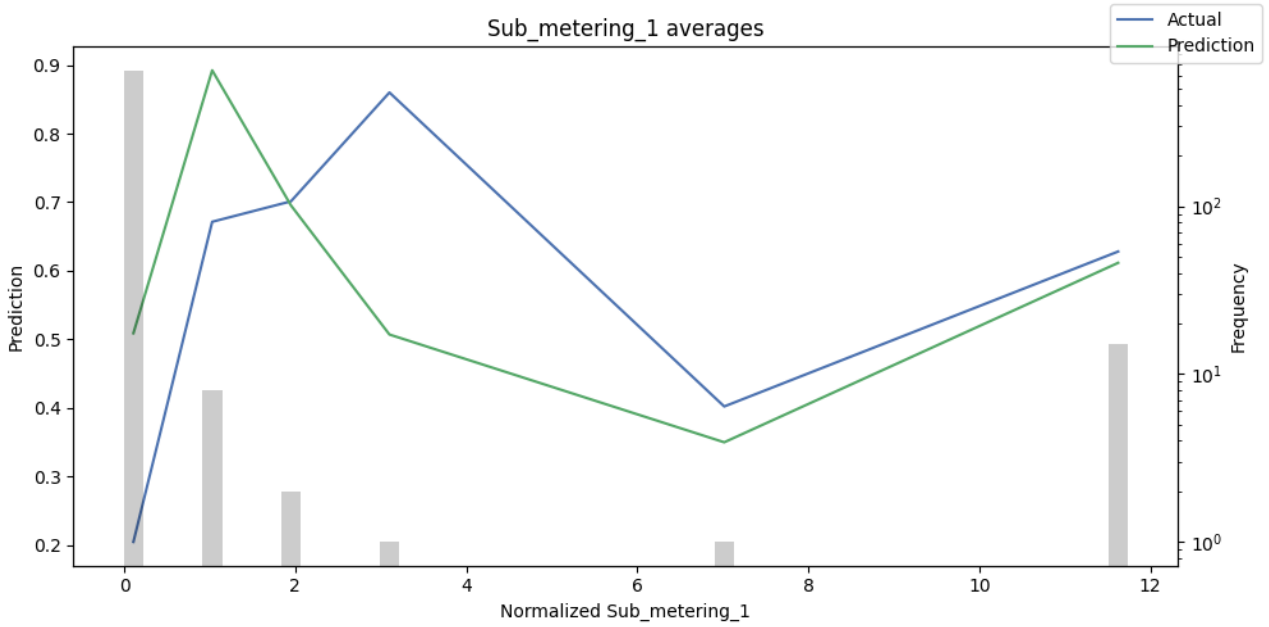

Decoder variables importance
hour
day_of_week
relative_time_idx
day
time_idx
month
year
0
10
20
30
40
Importance in %

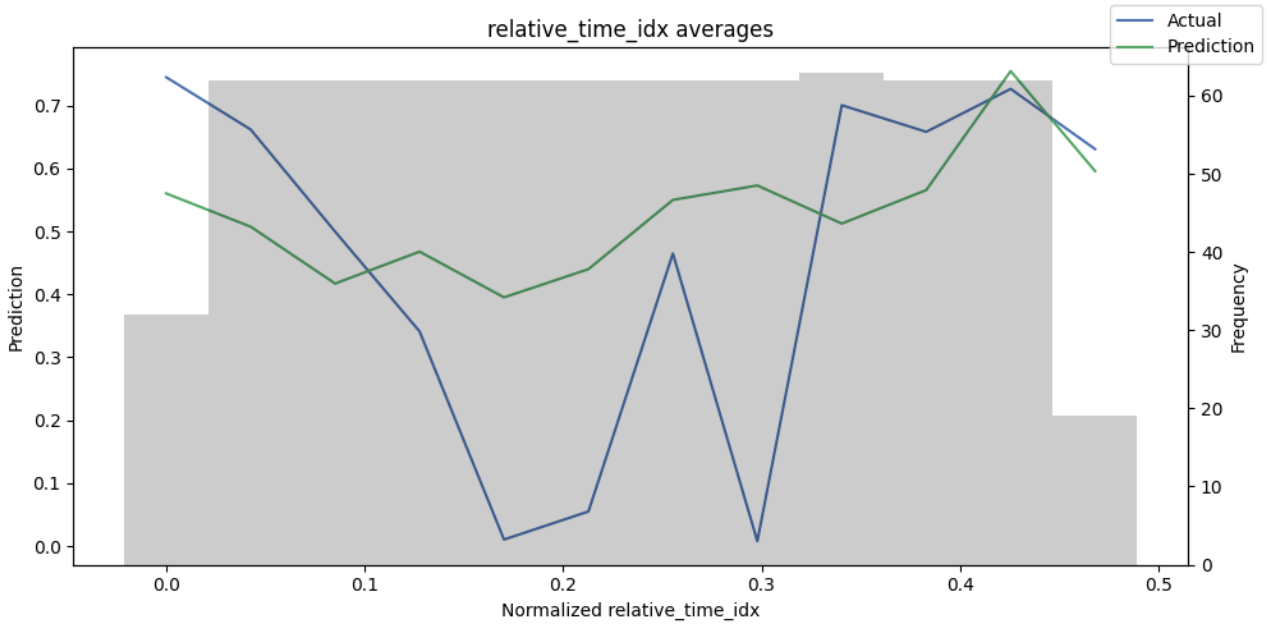
Using 'prediction' mode

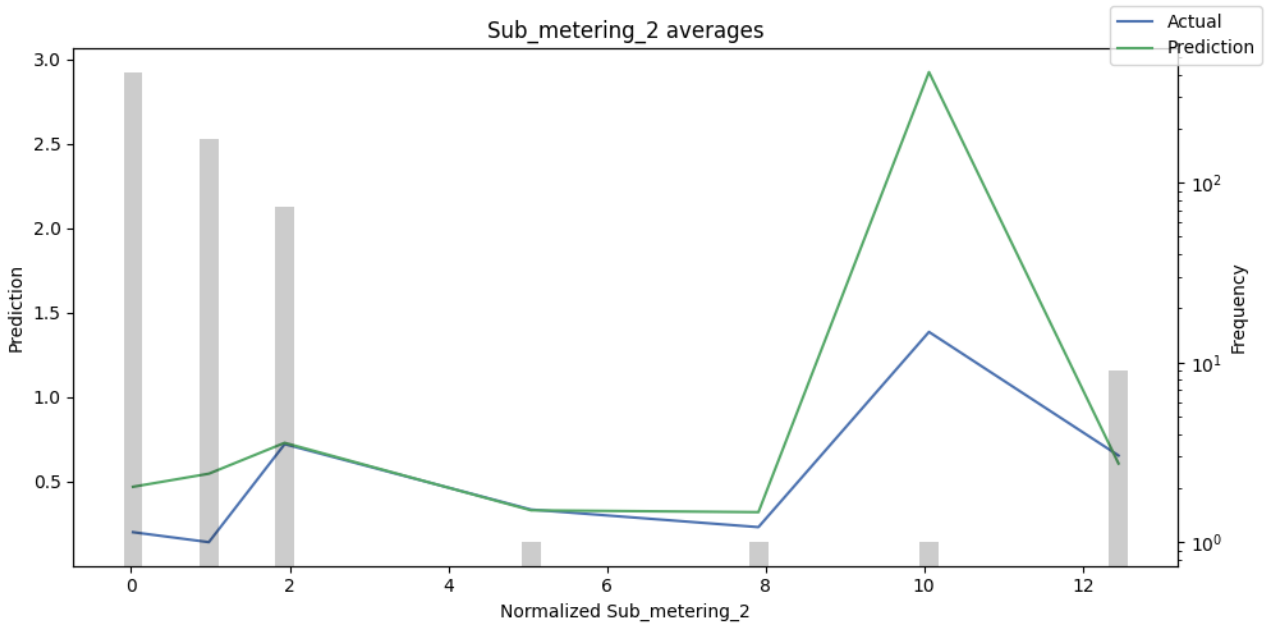
In [ ]:
```
predictions=best_tft.predict(val_dataloader,mode='prediction',return_x=True)
```

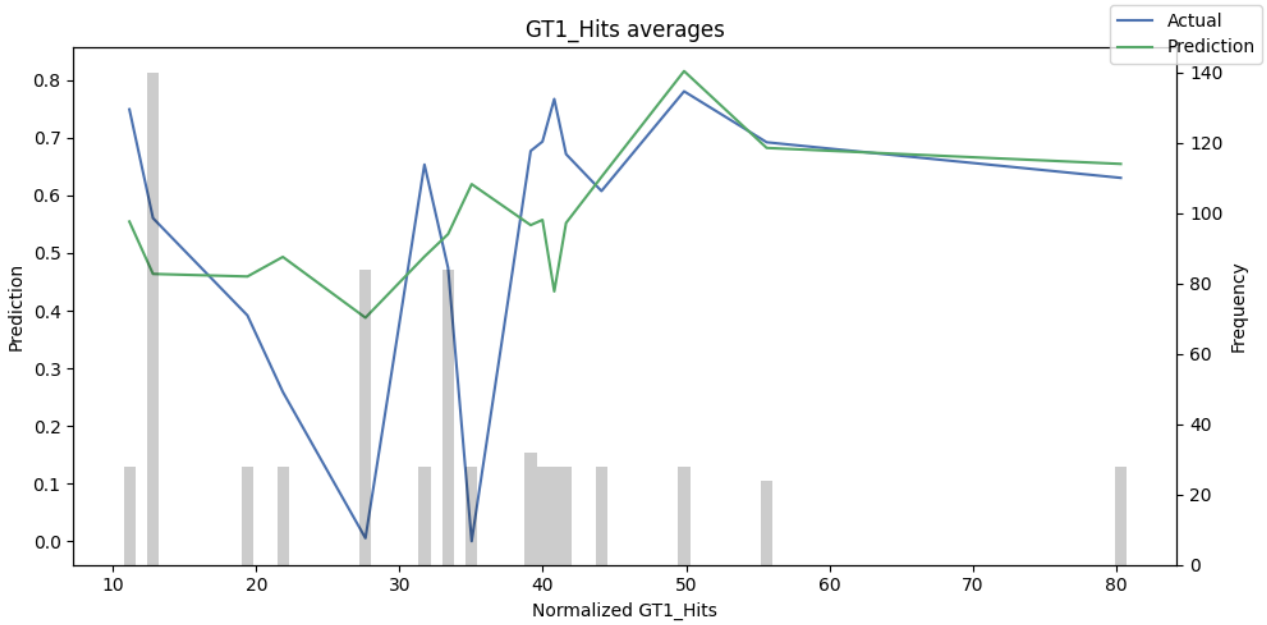
```
INFO: GPU available: True (cuda), used: True
INFO:lightning.pytorch.utilities.rank_zero:GPU available: True (cuda), used: True
INFO: TPU available: False, using: 0 TPU cores
INFO:lightning.pytorch.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO: IPU available: False, using: 0 IPUs
INFO:lightning.pytorch.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO: HPU available: False, using: 0 HPUs
INFO:lightning.pytorch.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO: LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:lightning.pytorch.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/torch/utils/data/dataloader.py:557: UserWarning: This DataLoader wi
ll create 10 worker processes in total. Our suggested max number of worker in current system is 8, which is
smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might
get DataLoader running slow or even freeze, lower the worker number to avoid potential slowness/freeze if n
ecessary.
  warnings.warn(_create_warning_msg(
```

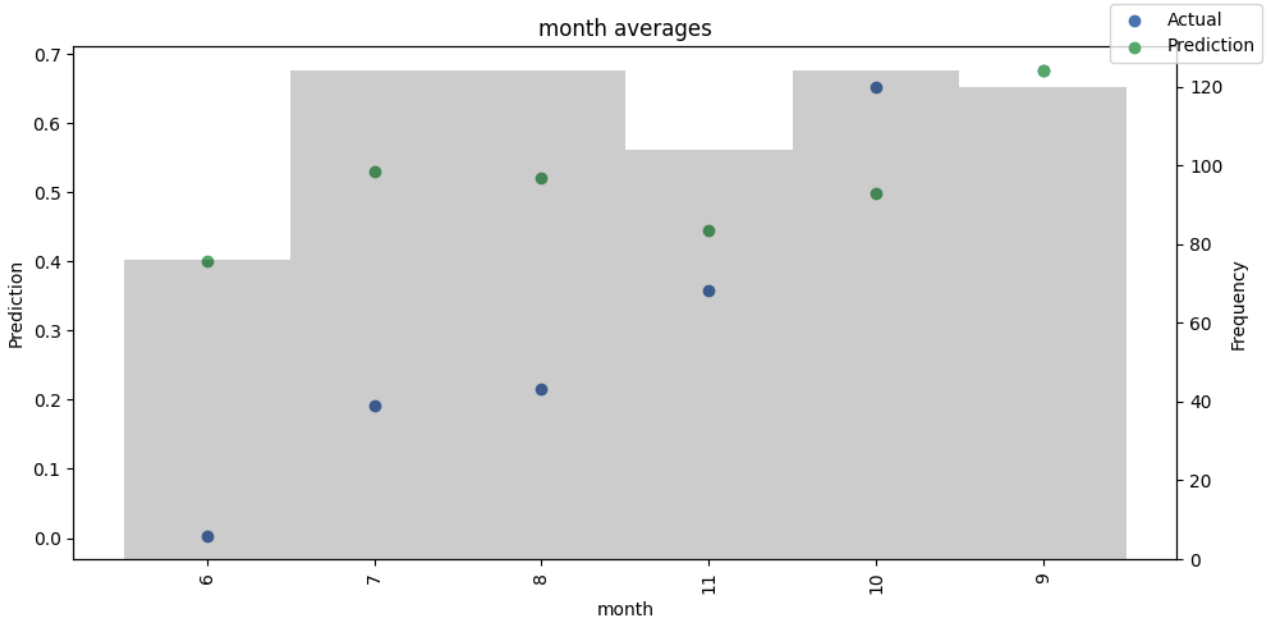
In [ ]:
```
predictions_vs_actuals = best_tft.calculate_prediction_actual_by_variable(predictions.x, predictions.output
all_features = list(set(predictions_vs_actuals['support'].keys())-set(['year', 'encoder_length', 'Global_a
for feature in all_features:
    best_tft.plot_prediction_actual_by_variable(predictions_vs_actuals, name=feature);
```

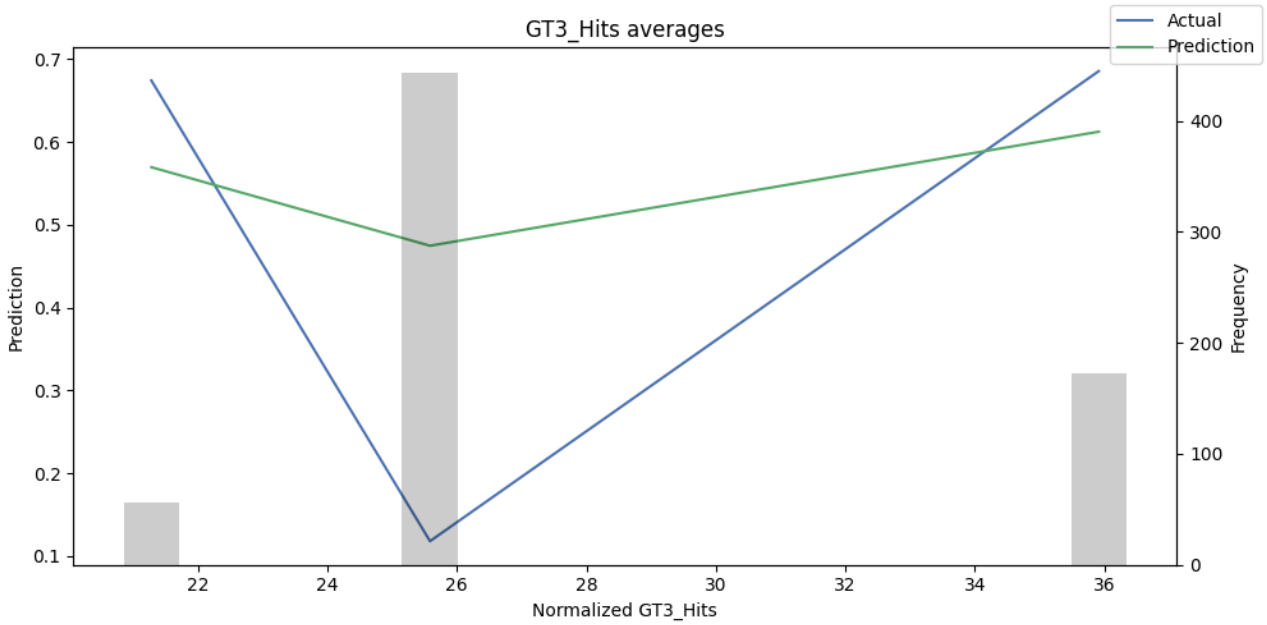


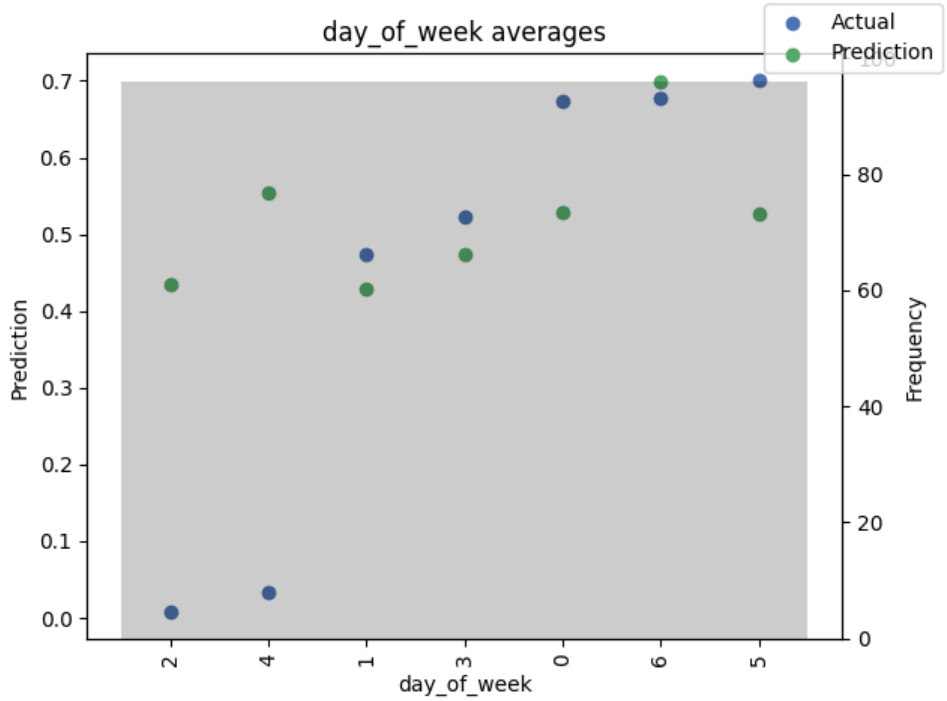

relative_time_idx averages
Actual
Prediction
Prediction
Frequency
Normalized relative_time_idx
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60

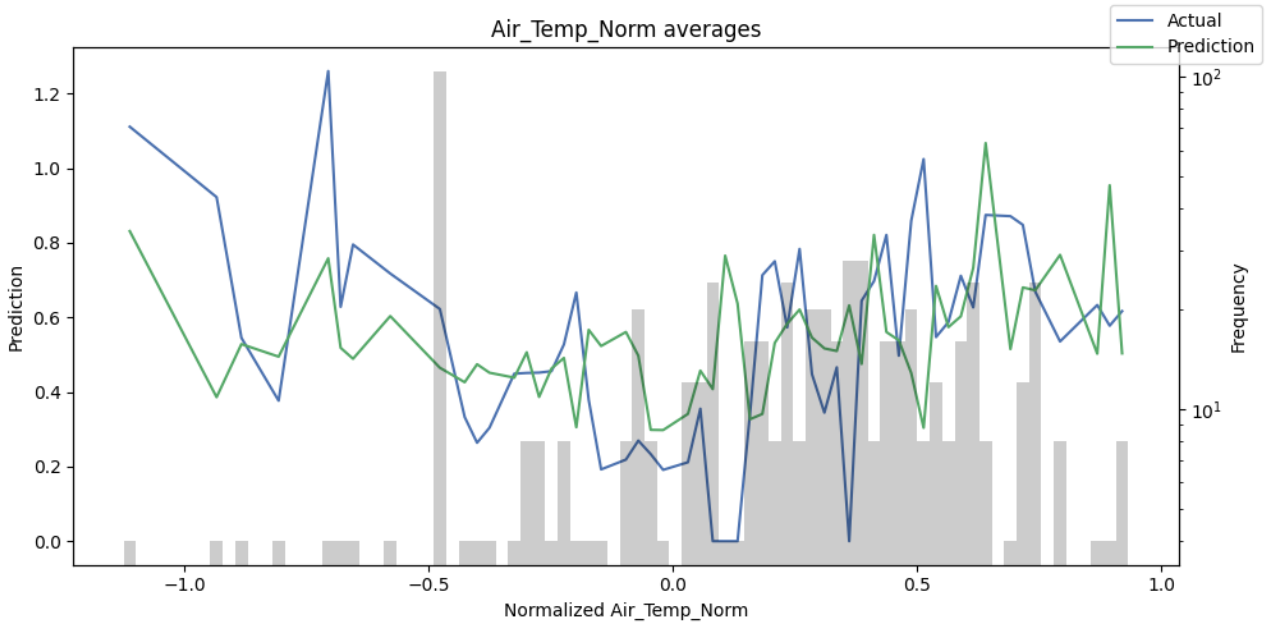

Sub_metering_2 averages
Actual
Prediction
Prediction
Frequency
Normalized Sub_metering_2
0
2
4
6
8
10
12
0.5
1.0
1.5
2.0
2.5
3.0
10^0
10^1
10^2

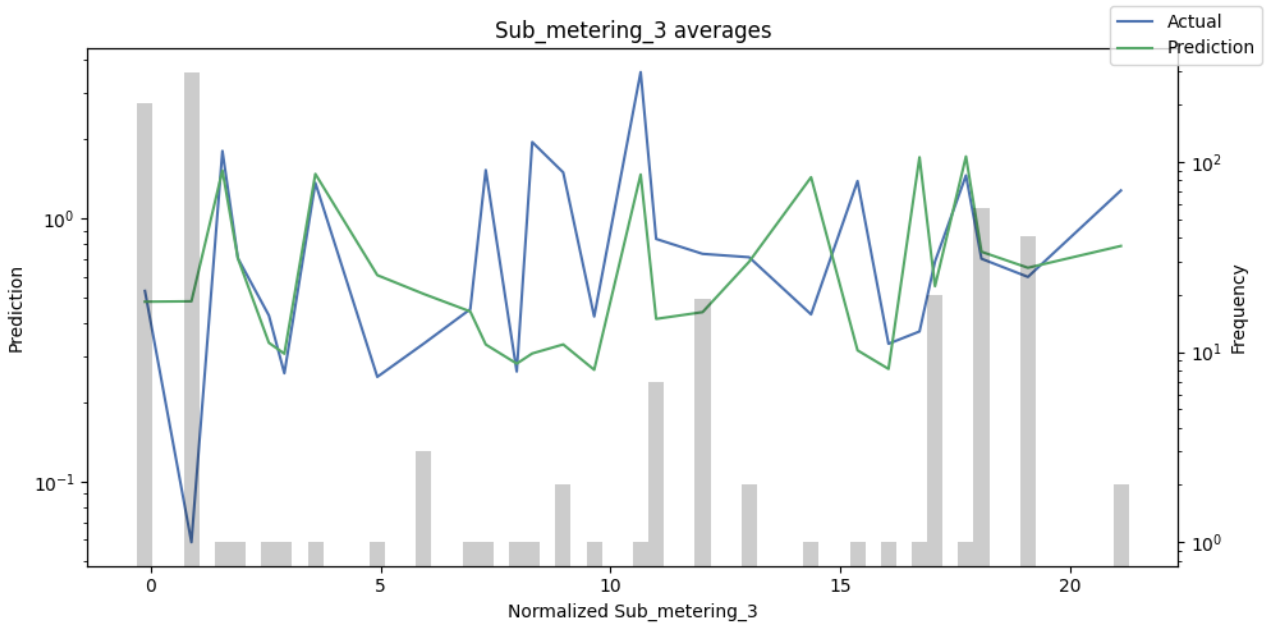

GT1_Hits averages
Actual
Prediction
Prediction
Frequency
Normalized GT1_Hits

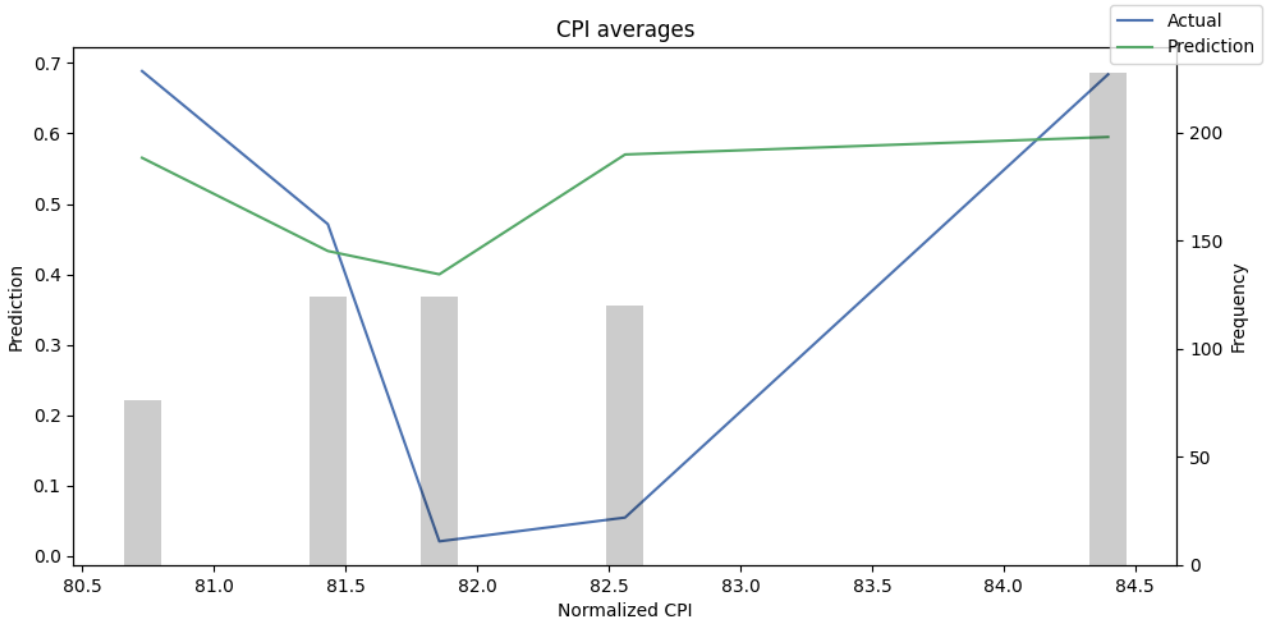

month averages
Actual
Prediction
Prediction
Frequency
month

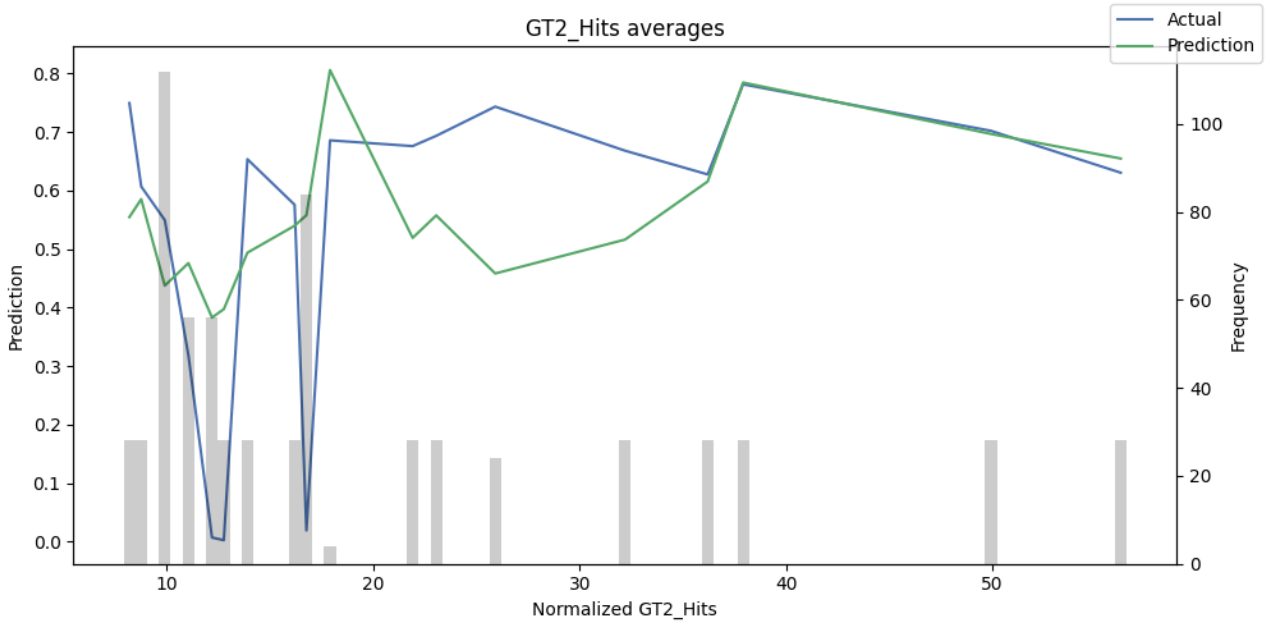

GT3_Hits averages
Actual
Prediction
Prediction
Frequency
Normalized GT3_Hits
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
100
200
300
400
22
24
26
28
30
32
34
36

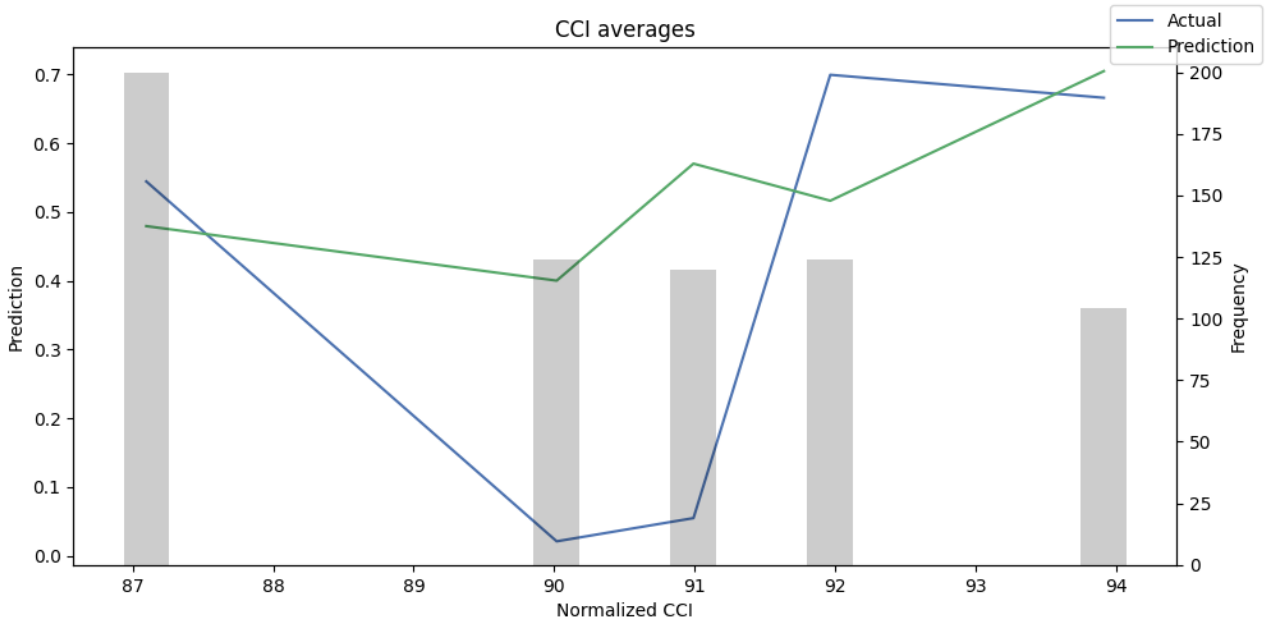

day_of_week averages
Actual
Prediction
Prediction
Frequency
day_of_week
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80
2
4
1
3
0
6
5

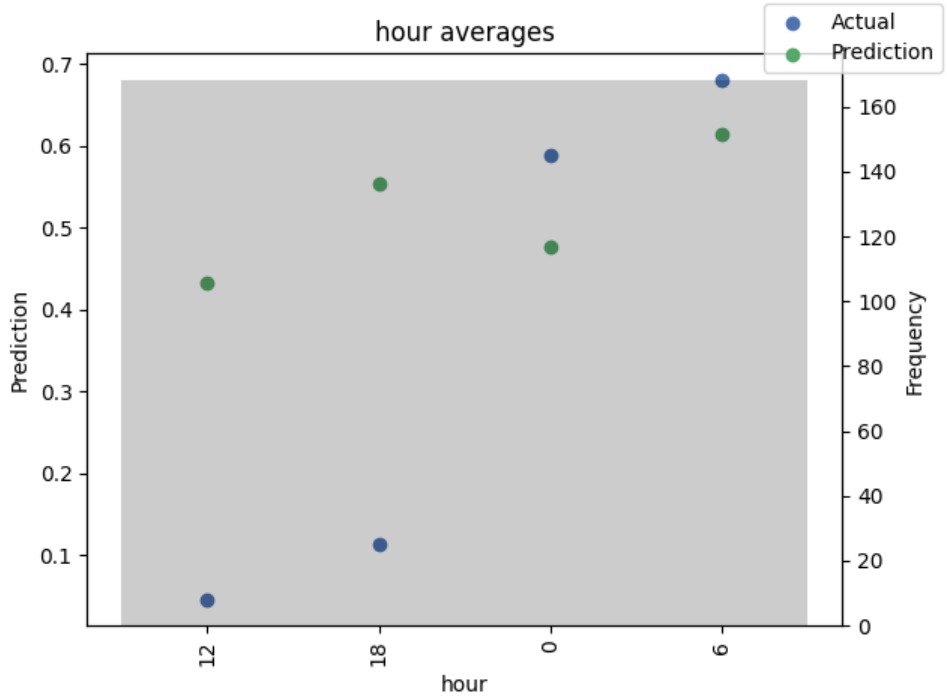

Air_Temp_Norm averages
Actual
Prediction
Prediction
Frequency
Normalized Air_Temp_Norm

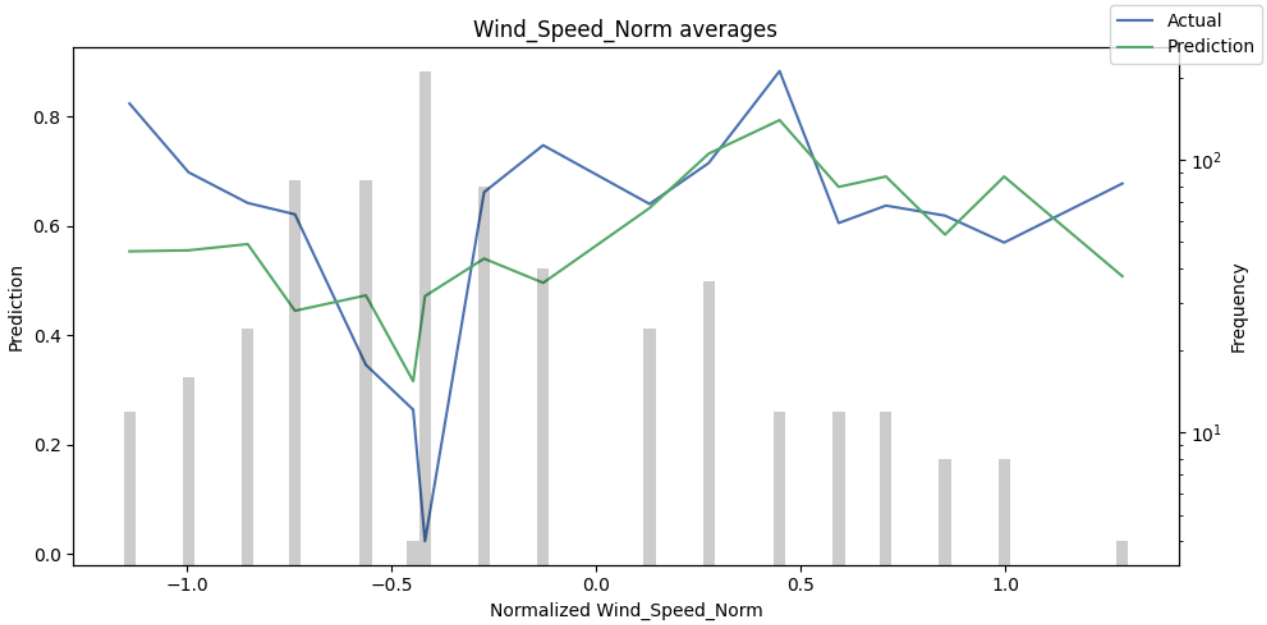

Sub_metering_3 averages
Actual
Prediction
Prediction
Frequency
Normalized Sub_metering_3

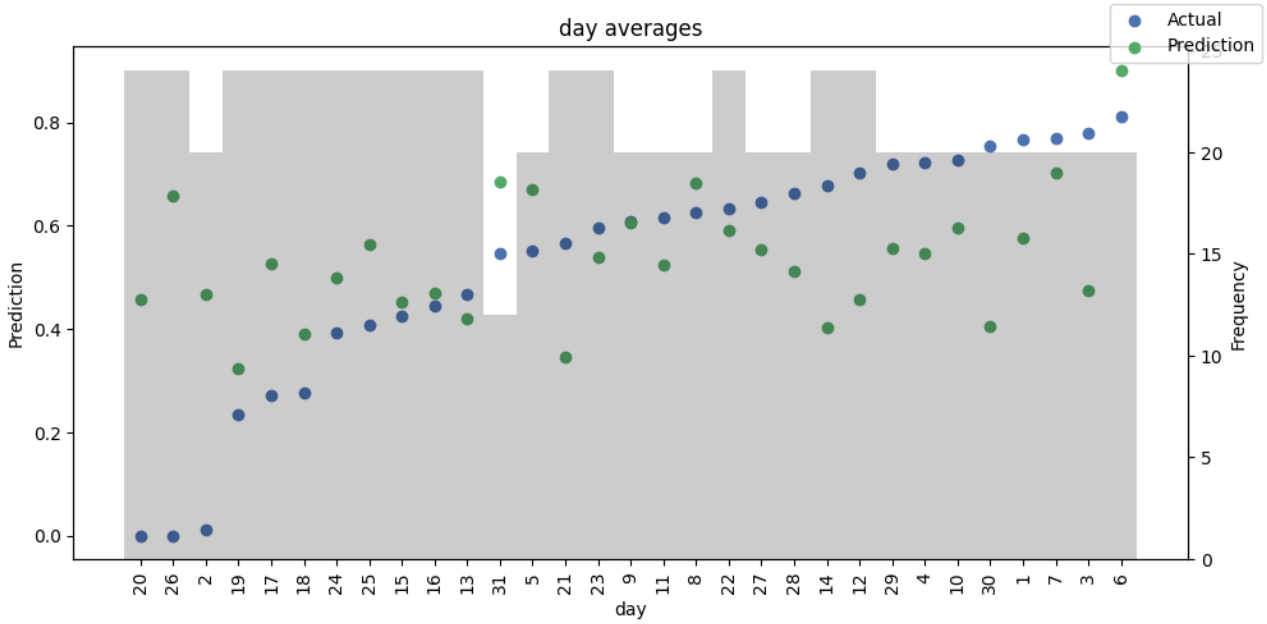

CPI averages
Actual
Prediction
Prediction
Frequency
Normalized CPI
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
50
100
150
200
80.5
81.0
81.5
82.0
82.5
83.0
83.5
84.0
84.5

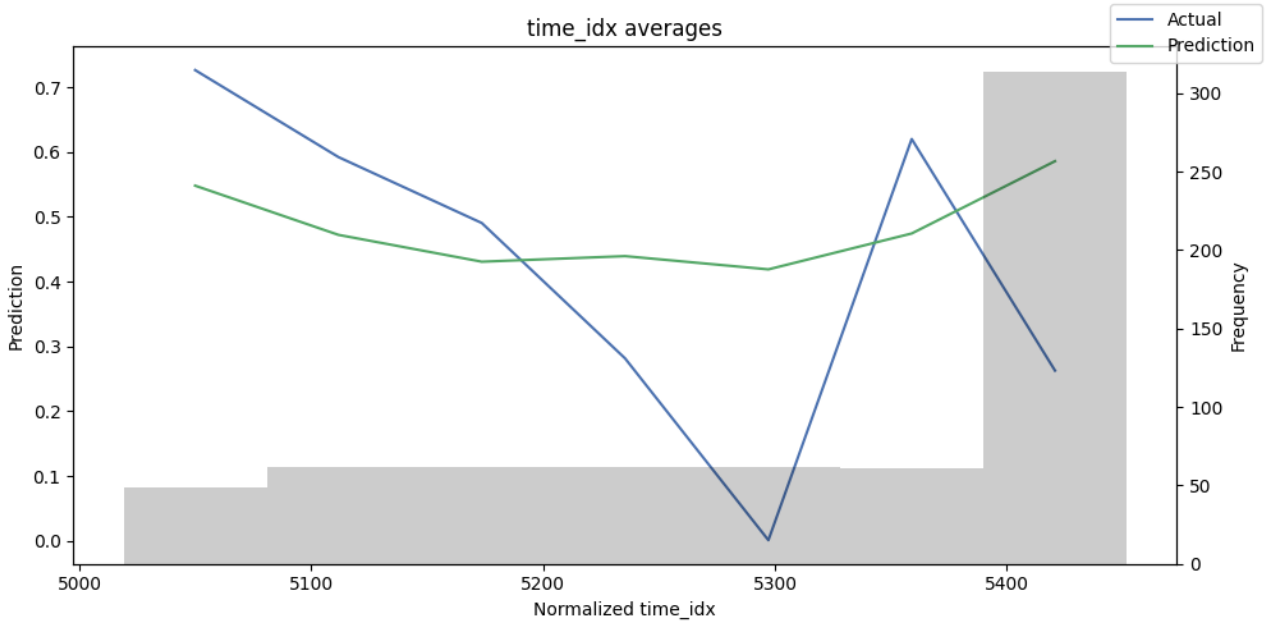

GT2_Hits averages
Actual
Prediction
Prediction
Frequency
Normalized GT2_Hits
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100
10
20
30
40
50

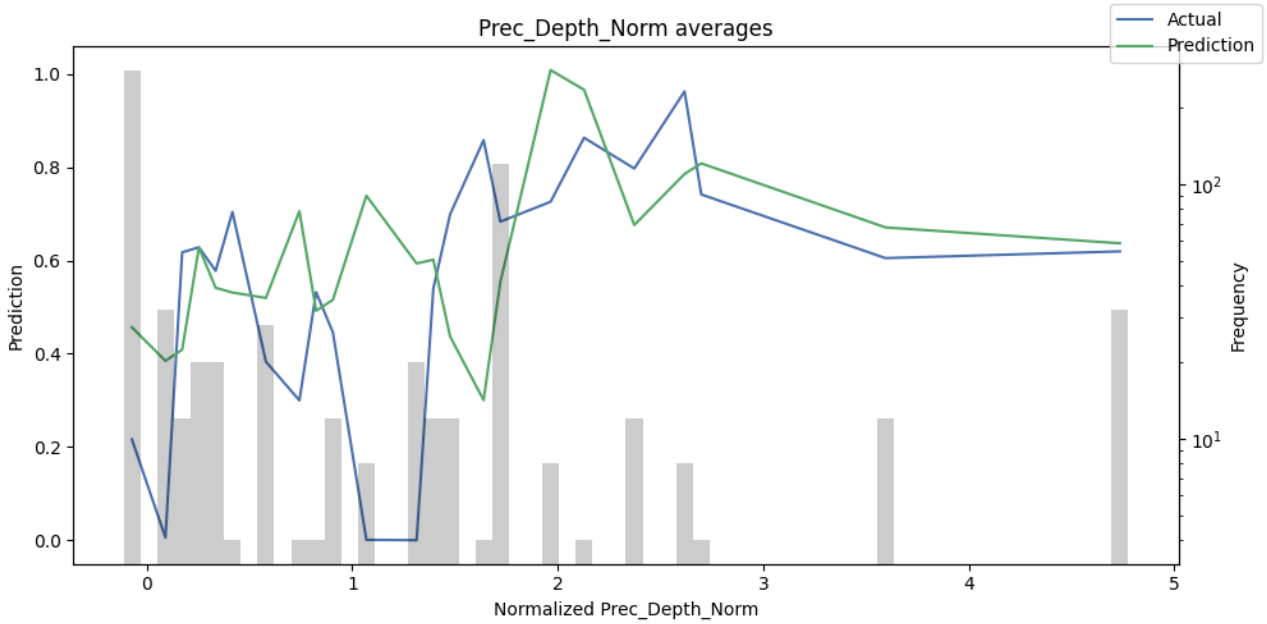

CCI averages
Actual
Prediction
Prediction
Frequency
Normalized CCI
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
25
50
75
100
125
150
175
200
87
88
89
90
91
92
93
94


hour averages
Actual
Prediction
Prediction
Frequency
hour
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80
100
120
140
160
12
18
0
6


Wind_Speed_Norm averages
Actual
Prediction
Prediction
Frequency
Normalized Wind_Speed_Norm
0.0
0.2
0.4
0.6
0.8
−1.0
−0.5
0.0
0.5
1.0
10^1
10^2


day averages
Actual
Prediction
Prediction
Frequency
day
0.0
0.2
0.4
0.6
0.8
0
5
10
15
20
20 26 2 19 17 18 24 25 15 16 13 31 5 21 23 9 11 8 22 27 28 14 12 29 4 10 30 1 7 3 6





In [ ]:
```
dependency = best_tft.predict_dependency(val_dataloader.dataset, 'relative_time_idx', np.linspace(0, 300, 3
# plotting median and 25% and 75% percentile
agg_dependency = dependency.groupby('relative_time_idx').normalized_prediction.agg(median="median", q25=lar
ax = agg_dependency.plot(y="median")
ax.fill_between(agg_dependency.index, agg_dependency.q25, agg_dependency.q75, alpha=0.01)
```

```
Predict:   0%|          | 0/30 [00:00<?, ? batches/s]
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature nam
es, but StandardScaler was fitted with feature names
  warnings.warn(
INFO: GPU available: True (cuda), used: True
INFO:lightning.pytorch.utilities.rank_zero:GPU available: True (cuda), used: True
INFO: TPU available: False, using: 0 TPU cores
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INFO: LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
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Out[ ]: `<matplotlib.collections.PolyCollection at 0x7d0be1430fa0>`